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UK ABWR

Document ID	:	GA91-9101-0101-31000
Document Number	:	DCE-GD-0007
Revision Number	:	C

UK ABWR Generic Design Assessment

Generic PCSR Chapter 31 : Decommissioning

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Executive Summary

This chapter describes the proposed approach to decommissioning the UK ABWR. It demonstrates, for the purposes of GDA, that the UK ABWR may be decommissioned safely using currently available tools and techniques.

The aim for this assessment is to outline high-level plans / strategies, and to confirm wastes from decommissioning can be disposed of appropriately. It demonstrates that practical techniques are available, the UK ABWR design has been developed in a way that supports decommissioning, the design does not foreclose future options, and decommissioning can be undertaken safely without relying on future advancement in decommissioning technology and techniques.

As part of the review of the GDA design some areas have been identified where design changes (e.g. changes to civil structures) would facilitate decommissioning and these have been incorporated into the UK ABWR reference design.

The chapter demonstrates that the risks associated with decommissioning the UK ABWR are reduced, or are capable of being reduced, ALARP. It shows that viable disposal routes are available or will be available, (i.e. the UK geological disposal facility) for all decommissioning wastes.

At this stage of the design, high-level decommissioning plans and strategies have been produced, however as decommissioning is an end of life activity additional work is required by the future nuclear licensee to develop them throughout the life of the UK ABWR. It is also acknowledged that further work will be required post GDA to develop the design and to fully incorporate site specific aspects of decommissioning. This work will be the responsibility of the future licensee.

31.1 Introduction

The purpose of this Pre-Construction Safety Report (PCSR) chapter is to consider and discuss the overall safety case elements for the future decommissioning of the United Kingdom (UK) Advanced Boiling Water Reactor (ABWR). Although decommissioning is the last stage in the overall life cycle of a facility, it must be considered at the planning and design stages to ensure appropriate steps are taken to prevent or mitigate potential decommissioning challenges and risks, and where possible to prevent the foreclosure of options to further optimise decommissioning. This document includes sections and sections covering how the UK ABWR can be decommissioned in a safe and environmentally acceptable way to meet the expectations and requirements set forth by both the Office for Nuclear Regulation (ONR) and Environment Agency (EA).

The overall aim of this PCSR chapter is to demonstrate that decommissioning of the UK ABWR can be undertaken safely with the associated risks reduced As Low As Reasonably Practicable (ALARP). Although decommissioning the UK ABWR will be the responsibility of the future licensee, Hitachi-GE Nuclear Energy, Ltd (Hitachi-GE) needs to demonstrate that it has been taken into account in the UK ABWR design in order to satisfy the requirements of Generic Design Assessment (GDA). Given that decommissioning is not due to occur until the plant has been operating for at least 60 years, this chapter demonstrates that the design of the UK ABWR has considered requirements for safe decommissioning using currently available tools and techniques. This provides an initial plan for the future decommissioning of the UK ABWR in a safe and environmentally acceptable manner.

Background

At the end of the life of any Nuclear Power Plant (NPP) 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. Various stakeholders hold responsibilities when it comes to the decommissioning of NPPs:

- Government – Determine policy in light of international agreements and guidance, and prepare statutory legislation;
- Regulators – Enforce government policy and publish relevant guidance on those policies and applicable site licence conditions. Ensure that appropriate permits are in place to cover decommissioning work and the delicensing of the site;
- Licensee – Prepare appropriate decommissioning strategies and plans, in compliance with government policies and legislation, and regulatory requirements and guidance. In the case of nuclear new build projects in the UK, the Licensee also has a responsibility to implement arrangements to ensure decommissioning is adequately funded.

International and national guidance is identified in [Ref. 31-1] - [Ref. 31-4]. A key piece of legislation applicable during the planning phase of a new plant is the Energy Act 2008 (The Act), which places specific obligations upon the future licensee. Section 45 of the Act states that in applying for a nuclear site license, the future licensee are required to give written notice of the application to the Secretary of State, and prepare and submit a Funded Decommissioning Programme (FDP) [Ref. 31-5].

In alignment with UK policy and regulatory expectations, Hitachi-GE has opted for a “prompt” decommissioning strategy. This is defined as:

- Decommission the site promptly and continuously as far as external constraints will allow;
- Simplify the plant and systems which will remain active during decommissioning to allow for simplification of the site arrangements and the formation of the decommissioning organisation;
- Dispose of Low Level Waste (LLW), Intermediate Level Waste (ILW), spent fuel and all other decommissioning wastes to authorised off-site facilities as soon as these facilities are available;
- De-license the site.

Decommissioning strategies and plans have been developed in line with government policies and encompass the full extent of decommissioning liabilities and interdependencies between facilities. The strategy is integrated with other relevant UK ABWR strategies such as radioactive waste management (Chapter 18) and spent fuel management (Chapter 32).

Conventional Boiling Water Reactor (BWR) technology, first introduced in the 1950's, has undergone continuous improvement and provided the basis for ABWR design in Japan (J-ABWR). Evolution of BWR technology is discussed in further detail in PCSR Chapter 28 – ALARP Evaluation. The UK ABWR design has then been developed based on the technology demonstrated from operating stations in Japan and around the world.

As no ABWR has entered decommissioning specific Operational Experience (OPEX) related to decommissioning is limited. However, numerous earlier BWR designs have successfully undergone, or are currently undergoing decommissioning. Relevant lessons learned from decommissioning these facilities are available and have been taken into consideration during the development of the UK ABWR design. This has been supplemented by lessons learned from other decommissioning programmes e.g. Pressurised Water Rreactors (PWRs).

31.1.1 Purpose and Scope

31.1.1.1 Purpose

The purpose of this chapter is to:

- Provide a demonstration that the UK ABWR design facilitates decommissioning so that hazards are progressively reduced, and decommissioning activities are undertaken in such a way that the workforce, society and the environment are protected;
- Provide an overview of the strategy for decommissioning;
- Describe the planned approach for decommissioning the UK ABWR. Provide a demonstration that the UK ABWR can be safely decommissioned using tools and techniques currently available, but options are not foreclosed for use of alternative techniques as deemed appropriate nearer to the time of decommissioning;
- Identify wastes likely to be generated through decommissioning and determine possible disposal routes;
- Identify the main hazards during decommissioning (radiological and non-radiological) and the design features to aid their reduction;

- Demonstrate that all risks are reduced, or capable of being reduced, ALARP by the future licensee at the appropriate point during the decommissioning phase;
- Provide confidence that the UK ABWR can be decommissioned safely.

31.1.1.2 Scope of GDA Decommissioning

The objective of decommissioning a nuclear power station is to transition the site from its operational state to an agreed end state. It is essential that decommissioning is planned in detail prior to station shutdown to ensure that decommissioning operations can be implemented in a safe manner. Once the reactor has shutdown permanently, all activities carried out on and around the site will be part of the “Decommissioning Scope”. This scope includes:

- Pre-closure planning (including licensing and permitting activities);
- De-fuelling and spent fuel management;
- Maintenance and modification of the site infrastructure and services. This will include activities concerned with site security, site monitoring, maintenance activities, etc.;
- Dismantling and demolition;
- Waste management of both remaining operational wastes and decommissioning wastes (both radioactive and conventional hazardous wastes);
- Storage of ILW, High-level Waste (HLW) and spent fuel;
- Site remediation activities;
- De-licensing.

To ensure consistency across the whole safety case this chapter identifies links to other relevant PCSR chapters and also provides a description of where the arguments and evidence that substantiate all relevant safety case claims can be located in supporting documents. More information regarding compliance with the NSEDPs can be found in PCSR Chapter 5: General Design Aspects.

31.1.2 Document Structure

This PCSR chapter is divided into key sections. A brief description of the sections that make up the contents of this chapter is provided below:

Section 31.2 - Safety Claims: This section sets out the decommissioning safety claims and identifies where the arguments and evidence can be found to support them.

Section 31.3 - Operational Experience: This section identifies national and international OPEX and Good Practice (GP) relevant to decommissioning.

Section 31.4 - Design for Decommissioning – Principles and Techniques: This section sets out the principles adopted during UK ABWR design development to minimise dose and waste and the design requirements to facilitate safe decommissioning. It also reviews the techniques currently available to enable the UK ABWR to be decommissioned.

Section 31.5 - Key Decommissioning Operations and Design Features: This section describes the main hazards during decommissioning and the features incorporated into the UK ABWR design to aid the reduction of those hazards.

Section 31.6 - Decommissioning Strategy: Provides a high-level discussion of the strategy for transition of a generic site containing a single UK ABWR from its operational state to an agreed end state.

Section 31.7 - Decommissioning Plan: Provides an overview of the plan for decommissioning of each of the main buildings associated with the UK ABWR. This includes a brief description of each building, the expected conditions at End of Generation (EoG), what further use, if any, each building will have during decommissioning, and when each facility will be decommissioned.

Section 31.8 - Decommissioning Waste and Wastes Remaining on Site: This section summarises the waste safely stored on site when the reactor ceases operation and the plan for processing of wastes during the decommissioning phase. Safe waste storage and final disposal of all wastes at the Geological Disposal Facility (GDF), including those generated during decommissioning, are also covered at a high-level in this section.

Section 31.9 - Decommissioning Management Arrangements: Summarises the records management and design change control requirements to ensure that the expected conditions when the reactor ceases operation do not significantly affect safe decommissioning. This section also ensures that conditions required for safe storage, repackaging (if required) and disposal are not adversely affected.

Section 31.10 - Assumptions, Limits and Conditions for Operations: States the assumptions that the PCSR chapter and decommissioning scope of work is based on.

Section 31.11 - Summary of ALARP Justification: This section provides a summary of the justification that the UK ABWR has been designed such that the risks associated with decommissioning have been reduced, or are capable of being reduced, ALARP.

Section 31.12 - Conclusion: This section provides a summary of the main aspects of this chapter.

Additional information in support of this chapter is provided within Appendices A-C:

Appendix A – Document map;

Appendix B – Interactions with other PCSR chapters;

Appendix C – Decommissioning Safety Claims.

This chapter is supported by a suite of reference documents, primarily decommissioning Topic Reports [Ref. 31-6] - [Ref. 31-12]. Collectively they describe the arguments and point to the relevant evidence to substantiate the decommissioning safety claims made. The full list of supporting Topic Reports is shown in the document map in Appendix A.

Given the cross cutting nature of decommissioning this chapter has a number of links to other PCSR chapters. Key links include:

- Main plant conditions are described in PCSR Chapter 2: Generic Site Envelope

- General requirements related to conventional safety aspects are described in PCSR Chapter 4: Safety Management Throughout Plant Lifecycle;
- The assessment of the civil structures of the plant in normal and fault loads is described in Chapter 10: Civil Works and Structures;
- The safety case for the Steam and Power Conversion Systems and Auxiliary Systems is described in Chapters 16: Auxiliary Systems and Chapter 17: Steam and Power Conversion Systems;
- The overall approach to the management of radioactive waste, is described in Chapter 18: Radioactive Waste Management. In particular, Sections 18.10, 18.11, and 18.12, discuss the safe management of HLW, ILW, and LLW;
- Radiation protection throughout the life cycle of the plant is discussed in PCSR Chapter 20: Radiation Protection;
- The chemistry of the reactor and the pools are discussed in PCSR Chapter 23: Reactor Chemistry. This chapter includes information surrounding how chemistry will be maintained and sampling that will be undertaken throughout the life cycle of the plant;
- The safety case for de-fuelling and storing spent fuel is provided in PCSR Chapter 19: Fuel Storage and Handling and PCSR Chapter 32: Spent Fuel Interim Storage. These two chapters consider the requirements for spent fuel - storage and treatment beyond the operational life of the reactor.

For links to the Generic Environmental Permit (GEP) and Conceptual Security Arrangements (CSA), please refer to Generic PCSR Chapter 1: Introduction. For the GEP, where specific references are required, e.g. in Radioactive Waste Management, Radiation Protection, these will be included in the specific sections within the relevant chapter.

31.1.3 Basis of Assessment

Section 31.10 details the assumptions, limits and conditions that underpin this PCSR chapter. The following is a list of high-level bounding conditions that provide context to the decommissioning assessment.

- 60 year operating period;
- Decommissioning of the reactor begins at the EoG;
- Once the plant has been shutdown decommissioning works will be conducted as soon as possible. For most buildings (excluding the Reactor Building [R/B)), there is no period of care and maintenance to allow radioactive decay. This strategy is referred to as prompt decommissioning;
- Existing buildings and facilities will be utilised for decommissioning purposes where this is appropriate to ensure risks are reduced to ALARP and wastes are minimised;
- The walls of buildings will be utilised as boundaries for decommissioning to prevent of spread of contamination and provide radiation protection. If the walls of buildings are not utilised (e.g. if they are removed to facilitate decommissioning operations), usable temporary containment and shielding will be established. Protection will be provided to prevent contamination of the walls where appropriate;

- Any LLW / Very Low Level Waste (VLLW) or industrial waste generated will be disposed of immediately;
- The proposed decommissioning plan reflects only currently available technologies;
- ILW (including decayed HLW) and spent fuel will be stored on-site within interim storage facilities until a GDF becomes available;
- Spent fuel will be safely stored for up to 140 years after the EoG;
- Decommissioning ends when all station buildings and facilities have been demolished and the site has been returned to an end state that has been agreed with the regulators and planning authority.

31.2 Safety Claims

The safety case for decommissioning the UK ABWR is based on the high-level decommissioning safety objective: ‘the UK ABWR can be decommissioned safely’. To support the decommissioning safety case, a Claims, Arguments, and Evidence (CAE) tree has been produced. The CAE tree collates all the decommissioning safety claims and provides traceability to arguments and supporting evidence. In conjunction with the decommissioning assumptions, these claims make up the design requirements for decommissioning. The full CAE tree can be found within Topic Report on Decommissioning: Decommissioning Safety Assessment [Ref. 31-12]. A consolidated CAE table can be found in Table 31.2-1, and a table detailing the supporting arguments can be found in Appendix C.

Table 31.2-1 and Appendix C both provide links between the decommissioning safety claims and interaction with other relevant chapters. The links demonstrate that these claims have been captured and discussed as part of the generic UK ABWR design in support of decommissioning.

Table 31.2-1 UK ABWR Decommissioning Safety Claims

Claim	Sub-claim	PCSR Section	Related PCSR Chapter
Decom-SC 1: The UK ABWR design incorporates features that facilitate decommissioning.	Decom-SC 1.1: The design of the UK ABWR minimises the decommissioning Source Term (ST) ALARP.	31.5.2.1 31.5.2.2 31.5.2.3 31.5.2.9	Chapter 8 Chapter 10 Chapter 23
	Decom-SC 1.2: The UK ABWR pipework and drainage design reduces decommissioning risks ALARP.	31.5.2.2 31.5.2.7	Chapter 10 Chapter 16
	Decom-SC 1.3: The UK ABWR design minimises conventional safety risks during decommissioning.	31.5.2.1 31.5.2.6	Chapter 10 Chapter 27
	Decom-SC 1.4: The design of the UK ABWR ensures sufficient access and space for decommissioning activities to be undertaken.	31.5.2.6 31.5.2.11	Chapter 10 Chapter 27
	Decom-SC 1.5: The UK ABWR design has considered decommissioning logistics to ensure risks are reduced ALARP.	31.5.2.6	Chapter 10 Chapter 16 Chapter 27
	Decom-SC 1.6: A variety of decommissioning techniques are available to decommission the UK ABWR.	31.4.2	Decommissioning Specific
	Decom-SC 1.7: The UK ABWR design	31.5.2.10	Chapter 10

Claim	Sub-claim	PCSR Section	Related PCSR Chapter
	has considered the impact of construction techniques on decommissioning in the design.		Chapter 16 Chapter 27
	Decom-SC 1.8: The design of the UK ABWR ensures long-term structural integrity and containment.	31.5.2.8	Chapter 8 Chapter 10 Chapter 14 Chapter 23
	Decom-SC 1.9: Ancillary systems will have the functionality to be adapted or modified to facilitate the different operational profile of decommissioning activities.	31.5.2.4	Chapter 12 Chapter 14 Chapter 16 Chapter 18 Chapter 19
Decom-SC 2: Appropriate decommissioning plans / strategies are in place, and will continue to be developed by the future licensee.	Decom-SC 2.1: The UK ABWR can safely transition from its operational state to an agreed end state where the site can be delicensed and remediated to a level near to greenfield site.	31.6 31.7	Decommissioning Specific
	Decom-SC 2.2: Records will be managed appropriately and reviewed periodically.	31.9.1	Chapter 4 Chapter 29
Decom-SC 3: Faults and hazards during decommissioning are identified, assessed and all risks shown to be ALARP.	Decom-SC 3.1: Conventional and radiological hazards arising from decommissioning operations and faults have been identified.	31.5.1	Decommissioning Specific
	Decom-SC 3.2: Appropriate design features to facilitate decommissioning and provide hazard reduction have been identified.	31.5.2	Chapter 8 Chapter 10 Chapter 12 Chapter 14 Chapter 16 Chapter 18 Chapter 19 Chapter 23 Chapter 27
	Decom-SC 3.3: An assessment of decommissioning risks has been	31.5.1	Decommissioning Specific

Claim	Sub-claim	PCSR Section	Related PCSR Chapter
	undertaken to show that risks have been reduced, or are capable of being reduced ALARP.		
	Decom-SC 3.4: The design challenge process has taken account of decommissioning GP so that risks associated with decommissioning are ALARP.	31.3 31.5.1	Decommissioning Specific
Decom-SC 4: Viable disposal routes are available (or will be available) for all decommissioning wastes.	Decom-SC 4.1: Decommissioning wastes can be disposed of via viable routes.	31.8	Decommissioning Specific
	Decom-SC 4.2: Waste generation during decommissioning will be minimised.	31.8	Chapter 8 Chapter 10 Chapter 11 Chapter 16 Chapter 23
	Decom-SC 4.3: Waste will be minimised during operations.	31.8	Generic Environmental Permit Chapter 8 Chapter 10 Chapter 23
	Decom-SC 4.4: UK ABWR minimises waste generation by design.	31.8	Generic Environmental Permit Chapter 8 Chapter 10 Chapter 16 Chapter 23
	Decom-SC 4.5: The waste hierarchy will be applied to all decommissioning wastes.	31.8	Chapter 8 Chapter 23

Claim	Sub-claim	PCSR Section	Related PCSR Chapter
Decom-SC 5: The UK ABWR can be decommissioned using today's technology.	Decom-SC 5.1: Appropriate decommissioning techniques exist to decommission the UK ABWR.	31.4.2	Decommissioning Specific

31.3 Operational Experience

The BWR design has evolved through many iterations since its inception in the 1950s. Through each evolution lessons have been learned to enable successive BWR designs to be decommissioned with improved efficiency, reduced risk [Ref. 31-7] and enhanced safety. This is discussed further in PCSR Chapter 4 – Safety Management throughout the Plant Lifecycle.

To date no ABWR has been decommissioned or entered decommissioning and therefore specific OPEX is limited. However, earlier BWR variants have been successfully decommissioned and lessons learned from these decommissioning projects and other decommissioned nuclear facilities internationally and within the UK have been gathered and considered as part of the development of the UK ABWR decommissioning strategy. Specifically, decommissioning OPEX has been reviewed to understand;

- GP for main decommissioning tasks e.g.:
    - Decontamination techniques;
    - Reactor Pressure Vessel (RPV) dismantling approach;
    - Reactor Internal (RIN) dismantling approach;
    - Deplanting techniques e.g. plasma arc, nibblers, grinders;
    - Spatial environment e.g. import / export routes;
    - Embedded pipework removal;
    - Drainage of systems;
    - Ventilation requirements;
    - Lifting requirements.
- Risks in decommissioning
- Decommissioning difficulties associated with older NPP design and associated facilities

Whilst GP and decommissioning OPEX has been gathered and fed into the UK ABWR design, the design does not foreclose options ensuring that the future licensee has the flexibility to change and incorporate improvements in decommissioning.

NPPs that have been decommissioned, or are currently undergoing decommissioning, have informed the development of the UK ABWR design to support decommissioning through insight of the approaches and techniques undertaken previously and in the nuclear industry today [Ref. 31-7][Ref. 31-9].

It is worth noting that techniques employed today have themselves been informed by previous decommissioning projects as to their suitability and performance. GP which has been extensively endorsed and proven to work successfully in practice often provides strong indications of an ALARP solution and have been considered for adoption for decommissioning of the UK ABWR.

31.3.1 International NPP Decommissioning Experience

Pertinent GP and OPEX from international NPP decommissioning projects are presented in Table

31.3-1:

Table 31.3-1 GP and OPEX from International Decommissioning Projects

Reactor	Reactor Type	Shutdown Date	Status of Decommissioning	Decommissioning Features	Ref
Gundremmingen (Germany)	BWR	1977	Decommissioning Complete	• Prompt decommissioning • Segmentation of RIN within Spent Fuel Pool (SFP) • Segmentation of RPV in air	[Ref. 31-13]
Wurgassen (Germany)	BWR	1994	Decommissioning Complete	• Prompt decommissioning • Segmentation of RIN within SFP • Segmentation of RPV in air • Space to manage waste exports	[Ref. 31-14] [Ref. 31-15]
Stade (Germany)	BWR	2003	• Fuel removed • Post Operations Clean Out (POCO) completed • RPV and RIN removed • Deplanting of plant systems • Waste processed and packaged	• Prompt decommissioning • Segmentation of RIN within SFP • Segmentation of RPV in air • Space to manage waste exports	[Ref. 31-14] [Ref. 31-15]
Isar-1 (Germany)	BWR	2011	• Defuelled • Fuel held in SFP • Enabling works to convert Turbine Building (T/B) in to a waste processing and packaging in progress • Waste is being processed and packaged	• Prompt decommissioning • Space to manage waste exports	[Ref. 31-16]

Reactor	Reactor Type	Shutdown Date	Status of Decommissioning	Decommissioning Features	Ref
Zion (USA)	PWR	1998	• Fuel removed • POCO completed • RPV and RINs removed • Deplanting of plant systems complete to 98% of radiological systems have been removed	• Prompt decommissioning • Segmentation of RIN within SFP • Segmentation of RPV in air • Large waste processing facility • Relatively young plant – operated for 20 years, benefitted from decommissioning considerations	[Ref. 31-17]

31.3.2 UK Decommissioning Experience

The UK has no specific experience of decommissioning a UK ABWR, an ABWR, or indeed any variant of BWR. However, there is significant transferable experience gathered from decommissioning alternative reactor types and other nuclear facilities.

The table below presents the successful application of decontamination and segmentation techniques from packaging and disposal of wastes (including HLW, ILW, LLW, VLLW, and Out of Scope) within the UK context and guidelines.

Table 31.3-2 UK Decommissioning Projects Providing GP and OPEX

Sites	Reactor Type / Facility	Shutdown Date	Status of Decommissioning	Ref
Winfrith	Steam Generating Heavy Water Reactor (SGHWR)	1990	Currently planning removal and segmentation of reactor core Progress to date include: • Redundant pipework has been removed • Removal of 50 tonne plug and asbestos	[Ref. 31-18]
Magnox fleet	Magnox	1989 - 2015	Variety of plant states across the fleet from defueling through to long-term care and maintenance	[Ref. 31-19] to [Ref. 31-22]

Sellafield	Windscale Advanced Gas Cooled Reactor (WAGR)	-	Active decommissioning operations are being undertaken on existing plants. Successful decommissioning projects include: • Windscale • WAGR -full core decommissioning and heat exchanger removal	[Ref. 31-23]
Sellafield	Other – Reprocessing plant	-	• Pile chimneys • Mixed Oxide Fuel production plant • Research and Development (R and D) plants • Pilot Plants	[Ref. 31-24]
Dounreay	Fast Breeder Reactor – Dounreay Fast Reactor (DFR) Shaft Silo facility	1977	Completed activities for DFR include: • Fuel removed • New ventilation installed • Pond decommissioned Shaft Silo facility: • Hydraulic isolation completed • Waste retrievals are planned for 2024	[Ref. 31-25] [Ref. 31-26]

31.3.3 Key Elements of OPEX Applied to the UK ABWR

31.3.3.1 Decontamination

International experience from both PWR and BWR plant types shows that decontamination of the recirculating primary circuit reduces contamination levels and subsequent dose uptake to operators during dismantling tasks [Ref. 31-27] - [Ref. 31-31].

Decontamination processes are proven to aid decommissioning of NPPs, in particular:

- Significantly reducing worker doses during deplanting operations to ensure risks are ALARP;
- Removal of loose contamination – minimisation of airborne contamination;
- Potential to reclassify waste i.e. LLW to Out of Scope.

Decontamination techniques that are available and have been successfully applied to NPPs [Ref. 31-9]:

- Chemical Oxidation Reduction Decontamination (CORD)– Wurgassen, Lingen, Caorso Oskershamn 1;
- Low Oxidation State Metal Ion (LOMI) – Surry 1;
- Decontamination for Decommissioning (DfD) – Electric Power Research Institute (EPRI) – Big Rock;
- Nitric acid + potassium permanganate – Ignalina.

These techniques produce secondary wastes, typically in the form of ion exchange resin. The application of the CORD-UV decontamination technique was successfully implemented on the recirculating circuit at Oskershamn 1 and consisted of a circuit volume of 160 m^3 with surface area of 1500 m^2. Decontamination was conducted by 4 cycles of CORD-UV over a 7 day period resulting in removal of over 99.5 % of the target activity. The resulting RPV bottom dose rate was reduced from 30 mSv/h to 0.025 mSv/h. Waste production figures relating to ion exchange resins utilised in the cleanup after in-situ decontamination produced to 16 m^3 of resin wastes.

The application of EPRI DfD process for full circuit decontamination at Big Rock Point involved a circuit with a volume of 121 m^3 and surface area of 1,000 m^2, this resulted in 15.2 m^3 of dewatered ion exchange resin waste and afforded a Decontamination Factor (DF) of 27.

The UK ABWR design has considered the application of available decontamination techniques and leaves open the opportunity for the future licensee to choose the most appropriate technique to ensure that risks to workers are reduced ALARP. Design features to facilitate decontamination processes have been incorporated and are discussed in detail in Section 31.5.2.2.

31.3.3.2 Concrete Structures / Liners

OPEX has shown that minor spills of contaminated fluid can occur throughout the operational life of a reactor resulting in contamination to varying degree of depth (10 mm to 40 mm) within the concrete [Ref. 31-33]. Whilst it is never the intention to lose containment, it is prudent to ensure that there are techniques available to prevent activity migrating in to the concrete (concrete coatings) and to remediate localised areas.

Design features to minimise the potential for leakage from containment are discussed further in Section 31.5.2.9. The UK ABWR has incorporated design features which mitigate against significant contamination of concrete surfaces including; stainless steel lining of the SFP and decontaminable sealed surfaces to prevent penetration of liquid from leaks or spills in to concrete structures from rooms containing wet process systems.

There are many techniques for removal of surface contaminated concrete that have been successfully applied on a variety of decommissioning projects. As it is not anticipated that the UK ABWR will have a significant contamination event only potential techniques to remove the top concrete surface layer have been considered. Techniques employed to remove contamination generally result in the production of airborne dust / spray. Risks to workers undertaking these techniques are minimised through use of remotely operated tools, mobile ventilation equipment, temporary tenting to prevent spread of contamination and the use of Personal Protective Equipment (PPE). Where porous surfaces are contaminated, mechanical methods may be the only choice to achieve the desired level of decontamination. The following techniques have been successfully employed in the UK and are relevant to the UK ABWR:

- Mechanical scabbling – Trawsfynydd ponds, Figure 31.3-1 [Ref. 31-32];
- Shaving – Windscale Pile 2 [Ref. 31-18];
- Vacuum blasting – Harwell Local Effluent Treatment Plant [Ref. 31-19];
- Ultra-High Pressure (UHP) water jet – Hunterston A ponds, Bradwell ponds, Berkeley ponds [Ref. 31-19];
- Strippable coatings – Dounreay ponds [Ref. 31-26].

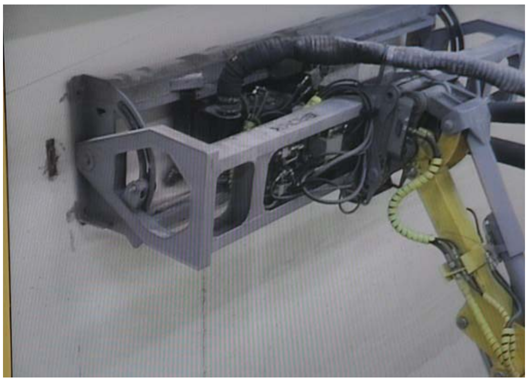


Figure 31.3-1 Scabbling pond walls at Trawsfynydd [Ref. 31-33]

The UK ABWR will adopt a toolbox approach whereby techniques are chosen based on their suitability for plant conditions. This approach has been utilised by other international decommissioning projects [Ref. 31-9].

Stainless steel liners are incorporated into the UK ABWR design to prevent concrete contamination. However, the liners themselves will conversely become contaminated. Techniques applied in other decommissioning projects have been shown to successfully decontaminate concrete walls and steel liners. These techniques are similar in nature to those considered against decontamination of concrete structures and include:

- Vacuum blasting – Sellafield ponds [Ref. 31-19];
- UHP water jet – Hunterston A ponds, Bradwell ponds see Figure 31.3-2 [Ref. 31-19];
- Strippable coatings - Dounreay ponds [Ref. 31-26].

Figure 31.3-2 Decontamination of ponds at Bradwell using UHP water jet [Ref. 31-33]

An established approach for decontaminating pool structures is use of an UHP / High Pressure (HP) water jet. HP water is directed just above the water line as the water level of the pool is gradually lowered. This approach avoids exposure of excessive contaminated surface areas which could lead to increased airborne contamination levels as they dry. Recent technological developments allow remote application of HP water, removing the need for operators to undertake the task at the workface.

In conclusion, there are established techniques available for removal of surface contamination. These techniques are proven to be reliable and effective, and there are cases where complete removal of contamination has been achieved.

31.3.3.3 Dismantling of the RPV and RINs

The RPV and RINs are the most activated parts of a NPP and have been shown to pose a significant radiological hazard to workers. Understanding the hazards and risks previously encountered in dismantling the RPV and RINs from other decommissioning projects has allowed the UK ABWR design to be optimised for decommissioning. The approach has been widely endorsed as the best approach to dismantle the RPV and RINs with the use of appropriate techniques and processes that ensure that the activity can be performed safely and efficiently. This is discussed in more detail in Section 31.5.

Key aspects of the deplanting approach which collectively ensure that the risks associated with dismantling of the RPV and RINs can be reduced to ALARP include:

- Sampling and characterisation – Use of remotely operated equipment erected and deployed from the operating deck allow an understanding of the radiological levels of the reactor components at the EoG. Providing distance between the worker and sampling operations ensures that the radiological risks to the worker are ALARP;
- Segmentation and lifting – Segmentation and lifting operations of reactor components and the RPV can be performed remotely. A dedicated control station that is remote to the RPV has been successfully used to remove and size reduce the RPV and RINs. Providing distance between the worker and decommissioning activities ensures that risks to the worker are ALARP;
- Shielding – Segmentation of RINs within the SFP provides protection to workers from radiological consequences during segmentation operations. Use of mobile shielding to provide protection to workers along waste export routes can be utilised to ensure that risks are minimised to workers;
- Waste transfer – Wastes associated with RPV and RINs can be safely retrieved, packaged and exported;
- Fuel pool management – Maintenance of water clarity within the SFP provides visibility to workers performing cutting operations which mitigate against the risk of undertaking unnecessary operations and also facilitates the efficiency of the segmentation process;
- Ventilation – Erection of mobile ventilation housing on the operating deck provides a dedicated ventilation extract source which both extracts from the area of highest airborne contamination (providing a cascade effect) and prevents the spread of any airborne contamination to other plant areas which may be generated from decommissioning operations;
- Use of existing equipment – Utilisation of the R/B crane minimises the requirement to bring in new equipment to perform decommissioning operations and removes the potential for contaminating equipment and generating additional waste volumes.

A pictorial representation of the segmentation procedure successfully performed at the Stade NPP capturing all the salient features described above is shown Figure 31.3-3 [Ref. 31-17].

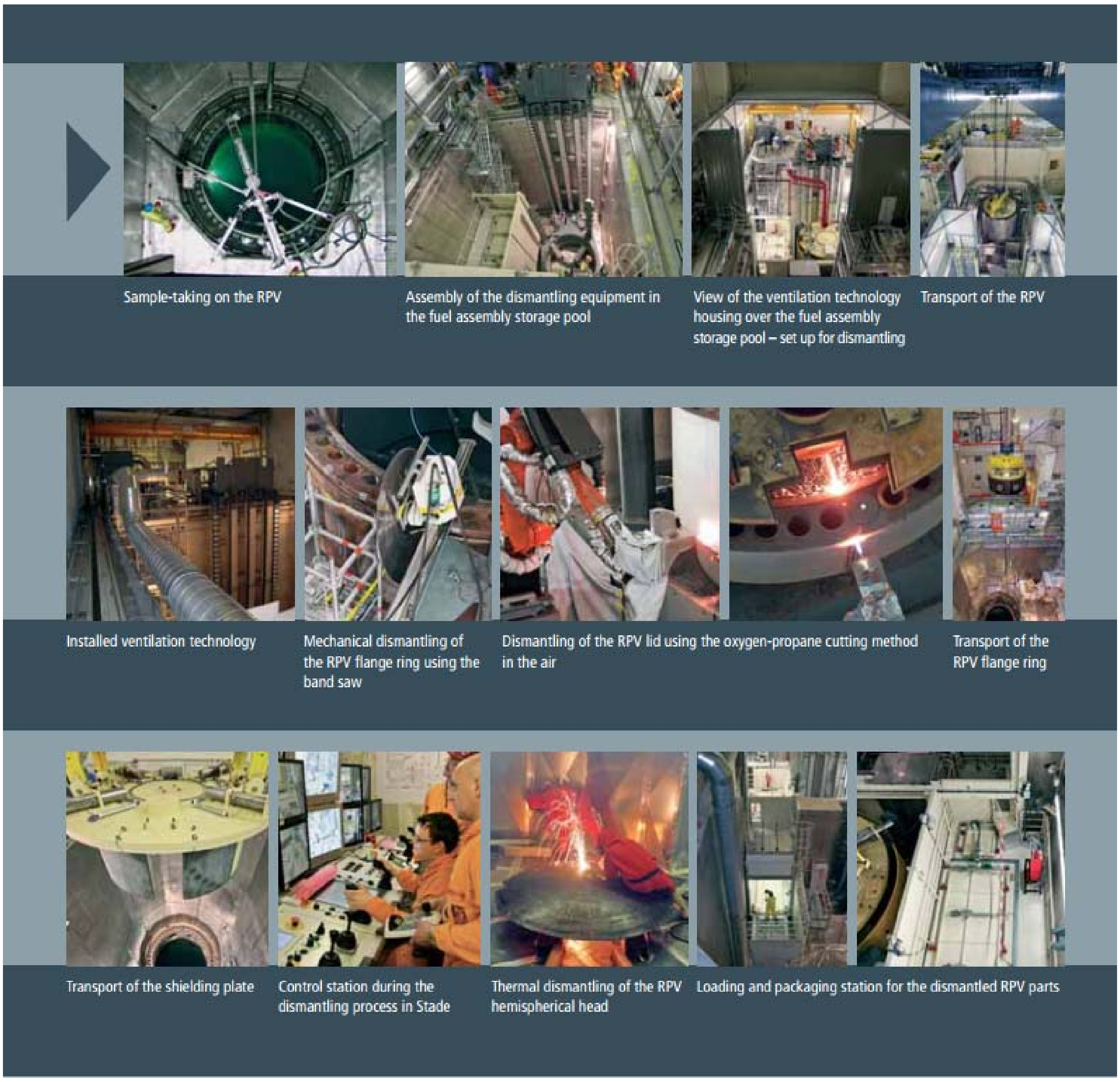


Figure 31.3-3 Illustration of dismantling procedure of the RPV at Stade [Ref. 31-17].

31.3.3.4 RIN Size Reduction

The activated RINs will be retrieved from the RPV and placed in the Dryer Separator Pool (DSP) adjacent to the RPV well. The RINs will be size reduced underwater in the DSP which will provide shielding to the worker. A variety of techniques are available which could be utilised to perform size reduction tasks, including:

- Plasma Arc Cutting (PAC) – Gundremmingen A [Ref. 31-13];
- Reciprocating saw – Gundremmingen A [Ref. 31-13];
- Nibblers, Band Saw and Jig Saw – Wurgassen [Ref. 31-15];

- Abrasive Water Jet Cutting (AWJC) – San Onofre [Ref. 31-34].

Current international GP for RIN dismantling involves a change of cutting technique as dismantling progresses down through the reactor due to increasing levels of activation experienced by the lower internals. Changing the technique reduces airborne release of activation products during the segmentation process and ensures that radiological exposure to workers is reduced ALARP. As such, the proposed approach for the UK ABWR is a change from PAC for the upper internals (steam dryer, steam separator) to AWJC for the lower internals (core shroud, core plate).

For areas with lower activity, e.g. steam separators, use of hot cutting techniques such as PAC is preferred over AWJC due to the lower volumes of secondary waste (spent grit) produced.

OPEX has shown that poor tool selection can lead to elevated levels of loose particulate being generated within the pool leading to decreased visibility for the worker. Consequently, a balance between appropriate tool selection and having a cutting environment which permits efficient operations is required to ensure that risks are managed and reduced ALARP.

31.3.3.5 RPV Size Reduction

In contrast to the approach undertaken to segment the RINs, OPEX shows that segmentation of the RPV has been successfully and safely performed in air with the RPV flooded for shielding and particle capture purposes.

As mentioned above, fuel pool water management is reliant on appropriate tool selection. OPEX has demonstrated that segmentation of large components requires extended cutting operations which can result in the generation of significant amounts of grit and particulate, subsequently impacting on worker visibility, and placing an additional burden on the pool cleanup systems. The fuel pools are not sized to accommodate an entire RPV. This precludes the option for relocation of the RPV for segmentation underwater. If the fuel pools were sized to accommodate the RPV, the lifting capacity of the Reactor Building Crane (RBC) would need to be significantly uprated and re-commissioned post generation to allow for its relocation. Given the radiological risks associated with lifting a large, heavy and activated component, an accepted and widely endorsed approach which negates the requirement to lift the RPV has been established and is supported by significant OPEX.

The RPV will be segmented remotely in-situ into ring sections, removed from the Reactor Well (R/W), and placed in the DSP where they will be size reduced using similar techniques to those used for the RINs. A key component required to allow this approach to be undertaken is the refuelling machine which will be used in combination with the remote segmentation equipment to allow the deployment of tooling. The types of techniques which have previously been applied to segment the RPV include:

- Oxy-acetylene/propane – Gundremmingen A, Stade [Ref. 31-13];
- Milling cutter – Gundremmingen A, BR3 [Ref. 31-13];
- AWJC – Wurgassen, Rancho Seco [Ref. 31-14] and [Ref. 31-15];
- Arc saw – Japan Power Demonstration Reactor [Ref. 31-35] and [Ref. 31-36].

Through adoption of the good working practices discussed in Section 31.3.3.3, OPEX has shown that segmentation of the RPV can be undertaken safely. The approach is well established i.e. the associated risks and hazards are well understood, has been successfully performed on other decommissioning projects, and benefits from being performed remotely thereby minimising the radiological risk to workers (see Figure 31.3-1). The proposed RPV segmentation technique is deemed to be GP.

To facilitate removal of the large RPV ring sections from the R/W, the future licensee may seek to widen the DSP gate. This will require the pool to be drained, concrete to be removed to widen the opening and steps taken to protect the newly exposed concrete surfaces. Such an approach has successfully been performed at other NPPs such as Zorita in Spain. The UK ABWR benefits from having a large pool area within the DSP and the design provides flexibility to widen the pool gates at the time of decommissioning if required.

An assessment of the benefits of undertaking this design modification during reference design has been undertaken, however it is recognised that this may bring potential safety implications during operations i.e. compromising structural integrity and increased potential for loss of pool containment. OPEX demonstrates that gate widening has successfully been achieved on older NPPs at the time of decommissioning and as such the option is not foreclosed to future licensee.

31.3.4 Site Walkdown of BWR, ISAR-1, Niederaichbach (Germany)

To gain an up to date understanding of the challenges linked with decommissioning BWR NPPs, Hitachi-GE’s decommissioning project team undertook a site walk down of the ISAR-1 BWR which has recently been approved for decommissioning. Opportunities were afforded by the plant workers to explain the decommissioning strategy being adopted and the associated challenges. The findings from this site visit have allowed lessons to be learned from other decommissioning programmes and subsequently optimise the UK ABWRs decommissioning strategy.

In many instances the visit reinforced Hitachi-GE’s approach to decommissioning the UK ABWR, and provided confidence that the design for decommissioning, and proposed decommissioning plan and techniques were supported by international decommissioning GP [Ref. 31-16].

31.3.5 Operational Experience Conclusion

The UK ABWR project has established an initial decommissioning approach based on previous UK and international decommissioning GP and OPEX [Ref. 31-9]. Technique selection has been established based upon mature technologies which have been demonstrably shown to be successful in decommissioning. In every aspect of decommissioning, strong established OPEX is available to support that the described approaches and techniques have been successfully applied, providing confidence that the UK ABWR can be decommissioned safely and that risks are ALARP.

31.4 Design for Decommissioning – Principles and Techniques

31.4.1 Design Principles

To ensure that risks associated with decommissioning are reduced ALARP, that the generation of radioactive waste is minimised, and that the Best Available Techniques (BAT) are successfully implemented, the UK ABWR design has been informed by a set of decommissioning design principles.

These principles have been identified from GP on other nuclear facilities during BWR design evolution and application of nuclear safety or environmental legislation and guidance. The relevant design principles are detailed further in "Topic Report on Decommissioning: Design for Decommissioning" [Ref. 31-7]. This section outlines those key design principles.

Adequate control of nuclear matter supports decommissioning. This is demonstrated throughout the PCSR and in particular in Chapter 18: Radwaste Management Safety Functional Claims (SFC) relating to Fundamental Safety Function (FSF) 4: Confinement / Containment of Radioactive Material.

31.4.1.1 Dose Minimisation

The following table summarises the broad decommissioning design principles that have been considered in the UK ABWR design to minimise dose.

Table 31.4-1. Design Principles to Ensure Dose Minimisation During Decommissioning

Design Principle	Relevant PCSR Section
Simplification of design to minimise components, pipes, tanks, etc. resulting in a volume reduction of equipment to be decommissioned, and subsequent reduction in worker dose uptake.	31.8
Access and egress during decommissioning. 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 limit the tools and techniques they use during decommissioning.	31.5.2.6
Design of concrete and metal surfaces to facilitate radiation source minimisation through POCO and decontamination prior to deplanting.	31.5.2.2
Piping design to minimise crud accumulation.	31.5.2.2
Optimisation of water chemistry control to minimise levels of contamination in the system.	31.5.2.3

Design Principle	Relevant PCSR Section
Material selection, including; choice of materials to reduce levels of trace elements that can become activated, use of alternate structural materials to prevent the activation of stable Cobalt (Co), and use of corrosion resistant materials for the core internals and piping to protect against loss of containment and spread of contamination / activation products.	31.5.2.1

31.4.1.2 Waste Minimisation

The operation of a nuclear reactor will inevitably result in the generation of radioactive waste. Waste minimisation principles have been applied in the design which seek to minimise the volume of solid waste and the activity of gaseous and aqueous waste. These are described in further detail in "Topic Report on Decommissioning: Design for Decommissioning" [Ref. 31-7] and the "Demonstration of BAT" report [Ref. 31-37].

Table 31.4-2. Design Principles to Ensure Waste Minimisation During Decommissioning

Design Principle	Relevant PCSR Section
Radiation source elimination by undertaking POCO and decontamination prior to deplanting and reduction in surface contamination by treatment of concrete and metal surfaces.	31.5.2.2
Material selection, including; choice of materials to reduce levels of trace elements that can become activated, use of alternate structural materials to prevent the activation of stable Co, and use of corrosion resistant materials for the core internals and piping to protect against loss of containment and spread of contamination / activation products.	31.5.2.1
Optimisation of water chemistry control to minimise levels of contamination in the system.	31.5.2.3
Simplification of design to minimise components, pipes, tanks, etc. resulting in a reduction of decommissioning waste.	31.8

31.4.1.3 Design Requirements

Decommissioning design requirements have been incorporated in the UK ABWR design as a result of GP from other nuclear facilities during BWR design evolution, or application of nuclear safety or environmental legislation and guidance. These design requirements are described in further detail in "Topic Report on Decommissioning: Design for Decommissioning" [Ref. 31-7] and captured in Table 31.4-3.

Table 31.4-3 UK ABWR Decommissioning Design Requirements

Design Requirements		Relevant PCSR Section
Integrity of Structures	Long-term integrity of the UK ABWR structural design for decommissioning purposes, including features aimed at minimising infiltration, containing spills and releases, and attenuating contaminant transport.	31.5.2.4
	Design of Systems, Structures and Components (SSCs) to optimise decommissioning i.e. systems that are utilised during the decommissioning phase such as water containment functions, water purification systems, overhead cranes, monorails and lifting devices are required to allow cooling of spent fuel, removal of equipment and access to all parts of the plant during the decommissioning phase.	
	Avoidance of use of prestressed concrete as the stored energy in the material can cause additional decommissioning hazards.	31.5.2
Material Selection	Material selection, including; choice of materials to reduce levels of trace elements that can become activated, use of alternate structural materials to prevent the activation of stable Co, and use of corrosion resistant materials for the core internals and piping to protect against loss of containment and spread of contamination / activation products.	31.5.2.1
Access for Decommissioning	Consideration of access routes during the design phase to ensure sufficient space is provided for workers to access equipment for replacement, laydown of machinery, lifting operations and removal of equipment in all phases of plant life, including operations, maintenance and decommissioning, especially in areas where there are elevated levels of radiation. Good design can also affect the time spent in the vicinity of elevated radiation by the workforce, the tools and techniques they use during decommissioning, and also assist in the ability to readily install local shielding.	31.5.2.6
Removability	Consideration of removal of large items for decommissioning, including identification of dismantling sequences and provisions for equipment lay-down areas. The design needs to ensure sufficient access and space to carry out removal of waste packages, especially in areas where there are elevated levels of radiation.	31.5.2.11
Embedded Piping	Avoidance of embedded piping where So Far As Is Reasonably Practicable (SFAIRP) to facilitate decommissioning.	31.5.2.7

Design Requirements		Relevant PCSR Section
Potential of Leakage from Containment	Consideration of potential leakage from containment in the design, to ensure measures are in place to address leakage during the entire plant life cycle (including during decommissioning i.e. leakage during system decontamination), taking account of leak prevention, leak detection, worker protection, and leak mitigation.	31.5.2.9
Record Management	Ensuring that adequate design and construction records are held for a period necessary to ensure that decommissioning can be undertaken safely, and that records are updated periodically throughout the lifetime of the plant up to the decommissioning phase.	31.9.1
Human Factors	Incorporation of Human Factors Engineering (HFE) considerations into the design to ensure potential hazards are managed and minimised.	31.5.2.6
Conventional Safety	Consideration of conventional hazards to ensure the UK ABWR design does not introduce additional and unnecessary conventional safety hazards which would hinder decommissioning being undertaken.	31.5.2.1 31.5.2.4 31.5.2.6

31.4.2 Decommissioning Techniques

Decommissioning is undertaken systematically and is comprised of distinct phases of work, beginning with initial planning and design prior to plant construction and continuing with periodic reviews of the decommissioning plan throughout the lifetime of the plant. A more detailed decommissioning plan will be produced as the plant approaches EoG allowing the site to transition smoothly from the generation phase to the decommissioning phase of its life cycle.

To allow identification of preferred techniques for decommissioning, an initial decommissioning methodology (addressing dismantling, decontamination and secondary processing requirements based on OPEX) for major areas of the UK ABWR plant has been developed. This is described in “Topic Report on Decommissioning: Decommissioning Techniques” [Ref. 31-9].

It is assumed the reactor will operate for a design lifetime of 60 years and decommissioning will not commence until after this time, with decommissioning of major active items such as the RPV some 10 years after this. As such, it is not considered appropriate to prescribe techniques for every individual plant item or to undertake a detailed quantitative assessment of the available decommissioning techniques during GDA. Therefore, except for major decommissioning activities e.g. RPV segmentation, the approach to POCO cleanup, turbine dismantling, plant and equipment have been broadly grouped where appropriate and single techniques, or a conservative single production rate for a group of techniques selected, to be representative of the grouping to support “Topic Report on Decommissioning: Decommissioning Plan” [Ref. 31-8].

An initial decommissioning technique selection process has been undertaken and is described in [Ref. 31-9]. As no ABWR has been decommissioned, the starting point for this process was a review of relevant international BWR and UK decommissioning experience and identification of existing and proven decommissioning techniques applicable to the UK ABWR. To inform the decommissioning plan a final stage of technique selection has then been undertaken, based on an assessment of the Technology Readiness Level (TRL) of the various decommissioning techniques and their associated advantages and disadvantages.

"Topic Report on Decommissioning: Decommissioning Techniques" [Ref. 31-9] and the "Demonstration of BAT" report [Ref. 31-37] do not seek to demonstrate that those techniques identified are both BAT and ALARP with regards to decommissioning, rather they identify multiple techniques that could be utilised to provide solutions to decommissioning the UK ABWR that are considered to be robust and are based on existing proven technologies. Whilst the decommissioning plan is based on techniques chosen using the approach described in [Ref. 31-8], it is important to highlight that the UK ABWR design does not foreclose options for the future licensee to apply BAT to the adoption of the most appropriate technique at the time of decommissioning and to ensure risks are reduced ALARP. The studies undertaken as part of the GDA support decommissioning sub claim, Decom-SC 5, that the UK ABWR can be decommissioned using today's technology.

31.5 Key Decommissioning Operations and Design Features

Decommissioning a nuclear facility is a significant and complex task with many cross-cutting deconstruction and decontamination activities being undertaken. In accordance with International Atomic Energy Agency (IAEA) guidance, prior to shutdown of the plant a final decommissioning plan shall be submitted to the relevant regulatory body for approval within an agreed period (typically within two to five years of permanent shutdown) [Ref. 31-38]. This will allow the site to transition smoothly from the power generation stage to the decommissioning stage of its life cycle.

Decommissioning can be broken down in to distinct phases, in line with the selected decommissioning strategy.

Planning and Approvals

Approximately five years prior to EoG a detailed planning and preparation phase will commence. This will consist of preparatory works, such as production of a decommissioning safety case, preparation of relevant regulatory submissions (i.e. Article 37 and 41 submissions, Nuclear Reactors Environmental Impact Assessment for Decommissioning Regulations (EIADR) submissions, modified [or new]) environmental permits), revisions to waste management plans where appropriate, and preparation of work plans and schedules. Further discussion on the work undertaken during this period, including a more comprehensive list of the tasks undertaken is provided in Section 31.7.

Spent Fuel Removal

Following EoG, spent fuel will remain within the SFP for a period of 10 years. This period allows the spent fuel to cool to an appropriate level to permit packaging into passively safe containers suitable for the Spent Fuel Interim Store (SFIS). The presence of spent fuel poses the largest hazard to decommissioning the R/B and consequently, major decommissioning tasks in this area e.g. deplanting RINs, are curtailed during this period. Following the spent fuel cooling period, spent fuel will be removed from the R/B significantly reducing the decommissioning hazard and allowing for major deplanting to commence. Repackaging and disposal of spent fuel is discussed in PCSR Chapter 32: Spent Fuel Interim Storage.

POCO

At EoG, it is common practice to carry out a flush of the key process systems with water followed by chemicals to reduce general area and contact dose rates to allow deconstruction tasks to be undertaken safely, whilst minimising the generation of secondary wastes. A chemical process is used to remove contamination from pipe systems although other decontamination options are also available to the future licensee. The plant condition at the EoG will dictate the decontamination process that will be adopted.

The precise scope of the systems to undergo decontamination will be assessed following plant characterisation and planning in the lead up to decommissioning but it is assumed that the most contaminated systems such as the Reactor Water Clean-up System (CUW) and the RPV will undergo chemical decontamination to ensure that the risk to workers from contaminated materials is ALARP.

RINs

In addition to spent fuel and control rods, the RINs are expected to be one of the highest radiological activity material on-site. Due to the level of activity of the RINs, it is proposed that segmentation operations are performed underwater in the DSP. The DSP will contain water and have liquid waste management systems to maintain water conditions and prevent buildup of activity within the pool.

Segmented components will be retrieved utilising a "basket" which will allow water to be drained prior to packaging in to compliant containers located on the operating deck. A number of functions, including pre-treatment, treatment, segregation, conditioning and packaging on the various items arising from decommissioning activities in the main buildings will be carried out in the Decommissioning Waste Management Facility (DWMF).

RPV

Following removal of the RINs, decontamination, deplanting and segmentation of the RPV can commence. In contrast to the RINs, the RPV will be segmented in air and not underwater. This greatly simplifies the segmentation process by improving visibility for workers and removing the risk associated with workers performing plant modifications. The adopted approach is based upon established OPEX from other international BWR decommissioning projects which have successfully demonstrated it can be performed safely. BWR decommissioning projects which are entering the decommissioning phase e.g. ISAR-1, Germany, continue to select this approach to remove and size reduce the RPV (see Section 31.3).

The approach is to cut the RPV into manageable ring segments whilst still in its original operational location. These rings will be lifted out and placed in a segmentation area established in the DSP. The weight of the rings being hoisted will be within the lifting capacity of the RBC (to 150 tonne). The ring segments will be further size reduced within the DSP before transfer into compliant waste containers for onward management. The UK ABWR design does not foreclose the option for the future licensee to adopt an alternative approach e.g. segmentation of the RPV in-situ.

Liners

Areas of the UK ABWR plant are equipped with stainless steel linings for containment or pressure resisting purposes which may become surface contaminated over the operational life of the plant e.g. Reinforced Concrete Containment Vessel (RCCV), SFP liner. The future licensee will determine at the time of decommissioning whether these liners will require decontamination. A variety of proven techniques exist to allow this to be accomplished [Ref. 31-9].

The walls and floor will be checked for any remaining hotspots which will then be rewashed, and decontaminated using more aggressive techniques or covered. The pool liners will not be removed at this stage. Decontamination of the SFP liner will be performed using jet washing techniques. The water level will be lowered in stages and the areas revealed will be jet-washed. Existing pool water cleanup systems will manage the waste water deposited into the pool as the level is lowered.

Steel liners for fuel and other internal storage pools will be size reduced in-situ and if required sentenced for further processing in the DWMF. Removal of liners will expose the underlying concrete which will allow characterisation of radiological contamination to be performed.

Pipework

The UK ABWR will contain an extensive amount of pipework and pipework removal will be one of the intensive tasks during the decommissioning phase. A variety of pipework diameter sizes are represented within the UK ABWR design and the approach for their removal has been informed through OPEX from international decommissioning projects. Pipework is grouped and a tool box approach is adopted which is based on a standard collection of tool cutting techniques. The selection of cutting tools is largely dependent on the size of pipework, cutting efficiency, decontamination applicability and handling considerations.

The adopted approach to deconstructing the UK ABWR is based upon OPEX and BAT [Ref. 31-37] from other international BWR decommissioning programs which have demonstrably shown that the proposed approach adopted for the UK ABWR can be performed safely with risks well understood.

Due to the extent of work required and low contamination of plant items, deplanting of the T/B will commence early in the decommissioning schedule. A uniform approach will be applied across the site to each of the other facilities and buildings. Work will continue through other radiological buildings and later in conventional buildings until de-planting is complete.

Waste Management

Cutting plans for major components e.g. RPV will be configured to ensure that both cutting and packaging arrangements are optimised [Ref. 31-37]. The cutting plan will aim to produce pieces that are at or close to the optimum that the size and weight limitations of waste containers can accommodate. This reduces double handling and aims to reduce any requirement for secondary segmentation to improve packing efficiency.

To support the decommissioning process a DWMF will be installed on site. It is proposed that this is a new build facility, with the layout of the site able to accommodate this [Ref. 31-11]. It may however be more prudent to refurbish existing infrastructure as opposed to constructing a new facility e.g. T/B. This option is not foreclosed and is available to the future licensee. The DWMF will predominantly be used to monitor, decontaminate, size reduce and package wastes. The types of waste will largely fall into the LLW category, but will also include a portion of HLW / ILW arising from the RINs. Details of the types of wastes being handled and treated within the DWMF are discussed in Section 31.8.

Plant items will be removed from the radiological area in the largest, easiest to handle form, with radioactive materials separated at source from non-radioactive materials where possible. The segregated materials will be surveyed and assigned for release or management as radiological wastes. Radiological waste materials will be sent to the DWMF for further processing which may include decontamination and dismantling / further segmentation to separate materials into LLW, VLLW and Out of Scope Waste categories.

HLW will be transferred to the HLW decay store for sufficient time to allow for decay to ILW. ILW will be packaged and transferred to the on-site ILW store to await dispatch to the GDF. Long term records will be prepared and stored capturing information needed for transportation and disposal. LLW, VLLW and non-radiological wastes arising during operation of the site will be transferred to authorised off-site waste processors for management in accordance with the waste hierarchy.

Deconstruction

The deconstruction of each of the plant buildings will be planned so that the removal of all plant and equipment from a room or zone is performed in a single operation. To protect workers, rooms and zones will be de-energised i.e. all systems have been shutdown, disconnected and are passive. Temporary services will provide lighting and power, etc. This approach helps minimise the risk of attempting to dismantle an in-service / energised system

Equipment for dismantling purposes will generally be mobile and will only be installed on a temporary basis as and when it is needed. Dismantling and decontamination works will initially concentrate on the main power island buildings (R/B, T/B, Radwaste Building [Rw/B], etc.) as these are expected to represent the critical path through the deplanting project.

Demolition

Following deplant of all electrical, mechanical and process systems the remaining civil structures will be demolished. Following deplanting and prior to demolition the radiological risk will be confirmed through plant surveys. Any active concrete surfaces will be decontaminated using established and proven techniques. Once radiation levels are established to be Out of Scope demolition activities can commence.

Below ground level structures, including building floors and embedded pipework greater than 1 m below ground level, will be left in-situ and shown to meet the ONRs ‘no danger’ criteria (dose to future site users must be <10 µSv/y) [Ref. 31-39]. Any pipework which cannot be demonstrated to be decontaminated to this level will be removed and disposed of appropriately through available waste routes for contaminated metallic wastes. Void spaces will be filled either with clean rubble from building demolition, or with new material brought to site. Any building rubble not used for void filling or landscaping will be managed off-site in accordance with the waste hierarchy and defined disposal routes.

Demolition will be undertaken by specialist contractors utilising standard demolition techniques with no special requirements beyond those employed for any work on a nuclear licensed site. On site crushing of concrete and segregation of recyclable or reusable materials will be undertaken with inert material being utilised for void filling on-site [Ref. 31-9].

End State

The EIADR requires assessment of the potential environmental impacts of projects to decommission nuclear power stations and nuclear reactors (except research installations whose maximum power does not exceed 1 kilowatt continuous thermal load). It also requires that the public and other relevant stakeholders be consulted from an early stage, regarding the environmental impacts of the options being considered for a proposed decommissioning project. The future licensee will be required to satisfy EIADR requirements, but for the purposes of the GDA, the current selected end state for the UK ABWR is prudent and is informed by current legacy site end state assumptions.

Once the site has been cleared and decommissioning tasks have been completed the future licensee will submit an application to delicense the site and remove it from regulatory control measures. Delicensing of the site is a key part in meeting the end state criteria for the site and regulatory authorities and their relevant agencies will examine the delicensing application and decide whether revocation of the site licence can be authorised. Confirmation of the validity of the application will be via radiological surveys of the site to ensure that the ONR’s ‘no danger’ criteria have been met.

31.5.1 Description of Main Decommissioning Hazards

The UK ABWR decommissioning strategy is to undertake prompt decommissioning. One of the key benefits in adopting this strategy is that a progressive reduction in the hazard the facility poses can be realised, giving due regard to security considerations, the safety of workers and the general public, and protection of the environment. There may be occasions where a short-term increase in risk is required to achieve longer term risk reduction. For instance, there may be a short-term increase in risk due to fuel assembly movements to remove them from the SFP (e.g. drop / impact involving a spent fuel assembly). However, this increased risk is required to reduce the long-term risk associated with storage of spent fuel in the SFP, and allow the SFP to be drained and decommissioned. The proposed decommissioning strategy and plan are addressed in further detail in Sections 31.6 and 31.7.

The nature of decommissioning means that intervention into sealed mechanical and process systems will be required to allow the plant to be deconstructed. A safety assessment has been undertaken to identify the key hazards associated with decommissioning the UK ABWR. This consisted of an augmented Hazard and Operability (HAZOP) process whereby radiological and conventional hazards arising from decommissioning operations were identified. Further detail of the safety assessment process undertaken is provided in "Topic Report on Decommissioning: Decommissioning Safety Assessment" [Ref. 31-12].

In conjunction with this exercise, a comprehensive, systematic and holistic review of the ABWR design was undertaken to understand and confirm whether identified hazards could be prevented or mitigated through confirmation of existing design features. A high-level view of design features which were credited to support prevention or minimisation of hazards associated with decommissioning accompany the identified hazards presented in Table 31.5-1:

Table 31.5-1 Key Hazards Associated with Decommissioning

Hazard	Decommissioning Context and Examples	Risk Reduction Measures
Worker dose	Decommissioning involves processing high dose plant items and components and can involve significant amounts of hands-on work. Example: • Cutting and removal of pipework and vessels. • Decontamination processes – POCO.	• Material selection to minimise activation (e.g. low Co steels). • Reactor chemistry to minimise corrosion products (crud). • Remote operations (e.g. underwater dismantling). • Characterisation.
Spread of contamination	Decommissioning tasks such as equipment dismantling, movement and decontamination can lead to the spread of contamination, and increased doses, both during normal operations and in fault conditions. Examples: • Aerosol and fine particulate generation from segmentation of pipework and vessels. • Scabbling of concrete to remove contamination.	• Installed Heating, Ventilation and Air Conditioning (HVAC) from the operations phase. • Temporary local extract / filtration. • Local containment. • Decontamination prior to handling / processing. • Remote operations (e.g. underwater dismantling). • Strippable coatings. • PPE.

Hazard	Decommissioning Context and Examples	Risk Reduction Measures
Loss of liquid containment (leaks)	Intervention in to sealed systems which have previously held effluent. Examples: • System decontamination, flushing and draining can lead to an increased potential for loss of liquid containment. • Penetrating and segmenting pipework and vessels can lead to a potential loss of containment.	• Secondary containment. • Leak detection. • Bunding – liners.
Dropped Loads	Decommissioning will involve movement of a significant number of large items. Examples: • Hoisting of RINs. • Hoisting of RPV segments. • Hoisting of turbine components.	• Design life of lifting equipment sufficient to support decommissioning. • Planning of equipment removal routes and spatial environment to allow large items to be removed.
Criticality	The export of spent fuel will effectively remove the potential for inadvertent criticality, however during fuel movements the criticality risk may be increased.	• SFP storage rack. • Fuel lifting and handling equipment. • Spent fuel storage cask.
Fire	Fire risk can be greater during decommissioning due to the increased presence of combustible materials, use of hot cutting techniques, etc. Examples: • Grinding of pipework or vessels will produce sparks. • Use of hot cutting techniques during segmentation of pipework and vessels.	• Minimisation of ignition sources. • Preferential use of cold cutting techniques where practicable. • Minimisation of combustible. material / housekeeping. • Fire detection and alarm system.
Contaminated wounds (e.g. use of mechanical equipment)	Decommissioning can involve an increased amount of hands-on work, leading to an increased risk of contaminated wounds which can lead to high doses. Examples: • Use of mechanical equipment to remove pipework and vessels. • Use of manual handling equipment e.g. plyers.	• Remote operations where practicable. • Risk assessment of hands-on operations. • PPE. • Sharp edge protection / deburring / consideration of sharp edges through technology selection.

Hazard	Decommissioning Context and Examples	Risk Reduction Measures
Conventional Safety	As decommissioning progresses, and the radiological hazard is progressively removed and conventional hazards will become the principal hazards at the plant. Examples: • Removal of HVAC ducting. • Removal of non-active components e.g. pumps, service pipework, valves. • Demolition of civil structures. • Removal of crane equipment.	• Minimisation of cutting operations. • Appropriate access / egress arrangements. • Design allows use of scaffolding. • PPE.
External Hazards (e.g. seismic, extreme wind, etc.)	The plant is designed to be robust to external hazards during operation. The radiological hazard on-site is reduced on shutdown and significantly further again once fuel has been removed. As the plant is deconstructed, partial structures present an additional hazard that must be considered as part of the demolition plan.	• Existing integrity of building infrastructure.
Internal Hazards (e.g. missiles, explosions, collisions, etc.)	Once generation has ceased the potential for many internal hazards is removed (e.g. turbine disintegration, high energy pipework, etc.), however during the decommissioning phase it is likely that gas canisters are introduced to the site to enable cutting or other decommissioning operations.	• Systems not in use will be de-energised and drained. • Dedicated gas bottle stores. • Safe systems of work during hot cutting.

Section 31.5.2 demonstrates that these hazards have been prevented or have been reduced ALARP through good plant design. Application of decommissioning GP and the evolution of the BWR design have contributed to optimising the UK ABWR for decommissioning. GP incorporated into the safety assessment process is detailed further in Section 31.3.

In conjunction with Section 31.3 this section supports safety claim, Decom-SC 3, that faults and hazards during decommissioning have been identified, assessed and that risks are shown to be ALARP.

31.5.2 Design Features that Enable Risk Reduction

The reference point for design development of the UK ABWR and associated facilities during GDA was the Kashiwazaki-Kariwa Nuclear Power Station Unit 6 and 7 (KK-6 and KK-7) J-ABWR [Ref. 31-40]. The J-ABWR design was based on the evolution of conventional BWR technology and therefore represents a significant improvement over conventional BWRs, including decommissioning aspects.

The demonstration of design for decommissioning has been assessed through an ALARP process that has been developed in accordance with the GDA ALARP methodology [Ref. 31-41]. This involved identification of existent safety measures to facilitate hazard reduction as described in Section 31.5.1, and further design challenge during GDA.

No decommissioning SSCs are formally assigned during GDA but it is recognised that certain systems require a design life appropriate for decommissioning, and will need to handle any change in demand and functionality that decommissioning introduces. Key systems important to decommissioning e.g. HVAC, RBC have been identified and decommissioning requirements for these systems have been captured. During decommissioning, SSCs are only removed from service when their safety functions are no longer required. Any safety systems supporting decommissioning will be maintained and only removed once declared redundant.

The following sections identify design features that support the decommissioning design principles discussed in Section 31.4.1 and design features identified as a result of the comprehensive design challenge process undertaken during GDA. Further evidence of their incorporation into the design is provided in “Topic Report on Decommissioning: Design for Decommissioning” [Ref. 31-7].

In some instances, design features are carried forward to site specific design as part of a Requirements and Assumptions (R and A) list. The process defined in “Technology Transfer to Licensee and Operating Regime” [Ref. 31-42] will be followed to ensure transfer of information is achieved and design intent is followed through to the site specific design. It is assumed that the future licensee will review and implement all of the design features carried forward to the site specific design with this assertion captured as part of the assumptions listed in Appendix B.

Summarised in the table below are key decommissioning activities and corresponding design features which positively support risk reduction for decommissioning.

Table 31.5-2 Key Design Features in Support of Decommissioning Operations

Decommissioning Activity	Design Aspects That Contribute to Hazard Reduction During Decommissioning
POCO	• Optimised material selection - reduction of Deposit Source Term (DST); • Existing pumps are used in decontamination; • Connection points are available to minimise break in to pipework and components; • Design of vessels incorporates sufficient sampling points; • Inclusion of low drain points, and sufficient piping gradients prevent liquid holdup during decommissioning activities; • Metal surfaces are designed to be smooth, non-porous and free of cracks, crevices and sharp corners to minimise contamination.

Decommissioning Activity	Design Aspects That Contribute to Hazard Reduction During Decommissioning
Reactor Internals	• Optimised material selection - reduction of DST; • RINs are readily removable to facilitate chemical decontamination; • Sufficient import / export routes are available; • Metal surfaces are designed to be smooth, non-porous and free of cracks, crevices and sharp corners to minimise contamination; • Export hatches are appropriately sized to accommodate large waste packages e.g. casks; • Design to ensure space to undertake decontamination activities.
RPV Removal / Segmentation	• Optimised material selection - reduction of DST; • Design to ensure space to undertake decontamination activities; • Sufficient import / export routes are available; • Metal surfaces are designed to be smooth, non-porous and free of cracks, crevices and sharp corners to minimise contamination; • Export hatches are appropriately sized to accommodate large waste packages e.g. casks [Ref. 31-37].
Pool Decommissioning	• Optimised material selection - reduction of DST; • Design to ensure space to undertake decontamination activities; • Metal surfaces are designed to be smooth, non-porous and free of cracks, crevices and sharp corners to minimise contamination; • Pools are designed to minimise leakage by inclusion of steel lining.
Dismantling of Pipework	• Optimised material selection - reduction of DST; • Metal surfaces are designed to be smooth, non-porous and free of cracks, crevices and sharp corners to minimise contamination; • Water chemistry is tightly controlled throughout the operational lifetime of the plant. Includes the addition of hydrogen which reduces Stress Corrosion Cracking (SCC), and injection of depleted zinc oxide which suppresses activated Co; • Inclusion of low drain points, and sufficient piping gradients prevent liquid holdup during decommissioning activities; • Embedded pipework is minimised where practicable to aid decommissioning.

Decommissioning Activity	Design Aspects That Contribute to Hazard Reduction During Decommissioning
Removal of large items	• Walls within the design have been identified and will improve the spatial environment for decommissioning and facilitate removal of large items e.g. vessels; • Egress routes for all large items are not obstructed during decommissioning; • Export hatches are appropriately sized to accommodate large waste packages e.g. casks [Ref. 31-38].

31.5.2.1 Materials Selection in Design

A key aspect to lessen the radiological exposure to workers during decommissioning, to minimise the activity of aqueous radioactive wastes and the volume of solid radioactive waste generated is to consider at the outset materials used in the design, construction and operation of the UK ABWR to ensure the ST is minimised. A balanced approach has been taken to ensure optimum materials have been selected to reduce risks ALARP. This considered not only ST reduction but also the requirements for structural integrity during operations, minimise degradation, availability of materials and application of BAT [Ref. 31-37]. Further detailed discussion on material selection for the UK ABWR is provided in Chapter 8: Structural Integrity and Chapter 23: Reactor Chemistry. In support of decommissioning, the following salient material considerations have informed the design.

Reduction and removal of Co-based alloy by design

Co-60 is the largest contributor to the UK ABWR decommissioning ST. Preventing the generation and release of Co-60 into the reactor water minimises the dose uptake to workers during decommissioning tasks and generation of radioactive waste when the reactor water is treated by the CUW [Ref. 31-37] [Ref. 31-43].

Where appropriate, steps to completely remove Co from the UK ABWR design has been adopted e.g. the pin and rollers of the control rods. A robust approach to Co-based alloy reduction and removal has been adopted throughout the design process for the UK ABWR, resulting in an approximate 50 % reduction in the amount of Co-60 generated during the operation of the ABWR compared to if these improvements weren't applied.

In some cases, Co based alloys have properties which make them crucial for some safety critical components e.g. valve seats for valves requiring an isolation function, and Fine Motion Control Rod Drive (FMCRD) components. Wherever possible, efforts have been made to select materials with low or ultra-low Co specification where it has been shown to provide similar high performance mechanical properties.

Use of Low Cobalt Material (LCM) ($\leqq$0.05% Co) reduces Co corrosion products and minimises the decommissioning ST. As such, components in the reactor will be manufactured from LCM, with some exceptions which only make a small contribution to activation and Co release. One such example is the high-pressure feedwater tube which releases 85% of the Co-59 in to the reactor water, and as such has been designed from a material with ultra-low Co content. Other reactor components that are designed with low Co materials within the UK ABWR include the core plate and control rods [Ref. 31-37].

Use of corrosion resistant material by design

Deposition of material generated by corrosion of reactor components can also lead to activation of deposited material. To mitigate this all materials in the UK ABWR are optimised against corrosion SFAIRP, particularly where Flow Accelerated Corrosion (FAC) could occur. In areas of specific vulnerability, corrosion resistant steel with increased Chromium (Cr) content will be used (OPEX shows increasing Cr content reduces FAC rates in steel). The effect of adopting corrosion resistant steel in pipework, along with the introduction of a dual condensate polishing system and oxygen injection, has significantly reduced the iron feedwater concentration. This has reduced the generation of corrosion products on the fuel cladding and thus reduced the generation of radioactive waste and dose rates [Ref. 31-37]. Similarly, material selected for condensers and heat exchangers will utilise stainless steel tubes or titanium in place of brass or copper-nickel alloys.

Minimising FAC will prevent loose material being transported throughout the coolant circuit and therefore minimise the levels of activation and contamination being spread throughout the coolant circuit. Additionally, minimising FAC also minimises the risk of deposition and the formation of hot spots which would hinder decommissioning deplanting activities and increase the risk to the worker.

Reduction of Copper alloy by design

OPEX has shown that a considerable contributor to the ST from existing BWRs has been Crud Induced Localised Corrosion (CILC). This causes failures in fuel rods, which can lead to escape of Actinide Products (AcTP) and Fission Products (FP) into the reactor water, resulting in an elevated decommissioning ST, elevated dose uptake to workers, and generation of increased waste volumes. Research has found that CILC and Copper (Cu) levels early in fuel life are concomitant and major sources of Cu in BWRs are Cu-alloy used within the main condensers. As such the UK ABWR utilises titanium in place of Cu-alloy for the main condensers. Cu content throughout the operating life of the plant will be controlled through use of a deep bed condensate treatment system ensuring Cu concentration levels within the coolant are ALARP. In addition, the design includes measures to reduce the frequency of fuel failure, including filters within the fuel assembly to remove debris that can damage the fuel, quality control improvements to reduce failures at the Pellet Cladding Interaction (PCI), and the introduction of a pure zirconium liner to reduce SCC [Ref. 31-37].

Reduction of Deposit Source Term by design

Deposition of radioactivity on pipework within a reactor significantly contributes to the decommissioning ST. Two key criteria to ensure that the DST is ALARP are found below and discussed in further detail in PCSR Chapter 20: Radiation Protection:

- Use of appropriate materials to prevent corrosion or spalling – The UK ABWR has adopted optimised material selection so that DST is minimised. For example, deposition of Co-60 is a recognised issue and the UK ABWR mitigates against this through adoption of stainless steel for piping and valves (body and bonnet) between the RPV and CUW Re-Generative Heat Exchanger (RHx). The UK ABWR has been assessed for areas where potential deposition can occur with areas being targeted to ensure that the DST for decommissioning has been minimised.

- Use of effective surface treatment methods – Reducing rough surfaces is an effective means in reducing radionuclide deposition and subsequently the DST. However, the selection of specific surface treatment techniques will be the responsibility of the future licensee, at GDA it is judged adequate to demonstrate that the techniques are available. A process will be followed at the site specific phase to ensure the most appropriate surface treatment techniques are adopted where there is the potential to further reduce the DST.

Insulation

No asbestos containing materials are to be utilised during construction of the UK ABWR and the use of insulating material will be minimised SFAIRP to ensure that waste during decommissioning is minimised. Where areas require lagging Man Made Mineral Fibre (MMMF) material will be used in encased shaped panels to facilitate removal in large sections and mitigate against inhalation of fibres. These requirements are carried forward to site specific design and as such form part of the GDA "base" design.

Aggregates

The RPV is supported by a concrete superstructure. Some areas of this will be subjected to neutron flux which will lead to activation of aggregate within the concrete. The volume of activated aggregate is expected to be small compared to the overall volume of concrete (limited to 10's of cm in depth). Evaluation of the activation ST has been modelled against concrete of a certain chemical composition which has been set based on industry standards. To maintain the validity of the activation ST and to ensure generation of higher activity waste is minimised, the aggregate used for construction will meet either the same chemical makeup as that modelled, or further reduce activation. For areas that are subjected to neutron flux there is potential to optimise concrete aggregates to minimise activated waste volumes, however this will not be to the detriment of integrity and performance of the civil structure.

31.5.2.2 Design for Decontamination

Decontamination operations to be performed during decommissioning can be separated into two categories: in-situ decontamination of the inner surfaces of contaminated systems to reduce worker dose uptake during subsequent deplanting, and ex-situ decontamination that may be applied to waste items at or after dismantling to aid waste management. The UK ABWR has been designed to support decontamination, and includes many design features to minimise the contamination burden at decommissioning.

Design for targeted in-situ decontamination of systems

An initial decontamination strategy has been defined based on international BWR and PWR experience which assumes that chemical decontamination of the recirculating circuit and RPV will be undertaken prior to dismantling. The assumptions and proposed solutions do not foreclose options to the future licensee to select the most appropriate techniques at the time of decommissioning [Ref. 31-44].

The UK ABWR includes the following design features to allow for the application of targeted in-situ decontamination of systems prior to deplanting [Ref. 31-7]:

- RINs are readily removable to facilitate in-situ chemical decontamination of the empty RPV;
- The in-situ decontamination process will utilise the Reactor Internal Pumps (RIPs) for circulation;
- The availability of connection points in targeted systems which will minimise the requirement to break into containment to undertake decontamination;

- The design of vessels ensures availability of sufficient sampling points and the ability to homogenise contents for characterisation prior to decommissioning. This includes radioactive waste vessels, which may present a high radiological risk to the worker during segmentation. As the final design of radioactive waste vessels has not been confirmed during GDA this design feature is carried forward for development during the site specific design phase;
- Sufficient space is provided for the placement of in-situ decontamination equipment (including tank design to allow for tank cleaning kit access);
- Import and export routes are available for equipment, bulk chemicals, radioactive solid and liquid wastes, Out of Scope waste equipment and unused chemicals.

Design for minimisation of contamination at decommissioning

Following dismantling of pipes and plant items, decontamination using physical and chemical methods will be applied to reduce contamination levels. To minimise the contamination burden following deplanting, the following features are incorporated into the UK ABWR design [Ref. 31-7] [Ref. 31-37].

- Concrete surfaces are designed to minimise contamination ALARP i.e. by application of coatings to limit adhesion of contaminants;
- Metal surfaces are designed to minimise contamination ALARP by; ensuring surfaces are smooth, non-porous and free of cracks, crevices and sharp corners. The following will be applied: rounded corners in ponds, vessels and bunds, smooth transitions from pipework of one diameter to another, smooth transitions of ductwork from one cross section to another; and use of external vessel reinforcements as opposed to internal;
- The UK ABWR pipework and drainage design minimises contamination ALARP. Components are designed with the ability to self-drain through the inclusion of low drain points, minimisation of horizontal surfaces (i.e. drains and piping to be installed with a minimum fall and floors to fall towards a drain point) and consideration of smooth surface finishes. Both piping and floor design use suitable gradients to ensure minimum liquid hold-up during decontamination, and piping design minimises contamination accumulation by minimisation of sharp corners and U-bends. Embedded piping is minimised SFAIRP and where embedded piping is present, relevant features are included to assist decontamination such as features to detecte radiation levels. Further information is captured in Chapter 16: Auxiliary Systems. All radioactive drains will collect and contain radioactive effluent at the point of origin and direct effluent to the Liquid Waste Management System (LWMS);
- The UK ABWR design incorporates features to ensure the potential for leakage from containment is minimised. In particular, internal storage pools are stainless steel lined to minimise the potential for leakage into the underlying structure. These design features are described in further detail in Section 31.5.2.10, PCSR Chapter 8: Structural Integrity, and PCSR Chapter 23: Reactor Chemistry;

- The UK ABWR layout incorporates features to mitigate contamination as a result of liquid leakage from containment i.e. wall height is sufficient to accommodate one quarter of the combined capacity of all containers and secondary containment can accommodate 110 % of the capacity of the largest container. Protective wall and floor coatings will be incorporated where reasonably practicable to minimise the potential for contamination of the underlying concrete structure in the event of a leak.

Design to ensure space for decontamination

The design of the UK ABWR includes sufficient space for decontamination activities to be carried out. This includes space for characterisation prior to decommissioning to enable workers to confirm expected levels of radiation and determine the physical and chemical properties of the waste, space for placement of in-situ decontamination equipment, and space for undertaking ex-situ decontamination using physical, chemical or mechanical methods.

In addition, the UK ABWR design allows for construction of a DWMF to support waste management operations. This will accept waste generated by the dismantling and removal of items of plant from the radiological area facilities in the main power island and will have the capability to carry out ex-situ decontamination operations within installed workshops.

Work has also been undertaken during GDA to identify all walls that do not affect structural integrity or that are not required for performance and capabilities of Class 1 systems and so could potentially be removed to facilitate decommissioning operations. The design's ability to accommodate breakout of those cell walls to facilitate removal of large plant items has been carried forward to site specific design. The suitability of this feature will be assessed on a case-by-case basis.

31.5.2.3 Design for Water Chemistry Control

Regulation of the water chemistry regime during operation of the plant plays a significant role in controlling the levels of contamination built up during its operational lifetime. It also contributes to maintaining the design life and structural integrity of process pipework and internal storage pools. Careful water chemistry control can therefore result in decommissioning benefits including reduction of dose uptake, and quantities of higher classified wastes.

The following treatments are applied to the UK ABWR water chemistry regime [Ref. 31-7]:

- Hydrogen Water Chemistry (HWC) – Injection of hydrogen has been shown on nuclear power plants to reduce the risk of SCC minimising the risk of loss of containment;
- Injection of Depleted Zinc Oxide (DZO) – Suppresses the concentration of activated Co within the CUW and Reactor Coolant System (RCS) hence minimising corrosion of the process pipework. Chemically stable Zinc (Zn) will reduce the DST and subsequently the decommissioning ST. Use of DZO over Natural Zinc Oxide (NZO) will prevent the activation of Zn-65, reducing dose rates post shutdown, and;
- Iron (Fe) Control:

- The level of activated Co within the reactor coolant can be managed through the inclusion of Fe within the process water. Resulting in a reduction of activated Co within the CUW and RCS translating into a lower DST. However, higher levels of Fe within the process water increase the risk of SCC, through interaction with Zn, therefore Fe concentration will be carefully controlled. The UK ABWR Fe management strategy and methodology will be developed in the future design stages.;

The water chemistry management measures employed minimise contamination and activation levels of the plant ensuring that the decommissioning ST is optimised. Further supporting information surrounding management of water chemistry can be found in PCSR Chapter 23: Reactor Chemistry.

31.5.2.4 Design of Ancillary Services

The specification of the following systems and services will ensure a design life that is appropriate for decommissioning. Consideration of the changes in the functional operation of systems in the decommissioning stage have been captured and the risks to personnel safety and the environment have been considered throughout plant life, and impact to the building and systems layout and size. These systems and services include:

- Auxiliary systems including HVAC, power supply systems, backup power systems, cooling water systems and fire protection systems;
- The RBC and Fuel Handling Machine (FHM) lifting equipment;
- Radioactive waste management services, including systems for the treatment of gaseous, liquid, and solid wastes;
- The reactor cooling system;
- Radiation monitoring equipment;
- Plant monitoring and instrumentation equipment.

As no SSCs are specified against decommissioning during GDA, the requirement for the design lives of the above systems is carried forward as part of the decommissioning design requirements list to site specific design. This does not however necessitate the need for the system installed at the beginning of the plant life to be operational at the end of generation, rather it places a requirement on the future licensee to ensure that a system exists that is appropriate at the time of decommissioning. It is recognised that the demands on certain systems will be greater in decommissioning than during the operational phase. The UK ABWR design ensures that these requirements can be met and that designated systems required for decommissioning will either, incorporate decommissioning performance criteria as part of the design or ensure that the design allows the future licensee the ability to reconfigure and refurbish systems to meet the performance requirements for decommissioning. Any safety system supporting decommissioning will be maintained whilst required and will only be removed once declared redundant.

More information regarding the design of SSCs with respect to auxiliary services can be found in PCSR Chapter 14: Control and Instrumentation, Chapter 16: Auxiliary Systems, Chapter 17: Steam and Power Conversion Systems, Chapter 18: Radioactive Waste Management, and Chapter 19: Fuel Storage and Handling.

31.5.2.5 Drain Down of Systems and Processes

As part of POCO any residual effluent within process systems will be drained. OPEX from historical decommissioning projects reveal that poor drainage has led to effluent remaining within systems e.g. heel inside a vessel. Intervention in to sealed systems with residual effluent poses a significant radiological risk to workers.

The UK ABWR pipework and drainage design minimises contamination ALARP through the inclusion of low drain points, minimisation of horizontal surfaces and consideration of smooth surface finishes. Both piping and floor design take into account suitable gradients to ensure minimum liquid hold-up during decontamination, and piping design minimises contamination accumulation by minimisation of sharp corners and U-bends.

31.5.2.6 Design to Ensure Access / Space

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 workers spend in the vicinity of elevated radiation levels as well as the tools, techniques, and additional shielding required during decommissioning. Providing adequate spatial environment to allow workers to undertake decommissioning tasks reduces the risk of worker injury and provides the opportunity for the worker to further optimise decommissioning activities supporting the application of BAT. Access and egress routes used regularly for maintenance purposes will also benefit decommissioning, further work has also been undertaken to ensure sufficient space is provided.

A human factors gap analysis has been performed against major decommissioning tasks using the design requirements detailed in the HFE specification to ensure that sufficient space is incorporated into the design to allow major decommissioning tasks to be undertaken unimpeded and without restriction. Human factors considerations are addressed in further detail in Chapter 27: Human Factors.

The following features are incorporated into the UK ABWR design to ensure sufficient access and space is provided for decommissioning activities to be undertaken:

- Adequate hallways and equipment removal paths, including access hatches, are provided for moving equipment from its installed position to its service area or out of the building for repair. Whilst maintenance and service areas will be regularly used during the operational phase, these areas and egress routes will benefit decommissioning. Human Factors considerations have ensured that the UK ABWR design has sufficient space to allow major decommissioning tasks to take place. Detailed information regarding this can be found in “Topic Report on Decommissioning: Design for Decommissioning” [Ref. 31-7];
- To avoid interference with the building structure an export route with appropriately sized hatches to accommodate large waste packages e.g. Multi-Purpose Containers (MPCs) from the R/B operating deck is available. This ensures that the design does not foreclose the use of alternative waste packaging options and can accommodate potential future variations in waste package selection;
- The UK ABWR design allows for construction of a DWMF where large items can be moved for size reduction;

- The UK ABWR design allows for removal of non-essential walls to facilitate decommissioning. This is only applicable to walls that do not affect structural integrity or that are not required for performance and capabilities of Class 1 systems. Where non-essential walls are to be removed to facilitate decommissioning zone classifications and HVAC requirements will not be compromised as a result. All non-essential walls that could potentially be removed to facilitate decommissioning have been identified during GDA. The option for their removal is carried forward to site specific design where suitability will be assessed on a case-by-case basis.

31.5.2.7 Reduction of Embedded Piping by Design

Embedded pipework may hinder decommissioning operations and impact upon reaching the defined end state for the UK ABWR. For example, unidentified leakage from embedded pipework presents a potential decommissioning hazard. However, it is acknowledged that embedded pipework also provides benefits e.g. shielding and optimised routing, therefore a balanced approach to embedded pipework within the UK ABWR design will minimise the presence of embedded pipework SFAIRP.

Where embedded pipework has been included in the GDA design, its presence has been challenged via an ALARP assessment [Ref. 31-45] to ensure it is minimised SFAIRP. Where it is not reasonably practicable to avoid embedded pipework, an approach to its decommissioning, based on currently available technology, is outlined in the ALARP assessment. OPEX from the Trojan NPP in the USA is available where plant workers have been successful in decontaminating embedded pipework [Ref. 31-46]. This plant included 8,800 m of contaminated embedded pipework and managed to remove contamination to acceptable levels in line with final site acceptance criteria. A combination of Dry Media Blasting and Chemical Decontamination was successfully used to and deemed acceptable by the regulator.

Consideration of measures to support decommissioning e.g. pipework sleeving, no rebar obstructing pipework removal could potentially be incorporated provided they do not impact on existing safety functions during the operation phase. The findings from the ALARP assessment will be transferred and applied at the site specific stage.

31.5.2.8 Design Integrity of Structures

The UK ABWR structural design will ensure long-term integrity for decommissioning purposes, allowing for the effects of material ageing and degradation processes. Civil construction materials shall be compliant with the appropriate design methodologies, and be suitable for enabling construction, operation, inspection, maintenance and decommissioning. The integrity of civil structures is addressed in PCSR Chapter 10: Civil Works and Structures, and takes into account decommissioning requirements.

31.5.2.9 Design to Minimise Leakage from Containment

The design of the UK ABWR is required to ensure the containment of radioactive substances within the facilities during normal and fault conditions and that they only enter the environment via appropriately permitted routes. The following design features are incorporated into the UK ABWR design to minimise leakage from containment:

- The design of the UK ABWR has evolved to enhance the leak tightness of the reactor coolant circuit by reducing the amount of pipework associated with plant operations and by improving the performance of welds, seals and connections;

- Welded joints will be used for systems where provision of containment is required. All pools in the UK ABWR are fitted with a weld seam leak detection system. This system incorporates leak chase channels in the stainless steel backing strip behind all liner welds, which collects any water leaking past the welds;
- Valve type specifications have low leak rate characteristics (i.e. bellow seal, double steam seal or equivalent);
- Drains are routed through steam traps to the main condenser;
- All equipment, piping and instruments including valves and lines discharging to the environment via other systems have stringent seat-leak specifications.

Specific design features to minimise the potential for leakage of containment are described in detail in relevant PCSR chapters against FSF 4: confinement / containment of radioactive materials. Specifically, design features are claimed against High-Level Safety Functions (HLSFs) 7 (functions to contain radioactive materials, shield radiation and reduce radioactive release), and 12 (functions to store the radioactive materials as liquid wastes).

In addition, the UK ABWR is required to consider potential leakage from containment during the design phase, to ensure measures are in place to address leakage during the entire plant life cycle, including: leak prevention, leak detection, worker protection, and leak mitigation. The UK ABWR design minimises the creation, transportation and deposition of contamination by leakage through incorporation of design features to facilitate decontamination as identified in Section 31.5.2.2 and features to ensure appropriate drainage of systems as identified in Section 31.5.2.5.

All internal storage pools are stainless steel lined to minimise the potential for loss of containment. Removal of secondary containment liners will be one of the final decommissioning activities to be performed once systems have been drained and components with peripheral equipment have been deplanted.

31.5.2.10 Design for Construction and Decommissioning

As part of the construction process, Hitachi-GE has the option to adopt advanced construction techniques, which have previously been implemented on the construction of existing J-ABWRs. During GDA an assessment of the impact of the following potential construction techniques on the decommissioning phase for the UK ABWR has been undertaken [Ref. 31-10]:

- Modular construction, including both modular installation of building structure components and large Mechanical, Electrical and HVAC (MEH) items;
- Open top installation during construction;
- Embedment construction method;
- Preceding construction method;
- Area unit construction and floor packaging construction methods;
- Additional construction considerations – avoiding use of prestressed concrete (associated demolition issues due to stored energy), and alternative methods for securing metal liners to concrete.

As a result of this assessment the following design features have been incorporated to ensure that where advanced construction techniques may be adopted no disbenefit to the decommissioning phase will be presented:

- Embedded pipework will be minimised SFAIRP to aid decommissioning. Where the use of embedded pipework is unavoidable the use of an advanced ‘embedment construction’ technique may be employed to support construction. This technique has previously been used during J-ABWR construction, and involves the embedding of MEH products such as piping, conduits, funnels, anchor bolts, etc. Currently the construction techniques for the UK ABWR have not been decided. Use of this technique will be reviewed ahead of construction to identify where potential benefits could be realised [Ref. 31-10];
- Avoid theuse of prestressed concrete as the stored energy in the material can cause additional decommissioning hazards. Embedded plates used for raising items during the preceding construction method will be considered for use to move items during decommissioning;
- The design for securing metal liner to concrete is to be considered further to optimize ease of separation during decommissioning.

J-ABWRs have been built via use of modular construction, which provides manufacturing quality benefits as well as reductions in construction timescales. Given the construction timescale reductions, and that modular construction involves more work being carried out off-site in controlled environments, there are also benefits in terms of reducing the conventional health and safety hazards on-site during the construction phase.

The main disbenefit presented by modular construction is the potential to introduce access restrictions and impede removability of items during the decommissioning phase. This is entirely dependent on the plant layout, which has been reviewed to understand where access restrictions may present issues during decommissioning. Design features to ensure sufficient access and space for decommissioning are incorporated into the UK ABWR design and are discussed in further detail in Section 31.5.2.6.

Further detail of the assessment of construction techniques for decommissioning is provided in “Topic Report on Decommissioning: Impact of Construction Techniques” [Ref. 31-10].

31.5.2.11 Removal of Large Items

It is important to consider the logistics surrounding the removal of large items during the design stages. There are features incorporated into the UK ABWR design to facilitate removal of large items:

- As discussed in Section 31.5.2.6 access routes have been considered for all equipment which needs maintenance and replacement during the operational phase of the UK ABWR and these will be utilised as access routes during decommissioning;
- The UK ABWR design ensures that egress routes for all large items are not obstructed during decommissioning. To avoid interference with the building structure, export hatches are appropriately sized to accommodate large waste packages e.g. casks, floor loadings are designed to accommodate larger shielded packages, and the design does not foreclose use of alternative waste packaging options;
- The UK ABWR design allows for removal of non-essential walls to facilitate decommissioning as described in Section 31.5.2.6.

All the design features discussed in Section 31.5.2 support the safety claim Decom-SC 1, that the UK ABWR design incorporates features that facilitate decommissioning.

31.5.2.12 Basis of Safety Claims

The safety case for decommissioning the UK ABWR is based on claims and sub-claims that have been derived to support the high-level decommissioning safety objective: ‘the UK ABWR can be decommissioned safely’. These claims and sub-claims are presented in Section 31.2.

As discussed in Section 31.5.1, a systematic approach has been undertaken to confirm where the UK ABWR reference design incorporates features to facilitate decommissioning and challenge the design to identify additional risk reduction measures for incorporation into the design to ensure decommissioning risks are reduced ALARP. Where features have been incorporated into the UK ABWR design to enable hazard reduction during decommissioning these have been summarised in the sections above. The incorporation of these design features provides a demonstration that risks are reduced, or are capable of being reduced ALARP and as such provide the majority of arguments to support the decommissioning claims and sub-claims. Appendix C summarises the decommissioning position during GDA by providing a list of arguments against each sub-claim.

31.6 Decommissioning Strategy

A decommissioning strategy for the UK ABWR and an outline of how it could be applied at a future UK site has been produced. The strategy selected by Hitachi-GE is a "prompt" decommissioning strategy, which aligns with UK policy and regulatory expectations, and involves the following:

- Decommission the site promptly and continuously as far as external constraints will allow;
- Simplify the plant and systems which will remain active during decommissioning to allow the simplification of the site arrangements and the structure of the decommissioning organisation;
- Dispose of LLW, ILW, spent fuel and all other decommissioning wastes to authorised off-site facilities when appropriate depending on time spent in decay storage and availability of the facility as soon as they are available and meet Conditions For Acceptance (CFA);
- De-license the site.

The strategy is presented in "Topic Report on Decommissioning: Decommissioning Strategy" [Ref. 31-6]. The following sections summarise the work undertaken to select the preferred "prompt" decommissioning strategy, and an overview of the main steps associated with prompt decommissioning to achieve the desired end state.

31.6.1 Brief Description of the Generic Site

The layout of the UK ABWR NPP as considered at GDA is shown in PCSR Chapter 9: General Description of the Unit (Facility). The decommissioning strategy has been based on an independent single unit at a generic UK site under generic site conditions. The scope of civil works and structures for GDA is as follows:

Main Buildings / Facilities:

- R/B;
- RCCV;
- Control Building (C/B);
- Heat Exchanger Building (Hx/B);
- Filter Vent Building (FV/B);
- Main Stack;
- Emergency Diesel Generator Buildings (EDG/B) (three buildings, one for each division);
- Backup Building (B/B);
- T/B;
- Rw/B;
- Service Building (S/B).

Tanks and Underground Facilities:

- Light Oil storage Tank (LOT) Basement;
- Flooding System of Specific Safety (FLSS) Facility Water Storage Tank (WST) Basement;
- Condensate water Storage Tank (CST) Structure.

Service Tunnels / Connections:

- Reactor Cooling Water (RCW) Tunnel;
- R/B-EDG/B Connecting Service Tunnels (three tunnels, one for each division);
- R/B-B/B Connecting Service Tunnel;
- B/B-LOT Connecting Service Tunnel;
- B/B-FLSS Water Storage Tank Connecting Service Tunnel;
- R/B-CST Connecting Service Tunnel.

The GDA scope specifies the buildings mentioned above and it is noted that some buildings are yet to be designed. However, it is intended that the decommissioning principles and approaches can be applied to all buildings on the site.

31.6.2 Timing of Decommissioning Operations

In developing the decommissioning strategy for the UK ABWR four decommissioning options have been considered [Ref. 31-6]:

1. **Prompt Decommissioning –** This option seeks to decommission the site as quickly as practicable, whilst recognising that there will be external constraints which may require the timescale from reactor closure to site delicensing to be extended.
2. **Deferred Dismantling of ILW** – Deferred dismantling attempts to overcome some of the difficulties introduced by prompt decommissioning as a result of a future licensee not having access to the GDF for ILW disposal. LLW and non-radiological plant and buildings are decommissioned on the same timescale as prompt decommissioning. However, the decommissioning of ILW plant, equipment and buildings is deferred until the ILW can be disposed of directly to the GDF. It may also be necessary to retain other systems required to support the deferral of ILW plant decommissioning.
3. **Deferred Dismantling of all Radiological Systems** – This option is similar to option 2, but the scope of deferred decommissioning work is more extensive. In this option, no decommissioning of radiological systems, plant or buildings, including LLW systems and buildings, commences until the ILW can be disposed of directly to the GDF. Hence more of the power plant systems and buildings would remain on-site for longer. Non-radiological systems and buildings would be dismantled as soon as is practicable.
4. **Entombment** – This option seeks to leave the majority of radiological material on the site for all time. In effect the site will become a disposal site subject to the same requirements as a site such as the Low Level Waste Repository (LLWR).

Option 4, Entombment, was discounted from detailed assessment as it was considered that the difficulties and disadvantages of this option outweighed the benefits, particularly in the areas of regulatory requirements, stakeholder acceptance and financial risk. This option did not align with the assumptions and expectation of key stakeholders with regard to remediation, delicensing and restoration of the site.

The remaining three options all involve removal of radioactive waste from the site such that it can be released from regulatory control. A workshop was held to determine which option would be most appropriate for the UK ABWR. The three options were scored against various criteria and the workshop concluded that Option 1, prompt decommissioning, was the highest scoring strategy option, followed by Option 2, deferred dismantling of ILW, and finally, Option 3, deferred dismantling of all radiological systems. A supporting sensitivity analysis has been undertaken which supports the selection of prompt decommissioning [Ref. 31-6].

The UK ABWR preferred prompt decommissioning strategy is to:

- Decommission the site promptly, and as continuously as external constraints will allow, progressively reducing the on-site hazard;
- Place fuel and wastes that cannot be transferred off-site into a passively safe condition for on site storage;
- Simplify the plant and systems which will remain active during decommissioning to allow the simplification of the safety case and site arrangements and the structure of the decommissioning organisation;
- Dispose of LLW, ILW and spent fuel to authorised off-site facilities as soon as they are available and meet CFA;
- De-license the site to allow it to be used for further activities;
- Surrender environmental permits associated with the site.

The entire decommissioning period can be divided into the following phases:

- Before EoG;
- Immediately after EoG;
- Power plant decommissioning;
- SF, HLW and ILW storage period;
- HLW / ILW store emptying, repackaging, and disposal;
- Spent fuel storage and SFIS emptying, repackaging, and disposal;
- Demolition and delicensing of the site.

A graphical representation of the preferred decommissioning strategy is presented in Figure 31.6-1. The phases presented are not completely rigid and to a large extent a degree of overlap between phases is likely.

The design has been optimised so that prompt decommissioning is a viable option. However, the design is flexible so that if the future licensee prefers to undertake an alternative strategy e.g. deferred decommissioning, the design does not foreclose the option.

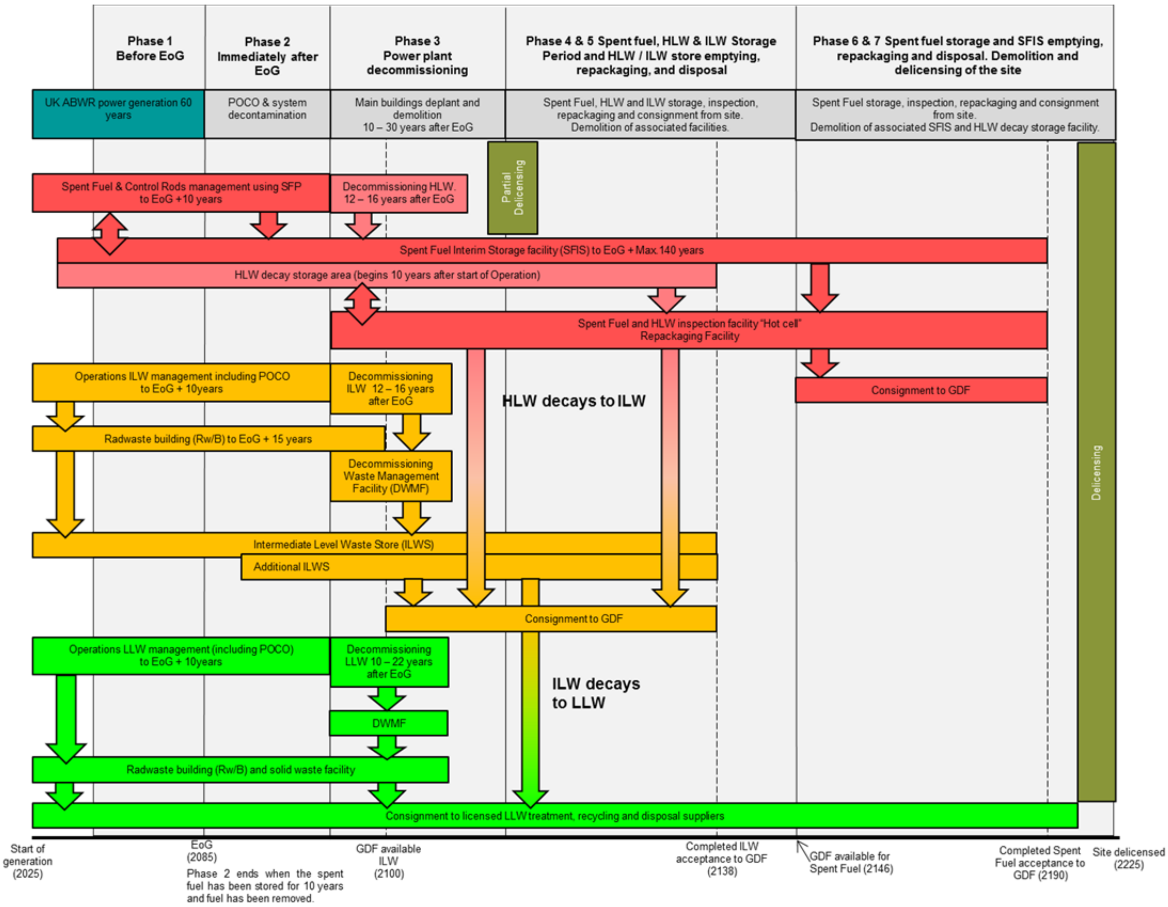


Figure 31.6-1: Graphical Representation of the UK ABWR Prompt Decommissioning Strategy

Section 31.7 describes the proposed decommissioning sequence and methodologies to demonstrate an understanding of the timings and processes required to achieve the preferred prompt decommissioning strategy. This includes an overview of how the main UK ABWR buildings will be decommissioned. Strategies and plans will be reviewed and updated on a periodic basis and information relating to these plans, including their costs, schedule and implementation will be recorded and preserved as discussed in Section 31.9.

31.6.3 End State

As discussed in Section 31.5, following deplanting and decontamination buildings will be demolished. The site end state is assumed to be when the site is remediated to a level near to greenfield i.e. allowing for unrestricted access. This translates to building structures above the 1 m below ground level being decontaminated and surveyed such that they can be confirmed radiologically clean and demolished using conventional demolition techniques. Below ground structures including building floors and embedded pipework greater than 1m below ground will be left in-situ and shown to meet the ONRs ‘no danger’ criteria (dose to future site users has to be <10 μSv/y) [Ref. 31-39]. Void spaces will be filled either with clean rubble from building demolition, or with new material brought to site. Any building rubble not used for void filling or landscaping will be managed off-site in accordance with the waste hierarchy and defined disposal routes.

Once the site has been cleared and decommissioning tasks have been completed an application to delicense the site to allow removal of regulatory site control measures will be submitted. The delicensing application will be approved based on the demonstration of meeting the ONR's 'no danger' criteria.

31.7 Decommissioning Plan

A decommissioning plan has been produced to demonstrate how the prompt decommissioning strategy can be employed in practice and how the UK ABWR can be safely decommissioned and delicensed at the end of plant life to achieve the desired end state. The following sections provide an outline of the decommissioning plan, including an explanation of the decommissioning activities that need to be undertaken and how decommissioning could be accomplished based on current experience and technology. This section includes an overview of how the main buildings of the UK ABWR will be decommissioned, based upon the OPEX and GP discussed in Sections 31.3 and 31.4. The handling and interim storage of spent fuel is described in PCSR Chapters 19: Fuel Storage and Handling and 32: Spent Fuel Interim Storage respectively. A more detailed decommissioning plan is provided in "Topic Report on Decommissioning: Decommissioning Plan" [Ref. 31-8].

Given that decommissioning is not due to occur until the plant has been operating for at least 60 years, further information and developments (e.g. improved technology), both in the UK and internationally, may prompt changes to improve safety and environmental protection (including reduction of doses) or reduce costs. Such potential improvements would be kept under review throughout the operational life the UK ABWR and would be factored into periodic reviews and updates of decommissioning plans. The detailed implementation plan will consider factors during its preparation in the period leading up to EoG and the start of decommissioning activities.

31.7.1 Major Project Activities

The decommissioning plan for the UK ABWR is divided into three principal Activities:

Activity 1. Pre-Generation – Covers those activities relevant to decommissioning which must be undertaken before construction of a NPP can begin. This is the period during which future licensees must obtain all the regulatory permissions required to begin generation.

Activity 2. During Generation – Operation of the station, including any modifications or refurbishment required during generating life and management of operational wastes. Preparation of a decommissioning plan and associated preparatory works to 5 years prior to EoG.

Activity 3. After EoG – Dismantling the station, management and disposal of remaining waste and cleanup of the site to a condition agreed with the regulators.

Within the decommissioning plan, Activities 2 and 3 have been broken into smaller sub-phases containing similar work. These sub-phases drive key milestones in the life cycle of the site during which significant changes occur (for example in strategy, plan, waste management, safety assessment, work scope, staff numbers, running costs, or regulatory requirements). The main tasks undertaken during each of these sub-phases to achieve prompt decommissioning are described in more detail in the following sections.

31.7.2 Phase 1 – Before EoG

This phase begins before the final shutdown of the UK ABWR and ends when the plant ceases generation. This phase is used for detailed decommissioning planning and for obtaining the various regulatory approvals required in preparation for decommissioning.

A new Decommissioning Project Management Organisation (DPMO) will be formed within this planning phase to commence detailed planning and preparation for decommissioning. This team will be responsible for preparatory works such as:

- Preparation of a decommissioning safety case;
- Forward planning of organisational change, including consideration of management of change arrangements and updates to the nuclear baseline;
- Preparation of regulatory submissions such as Article 37 and 41 submissions, Nuclear Reactors EIADR submissions, etc., preparation of any applications for modified (or new) environmental permits;
- Preparation of detailed work plans and schedules for the initial period after EoG;
- Preparation of any revisions to waste management plans;
- Preparation of work and contract specifications, contract management, etc. for any required site modifications (e.g. electrical system reconfigurations), and construction of an ILW store extension if required;
- National and local planning applications for the likely construction of new temporary buildings or significant modification to existing buildings;
- Procurement of any long lead items or long lead contracts.

Early in the operational phase multiple waste storage facilities will be constructed, including:

- SFIS - used to store spent fuel;
- HLW decay store (co-located with the SFIS) – used to store HLW until such time that wastes have decayed to ILW;
- Additional ILWS - for storage of ILW wastes packaged in a form acceptable to Radioactive Waste Management (RWM) for disposal in the GDF.

Packaged spent fuel, HLW and ILW waste arising during operation will be transferred to these facilities on a campaign basis. LLW, VLLW and non-radiological wastes arising during operation will be transferred off-site to authorised waste processors for management in accordance with the waste hierarchy.

Over the operating lifetime of the plant detailed decommissioning plans will continue to be developed which will take into consideration waste to be managed during the decommissioning phase.

31.7.3 Phase 2 – Immediately after EoG

This phase begins at the point when the UK ABWR ceases generation and ends when the SFP has been emptied. The following sections describe the activities in this phase in further detail.

31.7.3.1 Spent Fuel Management

Within a few days of EoG, all fuel will be transferred from the reactor into the SFP for a period of storage and cooling. The key activities required to maintain the operation of the SFP are expected to be ongoing monitoring of the spent fuel, inspection and regular maintenance of the pool and its support systems, and replenishment of consumables required by the pool water cleanup systems. A key assumption for planning purposes is that, whilst fuel remains in the SFP, supporting systems that serve the R/B will remain operational or available to support fault scenarios. Deplanting will only commence once the spent fuel has been removed from the SFP, hence little dismantling of plant systems is planned for this period.

It may be possible to carry out modifications to those systems supporting the management of fuel in the SFP, or to install alternative temporary systems, so that the SFP can be made to stand alone and isolated from the main plant systems. Subject to development of an appropriate safety case, this would allow installed systems to be declared redundant and available for early dismantling. This may be beneficial if it is determined that the spent fuel needs to remain in the SFP for an extended period, but is not currently part of the assumed implementation of the decommissioning strategy.

This decommissioning plan assumes that, as is the case during the reactor operations, spent fuel is expected to remain in the SFP for 10 years before transfer to the on-site SFIS facility. The transfer of spent fuel to the SFIS facility will follow the same process as that utilised during operations (see Chapters 19: Fuel Storage and Handling and 32: Spent Fuel Interim Storage). The ongoing management of spent fuel in the SFIS facility will continue throughout Phase 2.

Although there is no intention to conduct routine fuel inspections, it is regarded as GP to have the facilities and capability to do so if judged necessary at some time in the future. A “Hot Cell” will be built within the repackaging facility, which will allow for retrieval, inspection and repackaging of spent fuel. There will not be a regular, systematic program of inspection of spent fuel in dry storage, but facilities can allow “ad-hoc” inspections, for example, at the request of the regulator. Hot Cell requirements will be based on technology available at the time. More information is provided in Topic Report on Decommissioning: Decommissioning Plan [Ref. 31-8].

During this phase it is also assumed that all control rods and other non-fuel core components removed from the reactor with the final core will be stored in the SFP, alongside some non-fuel core components removed during the reactor life. As reactor components will be highly activated they will require alternative management strategies to spent fuel. Although there is currently no detailed design proposal for the HLW decay Store (see PCSR Chapter 18: Radioactive Waste Management), it is assumed that decay storage casks similar to the MPCs proposed for fuel storage will be used. Management of HLW / ILW is discussed further in Section 31.8.

31.7.3.2 Facility Shutdown and Decontamination of Closed Systems

This period will be used to ensure that redundant plant systems are taken out of service in an orderly manner. Some systems, such as the Fuel Pool Cooling (FPC) System, leakage detection system, fuel handling machine and crane, will remain operational to support spent fuel management or subsequent activities such as chemical decontamination of contaminated systems, which may rely on system pumps to be fully effective. The following work is undertaken during this period:

POCO

POCO is the removal of working fluids, resins and other operational material (radioactive and non-radioactive) at the end of a facility’s operational life, and the management of the resulting waste materials. Systems will be purged, vented and drained as required and some systems flushed to remove hazardous residues. One of the main drivers is to deactivate as many areas as soon as possible so they are in a passive state.

The work will be carried out by the future licensee, and will generally be performed using installed plant and equipment. As POCO is considered a part of the operational safety case, a specific decommissioning safety case will not be required.

Initial Characterisation Campaign

A targeted campaign of characterisation will be performed to update the information used for task planning purposes to reflect the effectiveness of works carried out during this phase. This will include investigation of the reactor and associated recirculation systems to confirm the extent of deposited contamination and how firmly it is fixed to structures and items. This will inform decisions about ALARP work procedures and waste management planning.

Chemical Decontamination

After EoG it is common practice to carry out a chemical decontamination of some of the more contaminated fluid systems. The purpose is to reduce general area and contact dose rates for specific tasks such as thermal insulation removal and plant dismantling, and allow for reclassification of waste.

Decontamination will be performed in two stages, both carried out using skid mounted equipment in the form of resin beds, heating equipment, etc. which will be brought to site by the contractor depending on the processes used. The first stage involves application of a chemical process to remove the internal oxide layer from contaminated pipe systems. The scope of the decontamination will include the CUW, Residual Heat Removal (RHR) system, FPC System and RPV/ RIN.

The second stage will use a more chemically aggressive process to remove a thin layer of the base metal from treated systems. Chemical decontamination processes are commercially available and are described in further detail in the decontamination strategy [Ref. 31-44]. Flexibility is provided to the future licensee to select the most appropriate technique based on BAT and ALARP considerations at the time.

Thermal Insulation Removal

Thermal insulation removal is a non-invasive preparatory task that can be performed during this period when it is assumed that little other deplanting will be done.

Much of the insulation will be of the clip-on modular type so can be simply removed and managed as a non-hazardous waste. The plant will not contain asbestos bearing insulation but there may be areas where MMMF is used; this will be removed by a specialist contractor using industry best practice.

31.7.3.3 New Build and Plant Modifications

Decommissioning Waste Management Facility

During Phase 2 a standalone DWMF will be constructed to support the decommissioning activities during Phase 3. The DWMF will accept waste generated by the dismantling and removal of items of plant from the radiological area facilities in the main power island. Components will then be processed and packaged for dispatch off-site for disposal or onward management. The DWMF will be decommissioned once all radiological area facilities have been deplanted and their wastes processed.

Repackaging Facility

Although there is no current intention to conduct routine fuel inspections, it is regarded as GP to provide the capability to do so if required. Following decommissioning of the SFP this capability will be lost. As such, a facility will be built, prior to decommissioning of the SFP to provide the facilities required for retrieval, inspection and repackaging of spent fuel. At this time, it is proposed that a dedicated Hot Cell with remote handling capability is used to perform this function. The Hot Cell will also be provided with equipment for the segmentation and packaging of HLW which has been decay stored to levels that will permit packaging as ILW.

Plant Electrical Reconfiguration

During decommissioning, once the main plant no longer needs to operate, the large incoming power supply direct from the high voltage grid is no longer appropriate and prevents decommissioning of the associated transformers and supply system. It is therefore proposed that a more appropriate incoming power supply, drawing from the local distribution network and a new on-site distribution system will need to be installed.

The new supply and distribution systems will be designed taking into account that some sections will become redundant as decommissioning proceeds while other sections will remain in service. Redundant sections will be easily removed without interference with the operating sections.

Alternative Effluent Discharge Line

During plant operations, most liquid waste arisings are treated and returned to the CST for reuse. Some liquid arisings, such as those from laundry and shower / hand-basin systems are unsuitable for reuse so are treated and discharged via the permitted discharge outlet. During decommissioning, the need for stored condensate will reduce so discharges of treated liquid wastes may increase temporarily.

After shutdown, the high water flow rates through the cooling water system are not required to support power generation. So the cooling water pumps can be turned off and the cooling water system plant can be decommissioned, an alternative route for liquid effluent discharges to sea will be necessary while liquid wastes continue to be produced.

The decommissioning plan proposes that a double walled discharge pipe is installed in the cooling water outlet channel to provide a suitable route to sea for discharges. Uprated pumps will be required in the liquid waste treatment facilities to account for the increased distance the discharges must be pumped. A BAT assessment will be undertaken nearer the time that considers the quantity, frequency and characterisation of any future liquid waste arisings to determine and justify the most appropriate alternative arrangement.

31.7.4 Phase 3 – Power Plant Decommissioning

This phase begins after the transfer of spent fuel to the SFIS facility and ends with the demolition of the main power production area of the site previously occupied by the power station buildings. At the end of the phase, the licensed site area will be smaller and be limited to the area occupied by the SFIS, the HLW decay store, the ILW store and the repackaging facility containing the Hot Cell.

31.7.4.1 Active Area Deplanting

The plant will be dismantled using the approach of removing all plant and equipment from a room or zone as one operation. Temporary services will be used to provide lighting and power, etc. This approach helps minimise the risk of attempting to dismantle an in-service / energised system. However, on a case-by-case basis, there may be merit in removing complete or partial systems, which pass through a series of rooms. Again, the preference will always be to accomplish this in a single step. Any equipment that is required specifically for dismantling purposes will generally be mobile and will only be installed on a temporary basis as and when it is needed.

31.7.4.1.1 Reactor Building Deplanting

There are various kinds of equipment and components in the R/B, some of which are considered to be hazardous. Following operation some equipment and components will be contaminated and / or activated, the extent of which will be confirmed through sampling and measurement. A removal plan for R/B waste packages shall ensure the safe removal and transportation of neutron irradiated and contaminated RPV and RINs.

R/B deplanting work commences once the fuel has been removed from the SFP. As such, the R/B is largely in an operational condition at the start of deplanting. Water management systems, HVAC systems, cranes, etc. will still be intact and operational to support the SFP, which is now empty of fuel. All plant systems redundant since shutdown will be taken out of service and insulation will have been removed where possible.

Work initially takes place in and around the SFP and DSP after which four main work faces are addressed with a certain amount of parallel working. The main sequence of work is:

- Works in the RCCV including removal of the RPV, main steam and feedwater pipework, D/W and wet well equipment and structures, and removal of activated concrete;
- Works on the main steam and feedwater pipework external to the RCCV;
- Radiologically controlled area works external to the RCCV involving removal of various reactor support and safety systems;
- Non-radiologically controlled area work external to the RCCV involving removal of control rod drive control room equipment, HVAC plant, etc.

The main sequence of work during R/B deplanting is as follows:

Reactor Internal Pumps

The impeller shaft of the RIPs provides a seal allowing removal of the pump motor. The task of removing the RINs may be simplified by being able to remove the RIPs diffuser / impeller at the same time, after which point it would not be possible to remove the RIPs motors while keeping the RPV watertight. The RIP motors are removed at an early point in the R/B deplanting sequence. The same procedures are used for removal of the RIP motors for maintenance. The motors are transferred to the DWMF for processing / disposal and the casing will be dismantled with the RPV.

Pressure Containment Vessel Head and Associated Equipment

The areas around the R/B pools are used for storage of various operational equipment items, many of which are redundant at this point. These items will be removed and disposed of via the DWMF, either intact for smaller items, or following segmentation for larger items. Removing these items will clear space for setting up equipment for removal of the RPV and RINs.

Spent Fuel Pool Racks

Once the spent fuel has been removed from the SFP, the fuel racks and other equipment within the pool can be removed and segmented. This will clear additional space within the pool which may be required for removal of the RINs. The racks will be lifted from the water, hosed down as they are lifted and moved to either a tented enclosure or the DWMF for size reduction.

Reactor Internals

The steam dryer assembly, shroud head and steam separator assembly are routinely removed during defuelling, however items such as the core shroud, core plate, feedwater / Low Pressure (LP) and HP flooder sparger, top guide, and control rod and in-core monitoring guide tubes are not.

The RINs will be segmented underwater in the DSP to provide shielding of activated components, in line with GP from previous RIN segmentation projects [Ref. 31-8]. Various cutting methods, either standalone or in combination, have been successfully used to segment the RINs of light water reactors in the USA and Europe. "Topic Report on Decommissioning: Decommissioning Techniques" [Ref. 31-9] discusses a combination of PAC for cutting inside the R/W, and AWJC for cutting of more activated parts of the RINs where PAC cutting gases could drive highly activated cutting debris to the surface of the pool. The choice of preferred decommissioning techniques is based on consideration of various options and international GP.

Once segmented underwater the RINs will be placed into appropriately sized containers based on their radiological activity. A small proportion of the RINs may be classified as HLW so these items will be placed into containers which can accomodate such waste types e.g. MPCs. The remaining parts of the RINs will be classified as ILW and will be placed in to alternative waste packages but not grouted to ensure that the opportunity for decay to LLW is available to the future licensee. The design does not preclude the use of alternatively sized packages for waste disposal.

Dismantling of the removed RINs within the DSP will require installation of suitable infrastructure to deploy tools and retrieve cut sections in conjunction with the existing cranes. Enabling works are required to be undertaken ahead of dismantling operations. These works will include installation of equipment within the DSP, set up of a remote control centre, and amendments to the water management and filtration system. The design can accommodate these enabling works with relative ease so that dismantling operations can be conducted safely and efficiently. Use of existing systems e.g. RBC, FHM, facilitate these activities negating the need to import further equipment which may impede operations. This is discussed in more detail in PCSR Chapter 14: Control and Instrumentation. The installed equipment will need to be able to perform cutting / handling operations within the RPV and perform further segmentation of pieces removed from the RPV.

A cutting and waste management plan will be developed based on the characterisation of the individual items that make up the RINs. At the end of the task, the SFP and DSP will be intact. The RPV will remain in place, but will have been emptied of all routinely and non-routinely removable components to leave just the vessel itself.

Pool Draining and Initial Decontamination

Once the RINs have been removed and the DSP and SFP cleared of all equipment, the pool liners can be decontaminated in anticipation of the subsequent RPV removal task. During this process the water level will be lowered in stages and the areas revealed will be decontaminated using HP water jets deployed from the control bridge installed for RINs removal. The pool water cleanup systems will manage the waste water deposited into the pool as the level is lowered. The walls and floor will be checked for any remaining hotspots which will then be rewashed, decontaminated using more aggressive techniques or sealed. The pool liners will not be removed at this stage.

Chemical Decontamination of the FPC System

As discussed in Section 31.7.3.2, chemical decontamination of the CUW, RHR system and the RPV/ RIN will be undertaken earlier in Phase 2. A smaller chemical decontamination campaign to reduce dose rates from the FPC System is planned to take place at this point in R/B decommissioning before the FPC System is dismantled. The benefits of this decontamination campaign would need to be assessed at the time.

RPV Removal

With the RINs removed, work will now proceed in parallel faces. The first task to be performed inside the RCCV is the removal of the RPV. The RPV will be segmented in air which removes the need to modify the R/W pool to maintain water tightness as the RPV is removed.

The preferred method for cutting of the RPV will be using oxy-propane cutters, as per the method used at Stade in Germany and Zion in the USA, and in alignment with the recommendations in the "Topic Report on Decommissioning: Decommissioning Techniques"[Ref. 31-9]. The cutters will cut from the outside of the vessel inwards, allowing extract systems to be fitted for fume management.

The RPV will be cut into manageable rings while in its operational location and the height of the rings will be specified such that segments of the ring, cut longitudinally, will fit directly into an appropriately sized disposal package. The design does not preclude alternative disposal packages being adopted.

As with the RINs, enabling works need to be undertaken to facilitate dismantling of the RPV including drainage and decontamination of the DSP, installation of equipment, provision of mobile ventilation and tenting to support cutting operations, and setup of a waste packaging station. Dismantling of the RPV will be undertaken in-situ due to the size of fuel pools. This will also reduce the production of waste, and ensure good visibility to operators. This is discussed in more detail in Section 31.3.3.5.

Cutting plans for major components such as the RPV need to take account of subsequent waste management activities. The cutting plan will aim to produce pieces that are at or close to the optimum size and weight limitations the waste package can accommodate. This reduces double handling and the requirement for secondary segmentation, thereby improving packing efficiency.

At the end of the task, the pools are assumed to be intact but there will be a penetration in the floor of the R/W pool where the RPV was previously. This will be fitted with a temporary cover and safety barriers. All segmentation and waste handling equipment installed for the task will be removed and a housekeeping exercise within the pools will have been performed.

Other Tasks inside the RCCV

With the RPV and RINs removed, radiological dose rates within the RCCV will be significantly reduced. Deplanting work will then commence in the Upper and Lower D/W, within which there are a number of plant and equipment to deplant:

- Upper D/W – D/W Equipment and Piping Support Structure (DEPSS), Main Steam Isolation Valves (MSIV), Safety Relief Valves (SRV), large diameter pipework, cooling fans, dehumidification cooler, HVAC ducting, etc. ;
- Lower D/W – Equipment and floor drain sump pumps, Low Conductivity Waste (LCW) sump cooler, Control Rod Drive (CRD) exchange equipment, RIP Heat Exchangers.

Once large items have been removed from the Lower D/W, the wet well is drained and decommissioning work in this area commences. This involves removal of the concrete reactor pedestal, wet well liner decontamination, and removal of contamination from walls and floors.

The general approach for decommissioning embedded pipework can be found in the "Topic Report on Decommissioning: Decommissioning Techniques" [Ref. 31-9]. Where possible, the UK ABWR structure below the 1 m below ground level, including embedded pipework is to remain in-situ at the decommissioning end state. Embedded pipework is to be decontaminated / treated such that it is demonstrably clean to achieve the delicensing criteria, whereupon it will remain within the structure. If this is not possible, embedded pipework is to be removed such that the achievement of the delicensing criteria is not compromised. Embedded pipework will be recovered as part of a controlled demolition process or during management of the demolition rubble.

Main Steam and Feedwater Pipework / Valves

There is limited access to the Main Steam and Feedwater pipework outside the RCCV, however these pipe systems run from the R/B, through the C/B to the T/B and so there is improved access to them following removal of a wall. As such, removal of the Main Steam and Feedwater pipes is better completed by starting at this access point and removing the pipework from the T/B, then the C/B and finally the R/B to the RCCV wall. Main Steam and feedwater pipework removal is therefore included in the scope of the T/B deplanting.

Work in Areas outside the RCCV

In parallel with the deplanting works inside the RCCV, work will commence on deplanting radiological areas outside the RCCV.

Once the RPV had been removed and the pools cleared of all equipment, the DSP and SFP liner will be cleaned of any debris deposited by the RPV segmentation works. Wiping and vacuuming techniques will be used as a preference for decontamination of the liners, although depending on the extent of contamination HP water jet techniques may be used.

The liners will then be removed by either cutting into sections via a PAC, or cutting down the concrete immediately behind the liner using a wire saw depending on how the liner is attached to the concrete. Following removal of the liner, the exposed concrete below will receive an initial survey for contamination, and appropriate decontamination methods such as scabbling or shaving applied as appropriate.

Work will then commence to deplant other radiological areas outside of the RCCV such as RHR and CUW system pumps and tanks, Hydraulic Control Unit (HCU) equipment, CRD and RIP maintenance rooms, FPC pumps and heat exchangers. Further details of the areas requiring deplanting are provided in "Topic Report on Decommissioning: Decommissioning Plan" [Ref. 31-8].

Floors in the R/B also include non-radiological zones i.e. for control system cabinets, HVAC system equipment, etc. These areas are provided with sufficient access and egress routes, and lifting equipment to remove all major plant items for maintenance purposes, therefore significant modifications are not anticipated. To prevent cross contamination work will proceed area by area, working inwards, to ensure sufficient space for the removal of items. In non-radiological areas work sequences will generally aim to clear the maximum space as soon as possible to provide improved access and space to install scaffolding and facilitate other tasks.

31.7.4.1.2 Turbine Building Deplanting

Main equipment housed in the T/B consists of the HP and LP turbines, Main Condenser (MC) and

Generator. POCO processes are applied prior to turbine equipment deplanting and inventory surveys on main steam piping and turbines are then undertaken to evaluate contamination levels. Equipment is subsequently decontaminated as necessary.

Although many items of equipment housed in the T/B are large, the same disassembling processes can be applied as in the maintenance period and used for removal to an area for size reduction. Work in the T/B will initially focus on removal of large plant items:

- Generator – This is expected to be a radiologically clean item and so will be removed before the turbines to prevent cross-contamination. The preferred option is for removal in parts. The rotor will be removed using routine operational maintenance procedures. Once the Generator has been separated from supporting cables, pipework, the LP Turbine coupling, any remaining ancillary equipment and the outer cladding sections will be removed and segmented. This will be followed by removal of bearing liners, seals, etc., from the rotor shaft and removal of the stator and rotor to a tented enclosure for size reduction;
- Turbines – The turbine units will be dismantled the same way they are during routine outages; however size reduction activities will need to take place on the upper and lower bodies of the units to allow for dispatch to the DWMF. The turbine rotors will require removal of the blades from the shaft to facilitate further processing and transport for recycling following decontamination;
- Moisture Separator / Reheaters – Deplanting will either involve progressive removal of sections of the vessel shell followed by segmentation of the revealed internals, or intact removal of the internals followed by segmentation of the remaining tanks and simplified internals;
- Charcoal Delay Beds – The charcoal delay beds are designed to allow for easy replacement of the activated charcoal. An engineered solution whereby a vacuum system removes all charcoal will be available during decommissioning. This system will be installed above the charcoal adsorber and uses a hose routed into the bed at the top through a small opening. The charcoal delay bed vessel will be deplanted and disposed of in line with the strategy for other activated components.

In parallel with works on the large components, deplanting work will proceed on other floor levels, addressing area by area starting near egress routes for material and working through the rest of the floor. Focus will generally be on removal of non-contaminated then contaminated pipework and smaller plant items to clear space for dismantling of larger components. Contaminated systems will then be removed, with plant items removed intact where possible for segmentation i.e. the Feedwater Heaters in the Condenser.

The sections of Main Steam and Feedwater Pipework that enter the T/B will then be removed. Access to the pipes from the C/B and to sections of these pipes outside the RCCV in the R/B is not considered practical. Therefore, the restricting blockwork wall will be removed and the entire length of these pipes through the C/B and to the RCCV will be removed using access via the T/B. When sufficient space around the Condenser has been cleared and the Feedwater Heaters have been removed, work will then begin on its dismantling.

31.7.4.1.3 Rw/B Building Deplanting

The Rw/B houses radioactive liquid and solid waste treatment equipment. As wastes will continue to be generated during the early stages of decommissioning, particularly while systems in support of the SFP and other liquid waste generating systems remain operational, it is expected that the Rw/B will become redundant later than some other buildings.

All operational wastes are to be processed by the Rw/B, i.e. all dry solid waste and spent resins that the Rw/B is designed to manage will have been processed, packaged and disposed of (either off-site or moved to storage elsewhere on-site).

Work sequences will aim to remove non-contaminated items first to reduce the potential for cross-contamination. Work will generally proceed area by area, starting from egress points out of the building (ground floor) and gradually working in towards areas furthest from the egress. Larger, heavy items such as sample and collection tanks will be removed last. The general sequence of item removal will however depend largely on their size and location. An initial area assessment may identify items that should be considered as exceptions to the approach described, due to their contribution to area dose rates or other logistical considerations.

31.7.4.1.4 Deplanting of Other Buildings

In addition to the R/B, T/B and Rw/B, consideration has also been given to the demolition of other outstanding structures which include the C/B, FV/B, S/B and redundant equipment including tanks. It is anticipated that these structures and plant components will have limited to zero levels of contamination and that conventional demolition procedures can be. This approach will be adopted following confirmation of plant conditions, and decontamination processes may be applied if required. The Main Stack (MS) will also be demolished at this stage, ensuring that HVAC requirements have been appropriately considered to ensure risks are reduced.

31.7.4.2 Demolition and Site Clearance

The scope of works involves the demolition of all building superstructures, the excavation of substructures to -1 m below ground level, the processing of demolition arisings and the backfilling of basement voids with foamed concrete. Once complete, further works will be completed to treat culverts and to remove other features (utilities, hard standings and fencing) which will leave the site ready for site restoration.

31.7.5 Phase 4 and Phase 5 – Spent Fuel, HLW and ILW Storage Period, and HLW / ILW Store Emptying, Repackaging and Disposal

This phase follows the demolition of the main power production area of the site. This is primarily a period of storage and stewardship of packaged spent fuel, HLW, and ILW. The only non-routine activities during this period are maintenance of the repackaging facility and radioactive waste storage buildings, and the periodic inspection of spent fuel and other waste packages. The duration of Phase 4 will be dictated by the availability of the GDF. Once available ILW will be removed and transported to the GDF.

The main facilities on the site will be the spent fuel store and an Intermediate Level Waste Store (ILWS) holding waste from the operational life of the power station and decommissioning waste. In addition, the Hot Cell within the repackaging facility will continue to be used for ad-hoc inspections of spent fuel during this period. The major activity will be the retrieval of ILW from storage and its transportation to the GDF for disposal (See Chapter 18: Radioactive Waste Management). Once complete, the ILWS will be deplanted and demolished.

31.7.6 Phase 6 and Phase 7 – Spent Fuel Storage and SFIS Emptying, Repackaging and Disposal. Demolition and Delicensing of the Site

Phase 6 is principally for inspection, repackaging, and consignment of spent fuel. To facilitate efficient removal, the Hot Cell will be refurbished, and from then the spent fuel will be removed from the storage container and repackaged into GDF compliant containers. The filled disposal containers will then be prepared for transport into the GDF. Phase 6 ends when all spent fuel has been repackaged and has left the site.

At the commencement of Phase 7, there will be no waste or spent fuel on the site and the remaining major buildings (SFIS, HLW decay store, and the repackaging facility) are expected to be clean and free from contamination. They will be de-planted and demolished, together with offices and welfare facilities and the site will be remediated and delicensed.

Sections 31.6 and 31.7 support decommissioning sub claim Decom-SC 2, that appropriate decommissioning plans / strategies are in place and will continue to be developed by the future licensee.

31.8 Decommissioning Wastes and Wastes Remaining on Site

The nature of decommissioning means that the generation of waste is unavoidable. However, through appropriate design and plant operating conditions, the generation of decommissioning waste can be minimised.

The waste hierarchy is a fundamental waste strategy principle. It encourages the management of waste materials to reduce the amount produced, and to recover maximum value from waste production. Waste prevention, reuse, recycling and recovery are collectively defined by the Organisation for Economic Co-operation and Development (OECD) as waste minimisation. Further supporting information surrounding management of wastes can be found in [Ref. 31-47] and [Ref.31-48].

The design of the UK ABWR has evolved to reduce the quantity of radioactive waste that will be generated during its lifecycle and also ensures that wastes that are unavoidably created are compatible with waste management techniques. Section 31.4.1.2 of this report sets out design for decommissioning principles that have been incorporated into UK ABWR designminimise potential waste arisings during decommissioning.

Management strategies for radioactive and non-radioactive wastes arising over the entire life cycle of a generic UK ABWR unit site are presented in the Radioactive Waste Management Arrangements (RWMA) [Ref. 31-48] and IWS [Ref. 31-47]. “Topic Report on Decommissioning: Decommissioning Waste Management” [Ref. 31-11] has not only been optimised for waste management but also facilitates the reduction of risk to the worker, public and environment ALARP. The final decommissioning waste management strategy will be chosen and implemented by the future licensee following application of the BAT selection process with due consideration of site specific opportunities and constraints. To better describe the associated works and subsequent waste management requirements, the decommissioning period is represented below:

- Before EoG;
- Immediately after EoG;
- Power plant decommissioning;
- Spent fuel, HLW and ILW storage period;
- HLW / ILW store emptying, repackaging, and disposal;
- Spent fuel storage and SFIS emptying, repackaging, and disposal;
- Demolition and delicensing of the site.

Total waste volumes for decommissioning are detailed in “Topic Report on Decommissioning: Decommissioning Waste Management” [Ref. 31-11]. The subsequent section provides a summary of where waste is generated in each phase of decommissioning. The End User Source Term for decommissioning radioactive waste is utilised to define the radioactive waste inventory.

31.8.1 Waste Generation and Processing

A holistic review based on OPEX and the design of the UK ABWR has captured the salient waste streams anticipated from decommissioning. Information about the structures which will be decommissioned can be found in:

- Chapter 9: General Description of the Unit (Facility);
- Chapter 10: Civil Works and Structures;
- Chapter 11: Reactor Core;
- Chapter 12: Reactor Coolant Systems, Reactivity Control Systems and Associated Systems;
- Chapter 14: Control and Instrumentation;
- Chapter 15: Electrical Power Supplies;
- Chapter 16: Auxiliary Systems;
- Chapter 17: Steam and Power Conversion Systems;
- Chapter 18: Radioactive Waste Management;
- Chapter 19: Fuel Storage and Handling;
- Chapter 32: Spent Fuel Interim storage.

To provide clarity, identified radioactive wastes have been categorised into the following:

Primary waste

Waste arising from the NPP structure and systems that has not been treated.

Secondary waste

Waste that results as a by-product from the processing of primary waste. This may include waste from pre-treatment or treatment operations, e.g. decontamination secondary waste.

Operational waste (also termed Reactor waste during operation of the power plant)

Waste arising from routine and essential operations and systems within the UK ABWR buildings and facilities including waste produced in the treatment of radioactive liquid and gaseous systems such as the LWMS, Solid Waste Management System (SWMS) and HVAC as well as miscellaneous wastes arising from maintenance tasks.

An indicative estimation of the generation of primary and secondary radioactive waste following EoG is shown in Table 31.8-1[Ref. 31-48].

Table 31.8-1 Overview of waste quantity arisings

	Year following EoG (years)	Total Mass/Volume	
		Waste quantities generated before decontamination	Waste quantities after decontamination for disposal
VLLW	10 – 22	15,690 tonne	25,360 tonne (73 tonne)
LLW		18,030 tonne	9,110 tonne (2,815 tonne, 73 m^3)
ILW / HLW	12 - 16	[1,490/70] 1,560 tonne	[740/70] 810 tonne (32 tonne, 87 m^3)

( ): Secondary waste volume arising from decommissioning activities.

Waste characterisation, segregation and effective record management are key aspects of the waste management process and are applied in all subsequent waste management process streams. Figure 31.8-1 identifies the general sources and processing routes of radioactive wastes arising from the generic UK ABWR. Depending on the radioactivity of the waste product, the following disposal routes are proposed, noting that the selection of decommissioning disposal routes will be subject to BAT and ALARP assessment:

- Gaseous waste will be discharged to air via Gaseous Waste Management Systems (local, area to building HVAC and discharge via stack, where applicable). Following removal of HVAC from service, discharges will be via temporary, local, High Efficiency Particulate Air (HEPA) filtered systems;
- Liquid aqueous waste will be treated via the LWMS (existing LWMS, replacement temporary LWMS, decontamination treatment and local water filtration systems). Water will be re-used where practicable before final discharge to sea;
- Out of scope (exempt or clearance) solid waste will be managed in accordance with the waste hierarchy; reused or recycled where practicable, and disposed of to landfill as a last resort;
- VLLW and LLW will be recycled where practicable (metals), otherwise volume reduced (e.g. incineration, super-compaction, metal melt) and sent to a suitably permitted landfill e.g. the LLWR. The DWMF will be constructed to carry out the pre-treatment, treatment, segregation, conditioning and packaging on the various items of VLLW and LLW arising from decommissioning activities;
- Spent fuel, HLW and ILW will be consigned to the GDF following a period of interim storage. It is expected that HLW will have decayed to ILW during interim storage. Waste packages will be accessible during interim storage.

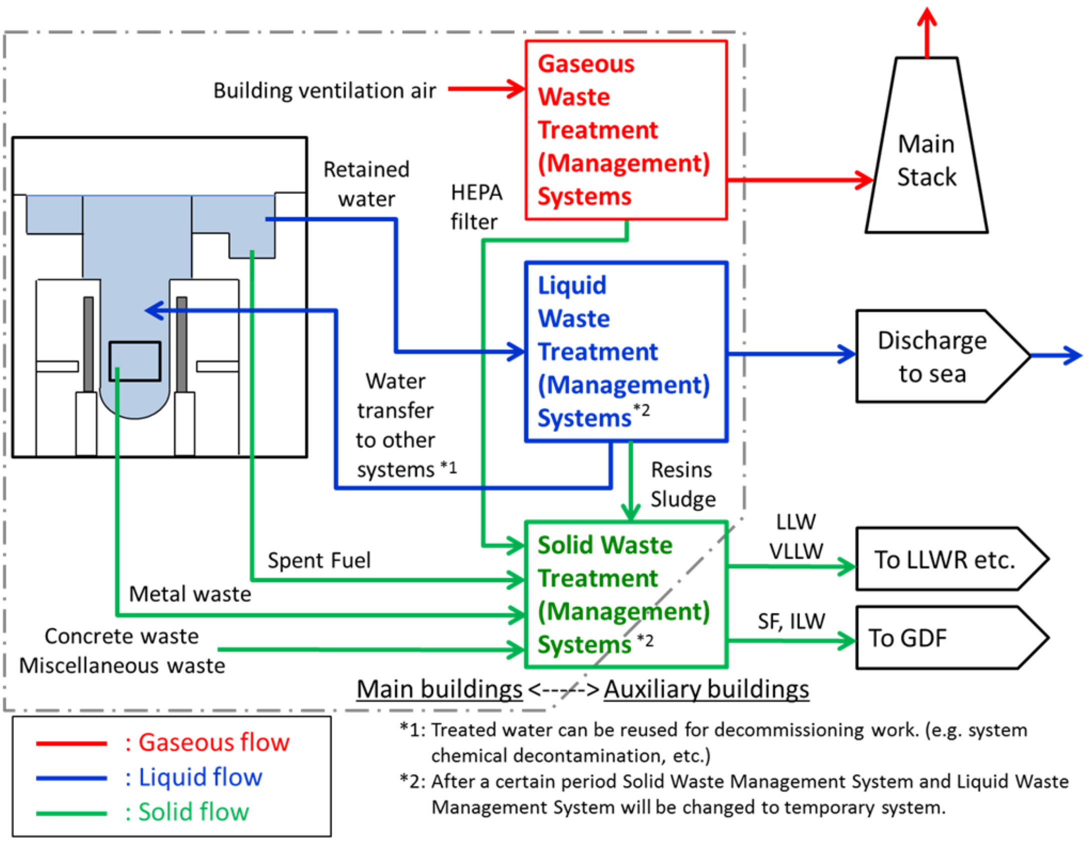


Figure 31.8-1 Overview of UK ABWR Decommissioning Radioactive Waste Generation, Treatment and Disposal

The nature of non-aqueous liquid waste (e.g. oil) prohibits its release directly to the environment and therefore the strategy for its management, treatment and disposal is similar to the strategy for solid waste; segregation, packaging and disposal via a suitably permitted incineration facility. Through optimisation and appropriate management control, generation of non-aqueous liquid waste will be minimised [Ref. 31-37].

The final strategy will be chosen and implemented by the future licensee following application of the ALARP and BAT selection processes with due reference to site specific opportunities and constraints [Ref. 31-37].

A summary of the waste arisings and processing methods in each phase of the decommissioning period is provided in the subsequent sections. Further detail of the classification and disposal route planned for all wastes that will arise during decommissioning is provided in “Topic Report on Decommissioning: Decommissioning Waste Management” [Ref. 31-11]. Further supporting information surrounding management of gaseous, liquid and solid wastes can be found in PCSR Chapter 18: Radioactive Waste Management, Sections 18.5, 18.6 and 18.7 and the RWMA [Ref. 31-47]. The management of HLW and ILW generated during operations, and stored awaiting GDF availability during the decommissioning phase, is described in PCSR Chapter 18: Radioactive Waste Management, Sections 18.10 and 18.11.

31.8.1.1 Phase 1: Before EoG

A SFIS and HLW decay store will be constructed early in the site's operational phase to accommodate spent fuel and HLW generated during operations. An additional ILWS will be constructed before EoG to accommodate ILW generated from decontamination operations conducted during decommissioning. The construction of the SFIS, HLW decay store and ILWS will produce quantities of non-radioactive construction waste. These construction wastes will be managed during the operational phase of the power station's lifetime in accordance with the waste hierarchy.

31.8.1.2 Phase 2: Immediately after EoG

Management of operational wastes which have arisen during the generation phase will continue after EoG. Typical wastes include high activity items from the reactor core, and operational wastes from the Rw/B. The retrieval and movement of spent fuel and control rods to the SFP requires continued operation of the liquid radioactive waste systems, in particular the FPC Systems, as fuel movement increases during this time. Until drained, all water containing circuits will require treatment to ensure controlled and known conditions are maintained.

The high dose rates associated with HLW items make deferred treatment prior to consignment to the GDF the preferred option. As such, spent fuel and any HLW (heat generating) will be removed from the R/B and placed in interim dry cask storage in operational phase, where it will remain until availability of the GDF. Following EoG, final spent fuel and operational HLW will be cooled for a period of 10 years in SFP before placed in interim dry cask storage and transferred to the HLW decay storage facility.

Following shutdown, a POCO campaign of the plant will be performed which will remove contamination from plant components. This will generate secondary waste streams between VLLW and ILW levels [Ref. 31-11]. POCO of the T/B, C/B, R/B, Rw/B and S/B will be carried out during this phase and will be covered by the existing operational safety case. Use of established waste management systems and disposal routes will be utilised and are presented in the RWMA [Ref. 31-48]. An illustration of the waste management routes for LLW generated in decommissioning is shown in Figure 31.8-2.

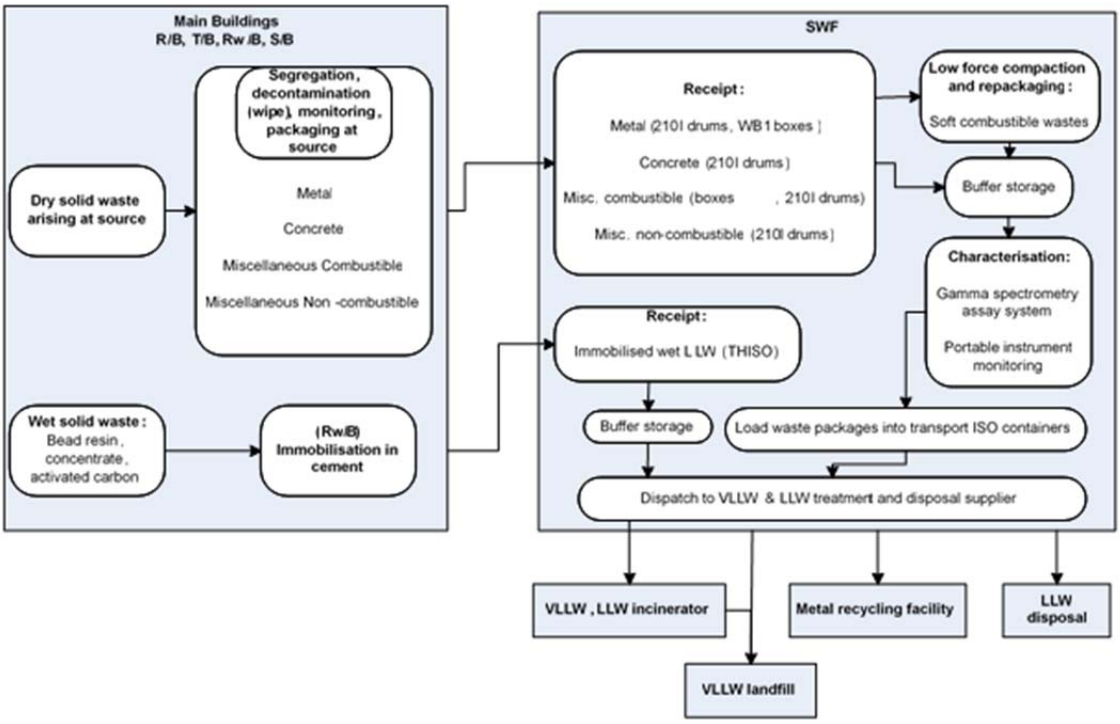


Figure 31.8-2 LLW Management Overview

New facilities will be constructed during Phase 2 and will include a facility to allow spent fuel inspection and ILW packaging, a DWMF, and an alternative effluent discharge line.

The constructed DWMF is expected to receive waste items (predominately LLW) from decommissioning activities in the main buildings and will have the capacity to monitor, characterise and process waste items. Typical activities will include size and volume reduction, decontamination, and conditioning into disposal packages. Whilst the decommissioning plan at GDA is based upon construction of a new facility on-site, consideration of site specific constraints and opportunities would be made by the future licensee for the option of refurbishment of an existing site building e.g. T/B, subject to the demonstration of BAT and ALARP [Ref. 31-37].

The processing requirements of the DWMF have been estimated and are presented in Table 31.8-2.

Table 31.8-2 Estimate of the DWMF Processing Requirements

Feed material	Size reduction	Decontamination	Conditioning for off-site consignment to:
LLW			
RPV, RIN, CUW and RHR LLW metal.	80 tonne / month.	400 tonne / month following segregation.	Metal treatment, melt and / or disposal supplier. Recycling where possible. 270 tonne / month.
Miscellaneous metal (equipment and piping).	Dismantling, cutting 320 tonne /		

Feed material	Size reduction	Decontamination	Conditioning for off-site consignment to:
	month.		
Non- combustible waste: miscellaneous and decontamination blast material.			LLW disposal facility. Includes immobilisation in cement if required. 20 tonne / month.
Concrete.			LLW disposal facility. Includes immobilisation with cement if required.
VLLW			
Miscellaneous metal (equipment and piping).	Dismantling, cutting 120 tonne / month.	<120 tonne / month following segregation.	Metal treatment and recycling supplier. 250 tonne / month (including decontaminated / segregated LLW).
Concrete.			VLLW disposal facility. Includes immobilisation with cement if required.

It is expected that primary fluid systems (CUW, RHR, RPV) and FPC System will require some level of decontamination, and OPEX has shown that this activity has been successfully and safely employed across decommissioning sites world-wide, as discussed in Section 31.3. A robust decontamination strategy based upon OPEX will be applied to the UK ABWR during decommissioning [Ref. 31-44]. Secondary waste is likely to be generated as part of the decontamination process and the type of decontamination approach applied will be decided following characterisation of the plant nearer the time of decommissioning. Construction of an additional ILW store will provide greater interim storage capacity during decommissioning.

The current decommissioning plan assumes decontamination of the primary closed loop systems (RPV, CUW, RHR, FPC) will be undertaken following fuel removal post EoG (after phase 2 in the case of the FPC System) as soon as is demonstrably BAT and ALARP, with the intention of removing contamination species from the circuits whilst they are still relatively mobile. The schedule for this is estimated to be approximately 1 to 2 years following spent fuel removal from the reactor. This will have a positive impact on dose reduction to workers during system dismantling operations, which may be undertaken 10 years after EoG in the case of primary closed loop system.

31.8.1.3 Phase 3: Power Plant Decommissioning

The focus during this period is the dismantling and demolition of power plant systems and buildings with the intention of leaving the power plant area of the site in the end state agreed with regulators. Almost all buildings will be removed from the site except for the SFIS, HLW decay store, and ILWS which will remain for some decades afterwards. At the end of this phase, a smaller footprint site will remain comprising the store buildings and any associated structures.

R/B: RPV and RINs

The RPV and RINs are manufactured from metal and will become activated during the operational phase. The Core Support Plate, Upper Grid Plate (Top Guide), Fuel Support Parts and HP Core Flooder Sparger are expected to be the most activated internal components. These components would potentially be HLW at the time of retrieval, but will have decayed to ILW prior to consignment to the GDF.

Waste arising from RINs and the RPV will be packaged into 3 m^3 boxes or 4 m boxes where appropriate. Where it is shown that prompt packaging of waste into these boxes cannot meet the ALARP principle (e.g. heat generating waste [Ref. 31-49]), provision is available for removal and storage in to alternative waste packages e.g. MPC. Such items will be decay stored prior to characterisation, segregation and repackaging into Non Fuel Waste Containers (NFWC). As discussed in Section 31.7.3.3, a Hot Cell within the repackaging facility will facilitate the repackaging of spent fuel and decayed HLW. Figure 31.8-3 shows the spent fuel and decommissioning HLW process for the UK ABWR.

HLW will be held within a NFWC, a stainless steel canister capable of holding between 25-50 control rods or baskets of dry solid HLW. This is used for interim storage only and is not an approved GDF disposal package. The NFWC will be placed in a storage overpack in the HLW Decay Storage facility. The overpack provides shielding and structural protection to the NFWC during interim storage. The overpack has variable shielding (up to ~760 mm) depending on the limiting dose rate. The typical maximum size of an overpack is 150 tonnes, 6 m tall and 3.4 m diameter. This is the same process as will be used during normal operation of the reactor.

Following storage in the SFP the control rods (component with highest activation levels) and part of the RINs after dismantling are still above the heat generation threshold for containers suitable for consignment to the GDF (for example the control rods will decay to below the heat generation threshold within approximately 20 years of discharge from the reactor). As such, HLW will be removed from the R/B using the spent fuel process and placed in interim dry cask storage, where it will remain until the GDF becomes available.

The ILW will be conditioned and transferred for interim storage (pending availability of the GDF) to the on-site ILWS as during generation. The ILWS is designed to allow export of waste when the GDF becomes available without modification using the reverse process for import.

LLW and VLLW generated in R/B (e.g. All equipment inside and outside of RCCV, SFP and DSP liner, etc.) will be managed through the DWMF.

Turbine Building

Following EoG, the turbine system will be redundant. The turbines and associated plant and equipment that have been in contact with the coolant will be dismantled, decontaminated, characterised, segregated, size reduced and packaged in-situ or within designated areas of the T/B. Due to the size of the items being dismantled in the T/B, the future licensee has the option to process the waste within the T/B and dispatch directly off-site to suitable disposal suppliers or direct waste via the DWMF.

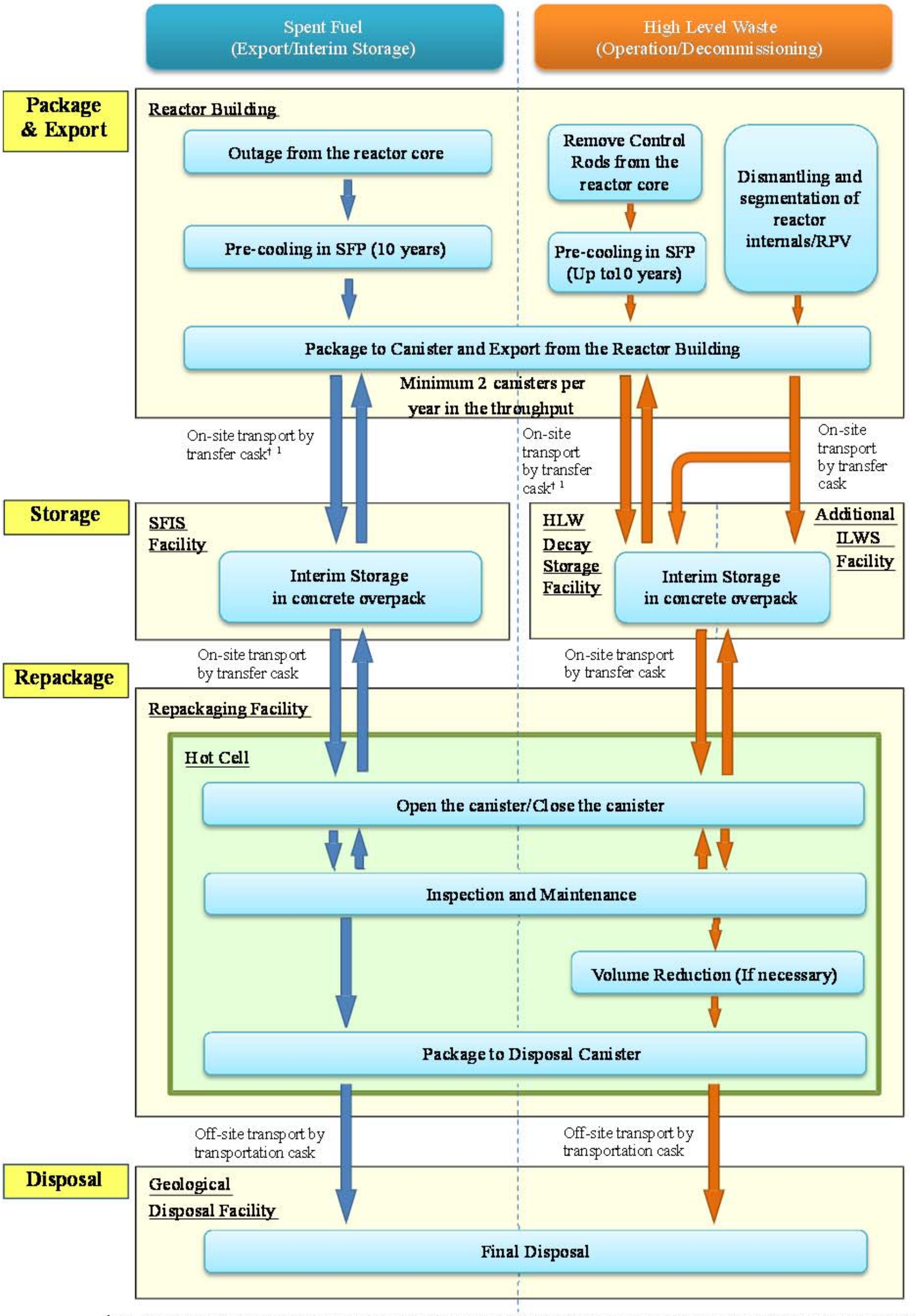
Radwaste Building

Once treatment of decommissioning radioactive waste has ceased and no there is no further requirement for the Rw/B, the facility will be deplanted with the resultant radioactive waste routed through the DWMF. A proportion of contaminated ILW may benefit from decontamination should an effective Decontamination Factor (DF) be identified.

Other Buildings

Other buildings e.g. C/B, FV/B Main stack, will be deplanted as described in Section (31.7) and the resultant radioactive waste items routed via the DWMF for further processing.

A flow chart showing the disposal route of spent fuel and HLW from the R/B to the GDF is shown in Figure 31.8-3 below.



† 1: Spent fuel and Activated waste casks are capable of being moved back to SFP for inspection if required until SFP is no-longer available

Figure 31.8-3 Spent Fuel and HLW Flow Chart

31.8.1.4 Phase 4: Spent fuel, HLW and ILW Storage Period

The types of solid waste anticipated from decommissioning the UK ABWR include spent fuel, HLW and ILW. In Phase 4 SF overpacks in the SFIS, HLW overpacks in the HLW decay store and the ILW packages in the ILWS are stored in normal conditions as described in PCSR Chapter 18: Radioactive Waste Management. The consideration of radioactive solid waste management strategy options and the selection of a preferred strategy are presented in detail in the RWMA document [Ref. 31-48]. Waste routes for the solid radioactive waste have been identified and are captured in detail in “Topic Report on Decommissioning: Decommissioning Waste Management” [Ref. 31-11].

Interim storage facilities housing radioactive wastes will yield low volumes of miscellaneous dry solid wastes e.g. HVAC filters. No significant issues are anticipated in handling these wastes and it is expected that they can be consigned for incineration at a suitably licensed facility.

31.8.1.5 Phase 5: HLW / ILW Store Emptying, Repackaging and Disposal

ILWS emptying is the final stage of ILW management on the site. Once the GDF is ready to accept waste packages, the ILW will be removed and transported for long-term storage. This waste will also include HLW which has decayed during storage to ILW.

Once all ILW has been removed from the ILWS, it will be demolished and the subsequent waste will be managed as non-radioactive waste.

The “Topic Report on Decommissioning: Decommissioning Waste Management” [Ref. 31-11] presents a breakdown of the potential waste generating tasks identified and the corresponding wastes anticipated to be produced within this phase.

31.8.1.6 Phase 6: Spent Fuel Storage and SFIS Emptying, Repackaging, and Disposal

Storage and management of spent fuel will be in a purpose built facility and will generate wastes associated through plant storage operations e.g. HVAC filters. These wastes will continue to be managed until a GDF becomes available to allow final removal and disposal off-site. Management of these wastes will be performed within the Hot Cell located within the repackaging facility.

The proposed interim dry storage casks are not certified by RWM for final disposal in the GDF and therefore the Hot Cell will provide the capacity to repackage spent fuel into endorsed disposal containers suitable for the GDF. Packaged spent fuel will be consigned to the GDF in accordance with the RWM requirements developed through the Letter of Compliance (LoC) assessment process.

Generation of secondary waste as a result of repackaging spent fuel is anticipated, noting that there is a high potential that the interim containers themselves will have become activated. Activated metal canisters will require characterisation, segregation and consignment to an appropriate disposal route. Current solutions include a metal recycling facility or volume reduction and consignment for direct disposal. The future licensee will make the BAT / ALARP decision based on the waste characteristics and disposal options available at the time.

The waste concrete casks and upper layer of the SFIS base slab may be activated and also require characterisation and segregation. If confirmed as radioactive waste, the future licensee will select the optimised management solution based on international OPEX, the waste characteristics, and disposal options available at the time. Current options include re-use as infill or disposal to VLLW landfill.

31.8.1.7 Phase 7: Demolition and Delicensing of the Site

The only wastes arising in this phase are generated from the demolition of waste storage infrastructure. These structures are expected to be clean and free from contamination. Once demolition has occurred the site will be remediated and delicensed.

31.8.2 Overview of Waste Generated

Figure 31.8-4 provides the quantity of waste generated during decommissioning of the UK ABWR. In addition, this diagram details the flow of all types of waste (solid spent fuel, HLW, ILW, LLW, and non-radioactive wastes) from generation through processing to disposal in decommissioning.

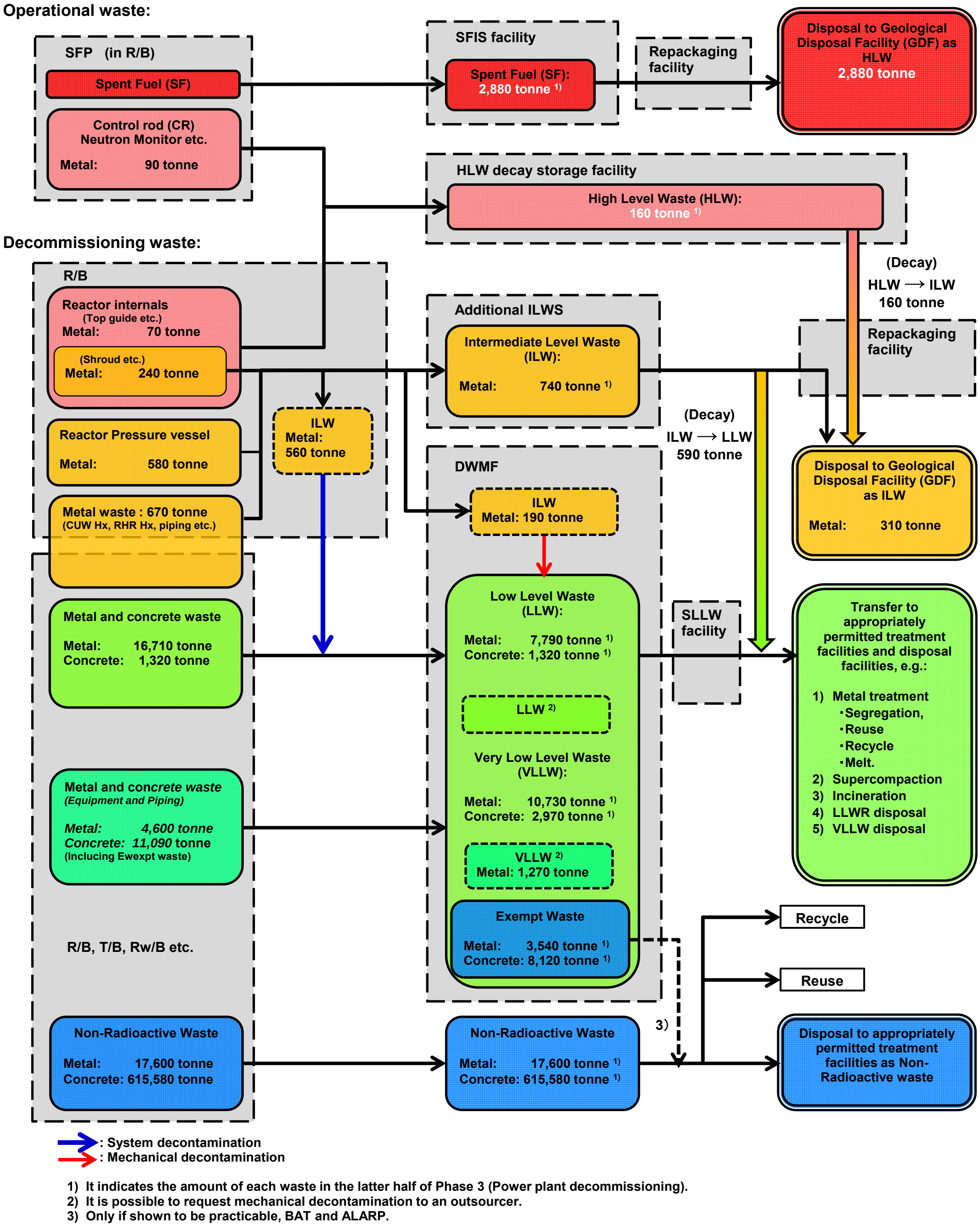


Figure 31.8-4 Spent Fuel and Solid Radioactive Waste Management Flow Chart

31.8.3 Disposability

For all VLLW and LLW streams, “Agreements in Principle” based on the decommissioning waste inventory have been obtained to demonstrate that the wastes can be managed and, where appropriate, disposed of in the UK. These have been obtained based on the assumption that LLW and VLLW storage sites will exist at the time of decommissioning.

Adequate records will be kept during the entire management cycle, the importance of which is discussed in Section 31.9. In the context of waste management, RWM require that records are kept to ensure that the history of the wastes and specific package properties are preserved to inform their disposability and that their long-term evolving properties will remain within acceptable limits. The waste management systems will generate a large quantity of records.

Documents and records will be maintained in a secure and accessible form for an appropriate period of time such that they will be available to inform the safe management of radioactive waste from arising to disposal. The future licensee will be responsible for putting in place a knowledge and document management system that ensures all relevant records generated during construction, commissioning and operation are available to support decommissioning waste management activities. This system must be acceptable to RWM.

A high-level summary of the GDA selected waste disposal options is given Table 31.8-3. Viable disposal routes are available (or will be available) for all decommissioning wastes.

Table 31.8-3: Summary of Waste and Spent Fuel Streams

No.	Title	Category	Form	GDA baseline management option
1	Dry active waste	VLLW	Solid	Recycle metals where practicable, compaction where possible, and direct disposal to a permitted disposal site.
2	HVAC Filters	LLW	Solid	Filters will be transferred off-site to suitably permitted LLW incinerator where practicable. Otherwise super-compaction disposal to a permitted disposal site.
3	Bead resin	LLW	Wet	Cement immobilisation, using in-line mixing of waste and cement and disposal to a permitted disposal site.
4	Concentrates	LLW	Wet	Cement immobilisation, using in-line mixing of waste and cement and disposal to a permitted disposal site.
5	Miscellaneous combustible	LLW	Solid	Transferred off-site to suitably permitted LLW incinerator and disposal to a permitted disposal site.

No.	Title	Category	Form	GDA baseline management option
6	Miscellaneous non-combustible	LLW	Solid	Recyclable metals will be transferred off-site to LLW Metal recycling or melting facilities and disposal to a permitted disposal site. Non-compactable waste and non-recyclable metals will be sentenced for direct disposal to a permitted disposal site in an approved transport container.
7	Sludge (crud)	ILW	Wet	Cementitious grouting in 3 m^3 drums then storage pending disposal to the GDF.
8	Powder resin	ILW	Wet	Cementitious grouting in 3 m^3 drums then storage pending disposal to the GDF.
	Ion exchange resin	ILW	Wet	Cementitious grouting in 3 m^3 drums then storage pending disposal to the GDF.
9	Higher activity metals – control rods	HLW at arising, ILW at disposal	Solid	Decay storage in SFP followed by dry interim storage in casks, retrieval, size reduction (if necessary), ILW / LLW segregation, ILW packaging for disposal in 3 m^3 box, storage pending final disposal to the GDF.
10	Higher activity metals – channel boxes	HLW / ILW	Solid	Co-disposed with spent fuel.
11	Higher activity metals - others	HLW at arising, ILW at disposal	Solid	Decay storage in SFP followed by dry interim storage in casks, retrieval, size reduction (if necessary), ILW/LLW segregation, ILW packaging for final disposal in 3 m^3 box, storage pending final disposal to the GDF.
12	Contaminated and irradiated metal and concrete	LLW	Solid	Recycle materials where practicable. Decontamination (as appropriate), size reduction and place in disposal container. Encapsulate in cementitious grout and dispose directly to permitted disposal site.

No.	Title	Category	Form	GDA baseline management option
13	Contaminated and irradiated metal	ILW	Solid	Size reduction, LLW / ILW segregation (if practicable), condition in an appropriate container for storage awaiting GDF available: • Canister and overpack (as for SF, see row 14); • Final ILW disposal package (e.g. $3m^3$ box); • Other containers will be used if they are estimated to decay to LLW during storage. The storage location will be appropriate to the waste classification and package type.
14	Spent Fuel	Used fuel assemblies	Solid	Storage in SFP, dry canister and overpack storage, repackaged into KBS-3V containers prior to GDF.
15	Decontamination equipment	LLW	Solid	Decontaminated (if necessary), dismantled (if necessary), consigned to appropriate waste route with preference for re-use on-site or elsewhere.
16	Decommissioning liquid wastes	-	Liquid	Re-used or discharged after cleanup. Secondary wastes from cleanup consigned to appropriate operational route (see resin, sludge, and crud).
17	Decommissioning gaseous wastes	-	Gaseous	Discharged after filtration. Secondary wastes from cleanup equipment consigned to appropriate operational route (see HVAC filters).
18	Miscellaneous non-radioactive waste	Clean	Solid	Collected on-site, sorted and stored in appropriate conditions awaiting removal using specialist waste treatment or disposal contractors. Re-use rubble as infill where practicable.
19	Non-radioactive Liquid Wastes	Trade waste	Liquid	Dedicated systems to capture and treat any non-radioactive liquid wastes generated to ensure that discharges remain within permitted environmental discharge limits.

No.	Title	Category	Form	GDA baseline management option
20	Non-radioactive gaseous wastes	Non-radioactive emissions	Gaseous	Dedicated systems to capture and treat any non-radioactive gaseous wastes as necessary to ensure that discharges remain within permitted environmental discharge limits.

31.9 Decommissioning Management Arrangements

31.9.1 Record Management

Detailed, complete and up-to-date information on the condition of the UK ABWR is essential to enable decommissioning to be undertaken with minimal safety risks and impact to the environment. Retention and management of important information relating to the design, construction, commissioning, operational history, maintenance and modifications will be important. This information should be collected systematically throughout the lifetime of the plant (from design to delicensing) and maintained in an accessible and usable format so that it can inform decommissioning planning, as well as other functions during the plant lifetime in compliance with Licence Condition 6.

Detailed and complete record management throughout the design, operational life and maintenance of the UK ABWR is critical to understanding the plant condition and ensuring appropriate strategies and techniques are employed. A process of characterisation will be undertaken at the EoG, to determine the plant state, but this will be greatly assisted by good record management throughout reactor life.

The following categories of information are of importance to decommissioning planning, and the future licensee's arrangements will need to ensure that relevant information is captured and managed. It is noted that the discussion focusses on the relevance to safe and efficient decommissioning, but there are other requirements and benefits from good record management in each area. This is discussed in further detail in PCSR Chapter 4: Safety Management throughout the Plant Lifecycle, Chapter 10: Civil Works and Structures, and Chapter 29: Commissioning.

31.9.1.1 Design Information

Retention of design information is important to ensure that the plant is well understood as well as for compliance with Construction (Design and Management) regulations (CDM) [Ref. 31-50]. Detailed design specifications and justifications for the plant and equipment selected will form an important element of future justifications that decommissioning can be achieved safely and efficiently. Retention of the following design information is required to ensure decommissioning can be undertaken safely:

- Design specifications for equipment and structures are to be recorded. This will be relevant to the decommissioning phase for determination of decontamination methods and agent, and assessment of STs for activation inventories, relevant to both waste management and radiological protection planning;
- Design calculation and evidence of design life for major SSCs, which are required for decommissioning;
- Records confirming compliance with design specifications;
- Construction phase records for as-built information of the plant and equipment will be important as the design information alone will not provide an adequate level of accuracy for the as-built plant.

31.9.1.2 Commissioning and Handover Information

The commissioning phase is important for determining the operational condition of plant and equipment, and it is usual for some modifications to be made during the commissioning phase to optimise the plant. Commissioning phase records for as-built information of the plant and equipment and processes performed include the following:

- Records confirming compliance with design specifications and of changes made during construction / commissioning;
- Procurement records for construction materials and to confirm the detailed specification of the structures employed in the reference design;
- Engineering drawings of the facility including manufacturers' drawings;
- General arrangement drawings, including where the design has been modified during commissioning;
- Construction materials samples and material quantities, etc.;
- Closure of temporary access openings – Records of the closure of temporary access openings and the method used to seal these openings;
- Water calibration within vessels – the presence of effluent remaining within vessels poses a risk to operators in decommissioning. The functionality to positively confirm that vessels have been drained and have no heel minimises risk to operators;
- Commissioning chemistry – a dedicated Commissioning Chemistry Topic Report provides detail of the types of activities that will be performed in commissioning. Key activities that support decommissioning include:
    - System flush - will allow the removal any potential impurities generated as a result of construction and installation of plant systems;
    - DZO – is used to promote the formation of stable oxides on internal pipe surfaces to minimise the accumulation of Co-60.

Retention of commissioning information, including commissioning schedules and surveys, records of all modifications made and the reasons for them, as well as the detailed handover information that will be generated at the end of the commissioning phase will all be important. This record, prior to the normal generation phase, represents the best understanding of the as-built plant prior to operations.

31.9.1.3 Plant Modifications

Any modifications made to the plant during commissioning, operation, maintenance or during the post generation phase of work relevant to the decommissioning of the plant must be recorded in detail to ensure that the current plant condition is known. OPEX from nuclear facilities in the UK demonstrates that failure to adequately record plant modifications can lead to a lack of understanding of the current plant condition. This could potentially lead to difficulties in planning and implementing and safe and efficient decommissioning programme. It will be important to identify modifications that may have an impact on decommissioning, for example changes to large equipment, access and egress routes, etc. Change control is discussed further in Section 31.9.2.

31.9.1.4 Maintenance Records

Throughout plant life, regular maintenance will be carried out on plant and equipment to ensure it is in an appropriate condition to carry out the required function. The frequency of maintenance will be determined by the safety significance of each particular SSC. It is important that records are kept of maintenance, so that decommissioning planners can understand the condition of the equipment within the plant. This can also provide useful data on dose uptake to workers, access issues and knowledge management on optimum methods to strip plant items that can be carried forward to the decommissioning phase.

31.9.1.5 Radiological Surveys and Non-Conformance Records

Control of contamination within the plant plays a key role in reducing decommissioning. If radiological surveys identify either a contamination issue, or unexpected dose rates in the plant, it is important that this information is recorded in detail, in compliance with Licence Condition 6. Clearly such an issue will be resolved by future licensee prior to decommissioning where possible, but whether the issue is resolved or not, radiological survey records are an important input to the decommissioning planning phase.

Non-conformance records are crucial to understanding how plant operation has deviated from normal operations and where activity is likely to be found on the plant. This information is especially important to capture and manage appropriately, since unplanned events have the potential to change plant condition in a manner that would not be obvious from other plant records. Learning lessons from non-conformance events through operation ensures that a safe and efficient decommissioning process is developed based on accurate records.

31.9.1.6 Safety Cases and Periodic Reviews of Safety

The safety case represents the justification that the plant can be operated safely, whichever phase of operation or decommissioning is ongoing. A full record of all the major safety cases and updates throughout plant life will provide important information to the decommissioning planning team on the aspects important to safety, as well as the operational history of the plant. The safety case includes a detailed engineering schedule that lists the SSCs important to safety, their safety functions and performance requirements. This provides an ongoing understanding of the systems required to operate the plant safely, throughout the plant life cycle and is an important input to decommissioning planning.

Following EoG, and particularly once fuel has been removed from the R/B after a period of cooling in the SFP, the SSCs required to operate the plant safety will decrease. A detailed record and justification of which SSCs are no longer required during decommissioning will be important to document during the transition from the operational to the decommissioning safety case.

Periodic review of safety provides the future licensee with an opportunity to understand the conditions of their plant and equipment, to comply with the active safety case and a review of incidents and events that have occurred during operation. The records from periodic reviews represent an important record of the conditions at a particular point in the operating life of the plant, and also provide useful information on where there may be future work required on plant and equipment. The output of periodic safety reviews may also drive plant modifications, and so retention of the justification for the modifications is important.

31.9.1.7 Summary

Record management assists planning of decommissioning operations, can be utilised for optimisation of waste management, and is of importance for the safety case for future decommissioning. Documents have been developed and controlled from Japanese reference design through to the GDA design reference point according to the "Generic Design Development Control" procedure [Ref. 31-51]. Transfer to the future licensee of significant requirements, assumptions, and limits, and conditions assessed and verified during GDA shall be assured to accomplish high-level safety and environmental protection throughout the UK ABWR life cycle. The process defined in "Technology Transfer to Licensee and Operating Regime" [Ref. 31-42] will be followed to ensure this is achieved.

31.9.2 Change Control

Change control is essential to ensure that all operations associated with the UK ABWR are safe and that changes to plant or equipment do not lead to unplanned or unsafe conditions.

Any significant changes to the operation or plant characterisation of the UK ABWR have the potential to impact decommissioning strategy and techniques. In addition to the importance of change control for ensuring safe operation, it is important that the impact of changes on decommissioning is considered and recorded throughout the plant life cycle. This will ensure that changes are not made based on expediency during operations, which lead to complications during decommissioning, although it is important to note that not all design changes will have an impact on decommissioning.

The UK ABWR design has, where practicable, deliberately not foreclosed options for adoption of decommissioning techniques. This should allow the future licensee to ensure that changes made during the plant life cycle consider the impact on the decommissioning strategy, which will be regularly reviewed throughout the plant life cycle. Information relating to the strategy, including costs, schedule and implementation will be recorded and preserved. In addition, the decommissioning strategy developed for the FDP will be reviewed periodically in accordance with government policy.

Chapter 4: Safety Management throughout Plant Lifecycle, presents detailed discussion on the design change process, including the transition from GDA to site specific stage and change control in construction and commissioning, during operations and after EoG.

31.10 Assumptions, Limits and Conditions for Operations

One purpose of this generic PCSR is to identify constraints that must be applied by a future UK ABWR licensee to ensure safety during normal operation, fault and accident conditions. Some of these constraints are maximum or minimum limits on the values of system parameters, such as pressure or temperature, whilst others are conditional, such as prohibiting certain operational states or requiring a minimum level of availability of specified equipment. They are collectively described in this GDA PCSR as Assumptions, Limits and Conditions for Operation (LCOs). The definition, context of Assumptions, LCOs in GDA is described in Chapter 4: Safety Management throughout Plant Lifecycle, Section 4.12.

There are inevitably uncertainties surrounding decommissioning given that actual decommissioning activities will start after EoG. As many of the relevant factors are unavoidably the subject of large uncertainties at this stage of the design assumptions are required. LCOs however have not been determined for the decommissioning topic area.

The generic PCSR chapter for decommissioning is based on the assumptions presented in Appendix B. Where applicable, assumptions are listed against potential interfaces with other relevant PCSR chapters. These assumptions are affected by changes in regulation, advances in technology and collection of OPEX, GP and lessons learned. As such, the latest information at the time of periodic review of decommissioning safety case will be reviewed.

The use of assumptions for the decommissioning topic is based on a precautionary approach to managing the associated uncertainties and risks. The assumed conditions are subject to change during the periodic review process until the actual decommissioning safety case is made and so sensitivities are included in the assumptions relating to plant conditions. The assessment of records, appropriate monitoring throughout the life of the plant, and / or sampling results prior to the commencement of specific decommissioning activities will allow the validity of assumptions to be verified, and the decommissioning plan can then be revised to take additional options into account at the time of decommissioning work if required. A number of assumptions are dependent on other technical areas to satisfy decommissioning safety claims made and are presented in Appendix B. These assumptions effectively provide the criteria required from other technical areas to ensure that these claims are supported and validated.

Design features that are assumed to form part of the GDA “base” design, but cannot be finalised in GDA are carried forward through the decommissioning assumptions and safety claims. This will ensure effective transfer of information between project phases. Transfer of significant requirements, assumptions, and limits and conditions assessed and verified during GDA to the future licensee shall be assured to accomplish high-level safety and environmental protection throughout the UK ABWR life cycle. This will be particularly important for those Long Lead Items that the future licensee may procure before the next safety case submission in the site specific phase. The process defined in “Technology Transfer to Licensee and Operating Regime” [Ref. 31-42] will be followed to ensure this is achieved.

The FDP base case [Ref. 31-5] sets out assumptions regarding how waste may be managed and disposed of and decommissioning carried out by a new NPP future licensee. These assumptions define a generic life cycle plan for new NPP known as the “Base Case”. The Base Case is built on existing policy and regulatory requirements and is primarily written to ensure sufficient financial provision is made to cover liabilities. It also provides each future licensee basic assumptions for which radioactive waste management, decommissioning and spent fuel management strategies can be developed. For example, the Base Case assumes that new nuclear power stations will adopt a prompt decommissioning strategy, with future licensee obliged to provide safe and secure interim storage facilities. The storage facilities must ensure that the waste stored is able to meet the GDF operator's CFA at the date scheduled for its disposal.

31.11 Summary of ALARP Justification

This section presents a high-level overview of how the ALARP principle has been applied for decommissioning, and how this contributes to the overall ALARP argument for the UK ABWR.

Chapter 28: ALARP Evaluation presents the high-level approach adopted for ALARP demonstration across all aspects of the design and operation. It presents an overview of how the UK ABWR design has evolved, the further options that have been considered across all technical areas resulting in design changes and how these contribute to the overall ALARP case. The approach to undertaking ALARP Assessment during GDA is described in the GDA ALARP Methodology [Ref. 31-41] and Safety Case Development Manual [Ref. 31-52].

As part of the Decommissioning Safety Assessment work stream, HAZOP workshops were held with the main purpose of reviewing decommissioning systems / processes anticipated to be used during the decommissioning phase. In line with expectations for GDA, the HAZOPs were conducted at a high-level whilst also being cognisant that decommissioning will be undertaken some 60 years after the reactor has commenced generation. The output from the HAZOP workshops was a set of minutes [Ref. 31-53] detailing the specific areas and systems reviewed, and subsequent hazards identified. The main hazards associated with decommissioning the UK ABWR are:

- Decontamination, cutting, unbolting and removal operations; involving direct worker contact resulting in radiological / conventional hazards and resulting in worker dose uptake;
- Contaminated wounds;
- Loss of containment of contaminated water, oils or liquors;
- Loss of ventilation resulting in increased aerosol concentration and spread of contamination;
- Dropped load / impact;
- Fire / explosion;
- Dose uptake during waste transfer as a result of exposure to contaminated resins;
- Access restrictions.

Minimising contamination and activation to levels that are ALARP through appropriate plant design is particularly important for reducing the hazard associated with decommissioning, ultimately leading to reduced worker dose uptake and a decrease in the volume of waste generated. Adequate control of nuclear matter supports decommissioning and FSF 4: Confinement / Containment of Radioactive Material has ensured that this requirement has been captured within the design.

A key design aspect to minimise contamination and activation is consideration of the materials used in the design, construction and operation of the plant. Hitachi-GE has undertaken a comprehensive evaluation of materials [Ref. 31-54] during GDA, taking into consideration factors such as reliability, degradation, application of BAT and availability. The UK ABWR design materials have been optimised to positively support decommissioning. Materials have been selected on the basis of OPEX identified from existing BWRs, challenge during the ALARP process and application of optimisation processes. A balanced approach has been taken and where necessary other considerations such as safe and reliable operation or operational dose and waste have taken priority over decommissioning. Examples of where materials have been optimised to minimise activation and contamination are as follows:

- Materials to reduce levels of trace elements that can become activated;
- Alternate structural materials to prevent the activation of stable Co;
- Corrosion resistant materials for the RINs, and piping to protect against loss of containment and spread of contamination.

Regulation of the water chemistry regime plays a significant role in controlling the levels of contamination built up during the operational lifetime of the plant. At decommissioning this leads to reductions in contamination, activation, dose uptake and quantities of higher classified wastes. Effective water chemistry management also maintains the integrity of pool liners and fuel assemblies minimising the risk of loss of containment and fuel failures, which could potentially impact on decommissioning. As such, water chemistry management is significant for reduction of risks associated with decommissioning ALARP [Ref. 31-55].

Hitachi-GE has adopted a design approach [Ref. 31-56] to identify and provide both permanent and temporary features necessary to adequately control radioactive contamination across the full lifetime of the UK ABWR. Radiation source reduction will be achieved by undertaking POCO and decontamination to remove contaminants prior to deplanting. Undertaking these processes lowers risk to workers undertaking decommissioning tasks and may potentially sentence waste into a lower waste category and hence reduce the burden on the future GDF [Ref. 31-11]. The UK ABWR has been designed to allow prompt decommissioning [Ref. 31-6], to be undertaken by providing features that can support a variety of decontamination techniques. This is in line with relevant GP.

International decontamination techniques have been evaluated and assessed for their applicability to the UK ABWR [Ref. 31-9]. The techniques selected, which cover all major plant decommissioning activities, are currently available and have been successfully deployed either on nuclear decommissioning projects within the UK or in the decommissioning of BWR plant elsewhere in the world. However, it should be recognised that the UK ABWR has been designed to facilitate use of a wide range of decommissioning techniques and options are not foreclosed in the design to allow for adoption of alternatives (for example between the GDA and decommissioning phases, technological developments are anticipated to provide improvements on the chosen techniques).

The UK ABWR has been robustly challenged against the requirements of decommissioning, ensuring that features to reduce both radiological and conventional risks, as well as impact to the environment have been considered. It has been demonstrated that the design will allow for the application of BAT, as well as ALARP, so that the most appropriate decommissioning techniques are selected, and that waste generation and discharges are minimised during decommissioning.

Using lessons learned from past decommissioning projects, a systematic approach [Ref. 31-12] has been undertaken to identify where design features to aid decommissioning have already been incorporated into the reference design, and where additional benefits (for example reduction in safety risks and impact to the environment) could be realised from incorporation of additional design features. Reports have been produced which address key conventional hazards that may be realised during the lifetime of the UK ABWR, including during the decommissioning phase [Ref. 31-57] - [Ref. 31-61]. A review of the conventional hazards, which includes decommissioning activities, has been undertaken in line with relevant GP, particularly the CDM Regulations approved code of practice.

The UK ABWR reference design has been challenged as part of the systematic approach mentioned above, resulting in further consideration of multiple UK ABWR risk reduction measure options during GDA. Of those risk reduction measures, the ability to remove non-essential walls to facilitate decommissioning has been incorporated into the UK ABWR design for decommissioning. It is further assumed that inclusion of design features e.g. lintels in non-essential walls to facilitate removal of large items during decommissioning and to provide optimised export routes will be considered during detailed design development to optimise decommissioning.

The design of the UK ABWR and the facilitation of safe decommissioning have been shown to follow UK and international GP. By following a systematic and comprehensive process, all reasonably practicable risk reduction measures have been adopted. The work undertaken in support of this PCSR chapter demonstrates that the UK ABWR design has been robustly challenged against the requirements of decommissioning, that options for the future licensee to adopt alternative decommissioning techniques are not foreclosed and that the current GDA reference design reduces risks ALARP.

31.12 Conclusions

This generic PCSR chapter presents the safety case claims to carry out decommissioning of UK ABWR and is supported by arguments and evidence in the suite of topic reports on UK ABWR decommissioning.

As a result of decommissioning strategy optioneering studies, prompt decommissioning has been selected as the preferred option for UK ABWR. A comprehensive and systematic safety assessment approach has been undertaken to assess potential hazards associated with the reference design. This approach has confirmed that risks are reduced ALARP through incorporation of decommissioning considerations into the UK ABWR design.

A decommissioning plan for the UK ABWR has been developed. This plan covers pre-closure activities, main plant decommissioning, waste management, demolition and site clearance, and includes a decommissioning schedule of the UK ABWR for facilities which fall within the GDA scope. This plan is supported by proposed decommissioning techniques, which are selected on the basis of OPEX and GP. It has been demonstrated that the UK ABWR can be decommissioned using current techniques. Although construction methods are not fixed in the GDA scope, the impact of potential construction methods on the decommissioning has been assessed and it is not anticipated that the generic construction method would impact the UK ABWR decommissioning.

Decommissioning waste classification, categorisation and management, (including waste disposal), have been summarised for each phase of decommissioning for UK ABWR along with the UK requirements.

The UK ABWR design incorporates features that facilitate decommissioning to enable the UK ABWR to be decommissioned safely, following a decommissioning plan. This plan is supported by a proposed decommissioning strategy, use of today’s technology, and a waste management plan which identifies viable disposal route for decommissioning wastes. Faults and hazards have been identified and shown that all risks are reduced, or are capable of being reduced ALARP. In summary, this PCSR Chapter demonstrates that the UK ABWR can be decommissioned safely with the associated risks reduced ALARP.

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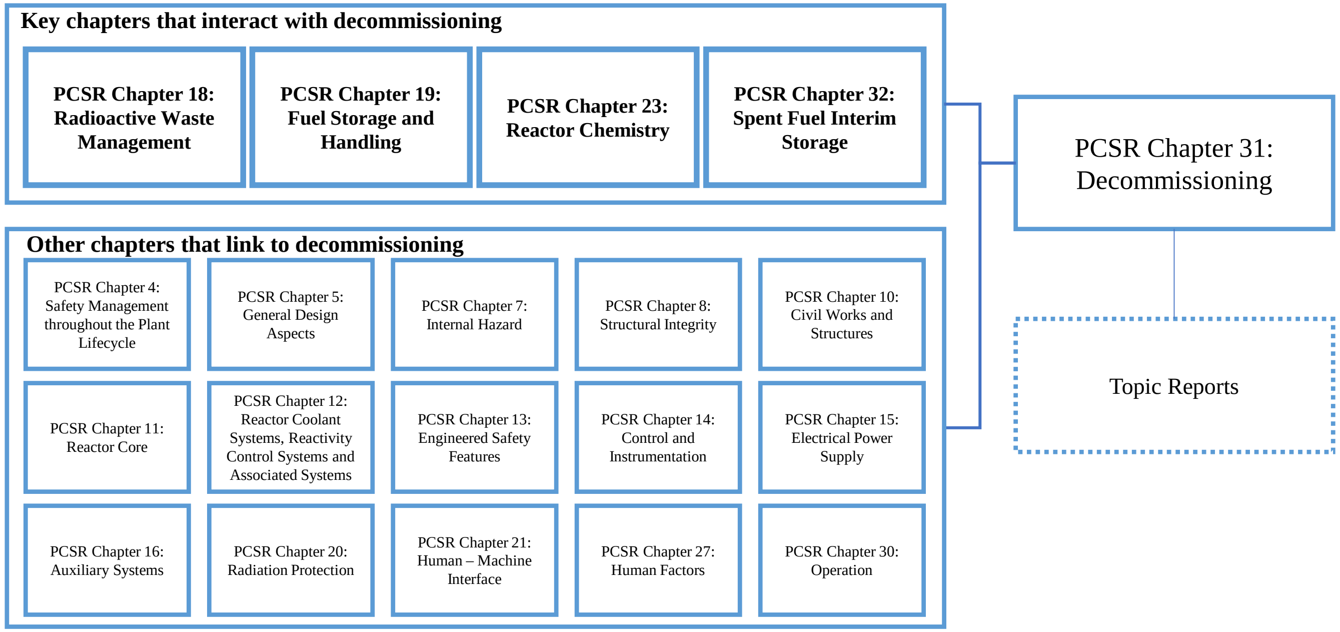
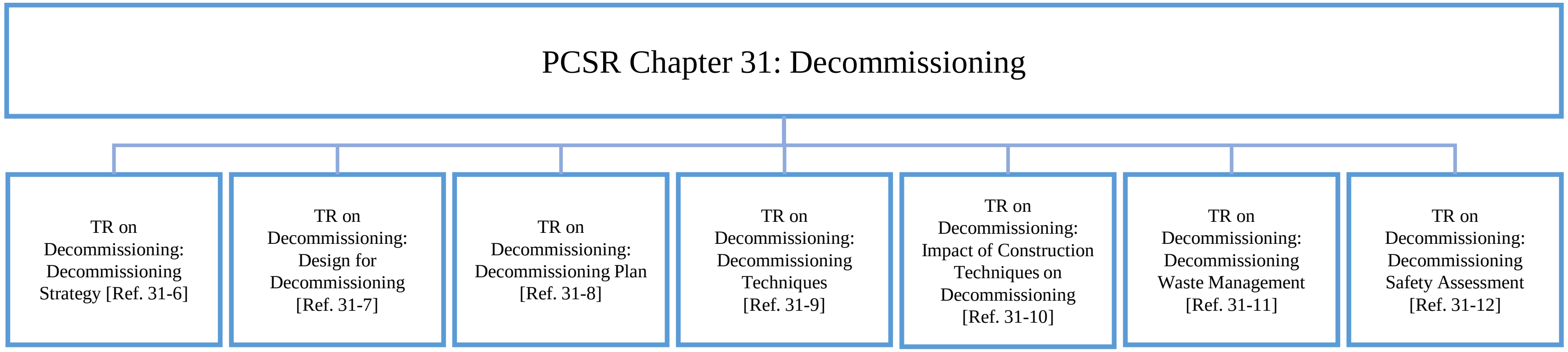
Appendix A: Document Map

(a) Document Map Showing the Interaction of Chapter 31 With Other Relevant PCSR Chapters

Collectively all the chapters stated below contribute to ensuring that the risks in decommissioning are ALARP but a small number of key chapters have been identified that significantly contribute to the content discussed in Chapter 31 and have been highlighted.



(b) Document Map of PCSR Chapter 31



Appendix B: Interactions with Other PCSR Chapters

Table B-1: Assumptions and Interaction Between Relevant PCSR Chapters

No.	Assumption	Relevant PCSR chapter
1	The UK ABWR decommissioning GDA assessment is based upon prompt decommissioning with an operating lifetime of 60 years.	PCSR Chapter 2: Generic Site Envelope
2	Decommissioning is assumed to end when all station buildings and facilities have been demolished and the site has been returned to an end state agreed with the regulators and planning authority. The decommissioning strategy assumes that the station footprint will be restored in two phases; the first following removal of the main power island i.e. R/B and T/B and the second once all spent fuel and any other radioactive waste has been consigned to the GDF or another appropriate disposal route.	Decommissioning specific assumption
3	It is assumed that ILW and spent fuel will be safely stored on-site within interim storage facilities until a GDF becomes available. A future licensee will make arrangements for interim storage and on-going monitoring and inspection of packages until the transfer of waste to the GDF is complete. The decommissioning strategy assumes that the GDF will be available to start to accept new build ILW and spent fuel in 2100 and 2146 respectively with transfer assumed to be completed by 2190.	PCSR Chapter 18: Radioactive Waste Management PCSR Chapter 32: Spent Fuel Interim Storage
4	The decommissioning waste management strategy assumes that the spent fuel and HLW interim storage period will last up to 140 years. Once spent fuel and HLW has sufficiently cooled, and assuming the GDF is available, assemblies and waste stored on-site will be retrieved, repackaged and consigned for final disposal in to compliant waste packages. A repackaging facility will be constructed on-site to undertake the repackaging campaign. Once complete, the decommissioning plan assumes that the SFIS, HLW decay store, and repackaging facility will be deplanted and demolished.	PCSR Chapter 18: Radioactive Waste Management PCSR Chapter 32: Spent Fuel Interim Storage

No.	Assumption	Relevant PCSR chapter
5	Disposal of UK ABWR decommissioning waste has been assessed and all waste expected to be generated has a disposal route. Additional wastes that could be generated in a Design Basis Accident are the same/similar to those evaluated in the disposability assessment and therefore the operational disposal routes can be utilised.	PCSR Chapter 18: Radioactive Waste Management
6	The waste inventory and hazard assessment has assumed that no significant contamination events have occurred that have not been adequately remediated during the operational period.	Decommissioning specific assumption
7	The decommissioning strategy assumes that the radiation and contamination zoning across the full site will be re-classified to support decommissioning operations.	PCSR Chapter 20: Radiation Protection
8	The decommissioning plan assumes that piping connections will be appropriate for all phases of plant life, considering all potential hazards such as loss of containment and conventional safety during cutting operations.	Decommissioning specific assumption
9	The decommissioning strategy assumes that spent fuel will remain in the SFP for 10 years before transfer to the on-site SFIS facility.	PCSR Chapter 32: Spent Fuel Interim Storage
10	The decommissioning plan assumes that at the start of the deplanting task, the building is assumed to be redundant and has been drained of all working or stored fluids during POCO.	Decommissioning specific assumption
11	The decommissioning strategy assumes that radiological plant buildings e.g. Rw/B, will continue to be used after EoG for the processing of stored operational waste and for operational wastes arising after EoG.	Decommissioning specific assumption
12	The decommissioning plan assumes that deplanting of the R/B will commence once all spent fuel has been removed from the SFP and R/B.	Decommissioning specific assumption
13	The decommissioning plan assumes that demolition works will commence once buildings have been deplanted and are demonstrated to be free from radioactive contamination.	Decommissioning specific assumption

No.	Assumption	Relevant PCSR chapter
14	It is assumed that neutron activation of the reactor pedestal concrete will result in activated steel rebar within a lower activity concrete matrix.	Decommissioning specific assumption
15	Spent Fuel Pool and internals storage pools i.e. DSP and R/W pool, are stainless steel lined and there will have been no significant leaks into the underlying concrete structure. The decommissioning plan assumes that there will be some degree of in-situ concrete decontamination required.	Decommissioning specific assumption
16	Where concrete is exposed, contamination is assumed to be present to a depth of 10mm. Contamination can be readily removed using currently available techniques.	Decommissioning specific assumption
17	The decommissioning plan assumes highly activated RINs will be moved to the DSP, where segmentation will be conducted ex-situ and underwater. Dismantling of the removed RINs within the DSP will require installation of suitable infrastructure to deploy tools and retrieve cut sections in conjunction with the existing cranes.	Decommissioning specific assumption
18	The decommissioning plan and waste management strategy assumes that the RPV will be segmented in-situ and further size reduced in the DSP.	Decommissioning specific assumption
19	The decommissioning plan assumes that small tanks and vessels will be transported intact to the DWMF for size reduction, however larger tanks and vessels will require size reduction in-situ. Storage pool liners will be size reduced in-situ following initial decontamination and dispatched to the DWMF for further processing.	Decommissioning specific assumption
20	The decommissioning strategy assumes that control rods and reactor internals will be removed following defueling operations using the fuel handling machine.	Decommissioning specific assumption
21	Tanks previously used to store radiologically or chemically contaminated fluids are assumed to have been adequately flushed, drained and washed down during the POCO phase prior to dismantling operations commencing.	Decommissioning specific assumption

No.	Assumption	Relevant PCSR chapter
22	The decommissioning strategy assumes that cranes will not be significantly contaminated and therefore their removal can be undertaken as part of the demolition process.	Decommissioning specific assumption
23	It is assumed that waste category definitions will remain the same and apply at the time of decommissioning.	Decommissioning specific assumption
24	The decommissioning strategy assumes that LLW disposal services are available throughout the operational and decommissioning phases and CFA will remain the same and apply at the time of decommissioning.	PCSR Chapter 18: Radioactive Waste Management
25	The decommissioning safety case assumes that the station and facilities will be operated in a manner that minimises the level of contamination.	PCSR Chapter 12: Reactor Coolant System PCSR Chapter 20: Radiation Protection PCSR Chapter 23: Reactor Chemistry
26	The station and facilities are assumed to apply the waste hierarchy throughout the lifetime of the facility to minimise the amount of waste to be managed during decommissioning.	PCSR Chapter 23: Reactor Chemistry
27	All events during operational life are assumed to be recorded such that any deviation from normal operations are understood.	Decommissioning specific assumption
28	The decommissioning strategy assumes that all plant areas will be surveyed and remediated as necessary prior to deplanting operations.	Decommissioning specific assumption
29	The decommissioning plan assumes that a characterisation verification programme is undertaken prior to decontamination to confirm expected nuclide compositions, concentrations, and chemical / physical forms.	Decommissioning specific assumption

No.	Assumption	Relevant PCSR chapter
30	In line with the Department of Business, Energy, and Industrial Strategy (formerly the Department of Energy and Climate Change) Base Case, it is assumed that SF will not be reprocessed but will be disposed of in the GDF. A future licensee will therefore need to make arrangements for interim storage, and inspection if required, of fuel until such time as the GDF is ready to accept spent fuel.	PCSR Chapter 32: Spent Fuel Interim Storage
31	It is assumed that design requirements detailed within the Forward Action Plan in the Decommissioning “Topic Report on Decommissioning: Design for Decommissioning” (Table 16), will be implemented within the site specific design phase.	Decommissioning Specific Assumption

Appendix C: Decommissioning Safety Claims

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
Claim 1. The UK-ABWR design incorporates features that facilitate decommissioning				
Decom-SC 1.1 The design of the UK ABWR minimises the decommissioning ST ALARP	A1	Co-based alloys are reduced SFAIRP to minimise the decommissioning ST. Where elimination of Co is unavoidable, the use of low Co materials has been applied where reasonably practicable.	31.5.2.1	Chapter 8
	A2	The UK ABWR design incorporates features that improve fuel management and reduce the frequency of fuel failures.	31.7.3.1	Chapter 23
	A3	All materials in the UK ABWR are optimised against corrosion SFAIRP.	31.5.2.1	Chapter 8
	A4	Cu alloys are replaced with titanium for the main condensers and Cu content throughout the operating life of the plant will be controlled.	31.5.2.1	Chapter 23
	A5	Fuels and internal storage pools are stainless steel lined to minimise the potential for leakage into underlying structure.	31.5.2.9	Chapter 10
	A6	Metal surfaces are designed to minimise contamination ALARP by ensuring surface finishes are smooth, non-porous and free of cracks, crevices and sharp corners.	31.5.2.1 31.5.2.2	Chapter 8
	A7	Concrete surfaces are designed to minimise contamination ALARP. This may be achieved by utilising, linings with impermeable membranes, paints, or stainless steel.	31.5.2.2	Chapter 10
	A8	The recirculating system and RPV will be subject to an in-situ chemical decontamination process prior to dismantling.	31.5.2.2	Decommissioning Specific
	A9	RINs are readily removable to facilitate in-situ chemical decontamination of the empty RPV.	31.5.2.2	-
	A10	In-situ decontamination processes will utilise existing Pumps for circulation.	31.5.2.2	Decommissioning Specific
	A11	The selection of aggregates used for construction minimises activation where reasonably practicable.	31.5.2.1 31.5.2.2	Chapter 10

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A12	The UK ABWR design incorporates features to ensure minimised potential for leakage from containment.	31.5.2.9	Chapter 8
	A13	The UK ABWR layout incorporates features to mitigate contamination as a result of liquid leakage from containment.	31.5.2.9	--
	A14	The UK ABWR adopts an optimised water chemistry regime to minimise the level of contamination and SCC.	31.5.2.3	Chapter 23
Decom-SC 1.2 **The UK ABWR pipework and drainage design reduces decommissioning risks ALARP**	A1	Components are designed with the ability to self-drain, through inclusion of low drain points, minimisation of horizontal surfaces, consideration of smooth surface finishes, etc.	31.5.2.2 31.5.2.5	-
	A2	Floor surfaces are designed with an appropriate gradient for effective drainage.	31.5.2.2 31.5.2.5	-
	A3	Piping design minimises contamination ALARP by taking into account suitable gradients for drainage and minimising sharp corners and U bends.	31.5.2.2 31.5.2.5	Chapter 16
	A4	Embedded piping is minimised SFAIRP.	31.5.2.2 31.5.2.7	Chapter 10 Chapter 16
	A5	Where embedded piping is present, relevant features are included to assist decontamination, such as features for detection of radiation levels prior to dismantling.	31.5.2.2	-
Decom-SC 1.3 **The UK ABWR design minimises conventional safety risks during decommissioning**	A1	No asbestos containing materials are to be utilised during construction of the plant.	31.7.1	-
	A2	Where MMMF material is required, encased shaped panels are used, minimising exposure of fibres during decommissioning.	31.7.1	-
	A3	Sufficient space is provided to workers for undertaking decommissioning tasks.	31.5.2.6	Chapter 10 Chapter 27
	A4	Measures to reduce conventional safety risks such as lifting lugs, temporary access fail-safe crane configuration, design for temporary access, reduction of working at height, etc. are incorporated in the UK ABWR design.	31.5.2.6 31.5.2.11	Chapter 27

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
Decom-SC 1.4 **The design of the UK ABWR ensures sufficient access and space for decommissioning activities to be undertaken**	A1	Unobstructed egress routes without impacting on man access and thoroughfares are available for all equipment and items to be removed during decommissioning.	31.5.2.6	Chapter 10 Chapter 27
	A2	Sufficient space is provided to workers for undertaking decommissioning tasks.	31.5.2.6	Chapter 10 Chapter 27
	A3	To avoid interference with the building structure, export hatches are appropriately sized to accommodate large waste packages e.g. casks, and the design does not foreclose use of alternative waste packaging options.	31.5.2.6	Chapter 10
	A4	The UK ABWR can accommodate removal of non-essential walls to facilitate decommissioning.	31.5.2.6	Chapter 10
Decom-SC 1.5 **The UK ABWR design has considered decommissioning logistics to ensure risks are reduced ALARP**	A1	Unobstructed egress routes without impacting on man access and thoroughfares are available for all equipment and items to be removed during decommissioning.	31.5.2.6	Chapter 10 Chapter 27
	A2	Sufficient space is provided to workers for undertaking decommissioning tasks.	31.5.2.6	Chapter 10 Chapter 27
	A3	To avoid interference with the building structure, export hatches are appropriately sized to accommodate large waste packages e.g. casks, and the design does not foreclose use of alternative waste packaging options.	31.5.2.6	Chapter 10
	A4	The UK ABWR can accommodate removal of non-essential walls to facilitate decommissioning.	31.5.2.6	Chapter 10
	A5	The design of the tanks ensures availability of sufficient sampling points and ability to homogenise for characterisation prior to decommissioning.	31.5.2.6	Chapter 16
	A6	Whilst the intention is for prompt decommissioning of the UK ABWR, the design does not foreclose the option for alternative strategies or sequencing options to be adopted.	31.4.2	Decommissioning Specific

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
Decom-SC1.6 **A variety of decommissioning techniques are available to decommission the UK ABWR**	A1	There are techniques currently available to successfully decommission the UK ABWR.	31.4.2	Decommissioning Specific
	A2	The UK ABWR design does not foreclose options for the future licensee to apply the most appropriate technique at the time of decommissioning and to ensure risks are reduced ALARP.	31.4.2	Decommissioning Specific
Decom-SC 1.7 **The UK ABWR design has considered the impact of construction techniques on decommissioning in the design**	A1	Embedded piping is minimised SFAIRP.	31.5.2.7	Chapter 10 Chapter 16
	A2	Pre-stressed concrete is minimised SFAIRP.	31.5.2.10	
	A3	Unobstructed egress routes without impacting on man access and thoroughfares are available for all equipment and items to be removed during decommissioning.	31.5.2.6	Chapter 10 Chapter 27
	A4	Sufficient space is provided to workers for undertaking decommissioning tasks.	31.5.2.6	Chapter 10 Chapter 27
	A5	To avoid interference with the building structure, export hatches are appropriately sized to accommodate large waste packages e.g. casks, and the design does not foreclose use of alternative waste packaging options.	31.5.2.6	-
	A6	The UK ABWR can accommodate removal of non-essential walls to facilitate decommissioning.	31.5.2.6	Chapter 10
Decom-SC 1.8 **The design of the UK ABWR ensures long-term structural integrity and containment**	A1	Equipment design life is appropriate for decommissioning, taking due consideration of the phases in which the SSC is required to be operable.	-	Chapter 14
	A2	The UK ABWR structural design ensures long-term integrity for decommissioning purposes.	31.5.2.8	Chapter 8 Chapter 23
	A3	The UK ABWR design incorporates features to ensure minimised potential for leakage from containment.	31.5.2.9	Chapter 8
	A4	Fuels and internal storage pools are stainless steel lined with no significant leaks into underlying structure.	31.5.2.9	Chapter 10

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A5	Protective floor and wall coatings will ensure that in the event of a leakage there is no extensive contamination to the underlying concrete structure.	31.5.2.2	-
Decom-SC 1.9 Ancillary systems will have the functionality to be adapted or modified to facilitate the different operational profile of decommissioning activities	A1	The design life of auxiliary systems including HVAC, power supply systems, backup power systems, cooling water systems and fire protection systems is appropriate for decommissioning.	31.5.2.4	Chapter 16
	A2	The design life and design operational profile of the RBC and FHM lifting equipment is appropriate for decommissioning activities.	31.5.2.4	Chapter 19
	A3	The design life of radioactive waste management services, including systems for the treatment of gaseous, liquid and solid wastes is appropriate for decommissioning.	31.5.2.4	Chapter 18
	A4	The design life of the reactor cooling system is appropriate for decommissioning.	31.5.2.4	Chapter 12
	A5	The design life of radiation monitoring equipment is appropriate for decommissioning.	31.5.2.4	Chapter 14
	A6	The design life of plant monitoring and instrumentation equipment is appropriate for decommissioning.	31.5.2.4	Chapter 14
Claim 2. Appropriate decommissioning plans/strategies are in place, and will continue to be developed by the future licensee.				
Decom-SC 2.1 The UK ABWR can safely transition from its operational state to an agreed end state where the site can be delicensed and remediated to a level near to greenfield i.e. allowing for unrestricted re-use	A1	A decommissioning plan has been produced to demonstrate how the UK ABWR can be safely decommissioned and delicensed at the end of plant life.	31.4.2	Decommissioning Specific
	A2	The hazard the facility poses is to be removed progressively, giving due regard to security considerations, the safety of workers and the general public, and protecting the environment.	31.6.2	Decommissioning Specific
	A3	Strategies and plans will be reviewed and updated on a periodic basis and information relating to these plans, including their costs, schedule and implementation will be recorded and preserved.	31.4.2	Decommissioning Specific

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
Decom-SC 2.2 Records will be managed appropriately and reviewed periodically	A1	Retention and management of important information relating to the design, construction, commissioning, operational history, maintenance and modifications will be collected systematically throughout the lifetime of the plant (from design to delicensing) and maintained in an accessible and usable format so that it can inform decommissioning planning, as well as other functions during the plant lifetime.	31.9	Chapter 4 Chapter 29
	A2	Transfer of significant RandAs and Limits and Conditions relating to the construction, operation and decommissioning assessed and verified in GDA to the Licensee shall be assured in order to accomplish high-level safety and environmental protection throughout the plant life cycle of the UK ABWR.	31.9	Chapter 4
Claim 3. Faults and Hazards during decommissioning are identified, assessed and all risks shown to be ALARP.				
Decom-SC 3.1 Conventional and radiological hazards arising from decommissioning operations and faults have been identified	A1	An augmented HAZOP process was undertaken to identify radiological and conventional hazards arising from decommissioning operations, identify safety features in the initial UK ABWR design, and provide a comprehensive, systematic and holistic review of the design of the ABWR.	31.5.1	Decommissioning Specific
Decom-SC 3.2 Appropriate design features to facilitate decommissioning and provide hazard reduction have been identified	A1	Co-based alloys are reduced SFAIRP to minimise the decommissioning ST. Where elimination of Co is unavoidable, the use of low Co materials have been applied where reasonably practicable.	31.5.2.1	Chapter 8
	A2	The UK ABWR design incorporates features that improve fuel management and reduce the frequency of fuel failures.	31.7.3.1	Chapter 23
	A3	All materials in the UK ABWR are optimised against corrosion SFAIRP.	31.5.2.1	Chapter 8
	A4	To reduce CILC, Cu alloys are replaced with titanium for the main condensers and Cu content throughout the operating life of the plant will be controlled.	31.5.2.1	Chapter 23

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A5	Fuels and internal storage pools are stainless steel lined with no significant leaks into underlying structure.	31.5.2.9	Chapter 10
	A6	Metal surfaces will minimise contamination ALARP by ensuring surface finishes are smooth, non-porous and free of cracks, crevices and sharp corners.	31.5.2.1 31.5.2.2	Chapter 8
	A7	Concrete surfaces will minimise contamination ALARP. This may be achieved by utilising, linings with impermeable membranes, paints, or stainless steel.	31.5.2.2	Chapter 10
	A8	The recirculating system and RPV will be subject to an in-situ chemical decontamination process prior to dismantling.	31.5.2.2	Decommissioning Specific
	A9	RINs are readily removable to facilitate in-situ chemical decontamination of the empty RPV.	31.5.2.2	-
	A10	In-situ decontamination processes will utilise existing RIPs for circulation.	31.5.2.2	Chapter 16
	A11	The selection of aggregates used for construction minimises activation where reasonably practicable.	31.5.2.1 31.5.2.2	Chapter 10
	A12	The UK ABWR design incorporates features to ensure minimised potential for leakage from containment.	31.5.2.9	Chapter 8
	A13	The UK ABWR layout incorporates features to mitigate contamination as a result of leakage from containment.	31.5.2.9	--
	A14	The UK ABWR adopts an optimised water chemistry regime to minimise the level of contamination and SCC.	31.5.2.3	Chapter 23
	A15	Components are designed with the ability to self-drain, through inclusion of low drain points, minimisation of horizontal surfaces, consideration of smooth surface finishes, etc.	31.5.2.2 31.5.2.5	Chapter 16
	A16	Floor surfaces are designed with an appropriate gradient for effective drainage.	31.5.2.2 31.5.2.5	-
	A17	Piping design minimises contamination ALARP by taking into account suitable gradients for drainage and minimising sharp corners and U bends.	31.5.2.2 31.5.2.5	Chapter 16

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A18	Embedded piping is minimised SFAIRP.	31.5.2.2	Chapter 10 Chapter 16
	A19	Where embedded piping is present, relevant features will be included to assist decontamination, such as features for detection of radiation levels prior to dismantling.	31.5.2.2	-
	A20	No asbestos containing materials are to be utilised during construction of the plant.	31.7.1	-
	A21	Where MMMF material is required, encased shaped panels are used, minimising exposure of fibres during decommissioning.	31.7.1	-
	A22	Sufficient space is provided to workers for undertaking decommissioning tasks.	31.5.2.6	Chapter 10 Chapter 27
	A23	Measures to reduce conventional safety risks such as lifting lugs, temporary access, fail-safe crane configuration, design for temporary access, reduction of working at height, etc are incorporated in the UK ABWR design.	31.5.2.6 31.5.2.11	Chapter 27
	A24	Unobstructed egress routes without impacting on man access and thoroughfares are available for all equipment and items to be removed during decommissioning.	31.5.2.6	Chapter 10
	A25	To avoid interference with the building structure, export hatches are appropriately sized to accommodate large waste packages e.g. casks, and the design does not foreclose use of alternative waste packaging options.	31.5.2.6	Chapter 10
	A26	The UK ABWR can accommodate removal of non-essential walls to facilitate decommissioning.	31.5.2.6	Chapter 10
	A27	The design of the tanks ensures availability of sufficient sampling points and ability to homogenise for characterisation prior to decommissioning.	-	Chapter 16
	A28	Pre-stressed concrete is minimised SFAIRP.	31.5.2.10	-
	A29	The UK ABWR structural design ensures long-term integrity for decommissioning purposes.	31.5.2.8	Chapter 8 Chapter 23

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A30	Fuels and internal storage pools are stainless steel lined with no significant leaks into underlying structure.	31.5.2.9	Chapter 10
	A31	Protective floor and wall coatings ensure that in the event of a leakage there is no extensive contamination to the underlying concrete structure.	31.5.2.2	-
	A32	The design life of auxiliary systems including HVAC, power supply systems, backup power systems, cooling water systems and fire protection systems is appropriate for decommissioning.	31.5.2.4	Chapter 16
	A33	The design life of the RBC and FHM lifting equipment is appropriate for decommissioning.	31.5.2.4	Chapter 19
	A34	The design life of radioactive waste management services, including systems for the treatment of gaseous, liquid and solid wastes is appropriate for decommissioning.	31.5.2.4	Chapter 18
	A35	The design life of the reactor cooling system is appropriate for decommissioning.	31.5.2.4	Chapter 12
	A36	The design life of radiation monitoring equipment is appropriate for decommissioning.	31.5.2.4	Chapter 14
	A37	The design life of plant monitoring and instrumentation equipment is appropriate for decommissioning.	31.5.2.4	Chapter 14
Decom-SC 3.3 **An assessment of decommissioning risks has been undertaken to show that risks have been reduced, or are capable of being reduced ALARP**	A1	A safety assessment has been undertaken to assess decommissioning risks and demonstrate that risks have been reduced, or are capable of being reduced, ALARP.	31.5.1	Decommissioning Specific

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
Decom-SC 3.4 **The design challenge process has taken account of decommissioning GP so that risks associated with decommissioning are ALARP**	A1	The incorporation of GP in to the UK ABWR design supports the claim that design features and measures are appropriate and reduce risks ALARP.	31.3	Decommissioning Specific
Claim 4. Viable disposal routes are available (or will be available) for all decommissioning wastes.				
Decom-SC 4.1 **Decommissioning wastes can be disposed of via viable routes**	A1	All decommissioning wastes will be categorised as either clean (out of regulatory scope), VLLW, LLW, ILW, or HLW. Viable disposal routes for each of these categories have been identified.	31.6.1	Decommissioning Specific
Decom-SC 4.2 **Waste generation during decommissioning will be minimised**	A1	The UK ABWR design minimises the volume of solid waste at the end of plant life to decommission (through BWR design evolution including incorporation of RIPs and reduction of pumps, valves and piping).	31.5.1	-
	A2	Co-based alloys are reduced SFAIRP to minimise the decommissioning ST. Where elimination of Co is unavoidable, the use of low Co materials has been applied where reasonably practicable.	31.5.2.1	Chapter 8
	A3	The UK ABWR design incorporates features that improve fuel management and reduce the frequency of fuel failures.	31.7.3.1	Chapter 23
	A4	All materials in the UK ABWR are optimised against corrosion SFAIRP.	31.5.2.1	Chapter 8
	A5	To reduce CILC, Cu alloys are replaced with titanium for the main condensers and Cu content throughout the operating life of the plant will be controlled.	31.5.2.1	Chapter 23
	A6	Fuels and internal storage pools are stainless steel lined with no significant leaks into underlying structure.	31.5.2.9	Chapter 10

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A7	Metal surfaces will minimise contamination ALARP by ensuring surface finishes are smooth, non-porous and free of cracks, crevices and sharp corners.	31.5.2.1 31.5.2.2	Chapter 8
	A8	Concrete surfaces will minimise contamination ALARP. This may be achieved by utilising, linings with impermeable membranes, paints, or stainless steel.	31.5.2.2	Chapter 10
	A9	The recirculating system and RPV will be subject to an in-situ chemical decontamination process prior to dismantling.	31.5.2.2	Decommissioning Specific
	A10	RINs are readily removable to facilitate in-situ chemical decontamination of the empty RPV.	31.5.2.2	Chapter 11
	A11	In-situ decontamination processes will utilise existing RIPs for circulation.	31.5.2.2	Decommissioning Specific
	A12	The selection of aggregates used for construction minimises activation where reasonably practicable.	31.5.2.1	Chapter 10
	A13	The UK ABWR design incorporates features to ensure minimised potential for leakage from containment.	31.5.2.9	Chapter 8
	A14	The UK ABWR layout incorporates features to mitigate contamination as a result of leakage from containment i.e. height of walls are sufficient to accommodate one quarter of the combined capacity of all containers and secondary containment can accommodate 110% of the capacity of the largest container.	31.5.2.9	-
	A15	The UK ABWR adopts an optimised water chemistry regime to minimise the level of contamination and SCC.	31.5.2.3	Chapter 23
	A16	Components are designed with the ability to self-drain, through inclusion of low drain points, minimisation of horizontal surfaces, consideration of smooth surface finishes, etc.	31.5.2.2	Chapter 16
	A17	Floor surfaces are designed with an appropriate gradient for effective drainage.	31.5.2.2 31.5.2.5	-
	A18	Piping design minimises contamination ALARP by taking into account suitable gradients for drainage and minimising sharp corners and U bends.	31.5.2.2 31.5.2.5	Chapter 16

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A19	Embedded piping is minimised SFAIRP.	31.5.2.2	Chapter 10 Chapter 16
	A20	Where embedded piping is present, relevant features are included to assist decontamination, such as features for detection of radiation levels prior to dismantling.	31.5.2.2	-
Decom-SC 4.3 **Waste will be minimised during operations**	A1	The UK ABWR design incorporates features that improve fuel management and reduce the frequency of fuel failures.	31.7.3.1	Chapter 23
	A2	Metal surfaces minimise contamination ALARP by ensuring surface finishes are smooth, non-porous and free of cracks, crevices and sharp corners.	31.5.2.1 31.5.2.2	Chapter 8
	A3	Concrete surfaces minimise contamination ALARP. This may be achieved by utilising, linings with impermeable membranes, paints, or stainless steel.	31.5.2.2	Chapter 10
	A4	The UK ABWR adopts an optimised water chemistry regime to minimise the level of contamination and SCC.	31.5.2.3	Chapter 23
Decom-SC 4.4 **UK ABWR minimises waste generation by design**	A1	The UK ABWR design minimises the volume of solid waste at the end of plant life to decommission (through BWR design evolution including incorporation of RIPs and reduction of pumps, valves and piping).	31.5.1	Generic Environmental Permit
	A2	Co-based alloys are reduced SFAIRP to minimise the decommissioning ST. Where elimination of Co is unavoidable, the use of low Co materials has been applied where reasonably practicable.	31.5.2.1	Chapter 8
	A3	The UK ABWR design incorporates features that improve fuel management and reduce the frequency of fuel failures.	31.7.3.1	Chapter 23
	A4	All materials in the UK ABWR are optimised against corrosion SFAIRP.	31.5.2.1	Chapter 8
	A5	Fuels and internal storage pools are stainless steel lined with no significant leaks into underlying structure.	31.5.2.9	Chapter 10

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A6	To reduce CILC, Cu alloys are replaced with titanium for the main condensers and Cu content throughout the operating life of the plant will be controlled.	31.5.2.1	Chapter 23
	A7	Metal surfaces will minimise contamination ALARP by ensuring surface finishes are smooth, non-porous and free of cracks, crevices and sharp corners.	31.5.2.1 31.5.2.2	Chapter 8
	A8	Concrete surfaces will minimise contamination ALARP. This may be achieved by utilising, linings with impermeable membranes, paints, or stainless steel.	31.5.2.2	Chapter 10
	A9	The recirculating system and RPV will be subject to an in-situ chemical decontamination process prior to dismantling.	31.5.2.2	Decommissioning Specific
	A10	RINs are readily removable to facilitate in-situ chemical decontamination of the empty RPV.	31.5.2.2	-
	A11	In-situ decontamination processes will utilise existing RIPs for circulation.	31.5.2.2	Decommissioning Specific
	A12	The selection of aggregates used for construction minimises activation where reasonably practicable.	31.5.2.1	Chapter 10
	A13	The UK ABWR design incorporates features to ensure minimised potential for leakage from containment.	31.5.2.9	Chapter 8
	A14	The UK ABWR layout incorporates features to mitigate contamination as a result of leakage from containment.	31.5.2.9	-
	A15	The UK ABWR adopts an optimised water chemistry regime to minimise the level of contamination and SCC.	31.5.2.3	Chapter 23
	A16	Components are designed with the ability to self-drain, through inclusion of low drain points, minimisation of horizontal surfaces, consideration of smooth surface finishes, etc.	31.5.2.5	Chapter 16
	A17	Floor surfaces are designed with an appropriate gradient for effective drainage.	31.5.2.2 31.5.2.5	-

Sub-Claim	No.	Arguments	PCSR Section	Related PCSR Chapter
	A18	Piping design minimises contamination ALARP by taking into account suitable gradients for drainage and minimising sharp corners and U bends.	31.5.2.5	Chapter 16
	A19	Embedded piping is minimised SFAIRP.	31.5.2.2	Chapter 10 Chapter 16
	A20	Where embedded piping is present, relevant features are included to assist decontamination, such as features for detection of radiation levels prior to dismantling.	31.5.2.2	-
Decom-SC 4.5 **The waste hierarchy will be applied to all decommissioning wastes**	A1	The UK ABWR minimises waste generation by design to drive waste down the hierarchy.	31.5.1 31.5.2.1	Chapter 8 Chapter 23
Claim 5. UK ABWR can be decommissioned using today's technology.				
Decom-SC 5.1 **Appropriate decommissioning techniques exist to decommission the UK ABWR**	A1	To inform the decommissioning plan, technique selection has been undertaken. All of the techniques selected, which cover all major plant decommissioning activities, are currently available and have been successfully deployed either on nuclear decommissioning projects within the UK or in the decommissioning of BWR plants elsewhere in the world.	31.3	Decommissioning Specific