Office for Nuclear Regulation

New Reactors Division – Generic Design Assessment

Step 2 Assessment of the Radioactive Waste management, Decommissioning and Spent Fuel Management for the UK HPR1000 Reactor

Assessment Report ONR-GDA-UKHPR1000-AR-18-016
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EXECUTIVE SUMMARY

This report presents the results of my Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment of the UK HPR1000 undertaken as part of Step 2 of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA).

The GDA process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's review of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR from permitting the construction of a power station based on the design.

During GDA Step 2 my work has focused on the assessment of the Radioactive Waste Management, Decommissioning and Spent Fuel Management aspects within the UK HPR1000 Preliminary Safety Report (PSR), and a number of supporting references and supplementary documents submitted by the RP, focusing on design concepts and claims.

The standards I have used to judge the adequacy of the RP's submissions in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management have been primarily ONR's Safety Assessment Principles (SAPs), in particular SAPs RW.1 – RW.7 (radioactive waste management), DC.1 – DC.6 (decommissioning), ENM.1, 3 and 5 - 7 (control of nuclear matter, relevant to spent fuel and radioactive waste management) and ECV.1, 2, 3, 4, 6 and 7 (containment and ventilation). I have also assessed against ONR's Technical Assessment Guides NS-TAST-GD-005 Revision 8 (Guidance on the demonstration of ALARP), NS-TAST-GD-024 Revision 5 (Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites), NS-TAST-GD-026 Revision 4 (Decommissioning) and NS-TAST-GD-081 Revision 2 (Safety Aspects Specific to Storage of Spent Nuclear Fuel). I have also made use of other relevant standards and guidance including International Atomic Energy Agency (IAEA) Safety Requirements, Guides and Reports and the Western European Nuclear Regulators' Association (WENRA) Safety Reference Levels.

My GDA Step 2 assessment work has involved regular engagement with the RP in the form of technical exchange workshops and progress meetings, including meetings with the plant designers.

The UK HPR1000 PSR is primarily based on the Reference Design, Fangchenggang Unit 3 (FCG3), which is currently under construction in China. Key aspects of the UK HPR1000 preliminary safety case related to Radioactive Waste Management, Decommissioning and Spent Fuel Management, as presented in the PSR, its supporting references and the supplementary documents submitted by the RP, can be summarised as follows:

<u>Radioactive waste management</u>

- Application of the principles of prevention and minimisation of the generation of radioactive waste in the design, based on Relevant Good Practice for Pressurised Water Reactors and consideration of the waste hierarchy.
- The definition of systems in the design for the management of gaseous, liquid and solid wastes based on the principle of segregation of wastes, taking account of the physical, chemical and radiological characteristics of the waste streams that will arise as a result of operation of the UK HPR1000.
- The RP's plan to produce a radioactive waste management strategy during Step 3, which will cover the lifecycle of radioactive wastes from generation to disposal.

Decommissioning

- The design of the UK HPR1000 is intended to facilitate safe decommissioning at the end of its operational life.
- The initial definition of a decommissioning strategy consistent with UK Government policy and regulatory expectations.
- The plan to produce a Preliminary Decommissioning Plan during Step 3.

Spent Fuel Management

- Recognition of the key safety functional requirements for a Spent Fuel Interim Storage (SFIS) facility, namely decay heat removal, reactivity (criticality control), containment and shielding, and the commitment to reduce risks associated with spent fuel management to as low as reasonably practicable (ALARP).
- Recognition of the need to package and store spent fuel in a way that does not foreclose its final disposal, a key difference from Chinese practice where fuel is reprocessed. This is consistent with UK Government policy.
- Preliminary identification of different technology options for the SFIS, noting selection of a preferred option will take place in a later step of the GDA process.

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety case related to Radioactive Waste Management, Decommissioning and Spent Fuel Management I have identified the following areas of strength:

Radioactive waste management

- Recognition of the need to manage radioactive wastes across their lifecycle.
- Useful preliminary information on the prevention and minimisation of radioactive waste in areas such as fuel design and use, minimisation of radioactivity in the reactor core, materials selection and control of water chemistry in the primary circuit.

Decommissioning

- Good awareness of international guidance and the need to draw on operational experience and good practice from similar reactors.
- Explicit recognition of the need for the design to facilitate safe decommissioning to reduce risks to ALARP.

Spent Fuel Management

- Preliminary consideration of the benefits and detriments of the main technology options for the SFIS facility, in the context of the need to demonstrate relevant risks are reduced to ALARP at the appropriate stage of its development.
- Good awareness of international practices in long term management of spent fuel.

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety case related to Radioactive Waste Management, Decommissioning and Spent Fuel Management I have identified the following areas that require follow-up:

- The UK HPR1000 Reference Plant design described in the PSR does not fully align with UK practices for radioactive waste management, particularly in respect of solid wastes. Whilst the RP has identified differences or gaps between UK and Chinese practices, there is a lack of clarity on the work that will be carried out to address them, which needs to be addressed in a robust underpinned radioactive waste management strategy. The RP needs to provide further information on this strategy and the impact of any changes necessary on the generic design of the UK HPR1000 in terms of systems, processes and facilities/buildings. The RP also needs to provide a clear demonstration that the risks associated with radioactive waste management will be ALARP. A

Regulatory Observation is being drafted to follow this up in Steps 3 and 4 of the GDA process.

During my GDA Step 2 assessment, I have not identified any fundamental safety shortfalls in the areas of Radioactive Waste Management, Decommissioning and Spent Fuel Management that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique(s)
BMS	Business Management System
BSL	Basic Safety Level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
CGN	China General Nuclear Power Corporation
DAC	Design Acceptance Confirmation
EA	Environment Agency
EDF	Électricité de France
FCG3	Fangchenggang3
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GNI	General Nuclear International
GNS	Generic Nuclear System Ltd
GSR	Generic Security Report
HAW	Higher Activity Waste
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IWS	Integrated Waste Strategy
JPO	(Regulators') Joint Programme Office
LLW	Low-Level Waste
NDA	Nuclear Decommissioning Authority
NPP	Nuclear Power Plant
OECD/ NEA	Organisation for Economic Cooperation and Development/Nuclear Energy Agency
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PCSR	Pre-construction Safety Report

PCER	Pre-construction Environmental Report
PSR	Preliminary Safety Report (includes security and environment)
PWR	Pressurised Water Reactor
RGP	Relevant Good Practice
RI	Regulatory Issue
RIA	Regulatory Issue Action
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party
RQ	Regulatory Query
RWM	Radioactive Waste Management Limited
SAP(s)	Safety Assessment Principle(s)
SSCs	Structures, Systems and Components
SFA	Spent Fuel Assembly
SFAIRP	So far as is reasonably practicable
SFIS	Spent Fuel Interim Storage
SFP	Spent Fuel Pool
TAG	Technical Assessment Guide(s)
TSC	Technical Support Contractor
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1. The Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. General Nuclear System Ltd (GNS) has been established to act on behalf of the three joint requesting parties (China General Nuclear Power Corporation (CGN), Électricité de France (EDF) and General Nuclear International (GNI)) to implement the GDA of the UK HPR1000 reactor. For practical purposes GNS is referred to as the 'UK HPR1000 GDA Requesting Party'.

2. During Step 1 of GDA, which is the preparatory part of the design assessment process, the RP established its project management and technical teams and made arrangements for the GDA of the UK HPR1000 reactor. Also, during Step 1 the RP prepared submissions to be assessed by ONR and the Environment Agency (EA) during Step 2.

3. Step 2 commenced in November 2017. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's assessment of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR permitting the construction of a power station based on the generic design.

4. My assessment has followed my GDA Step 2 Assessment Plan for Radioactive Waste Management, Decommissioning and Spent Fuel Management (Ref. 1) prepared in October 2017 and shared with GNS to maximise openness and transparency.

5. This report presents the results of my Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment of the UK HPR1000 as presented in the UK HPR1000 Preliminary Safety Report (PSR) (Refs 2 and 3) and its supporting documentation (Refs 4, 5, 6).

2 ASSESSMENT STRATEGY

6. This section presents my strategy for the GDA Step 2 assessment of the Radioactive Waste Management, Decommissioning and Spent Fuel Management aspects of the UK HPR1000 (Refs 2 and 3). It also includes the scope of the assessment and the standards and criteria I have applied.

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

7. The objective of my GDA Step 2 assessment was to assess relevant design concepts and claims made by the RP related to Radioactive Waste Management, Decommissioning and Spent Fuel Management. In particular, my assessment has focussed on the following:

Radioactive Waste Management

- How the RP is addressing ONR's fundamental expectations relating to radioactive waste management as set out in the relevant SAPs and TAGs;
- How the RP is approaching the demonstration that relevant risks have been, or are capable of, being reduced to ALARP for radioactive waste management;
- The strategy for radioactive waste management across the lifecycle of the UK HPR1000 and its compatibility with UK waste management practices and infrastructure;
- Identifications of gaps and/or differences between the design for the UK HPR1000, based on practices in China, and UK practices for radioactive waste management;
- Accumulation and storage of radioactive waste.

Decommissioning

- Decommissioning strategy and plan;
- Design for decommissioning;
- Consistency with UK Government policy on decommissioning
- How the RP is approaching the demonstration that relevant risks have been, or are capable of, being reduced to ALARP for decommissioning.

Spent fuel management

- The scope of GDA as it relates to the management of spent fuel after removal from the Spent Fuel Pool following short-term cooling;
- Identifications of gaps and/or differences between the design for the UK HPR1000, based on practices in China, and UK practices for spent fuel management;
- Management of spent fuel across its lifecycle to planned final disposal;
- Consistency with UK Government policy on spent fuel management;
- How the RP is approaching the demonstration that relevant risks have been, or are capable of, being reduced to ALARP for the long-term storage of spent fuel.

8. During GDA Step 2 I have also evaluated whether the safety claims related to Radioactive Waste Management, Decommissioning and Spent Fuel Management are supported by a body of technical documentation sufficient to allow me to proceed with GDA work beyond Step 2.

9. Finally, during Step 2 I have undertaken the following preparatory work for my Step 3 assessment:

- Undertaking a coarse review of a preliminary version of the RP's Pre-construction Safety Report for the UK HPR1000.
- Engagement with the RP on the planned body of technical documentation to support the safety claims related to Radioactive Waste Management,

Decommissioning and Spent Fuel Management. This will enable me to develop a Step 3 Assessment Plan.

- Drafting of a Regulatory Observation (RO) to address the main areas, in the radioactive waste management topic, that I consider need follow-up and enhanced regulatory scrutiny, in future steps of GDA, identified as a result of my assessment during Step 2.

2.2 Standards and Criteria

10. For ONR, the primary goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of a preliminary nuclear safety and security case for the reactor technology being assessed. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide NS-PER-GD-014 (Ref. 7).

11. In addition, the Safety Assessment Principles (SAPs) (Ref. 8) constitute the regulatory principles against which duty holders' and RP's safety cases are judged. Consequently the SAPs are the basis for ONR's nuclear safety assessment and have therefore been used for the GDA Step 2 assessment of the UK HPR1000. The SAPs 2014 Edition are aligned with the International Atomic Energy Agency (IAEA) standards and guidance.

12. Furthermore, ONR is a member of the Western European Nuclear Regulators Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.

13. The relevant SAPs, IAEA standards and WENRA Safety Reference Levels are embodied and expanded on in the Technical Assessment Guides (TAGs) on Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites, Decommissioning and Safety Aspects Specific to Storage of Spent Nuclear Fuel) (Ref. 9). These guides provide the principal means for assessing the Radioactive Waste Management, Decommissioning and Spent Fuel Management aspects in practice.

2.2.1 Safety Assessment Principles

14. The key SAPs (Ref. 8) applied within my assessment are SAPs RW.1 – RW.7 (radioactive waste management), DC.1 – DC.6 (decommissioning), ENM.1, 3 and 5 - 7 (control of nuclear matter, relevant to spent fuel management) and ECV.1, 2, 3, 4, 6 and 7 (containment and ventilation where relevant to this topic area) (see also Table 1 for further details).

2.2.2 Technical Assessment Guides

15. The following Technical Assessment Guides have been used as part of this assessment (Ref. 9):

- NS-TAST-GD-005 Revision 8 (Guidance on the demonstration of ALARP);
- NS-TAST-GD-024 Revision 5 (Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites);
- NS-TAST-GD-026 Revision 4 (Decommissioning); and
- NS-TAST-GD-081 Revision 2 (Safety Aspects Specific to Storage of Spent Nuclear Fuel)

2.2.3 National and International Standards and Guidance

16. The following national and international standards and guidance have been considered as part of this assessment:

- Relevant IAEA standards (Ref. 10):
  - IAEA Fundamental Safety Principles: Safety Fundamentals SF-1, IAEA, Vienna, 2006;
  - General Safety Requirements Part 5: Predisposal management of radioactive waste, No. GSR Part 5, IAEA, Vienna, 2009;
  - General Safety Requirements Part 6: Decommissioning of Facilities, No. GSR Part 6, IAEA, Vienna, 2014Specific Safety Guide No.15 Storage of Spent Nuclear Fuel, SSG-15, IAEA, Vienna 2012;
  - Specific Safety Guide No.40 Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors, SSG-40, IAEA, 2016;
  - Storage of Radioactive Waste, Safety Guide, WS-G-6.1, IAEA, Vienna, 2006;
  - Decommissioning of Nuclear Power Plants and Research Reactors. Safety Guide WS-G-2.1, IAEA Vienna, 1999;
  - Design Lessons Drawn from the Decommissioning of Nuclear Facilities, IAEA-TECDOC-1657, IAEA, Vienna, 2011.
- WENRA references (Ref. 11):
  - Safety Reference Levels for existing reactors, WENRA, September 2014;
  - Reactor Harmonisation Working Group report on Safety of new NPP designs, WENRA, March 2013;
  - WENRA Report on Treatment and Conditioning Safety Reference Levels, 2018;
  - Decommissioning Safety Reference Levels, version 2.2, WENRA, 2015;
  - Waste and Spent Fuel Storage Safety Reference Levels, version 2.2, WENRA, 2014.
- Other national standards (Ref. 12)
  - The management of higher activity radioactive waste on nuclear licensed sites - Joint guidance from the Office of Nuclear Regulation, the Environment Agency, the Scottish Environment Protection Agency and Natural Resources Wales to nuclear licensees, Revision 2, February 2015.

2.3 Use of Technical Support Contractors

17. During Step 2 I have not engaged Technical Support Contractors (TSCs) to support the assessment of Radioactive Waste Management, Decommissioning and Spent Fuel Management for the UK HPR1000.

2.4 Integration with Other Assessment Topics

18. Early in GDA, I recognised the importance of working closely with other inspectors (including Environment Agency's assessors) as part of the Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment process. Similarly, other inspectors sought input from my assessment of the Radioactive Waste Management, Decommissioning and Spent Fuel Management for the UK HPR1000. I consider these interactions are key to the success of the project in order to prevent or mitigate any gaps, duplications or inconsistencies in ONR's assessment. From the start of the project, I have endeavoured to identify potential interactions between the Radioactive Waste Management, Decommissioning and Spent Fuel Management and

other technical areas, with the understanding that this position will evolve throughout the UK HPR1000 GDA.

19. The key interactions I have identified are:

- Chemistry: provides input to the aspects of the Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment primarily relating to the minimisation of radioactive waste at source. This formal interaction has commenced during GDA Step 2. This work will be led by the Chemistry inspector.
- Fuel and Core: provides input relating to safety aspects of spent fuel management of the Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment. This formal interaction has commenced during GDA Step 2. This work is being led by myself in coordination with the Fuel and Core inspector. Spent Fuel Management is also being managed as a multi-disciplinary topic because aspects of spent fuel management is also of relevance to the Fault Studies, Severe Accident Analysis, Chemistry, Radiation Protection, Mechanical Engineering, Structural Integrity and Internal Hazards topic areas as well as to the Environment Agency.
- The Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment provides input to the containment and ventilation aspects and decommissioning aspects of the mechanical engineering assessment. This formal interaction has not commenced during GDA Step 2 but the interaction has been recognised. This work will be led by the Mechanical Engineering inspector.
- A number of aspects of the Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment are of interest to the Environment Agency's assessors. There are common interests in the minimisation of radioactive wastes across the lifecycle of the UK HPR1000, the management of higher activity radioactive wastes and spent fuel and the radioactive waste management strategy. I have engaged jointly with the Environment Agency throughout Step 2 and will continue to do so in future steps of GDA.
- There are areas of common interest between this topic area and Radiation Protection, relating to the minimisation of radiation doses to workers during activities relating to Radioactive Waste Management, Decommissioning and Spent Fuel Management.
- In addition there will be other interactions between this topic area and others as GDA proceeds. Examples include Civil Engineering, Conventional Health and Safety and Human Factors, particularly in relation to Decommissioning.

3 REQUESTING PARTY'S SAFETY CASE

20. During Step 2 of GDA the RP submitted a PSR and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. This section presents a summary of the RP's preliminary safety case in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management. It also identifies the documents submitted by the RP which have formed the basis of my Radioactive Waste Management, Decommissioning and Spent Fuel Management assessment of the UK HPR1000 during GDA Step 2.

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

21. The aspects covered by the UK HPR1000 preliminary safety case in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management can be broadly grouped under three headings which can be summarised as follows:

- Radioactive Waste Management: The main aspects covered include:
  - Claims that the general plant design and operational envelope limit the requirement to move nuclear matter, the plant design and operations limit (in terms of quantity and activity) the creation of radioactive waste and that Best Available Techniques (BAT) will be adopted for the managing, sampling/ monitoring, handling and storage/disposal of waste (including spent fuel) to limit the impact on the environment.
  - The planned development of a radioactive waste management strategy to reduce risks, so far as is reasonably practicable (SFAIRP) and address UK regulatory guidance, including expectations set out in the relevant SAPs and the need for consistency with UK Government policy;
  - Optimisation of radioactive waste management to ensure the safety and protection of the public, workers and the environment;
  - Consideration of radioactive waste management across the full lifecycle from generation to disposal, including recognition of the possible need for long term storage of some wastes prior to disposal;
  - Development of the inventory of radioactive waste volumes and activities, timescales of arisings and arrangements for storage, packaging, transport and disposal of spent fuel, operational and decommissioning wastes;
  - The objective of minimising radioactive waste arisings through application of the waste management hierarchy and use of waste reduction and activity abatement methods;
  - Characterisation and segregation of radioactive wastes to ensure their safe and effective management;
  - Processing of wastes into a passively safe state and storage in a passively safe condition;
  - Compatibility of waste packages with UK storage, handling, retrieval, transport and disposal requirements and seeking the necessary approvals for disposals;
  - Recording and preserving the information needed for the safe management of radioactive waste.
- Decommissioning: The main aspects covered include:
  - The claim that the generic design of the UK HPR1000 can be safely and effectively decommissioned at the end of its operational life;

- The claim that the design, intended construction and operation, and decommissioning of the UK HPR1000 will be developed to reduce, so far as is reasonably practicable, the impact on the workers, the public and the environment;
- Design for safe decommissioning, where the design facilitates decommissioning and minimises waste generation. Information is presented on aspects of design such as materials selection to minimise activation and facilitate decontamination, control of coolant chemistry to minimise the migration and deposition of activation and corrosion products, and optimisation of the design and layout of systems, equipment and buildings to facilitate decontamination and dismantling;
- The plan to prepare a decommissioning strategy that will be integrated with other relevant strategies;
- The plan to prepare a decommissioning plan which rigorously justifies the proposed timing of decommissioning and identifies the various stages of decommissioning and their associated activities. This plan is expected to be maintained to reflect developments in technologies and techniques during the lifetime of the UK HPR1000. This will ensure that the decommissioning methods will be safe and can protect the workers, public and the environment by reducing risks to ALARP and where BAT are applied to minimise waste arisings.
- Consideration of the two main decommissioning strategies of immediate and deferred dismantling and the factors relevant to making a decision on the timing of decommissioning. This includes a recommendation that immediate dismantling is feasible and is the preferred strategy for the UK HPR1000;
- Safe management of the different categories of waste produced during decommissioning and minimisation of wastes by means such as decontamination, controlled dismantling techniques, contamination controls, sorting and segregation of wastes and application of the waste management hierarchy.
- Application of operational experience (OPEX) feedback to draw upon good practices in similar reactors and to take account of good practices from organisations such as IAEA, WENRA and the Organisation for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA).

■ Fuel Storage: The main aspects covered include:

- Recognition of the need for safe management of the Spent Fuel Assemblies (SFAs) until final disposal and to reduce the associated risks to ALARP;
- Definition of the fundamental safety functions for spent fuel storage, namely of control of criticality (reactivity), heat removal, containment (confinement) of radioactive material and shielding against radiation;
- A three-phase approach to management of SFAs of initial short term storage in the Spent Fuel Pool (SFP) to allow removal of decay heat and decay of short-lived radionuclides, followed by interim storage in the Spent Fuel Interim Storage (SFIS) facility on-site and retrieval for final disposal after interim storage, with repackaging of SFAs if necessary;
- Consideration of requirements for long term management of spent fuel, including general requirements (e.g. operational lifetime, inspection and maintenance) and those specific to the SFAs, the Fuel Building, security and final disposal;
- Presentation of preliminary information on the two main technology options for long-term interim storage of spent fuel, namely wet and dry

storage, taking account of the key safety functional requirements identified above. The decision on the preferred technology option has not been made during Step 2 of GDA.

3.2 Basis of Assessment: RP's Documentation

22. The RP's documentation that has formed the primary basis for my GDA Step 2 assessment of the safety claims related to the Radioactive Waste Management, Decommissioning and Spent Fuel Management aspects of the UK HPR1000 is presented in Refs 2 and 3. I raised a total of eight Regulatory Queries (RQs) as a result of assessment of Refs 2 and 3 and assessed the responses to them. I also assessed Refs 4 (GDA Scope Report), 5 (ALARP Methodology) and 6 (ALARP and BAT – Principles and Requirements for UK HPR1000 GDA) which are supporting documents to the PSR.

23. In addition, during April 2018 the RP submitted to ONR, for information, an advance copy of the UK HPR1000 PCSR. Chapters 23, 24 and 29 (Ref. 13) addresses Radioactive Waste Management, Decommissioning and Spent Fuel Management, respectively. Despite the PCSR not forming part of the basis of assessment for Step 2 of GDA, having early visibility of the scope and content of this chapter/s has been useful in the planning and preparation of my GDA Step 3 assessment work.

4 ONR ASSESSMENT

24. This assessment has been carried out in accordance with HOW2 guide NS-PER-GD-014, “Purpose and Scope of Permissioning” (Ref. 7).

25. My Step 2 assessment work has involved regular engagement with the RP’s Radioactive Waste Management, Decommissioning and Spent Fuel Management specialists. This has included one Technical Exchange Workshop (in China) and two other face-to-face progress meetings have been held. IN addition, I have also held bi-weekly progress update meetings by telephone and I have also visited:

- The Daya Bay nuclear base where I was able to briefly view a solid radioactive waste management facility broadly similar to that planned for FCG3, for the management of low-level and intermediate level waste (LLW and ILW).

26. During my GDA Step 2 assessment, I have identified some gaps in the documentation formally submitted to ONR. Consistent with ONR’s Guidance to Requesting Parties (Ref. 14), these normally lead to Regulatory Queries (RQs) being issued. At the time of writing my assessment report, in Radioactive Waste Management, Decommissioning and Spent Fuel Management, during Step 2, I have raised eight RQs to facilitate my assessment, of which seven are relevant to this assessment report.

27. Similarly, and again consistent with ONR’s Guidance to Requesting Parties (Ref. 14), more significant shortfalls against regulatory expectations in the generic safety case are captured by issuing Regulatory Observations (ROs). In response to some of the information received relatively late during ONR’s Step 2 assessment reporting period one RO was being drafted in parallel with the production of my assessment report.

28. The Assessment Plan for these technical areas (Ref.1) assumed that work would be carried out to assess whether claims related to this topic area are supported by a body of detailed technical documentation sufficient to allow GDA work beyond Step 2. Engagement with the RP prior to commencement of Step 2 had indicated an initial intention to produce a small number of documents supporting the PSR during Step 2, based on preliminary identification by the RP of potential gaps between the UK context and Chinese practices in this topic area. The RP did not produce any additional submissions in this topic area beyond Refs 2 and 3 during Step 2 and has not yet formally issued information setting out the necessary body of planned detailed technical information for inclusion in the Master Document Submission List.

29. As set out in the Guidance to RPs (Ref. 14), one of ONR’s tasks during Step 2 is to identify any matters that might be in conflict with UK Government policy. UK policy relevant to this topic area is set out in the Funded Decommissioning Programme Guidance for New Nuclear Power Stations (Ref.15). Chapters 23 and 24 of the PSR (Refs 2 and 3) indicated some practices in China expected for FCG3 (e.g. reprocessing of spent nuclear fuel) that are not consistent with the assumptions set out in Ref.15. I therefore raised RQ-UKHPR1000-0045 (Ref.16) to seek information on how the RP would demonstrate consistency with the assumptions in Ref.15 and to clarify whether there were any significant differences relating to radioactive waste management, decommissioning and spent fuel management.

30. The RP’s response provided evidence that it is fully aware of the requirements of UK Government policy, identifying two significant differences. One relates to the storage of radioactive waste prior to disposal and the other to the reprocessing of spent nuclear fuel. In China both LLW and ILW are stored on site for 5 years prior to disposal, whereas in the UK LLW is removed as soon as reasonably practicable and ILW is stored pending availability of the Geological Disposal Facility (GDF). UK Government policy assumes that spent fuel from new nuclear power stations will not be reprocessed, instead being stored prior to disposal in the GDF. The RP indicated that

the UK HPR1000 would be developed and modified to ensure compliance with UK Government policy in these areas. I was therefore content with the response to the RQ.

31. I sought further information from the RP on gaps and differences, initially by means of RQ-UKHPR1000-0044 (Ref.16) and subsequently by RQ-UKHPR1000-0107 (Ref.16). I asked the RP to address this specific aspect in the technical engagements in China. The RP provided further information, by means of the responses to RQ-UKHPR1000-0108 (Ref.16) and RQ-UKHPR1000-0107 (Ref.16). The theme of gaps and differences between Chinese and UK practices is assessed in more detail in the following sub-sections of my report.

32. During Step 2 the RP produced an ALARP methodology (Ref.5) and a document on principles and requirements for ALARP and BAT for the UK HPR1000 GDA (Ref.6). These documents are intended to set out nuclear safety and environmental principles, holistic ALARP and BAT requirements and present an overview of the holistic processes to be applied in developing an optimised UK HPR1000 generic design, and adequate safety case, as GDA progresses.

33. Details of my GDA Step 2 assessment of the UK HPR1000 preliminary safety case in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management, including the conclusions I have reached, are presented in the following sub-sections of the report. This includes the areas of strength I have identified, as well as the items that require follow-up during subsequent Steps of the GDA of UK HPR1000.

4.1 Radioactive Waste Management

4.1.1 Assessment of PSR Chapter 23

34. The scope of Chapter 23 of the PSR (Ref. 2) includes both radioactive waste management and fuel storage. This sub-section addresses radioactive waste management. My assessment of spent fuel management is presented in a separate sub-section for the purpose of clarity.

35. In the first instance I assessed Ref. 2 against the expectations for radioactive waste management set out in the relevant SAPs (primarily but not exclusively SAPs RW.1 – RW.7 on radioactive waste management but also ECV.1, 2, 3, 4, 6 and 7 on containment and ventilation, at a high level). The expectations for radioactive waste management include:

- the production of a radioactive waste management strategy;
- the prevention and minimisation of the creation of radioactive waste;
- the minimisation of accumulation of radioactive waste;
- characterisation and segregation;
- safe storage;
- the systematic and progressive reduction of hazards and storage of radioactive waste in a passively safe condition; and
- the need to record and preserve information for safe management.

36. I was also seeking information on whether there were appropriate claims relating to reducing risks to ALARP in this technical area.

37. The information presented in Chapter 23 of the PSR (Ref.2), including the three main claims described in Section 3.1, addresses some but not all of these expectations. There are gaps relating to the minimisation of the accumulation of radioactive waste and limited information on the storage of radioactive waste, noting that long-term storage of Higher Activity Waste is necessary in the UK because there is no disposal

route, pending the availability of a GDF. As previously noted, these are some of the key differences between UK and Chinese radioactive waste management practices, which could have a significant impact on the UK HPR1000 generic design. On this basis I raised RQ-UKHPR1000-0046 (Ref.16) to seek information on how and where the RP's claims and sub-claims address/will address ONR's expectations for radioactive waste management (and spent nuclear fuel), with an emphasis on demonstrating safe accumulation and storage.

38. In the response to RQ-UKHPR1000-0046 the RP acknowledged that Chapter 23 of the PSR (Ref.2) did not adequately address ONR's standards, guidance and expectations for radioactive waste management, in this regard. The RP indicated that the expectations of all relevant SAPs will considered during their production of the PCSR and the Pre-Construction Environmental Report (PCER), which contains a summary of the necessary information which forms the basis of making the environmental case for the design, during Steps 3 and 4. This important information was omitted from the PSR and was not provided in the response to RQ-UKHPR1000-0046 either, which provided a commitment to fill the gap at a later date.

39. The RP's response did not describe what additional information will be provided to supplement the contents of the PCSR/PCER, other than to state "mapping" of the relevant SAPs to the chapters is under development. For Step 2 of GDA, in the radioactive waste management topic, this represents a significant gap in the information provided by the RP. Despite raising RQs to address this, the persistence of the gap throughout Step 2 of GDA is one of the factors contributing to the decision to draft an RO in this topic. Further information is presented in Section 4.1.3 below.

40. There was also limited information in Ref. 2 relating to the SAPs on containment and ventilation (ECV.1, 2, 3, 4, 6 and 7), so I have not assessed in detail against a number of these SAPs. However, confinement (containment) of radioactive material, the control of planned radioactive releases, and limitation of accidental radioactive releases are included in the fundamental safety functions of the design described in Chapter 4 General Safety and Design Principles (Ref.17).

41. In Ref. 2 the RP notes that containment and ventilation systems will be provided and that general steps have been taken aimed at minimising leakages from systems and components. The RP notes that collection systems for fluids will take account of leakage in their design. There is more detailed information on containment and ventilation to prevent the leakage and escape of radioactive material and radioactive waste in a number of other chapters of the PSR, including Chapter 7 Safety Systems (Ref.18) and Chapter 10 Auxiliary Systems (Ref.19), which are outside the scope of this topic area assessment.

42. Consideration of containment and ventilation is a matter for a number of technical disciplines. Different aspects of this topic will therefore be assessed by the most relevant technical discipline throughout GDA, and will be captured during the production of Step 3 assessment plans.

43. Ref.2 explicitly recognised that differences exist between "regulation and critical infrastructure" in the UK and China with respect to radioactive waste management (and fuel storage). It also acknowledged that the design of the UK HPR1000 may need to undergo some modification and incorporate additional features to meet UK requirements in reducing risks SFAIRP.

44. As noted above, I sought further information in RQ-UKHPR1000-0044 (Ref.16), firstly on the codes, standards and guidance used to identify the main gaps between the UK context and Chinese practice and secondly on how and why the main gaps were identified and thus the work needed to address them. The RP's response indicated good awareness of relevant UK and international guidance, a view reinforced in my

technical engagements. The RP provided information on the systematic approach taken to identify gaps and make decisions on the mitigation actions. This appears to be logical and based on application of codes, standards, relevant good practice and worldwide operating experience.

45. Whilst I was broadly content with the approach taken to gap identification, the RQ response focused on the methodology rather than the outcome of the application of the process. The RP noted that ongoing analysis would continue throughout the GDA process to identify additional gaps between the UK context and the design of the UK HPR1000 as based on FCG3. This raises some concern as to whether gaps will be identified in a timely manner to enable appropriate modification of the design and safety case to meet the timescales of the GDA process, should this be found to be necessary. I will address this matter in engagement with the RP on preparations for entry to Step 3.

46. The RP provided further information on identified gaps, based on “challenge” of the FCG3 design against the UK context, at the technical engagement in China. It also provided preliminary information on the documents planned to be produced in support of the PCSR and PCER, both of which were provided in the response to RQ-UKHPR1000-0108 (Ref.16). The list of supporting documents addressed the majority of the gaps identified by the RP for radioactive waste management at the time of writing. It also included other important documents such as the Integrated Waste Strategy (IWS) and ALARP assessment for radioactive waste management. I have some concerns about the proposed timing of the production of some of the supporting documents but propose to address this in preparations for Step 3.

47. I consider the gaps/differences identified between UK and Chinese practices in radioactive waste management to be significant, in terms of the potential need for changes to the design of the UK HPR1000 from the reference design of FCG3, most notably relating to the management of solid radioactive wastes (e.g. the requirement for the long term storage of some radioactive wastes on site). This should not be taken as implying that the changes are necessarily significant in terms of the nuclear safety and radiological risks associated with radioactive waste management, which the RP is required to reduce to ALARP.

48. The differences identified emphasised the importance of having a robust radioactive waste strategy to meet the expectations established in the relevant SAP RW.1. I thus raised RQ-UKHPR1000-0107 (Ref.16), seeking information on how the radioactive waste management strategy will be developed to address the key differences between the UK context and Chinese practices, with focus on solid radioactive wastes. I also sought information on how the resulting systems and processes will be incorporated into the generic UK HPR1000 design, and how the RP plans to incorporate the radioactive waste management strategy into the PCSR and its supporting documentation.

49. The RP’s response indicated that it will produce an Integrated Waste Strategy (IWS) document, to be written independently to comply with the UK context rather than evolving from an existing strategy that meets Chinese requirements. This is planned to be available at the beginning of Step 3 of GDA. Some information pertaining to the IWS is presented in the response to RQ-UKHPR1000-0107 (Ref.16) and in Ref. 20. The RP has indicated in technical engagements that it expects to underpin or substantiate the radioactive waste management strategies in the IWS by means of strategic options studies.

50. In the response to RQ-UKHPR1000-0107 the RP presented an example of the application of the methodology to the treatment process for spent ion exchange resins, a waste stream also produced in the operation of the UK’s only operational civil PWR at Sizewell B. The overall approach appeared to be broadly consistent with

optioneering methods typically applied in the UK, noting that the assessment criteria selected need to be relevant to the waste stream and options being considered.

51. Key gaps/differences identified by the RP include:

- management routes for Low Level Waste (LLW);
- the process for treatment of ILW resins;
- the containers to be used for packaging, storing and disposing of ILW; and
- the facility for interim storage of ILW.

52. A number of potential design modifications for the UK HPR1000 have been identified, including of the solid waste management system enabling LLW management, of the handling systems in the Waste Treatment Building to be compatible with UK waste containers, the resins treatment process plant and of the ILW storage facility.

53. I generally concur with the gaps identified by the RP but note that the information provided does not yet address the broader issue of the minimisation of accumulation of radioactive wastes. These include LLW and non-solid wastes (e.g. non-aqueous liquids such as contaminated oils and solvents). As GDA progresses further information will be needed on the availability and adequacy of storage capacity for all radioactive wastes, not just ILW.

54. The RP plans to produce its IWS document based on the structure in the guidance produced by the Nuclear Decommissioning Authority (NDA) (Ref.21), which is aimed at sites in decommissioning. Based on my knowledge and experience of the production and review of IWS documents in the UK, I am not fully confident that the IWS will meet the expectations for a radioactive waste management strategy set out in SAP RW.1. This is because they are typically high level summaries of waste strategies, used as vehicles for communication with stakeholders. The underpinning of justification of the chosen options described in the IWS, by means of strategic options studies and consideration of ALARP (and BAT), will thus be of particular importance. I will address this issue in the RO and also in my engagements with the RP during Steps 3 and 4.

55. In summary, I welcome the progress made by the RP in identifying gaps and differences between UK context and Chinese practice for radioactive waste management and in defining the supporting documentation that will be needed. As is common during GDAs, it is evident there are significant differences between waste management practices in the country in which the reactor technology has been developed (China in this case). The outcome of this Step 2 assessment has clearly demonstrated this will be an important area which requires enhanced regulatory scrutiny. As GDA progresses, I will be seeking the necessary assurances that these gaps/differences will be adequately addressed by the RP in the generic design and safety case for the UK HPR1000. My next steps for this topic are set out in detail in Section 4.1.3 below.

4.1.2 Strengths

56. I consider that the information in Chapter 23 (Ref.2) of the PSR, as summarised in Section 3.1, contained a number of areas I consider to be strengths:

- Application of the principles of prevention and minimisation of the generation of radioactive waste in the design, based on Relevant Good Practice for PWRs. Examples discussed include fuel design and handling, control of the production of radioactivity in the primary circuit through control of coolant (water) chemistry, selection of materials to minimise the production of activation products and in-process monitoring.
- The definition of systems in the design for the management of gaseous, liquid and solid wastes based on the well-established principle of segregation, taking

account of the physical, chemical and radiological characteristics of the waste streams that will arise as a result of operation of the UK HPR1000, based on established good practice for PWRs.

- The RP has shown willingness to consider relevant good practice and operational feedback in developing the radioactive waste management aspects of the UK HPR1000.

4.1.3 Items that Require Follow-up

57. During my GDA Step 2 assessment of Radioactive Waste Management I have identified the following specific shortfalls:

- The claims for radioactive waste management in Chapter 23 of the PSR are not complete. The RP will need to demonstrate that ONR's fundamental expectations for radioactive waste management can be fully met by the design. It is important to ensure all key differences/gaps between the UK context and Chinese radioactive waste management practices are identified and addressed in a robust, underpinned radioactive waste management strategy. The expectation is that this strategy should then be used to directly inform the requirements of the safety case for the UK HPR1000 safety case to demonstrate relevant risks are reduced to ALARP. This, along with other aspects related to the management of solid radioactive waste in the UK HPR1000 generic design, is being taken forward as part of an RO currently being drafted.

58. During my GDA Step 2 assessment of Radioactive Waste Management I have identified the following additional potential shortfalls that I will follow-up during Step 3 of GDA:

- As noted, the claims made in Chapter 23 of the PSR (Ref.2) are not sufficiently complete to demonstrate that ONR's fundamental expectations of aspects such as waste minimisation, the minimisation of accumulation and passive safe storage of radioactive waste are met. Chapter 23 of the PSR appeared to be focused primarily on addressing environmental regulatory expectations for radioactive waste management which, in part, may have contributed to the gaps in addressing ONR's expectations.
- The coarse review of the early draft of PCSR Chapter 23 (Ref.13) indicated that the RP's "system level" approach of high level, relatively non-specific claims in the PCSR would also not adequately address ONR's expectations for radioactive waste management.
- Claims, arguments and evidence relating to radioactive waste management are primarily addressed in the draft PCER and not the PCSR. The RP plans to provide cross-referencing in the PCSR. The balance of information between the safety and environmental cases needs to be such that each of them is fit-for-purpose and standalone in their own right. The RP's proposed approach may not be sufficient to make the ALARP justification expected in the PCSR for these aspects. I will engage with the RP to ensure that the PCSR/PCER makes the necessary claims and arguments relating to radioactive waste management and will be appropriately underpinned by evidence in the body of supporting technical information.

4.1.4 Conclusions

59. Based on the outcome of my Step 2 assessment of Radioactive Waste Management, I have concluded that further work needs to be carried out to ensure that the design of the UK HPR1000 meets UK regulatory expectations relating to radioactive waste management. The RP recognises gaps and differences between the UK context and Chinese practice. The RO in preparation will specifically address targeted aspects of this topic.

60. During Step 2 of GDA the RP has not yet adequately addressed all the relevant principles in the SAPs, most notably on accumulation and storage of radioactive waste. In response to my RQs the RP has acknowledged directly that this is the case. This will also be addressed by the RO. Despite this, for the purpose of the high level assessment carried out at Step 2 of GDA, I consider the RP's progress is adequate. This is because submissions of adequate quality to be provided in response to the RO should provide sufficient information to have confidence that the SAPs are likely to be satisfied as GDA progresses.

4.2 Decommissioning

4.2.1 Assessment of PSR Chapter 24

61. In the first instance I assessed Chapter 24 of the PSR (Ref.3) against the expectations for decommissioning set out in the relevant SAPs (DC.1 – DC.6, noting that SAPs DC.7 – 9 are of limited relevance to GDA). These expectations include:

- design and operation to enable safe decommissioning;
- the production of a decommissioning strategy;
- the justification of continuing safety prior to decommissioning;
- the need for passive safety before any period of care and maintenance (i.e. where decommissioning is deferred); and
- the need to record and preserve information required for decommissioning.

62. I was also seeking information on whether there were appropriate claims relating to reducing risks to ALARP in this technical area.

63. Chapter 24 of the PSR (Ref.3) includes a number of claims that address the key expectations of the decommissioning SAPs relevant to GDA. Most notably it includes design for safe decommissioning, the preparation of a decommissioning strategy and plan and the need to record information. The RP indicated that it is undertaking a thorough review of the HPR1000 design features, from the viewpoint of facilitating decommissioning, during the design stage, taking account of what has been done for FCG3.

64. I sought further information on design for decommissioning from the RP by means of RQ-UKHPR1000-0047 (Ref.16). This included a request for information on how the RP plans to take account of large components such as steam generators and the reactor pressure vessel, because these can present significant challenges in decommissioning. I also sought more information on the method used to review the design features for decommissioning referred to in Chapter 24 of the PSR. The RP's response did not provide sufficient clarity on all my queries so I issued RQ-UKHPR1000-0105 (Ref.15), following the technical engagement in China.

65. The RP's response indicated that the design of the UK HPR1000 takes into consideration the challenges associated with dismantling and removal of large components to minimise relevant risks to ALARP. I was broadly content with the response provided but will expect appropriate supporting evidence to be provided in Steps 3 and 4 of GDA.

66. The UK HPR1000 is a PWR and this reactor type has not been decommissioned in China to date. The UK has only one operating civil PWR, Sizewell B, which is of a different design. As this PWR continues to operate there is therefore no specific experience of decommissioning civil PWRs in the UK (although the UK has extensive experience of decommissioning of a range of nuclear facilities including research and gas-cooled reactors). However, there are a number of PWRs that have been, or are being, decommissioned successfully around the world, so there is relevant OPEX.

67. I sought information on the work being carried out by the RP to seek OPEX for PWR decommissioning in RQ-UKHPR1000-0047 (Ref.16). The RP recognises the need to collect global OPEX and is preparing a research report to be made available for assessment by ONR at a later stage of GDA. I welcome this but do not yet have sufficient clarity as to whether this report will be available on a timescale appropriate to inform the application of the design review method for decommissioning. I will seek further information during preparation for entry to Step 3 of GDA.

68. The RP provided information on the method used to assess the HPR1000 design from the viewpoint of facilitating decommissioning. This involves three stages, two of which are carried out in parallel. The design of FCG3 is assessed against initial design requirements for facilitating decommissioning. In parallel information is collected on UK HPR1000 design requirements for facilitating decommissioning, OPEX and RGP, including international safety standards. The results from Step 1 and 2 of the method will be used to assess the design with respect to facilitating decommissioning. The RP has indicated that a supporting document relating to evaluation of consistency of the design in facilitating decommissioning will be produced early in Step 3 of GDA and will be available for assessment by ONR.

69. The RP needs to provide adequate evidence to support the key claim of design for safe decommissioning made in Chapter 24 of the PSR (Ref.3). This will be an area of focus in this technical area for Step 3 of GDA. I welcome the recognition of its importance by the RP during Step 2 of GDA.

70. Chapter 24 of the PSR (Ref.3) provides information on the RP's decommissioning strategy and decommissioning plan. These will be key deliverables for ONR's assessment in Step 3 of GDA. The timing of decommissioning is a key factor for both of these deliverables. Chapter 24 of the PSR (Ref.3) describes the two main options of immediate and deferred dismantling, both of which are considered to be technically feasible and are recognised in international guidance on decommissioning. The RP has identified immediate dismantling as the preferred option for the UK HPR1000, noting the decision on the timing of decommissioning will be made and justified by the future operator. The assumption of immediate dismantling is consistent with UK Government policy (as set out in Ref.15). Further information will be presented in Step 3 of GDA. I am therefore broadly content with the information presented in these areas during Step 2 of GDA.

71. Overall, on the basis of my assessment, I consider that the RP has made appropriate claims, for this stage of GDA, relevant to the demonstration of ALARP with respect to decommissioning.

4.2.2 Strengths

72. I consider that the information in Chapter 24 of the PSR (Ref.3), as summarised in Section 3.1, contained a number of areas I consider to be strengths:

- The claim that the generic design of the UK HPR1000 is intended to facilitate safe decommissioning at the end of its operational life and the RP's plan to review the design with the intent of facilitating decommissioning;
- The initial definition of a decommissioning strategy to be consistent with UK Government policy and regulatory expectations;
- The commitment to produce a Preliminary Decommissioning Plan;
- The recognition of the importance of decommissioning OPEX;
- Recognition of the importance of waste management in decommissioning.

73. More generally the RP has shown good awareness of RGP and international guidance on decommissioning. Although not formally a part of the basis of my Step 2 assessment, early review of the PCSR indicated that the claims and sub-claims for

decommissioning are relevant and appropriate, and broadly consistent with relevant SAPs for decommissioning and radioactive waste management. I was pleased to see that the RP has appears to have undertaken preliminary identification of major hazards during decommissioning and appears to have suggested a number of possible mitigation measures in the PCSR. This is of benefit in building confidence in the direction of travel in this topic area, as GDA progresses.

4.2.3 Items that Require Follow-up

74. During my GDA Step 2 assessment of Decommissioning I have not identified any specific shortfalls.

75. During my GDA Step 2 assessment of Decommissioning I have identified the following additional potential shortfalls that I will follow-up during Step 3 of GDA:

- For Step 2, Whilst I am broadly content with the claims and sub-claims, I will seek further information during preparation for Step 3 on how the RP plans to substantiate them by means of arguments and evidence and how this will be addressed in the PCSR and its supporting documentation, as this is not yet clear, particularly on design for safe decommissioning.

4.2.4 Conclusions

76. Based on the outcome of my Step 2 assessment of Decommissioning, I have concluded the RP has adequately addressed the relevant principles in the SAPs appropriate to Step 2 of GDA, and that sufficient information has been provided to have confidence that the SAPs are likely to be satisfied as GDA progresses.

4.3 Spent Fuel Management

4.3.1 Assessment of Chapter 23

77. Chapter 23 of the PSR (Ref.2) provides information on fuel route operations and the interim storage of spent fuel in the SFIS. After removal from the reactor SFAs will be temporarily stored in the Spent Fuel Pool (SFP) to allow cooling and decay of short-lived radionuclides, before transfer to the SFIS for long-term storage prior to eventual disposal in the GDF. It is currently assumed that the SFIS will have an operating lifetime of 100 years, and will remain on the site long after the reactor has stopped operating.

78. The capacity of the SFP to store SFAs is such (11 refuelling cycles) that it is not necessary for the SFIS to be in place and operational at the start of reactor operations. It is thus not essential to make detailed decisions on the design of the SFIS during GDA. A future operator may wish to implement an alternative technology option. It is important for the GDA process to provide sufficient information for ONR to undertake a meaningful assessment, whilst demonstrating the UK HPR1000 generic design will not unduly constrain the choices a future operator may wish to make. The RP has provided information in Chapter 23 of the PSR (Ref.2), which describes the overall spent fuel management strategy and high-level design and safety requirements for the SFIS.

79. In the first instance I assessed Chapter 23 of the PSR (Ref. 2) against the expectations for Spent Fuel Management set out in the relevant SAPs. There are no specific SAPs for spent nuclear fuel but nuclear fuel is defined as nuclear matter under the Nuclear Installations Act 1965 (as amended). I thus assessed against the SAPs for control of nuclear matter, the most relevant of which to GDA are ENM.1 (strategies for managing nuclear matter), ENM. 3 (Transfers and accumulation of nuclear matter), ENM.5 (characterisation and segregation), ENM.6 (storage in a condition of passive safety)

and ENM.7 (retrieval and inspection of stored nuclear matter). I have also taken due cognisance of the relevant radioactive waste management SAPs (RW. 1 – 7), noting that these may apply when nuclear matter is designated as radioactive waste. It is assumed that the spent fuel will be disposed of in the GDF, but the timing of any declaration of spent fuel as radioactive waste is a decision for a future operator of the UK HPR1000. The assumption that spent fuel will be stored on site pending future disposal in the GDF is consistent with UK government policy on this topic.

80. I have also assessed against the TAG on safety aspects specific to storage of spent nuclear fuel (Ref. 9). I concluded that the design of the SFIS is not yet at a stage of development where meaningful assessment against this TAG can be carried out.

81. Chapter 23 of the PSR (Ref.2) provides an overview of the two main technology options for SFIS facilities, namely wet and dry storage. The overview includes their main features and how they address the key safety functional requirements for spent fuel including: cooling, control of reactivity (criticality), containment (confinement) and shielding. I requested information on interim storage of spent fuel presented in technical engagements with the RP by means of RQ-UKHPR1000-0108 (Ref.16). Information provided in the response to the RQ also addressed the key principle of retrievability. These five key requirements are consistent with those set out in international safety guidance for storage of spent fuel. Chapter 23 of the PSR (Ref.2) indicated that the RP has good awareness of international practices for interim storage of spent fuel. It also included preliminary information on the advantages and disadvantages of the available technology options, in the context of the key safety functional requirements.

82. The RP has indicated it would complete the assessment of the two main technology options during Step 2, with a view to including a selected technology option in the PCSR during Step 3, including a preliminary assessment to demonstrate that relevant risks can be reduced to ALARP.

83. Further information on the scope of interim storage of spent fuel in GDA has been provided in the Scope Report (Ref. 4), provided during Step 2. This indicated that the RP intends the scope of SFIS to be limited and high-level, and that a site-specific solution will be capable of demonstrating that risks will be ALARP in the future. The RP does not wish to preclude adoption of other technology options, if needed. Transport of spent fuel to the GDF is out of scope of GDA, which I consider to be a reasonable assumption.

84. At present the RP has excluded design information for the SFIS from the scope of GDA. It excludes aspects such as concept design, identification of operations and associated limits and conditions, fault analysis and probabilistic safety assessment. It also excludes detailed assessment of the impacts of the SFIS on the generic site and other structures, systems and components (SSCs), such as the Fuel Building and fuel design criteria.

85. The currently proposed scope may not be sufficient to allow ONR to complete a meaningful assessment of SFIS for GDA and ultimately issue a Design Acceptance Certificate (DAC) as set out in the Guidance to Requesting Parties (Ref.14), insofar as it relates to the SFIS. The scope of GDA does not need to be fixed until the end of Step 3. Whilst Ref.4 is a useful starting point, ONR expects to have further discussions with the RP on the scope of SFIS and its impacts on the generic site and SSCs during Step 3 of GDA, in order to define the safety assessment work needed to underpin the agreed scope in the GDA process, to enable a meaningful assessment to be carried out. During technical exchanges (Ref.20) the RP has demonstrated a willingness to participate in such discussions, and has acknowledged that aspects of Ref.4 relevant to SFIS may not represent the final agreed scope of work to be delivered. This will be an important area to follow up during Step 3 of GDA.

86. The disposal of spent fuel to the GDF is primarily a matter for the EA, but is one where both regulators work closely together as a matter of joint interest (spent fuel will be stored on site until a disposal route is available). It is important that the future means and manner of storage of spent fuel does not foreclose disposal in the GDF. Chapter 23 of the PSR (Ref.2) indicated that, during GDA, the RP will collect information to enable an assessment of disposability of radioactive wastes and spent fuel to be conducted by Radioactive Waste Management Limited (RWM, the authoritative source of advice on disposal of HAW and spent fuel in England and Wales and the prospective operator of the planned GDF), as expected in the Guidance to Requesting Parties (Ref.14). Both EA and ONR will engage with the RP on the assessment of disposability of radioactive waste and spent fuel during Steps 3 and 4 to ensure that the necessary advice is obtained in a timely manner.

4.3.2 Strengths

87. I consider that the information presented in Chapter 23 of the PSR (Ref.2), as summarised in Section 3.1, contained a number of areas I consider to be strengths:

- A preliminary consideration of the benefits and detriments of the main technology options for the UK HPR1000 SFIS facility in terms of the key safety functional requirements for storage of spent fuel, in the context of the need to demonstrate relevant risks will be reduced to ALARP at the appropriate stage of its development;
- The RP has demonstrated good awareness of international practices in the long term management of spent fuel.

4.3.3 Items that Require Follow-up

88. During my Step 2 assessment of Spent Fuel Management I have not identified any specific shortfalls.

89. In view of the need for further discussion with the RP on the scope of GDA for Spent Fuel Management, I do not consider it appropriate to identify detailed potential shortfalls that I need to follow up during Step 3 of GDA, other than to note the need for the RP to provide sufficient information to enable ONR to carry out a meaningful safety assessment for the scope that is ultimately decided for this technical area during GDA.

90. The management of spent fuel through its lifecycle from generation in the reactor to long term storage on-site has significant safety implications. There are now a number of SFIS facilities in operation worldwide, including in the UK. Assessment of Spent Fuel Management involves a number of technical disciplines to determine whether the associated relevant risks are reduced to ALARP. ONR will ensure that it takes due account of them by means of a coordinated multi-disciplinary approach to safety assessment of Spent Fuel Management during the remainder of the GDA process. I will also continue to engage jointly with EA on the assessment of disposability of spent fuel, as appropriate.

4.3.4 Conclusions

91. I consider the information presented in Chapter 23 of the PSR (Ref. 2) on Spent Fuel Management addresses the relevant SAPs for the control of nuclear matter (and radioactive waste management) in high-level terms, noting that a decision on the preferred technology option for the SFIS has yet to be made. The spent fuel strategy is consistent with UK Government policy.

92. Based on the outcome of my Step 2 assessment of Spent Fuel Management, I have concluded that the information provided by the RP in Ref. 2 meets the general

expectations of the Guidance to Requesting Parties for Step 2 for Spent Fuel Management.

4.4 ALARP Considerations

4.4.1 Assessment

93. The need to demonstrate that relevant risks are reduced to ALARP is relevant to all ONR technical disciplines and is thus managed by ONR as a cross-cutting issue. ONR's overall consolidated judgement on the adequacy of the ALARP methodology at the current stage of development is presented in the Summary of the Step 2 Assessment of the UK HPR1000 Reactor (Ref.22). However, I am presenting information specific to these technical areas in my Step 2 assessment, because of the need to recognise the interface between ALARP and the EA's regulatory requirement that the RP demonstrates application of BAT, which is of particular relevance in these technical areas.

94. Chapter 23 of the PSR (Ref. 2) clearly recognises the overall UK regulatory requirement to reduce risks, so far as is reasonably practicable (equivalent to reducing risks to ALARP). This is the only reference to ALARP in the context of radioactive waste management in Ref. 2. The need to reduce risks to ALARP is specifically recognised in the information presented on Spent Fuel Management and it is mentioned in various parts of Chapter 24 of the PSR (Ref.3) on Decommissioning.

95. Chapter 23 of the PSR(Ref. 2) sets out the requirements presented in the EA's Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs (the P&ID, Ref. 23), including the demonstration of BAT in the context of radioactive waste management. Ref. 2 includes preliminary BAT assessments for the UK HPR1000. There are no corresponding preliminary ALARP assessments.

96. Some of the information provided in the BAT assessments is directly relevant to the radioactive waste management SAPs and thus to the demonstration of ALARP, particularly the prevention and minimisation of the creation of radioactive waste and the minimisation of solid radioactive waste and spent fuel. However, the RP did not explicitly recognise this relevance in Ref. 2.

97. I sought information on the assessment of ALARP as it relates to Radioactive Waste Management, Decommissioning and Spent Fuel Management throughout Step 2 as discussed above. As noted in Section 4.1.3 I raised RQs seeking more information on the demonstration of ALARP for radioactive waste management, the responses to which did not meet my expectations. As explained above, I am drafting an RO in parallel with the production of this report. This will set out ONR's regulatory expectation that the RP provides appropriate justification that relevant risks associated with managing the radioactive wastes generated by the UK HPR1000 (generic design) are reduced to ALARP.

98. During Step 2 of GDA I have undertaken preliminary assessment of the RP's ALARP Methodology (Ref.5) and the document which sets out ALARP and BAT – Principles and Requirements for the UK HPR1000 GDA (Ref.6). Whilst both Ref.5 and Ref.6 provide information on the ALARP methodology, including the assessment of options in identifying potential improvements, neither provides information on how the RP will select and justify the relevant factors (assessment criteria) it will use in evaluating options. This needs further consideration during Step 3 of GDA, especially as ONR starts to receive and assess examples of the application of the ALARP methodology to justify the safety of the UK HPR1000 generic design.

99. The RP has to demonstrate both ALARP and BAT for the UK HPR1000, which is why it produced Ref.6. ONR's TAG on Guidance on the demonstration of ALARP (Ref.8) recognises the possibility for conflict in the different regulatory application of ALARP and BAT in nuclear safety and environmental protection. The TAG states it is important that, during optioneering studies carried out by the licensee (which equates to the RP in the case of GDA) to establish BAT, that adequate weighting is given to health and safety aspects so that an overall ALARP solution that balances health, safety and environmental aspects is reached in an optimised manner.

100. During technical engagements in Step 2 of GDA it became apparent that the BAT and ALARP methodologies were being developed separately. This could lead to difficulties in balancing safety and environmental factors in making an overall decision on optimisation, especially in radioactive waste management.

101. One of the objectives of Ref.6 was to present an overview of the holistic ALARP and BAT processes to support achieving demonstration of an optimised UK HPR1000 generic design. Preliminary examination indicates that the two processes will be applied separately, depending on whether the identified improvement relates to safety or environmental protection. However, a number of the steps, including optioneering, will include a holistic review of ALARP and BAT where relevant. The RP will need to decide what process to apply for those improvements which may challenge both nuclear safety and environmental protection principles. I consider that decisions relating to radioactive waste management may be likely to fall into this latter category. I will seek further information during Step 3 of GDA on how the BAT and ALARP methodologies are being integrated in practice to reach an optimised and demonstrably robust decision.

4.4.2 Strengths

102. The RP's ALARP and BAT requirements document includes a number of key requirements that meet the expectations of the ALARP TAG (Ref.8), including demonstration of RGP, examination of options, application of risk assessment and the demonstration that all practicable measures have been adopted.

4.4.3 Items that Require Follow-up

103. During my GDA Step 2 assessment of ALARP considerations I have already identified the following specific shortfall relating to demonstration that the risks associated with radioactive waste management are reduced to ALARP.

104. During my GDA Step 2 assessment of ALARP considerations I have identified the following additional potential shortfall that I will follow up during Step 3 of GDA:

- The integration and optimisation of the ALARP and BAT methodologies in the area of radioactive waste management, taking account of the RP's experience of applying the methodologies to key aspects of the UK HPR1000 generic design.

4.4.4 Conclusions

105. Based on the outcome of my Step 2 assessment of ALARP considerations, I have concluded that further work needs to be carried out to ensure that the generic design of the UK HPR1000 meets UK regulatory expectations in demonstrating risks associated with radioactive waste management will be reduced to ALARP.

4.5 Out of Scope Items

106. The following items have been left outside the scope of my GDA Step 2 assessment of the UK HPR1000 Radioactive Waste Management, Decommissioning and Spent Fuel Management.

- Consideration of the Categorisation of safety functions and classification of systems, structures and components, as minimal information was presented on this in Chapters 23 (Ref.2) and 24 (Ref.3) of the PSR. I will consider any relevant information on categorisation and classification and in submissions from the RP as part of my assessment during Step 3 of GDA. This is a cross-cutting topic and is addressed in the Summary of the Step 2 Assessment of the UK HPR1000 Reactor (Ref.22).
- Assessment against SAPs EHT 1, 3 and 4 (Heat Transport Systems) as originally envisaged in the Step 2 Assessment Plan (Ref.1). I left this matter out of the scope of my GDA Step 2 assessment is because there was very limited information on heat transport aspects in the relevant Chapters of the PSR (23 and 24, Refs 2 and 3) and because heat transport is largely dealt with by other assessment technical areas. I will engage on any heat transfer aspects relevant to this topic area as appropriate with other assessment disciplines (e.g. Fuel and Core and Mechanical Engineering, Fault Studies, etc.) during Step 3. This would be most likely to be most relevant to Spent Fuel Management.
- The radioactive waste management SAPs include an expectation to provide information on the management of wastes arising from accidents, which the RP has excluded from the scope of GDA.

107. It should be noted that the above omissions do not invalidate the conclusions from my GDA Step 2 assessment. During my GDA Step 3 assessment I will follow-up the above out-of-scope items as appropriate; I will capture this within my GDA Step 3 Assessment Plan.

4.6 Comparison with Standards, Guidance and Relevant Good Practice

108. In Section 2.2, above, I have listed the standards and criteria I have used during my GDA Step 2 assessment of the UK UKHPR1000 Radioactive Waste Management. Decommissioning and Spent Fuel Management, to judge the adequacy of the preliminary safety case. In this regard, my overall conclusions can be summarised as follows:

- SAPs: The RP has not yet adequately addressed all the relevant principles in the SAPs on Radioactive Waste Management, most notably on waste accumulation and storage. This will be addressed by the RO. On Decommissioning the RP has adequately addressed the relevant principles in the SAPs for this stage in GDA. The information presented on Spent Fuel Management addresses the relevant SAPs for the control of nuclear matter (and radioactive waste management) in high level terms, noting a decision on the preferred technology option for interim storage of spent fuel has yet to be made. The information provided meets the general expectations of the Guidance to Requesting Parties (Ref.14) for Step 2 for Spent Fuel Management. Overall sufficient information has either been provided or I expect to be provided to have confidence that the SAPs are likely to be satisfied in all three technical areas as GDA progresses. Table 1 provides further details.
- TAGs: Broadly the information provided by the RP indicates that the expectations in the relevant TAGs should be met except where noted above, in instances where they do not currently meet the expectations of the SAPs. The design of the SFIS facility is not at a stage of development appropriate to detailed assessment against the TAG for storage of spent nuclear fuel. The

ALARP and BAT methodologies may not yet meet the expectation of adequate integration of safety and environmental considerations.

- Others: The expectations set out in international standards and guidance are largely addressed in the SAPs and TAGs used during this assessment. I am content that the high level safety functional requirements for spent fuel storage are consistent with relevant IAEA Guidance (Ref. 9).

4.7 Interactions with Other Regulators

109. I have worked closely with the EA throughout Step 2, because of the areas of common interest in Radioactive Waste Management, Decommissioning and Spent Fuel Management. All my technical engagements have been carried out jointly with EA. This close working will continue during Steps 3 and 4 of GDA, with the aim of ensuring that the RP receives consistent messages from both regulators.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

110. During Step 2 of GDA the RP submitted a PSR and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. These documents have been formally assessed by ONR. The PSR together with its supporting references present to some extent the claims in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management that underpin the safety of the UK HPR1000.

111. During Step 2 of GDA I have targeted my assessment at the content of the PSR and its references that is of most relevance to the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management; against the expectations of ONR's SAPs and TAGs and other guidance which ONR regards as Relevant Good Practice. From the UK HPR1000 assessment done so far, I conclude the following:

- The RP has recognised the importance of the management of radioactive wastes and spent fuel across their lifecycles from generation to disposal and the principle of design to facilitate safe decommissioning. I conclude that the claims relating to radioactive waste management are not yet complete. I am not yet confident that the RP will articulate reasonable claims in the PCSR for radioactive waste management and underpin them with sufficient arguments and robust evidence.
- I am broadly content with the claims made for decommissioning. I am confident the RP will articulate reasonable claims for decommissioning in the PCSR but not yet confident about the arguments and evidence to be provided to underpin these claims.
- For Spent Fuel Management I conclude the information provided meets the general expectations of the Guidance to Requesting Parties (Ref.14) for Step 2. Further discussions are needed on the scope of the interim storage of spent fuel in GDA and thus of the work needed to enable meaningful assessment to be carried out by ONR as GDA progresses.
- There are important differences between UK practices and the relevant design features incorporated into the UK HPR1000 design with respect to radioactive waste management. There is a lack of clarity on the work that will be carried out to address these differences and the impact of any changes necessary on the generic design of the UK HPR1000, in terms of systems, processes and facilities/buildings and the demonstration of ALARP. I am drafting an RO to follow this up in Steps 3 and 4 of the GDA process.
- Further engagement is needed to ensure that the ALARP and BAT methodologies are appropriately integrated to provide balanced assessment of safety and environmental considerations.
- My understanding of the UK HPR1000 technology is high-level at the moment and is commensurate with the level of detail required to undertaken a meaningful assessment for Step 2. I expect to develop my understanding further as GDA progresses.
- I do not yet have sufficient visibility of the necessary body of planned detailed technical information for this topic area to be able to comment on the adequacy of arguments/evidence likely to be available later in GDA.

112. Overall, during my GDA Step 2 assessment, I have not identified any fundamental safety shortfalls in the area of Radioactive Waste Management, Decommissioning and Spent Fuel Management that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design.

5.2 Recommendations

113. My recommendations are as follows:

- Recommendation 1: ONR should consider the findings of my assessment in deciding whether to proceed to Step 3 of GDA for the UK HPR1000.
- Recommendation 2: All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 Radioactive Waste Management, Decommissioning and Spent Fuel Management Assessment Plan for the UK HPR1000.
- Recommendation 3: All the relevant out-of-scope items identified in sub-section 4.7 of this report should be included in ONR's GDA Step 3 Radioactive Waste Management, Decommissioning and Spent Fuel Management Assessment Plan for the UK HPR1000.

6 REFERENCES

1. Generic Design of GNS's UK HPR1000 Reactor, Step 2 Assessment Plan for Nuclear Liabilities Regulation, ONR-GDA-UKHPR1000-AP-17-016 Revision 0, ONR, November 2017, TRIM reference 2017/359721.

2. Preliminary Safety Report, Chapter 23 Radioactive Waste Management and Fuel Storage, HPR/GDA/PSR/0023 Revision 000, GNS, October 2017, TRIM reference 2017/401394.

3. Preliminary Safety Report, Chapter 24 Decommissioning, HPR/GDA/PSR/0024, Revision 000, GNS, October 2017, TRIM reference 2017/401395.

4. Scope for UK HPR1000 GDA Project, HPR/GDA/RPEO/0007, Revision 0000, GNS, May 2018, TRIM reference 2018/179809.

5. Generic Design Assessment (GDA) for UK HPR1000, ALARP Methodology, GH X 00100 051 DOZJ 03 GN, Revision B, GNS, April 2018, TRIM reference 2018/181415.

6. GDA Project, ALARP & BAT – Principles & Requirements for UK HPR1000 GDA, HPR/GDA/PROC/0089, Revision 000, GNS, May 2018, TRIM reference 2018/181393.

7. ONR HOW2 Guide NS-PER-GD-014 Revision 6 - Purpose and Scope of Permissioning. November 2016.
http://www.onr.org.uk/operational/assessment/index.htm

8. Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014.

   http://www.onr.org.uk/saps/saps2014.pdf

9. Technical Assessment Guides –.

   NS-TAST-GD-005 Revision 8 (Guidance on the demonstration of ALARP),

   NS-TAST-GD-024 Revision 5 (Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites),

   NS-TAST-GD-026 Revision 4 (Decommissioning)

   NS-TAST-GD-081 Revision 2 (Safety Aspects Specific to Storage of Spent Nuclear Fuel)

   http://www.onr.org.uk/operational/tech_asst_guides/index.htm

10. IAEA guidance:

    IAEA Fundamental Safety Principles: Safety Fundamentals SF-1, IAEA, Vienna, 2006.

    General Safety Requirements Part 5: Predisposal management of radioactive waste, No. GSR Part 5, IAEA, Vienna, 2009.

    General Safety Requirements Part 6: Decommissioning of Facilities, No. GSR Part 6, IAEA, Vienna, 2014.

Specific Safety Guide No.15 Storage of Spent Nuclear Fuel, SSG-15, IAEA, Vienna 2012

Specific Safety Guide No.40 Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors, SSG-40, IAEA, 2016

Storage of Radioactive Waste, Safety Guide, WS-G-6.1, IAEA, Vienna, 2006

Decommissioning of Nuclear Power Plants and Research Reactors. Safety Guide WS-G-2.1, IAEA Vienna, 1999.

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

www.iaea.org.

11. Western European Nuclear Regulators' Association:

Safety Reference Levels for existing reactors, WENRA, September 2014,

Reactor Harmonisation Working Group report on Safety of new NPP designs, WENRA, March 2013

WENRA Report on Treatment and Conditioning Safety Reference Levels, 2018

Decommissioning Safety Reference Levels, version 2.2, WENRA, 2015

Waste and Spent Fuel Storage Safety Reference Levels, version 2.2, WENRA, 2014

http://www.wenra.org/

12. The management of higher activity radioactive waste on nuclear licensed sites - Joint guidance from the Office of Nuclear Regulation, the Environment Agency, the Scottish Environment Protection Agency and Natural Resources Wales to nuclear licensees, Revision 2, February 2015.

13. Generic Design Assessment (GDA) for UK HPR1000 Pre-Construction Safety Report:

Chapter 23 Radioactive Waste Management, GH X 00620 023 KPGB 02 GN, Revision B, CGN, February 2018, TRIM reference 2018/105302

Chapter 24 Decommissioning, GH X 00620 024 KPGB 02 GN, Revision B, CGN, February 2018, TRIM reference 2018/105301

Chapter 29 Interim Storage of Spent Fuel. GH X 00620 029 KPGB 02 GN, Revision B, CGN February 2018, TRIM reference 2018/105294.

14. New nuclear reactors: Generic Design Assessment, guidance to Requesting Parties, ONR-GDA-GD-001 Revision 3, Office for Nuclear Regulation, September 2016, http://www.onr.org.uk/new-reactors/ngn03.pdf.

15. Funded Decommissioning Programme Guidance for New Nuclear Power Stations, Department of Energy and Climate Change, 8 December 2011 (https://www.gov.uk/government/consultations/revised-funded-decommissioning-programme-guidance-for-new-nuclear-power-stations).

16. Regulatory Queries:

UK HPR1000 - Regulatory Query (RQ) Tracking Sheet - 2 November 2017 – Reference for Step 2 Assessment Reports, TRIM reference 2018/315144

RQ-UKHPR1000-0044, January 2018, TRIM reference 2018/36218

RQ-UKHPR1000-0045, January 2018, TRIM reference 2018/36249

RQ-UKHPR1000-0046, January 2018, TRIM reference 2018/36271

RQ-UKHPR1000-0047, January 2018, TRIM reference 2018/36318

RQ-UKHPR1000-0105, May 2018, TRIM reference 2018/175723

RQ-UKHPR1000-0107, May 2018, TRIM reference 2018/175767

RQ-UKHPR1000-0108, May 2018, TRIM reference 2018/175840.

17. Preliminary Safety Report, Chapter 4 General Safety and Design Principles, HPR/GDA/PSR/004, Revision 000, GNS, October 2017, TRIM reference 2017/401351.

18. Preliminary Safety Report, Chapter 7 Safety Systems, HPR/GDA/PSR/007, Revision 000, GNS, October 2017, TRIM reference 2017/401356.

19. Preliminary Safety Report, Chapter 10 Auxiliary Systems, HPR/GDA/PSR/0010, Revision 000, GNS, October 2017, TRIM reference 2017/401360.

20. ONR-NR-CR-18-207 Revision 0, GNS-ONR/EA Level 4 Technical Meeting – Radioactive Waste Management, Decommissioning and Spent Fuel Management, 26 June 2018, TRIM reference 2018/209048.

21. Specification and Guidance on the content and format of an Integrated Waste Strategy, Doc No ENG 01, Rev 3, Nuclear Decommissioning Authority, October 2012, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/517827/ENG01-Specification-and-Guidance-on-the-Content-and-Format-of-an-Integrated-Waste-Strategy.pdf.

22. ONR-GDA-UKHPR1000-AR-18-020, Summary of the Step 2 Assessment of the UK HPR1000 Reactor, TRIM Reference 2018/238474.

23. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Revision 3, Environment Agency, October 2016, https://www.gov.uk/government/publications/assessment-of-candidate-nuclear-power-plant-designs

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Interpretation	Comment
RW.1 Radioactive Waste Management Strategies for radioactive waste	A strategy should be produced and implemented for the management of radioactive waste on a site	This principle sets the requirements for a radioactive waste management strategy, which is considered to be a pre-requisite for the safe and timely management of radioactive waste and to meet Government policy.	Addressed in Section 4 of this report. The RP has committed to producing an Integrated Waste Strategy (IWS) document. I am not fully confident that the IWS will meet the expectations for a radioactive waste management strategy set out in SAP RW.1. I will address radioactive waste management strategy in the RO to be drafted in Step 2 but expect this SAP to be satisfied during GDA.
RW.2 Generation of radioactive waste	The generation of radioactive waste should be prevent or, where this is not reasonably practicable, minimised in terms of quantity and activity	Avoiding the creation of radioactive waste and minimising the generation of unavoidable waste are fundamental principles of good waste management, which are embedded in international guidance and Government policy, to be considered at all stages of a facility's lifecycle including design.	Addressed in Section 4 of this report. The RP recognises the importance of this principle in Ref.2. Clearly arguments and evidence will be needed but I expect this SAP to be satisfied during GDA.
RW.3 Accumulation of radioactive waste	The total quantity of radioactive waste accumulated on site at any time should be minimised so far as is reasonably practicable.	The accumulation of waste should be minimised at all times, taking consideration of volume reduction, and full use made of appropriate duly authorised disposal routes.	Addressed in Section 4 of this report. Ref.2 did not adequately address the SAP on accumulation of waste, as it was primarily focused on meeting EA requirements as set out in the P&ID (Ref.23). The RP has not yet made adequate claims relating to the accumulation of radioactive waste. I am not yet confident this SAP will be satisfied during GDA. This issue will form part of the RO being drafted during Step 2.
RW.4 Characterisation and segregation	Radioactive waste should be characterised and segregated to facilitate its subsequent safe management	The application of good characterisation and segregation practices provide a sound foundation for safe and effective management from generation through to disposal.	Addressed in Section 4 of this report. I expect this SAP to be satisfied in this GDA, subject to the provision of appropriate arguments and evidence.
RW.5	Radioactive waste should be	The application of this principle, which takes	Addressed in Section 4 of this report. In general

Storage of radioactive waste and passive safety	stored in accordance with good engineering practice and in a passively safe condition	account of the characteristics of radioactive wastes and its storage facility, provides a sound foundation for the safe management of stored radioactive wastes. Radioactive wastes may be stored for long periods (decades or more) awaiting the availability of disposal routes.	storage was not adequately addressed in Ref. 2. The need for prolonged storage of HAW on site pending the availability of the GDF is recognised by the RP as a key difference between the UK context and Chinese practice. The issue of storage will be addressed in the RO to be drafted during Step 2 and this should be of benefit in providing confidence that this SAP will be satisfied during GDA.
RW.6 Passive safety timescales	Radiological hazards should be reduced systematically and progressively. The waste should be processed into a passive safe state as soon as is reasonably practicable.	Decisions on the timing of the processing of radioactive waste into a passive safe state needs to be carried out in a transparent manner taking account of the balance between a range of relevant factors.	Not addressed explicitly in Section 4 but Ref.2 makes specific reference to this principle. I expect the timing of processing of radioactive waste into a passively safe state to be addressed in the development of the radioactive waste management strategies for the various waste streams. It is also an area potentially affected by the differences between UK and Chinese practices. I expect this principle to be satisfied during GDA, noting that decisions on timing will be the responsibility of a future operator.
RW.7 Making and keeping records	Information that might be needed for the current and future safe management of radioactive waste should be recorded and preserved	Radioactive wastes need to be managed safely in the present and, for those wastes which have to be stored for long periods, future generations will need to be provided with suitable information that will safe management and eventual safe disposal. Adequate records	Not explicitly addressed in Section 4 but I was broadly content with the information presented in Ref.2 on records and preserving information, which I considered to be appropriate to Step 2. Further information will be needed in Steps 3 and 4. I expect this principle to be satisfied during GDA.
DC.1 Design and operation	Facilities should be designed and operated so that they can be safely decommissioned	Decommissioning needs to be taken into account at all stages in the lifecycle; starting at the planning and design stage.	Addressed in Section 4 of this report. This is discussed in Ref.3. I am broadly content with the claims relating to design for decommissioning. I will seek further information during preparation for Step 3 on how the RP plans to substantiate them by means of arguments and evidence and how this will be addressed in the PCSR and its supporting documentation.
DC.2 Decommissioning strategies	A decommissioning strategy should be prepared and maintained for each site and	The decommissioning strategy should be initially produced during the planning phase, be consistent with government policies and strategies and take	Addressed in Section 4 of this report. Ref.3 presents information on decommissioning strategy. Further information will be provided in Steps 3 and

	should be integrated with other relevant strategies	account of relevant factors. The decommissioning strategy should be integrated with strategies for management of radioactive material and radioactive wastes.	4. I was content with the claim made during Step 2 and expect the SAP to be satisfied during GDA.
DC.3 Timing of decommissioning	The safety case should justify the continuing safety of the facility prior to its decommissioning. Where adequate levels of safety cannot be demonstrated, prompt decommissioning should be carried out and, where necessary prompt remedial and operational measures should be implemented to reduce the risk.	The timing of decommissioning an important aspect of decommissioning strategies and is influenced by many factors. The rationale for the timing of decommissioning needs to be transparent and properly justified, taking account of relevant factors. Decommissioning should be carried out as soon as is reasonably practicable, taking account of all relevant factors.	Addressed in Section 4 of this report. Ref. 3 presents information on the two main options of immediate and deferred dismantling and makes the assumption that immediate dismantling is the preferred option (noting the timing of decommissioning will be a matter for the future operator of the UK HPR1000). This assumption is consistent with UK government policy. I am content this SAP will be satisfied during GDA, noting its limited applicability to GDA.
DC.4 Planning for decommissioning	A decommissioning plan should be prepared for each facility that sets out how the facility will be safely decommissioned	Account needs to be taken throughout the lifecycle of a facility of its decommissioning and management of the resulting wastes. The decommissioning plan should form part of the demonstration that the facility can be safely decommissioned.	Addressed in Section 4 of this report. Ref.3 refers to preparation of a decommissioning plan and the RP has indicated this will be provided during Step 3. I am content this SAP will be satisfied during GDA.
DC.5 Passive safety	Facilities should be made passively safe before entering a care and maintenance phase.	This applies to situations where completion of decommissioning has been deferred and there is thus a period of time when the facility will need to be placed in a passively safe state pending further decommissioning.	Not explicitly addressed in Section 4 of this report but the assumption of immediate dismantling means this principle is not applicable. There is no need to satisfy this principle during GDA whilst this assumption remains applicable.
DC.6 Records for decommissioning	Documents and records that may be required for decommissioning purposes should be identified, prepared, updated, retained and owned so that they will be available when needed.	There is a general requirement in the licence condition to make and preserve adequate records to demonstrate compliance with licence conditions. Records are needed for decommissioning operations in both the short and long term. The process of making and preserving documents and records should start at the planning and design stage.	Not explicitly addressed in Section 4 but I was broadly content with the information presented in Ref.3 on records and preserving information, which I considered to be appropriate to Step 2. Further information will be needed in Steps 3 and 4. I expect this principle to be satisfied during GDA.
ENM.1 Strategies for managing	A strategy (or strategies) should be made and implemented for the	This requires a strategy for nuclear matter (which includes spent nuclear fuel) which should be	Addressed in Section 4 of this document. The strategy for management of spent fuel is still being

nuclear matter	management of nuclear matter.	consistent with government policy and integrated with other relevant strategies.	developed, with a decision to be made on the preferred technology option at the beginning of Step 3. The information provided meets the general expectations of the Guidance to Requesting Parties for Step 2 for Spent Fuel Management.
ENM.3 Transfers and accumulation of nuclear matter should be avoided	Unnecessary or unintended generation, transfer or accumulation of nuclear matter should be avoided.	Plants should be designed to avoid unintended accumulation of nuclear matter and facilitate decontamination.	Not addressed in Section 4 of this report but I consider there is insufficient information to assess in Ref.2, in the absence of a preferred technology option for spent fuel storage.
ENM.5 Characterisation and segregation	**Nuclear matter should be characterised and segregated whenever practicable to facilitate its safe management**	The application of good characterisation and segregation practices provide a sound foundation for safe and effective management of nuclear matter.	Not explicitly addressed in Section 4 of this report but the preliminary information presented in Ref.2 indicates that this principle will be addressed for spent fuel management during GDA.
ENM.6 Storage in a condition of passive safety	**When nuclear matter is to be stored on site for a significant period of time it should be stored in a condition of passive safety whenever practicable and in accordance with good engineering practice**	The application of this principle, which takes account of the characteristics of nuclear matter and its storage facility, provides a sound foundation for the safe management of nuclear matter over a long period of time.	Not explicitly addressed in Section 4 of this report. The RP has not yet selected a preferred option for the SFIS but Ref.3 so it is not appropriate to assess fully against this principle. The information provided meets the general expectations of the Guidance to Requesting Parties for Step 2 for Spent Fuel Management.
ENM.7 Retrieval and inspection of stored nuclear matter	Storage of nuclear matter should be in a form and manner and allows it to be retrieved and, where appropriate, inspected.	The application of this principle relates to the design and operation of storage facilities to enable retrieval of nuclear matter, including for inspection, taking account of the planned duration of storage and any changes that might take place during the storage period.	The issue of retrievability is referred to briefly in Section 4 of this report. The RP has not yet selected a preferred option for the SFIS but Ref.3 so it is not appropriate to assess fully against this principle. The information provided meets the general expectations of the Guidance to Requesting Parties for Step 2 for Spent Fuel Management.
ECV.1 Prevention of leakage	Radioactive material should be contained and the generation of radioactive waste through the spread of contamination by leakage should be prevented.	Containment and ventilation systems should confine radioactive material in the facility and prevent its leakage or escape to the environment in normal operation and fault conditions, except in accordance with authorised discharge conditions or planned transfers.	Discussed briefly in Section 4 of this report. In Ref. 2 the RP notes that containment and ventilation systems will be provided and that general steps have been taken aimed at minimising leakages from systems and components. Collection systems for fluids will take account of leakage in their design. This topic is covered in other Chapters of the PSR and thus assessed by other technical disciplines.

			There was insufficient information in Ref. 2 to fully assess against this principle in this discipline assessment. I will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.
ECV.2 Minimisation of releases	Containment and associated systems should be designed to minimise radioactive releases to the environment in normal operation, fault and accident conditions	No additional explanation required.	Not discussed in Section 4 of this report. Ref. 2 includes extensive information on the minimisation of releases to the environment during normal operations, aimed at meeting the requirements of the EA in its P&ID document. I will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.
ECV.3 Means of confinement	The primary means of confining radioactive materials should be through the provision of passive sealed containment systems and intrinsic safety features, in preference to the use of active dynamic systems and components	This principle sets an expectation that the safety functions should be defined for normal, fault and accident conditions.	Not discussed in Section 4 of this report. There was insufficient information in Ref. 2 to fully assess against this principle in this discipline assessment. I will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.
ECV.4 Provision of further containment barriers	Where the radiological challenge dictates, waste storage vessels, process vessels, piping, ducting and drains (including those that may serve as routes for escape or leakage from containment) and other plant items that act as containment for radioactive material, should be provided with further containment barrier(s) that have sufficient capacity to deal safely with the leakage resulting from any design basis fault	No additional explanation required	Not discussed in Section 4 of this report. There was insufficient information in Ref. 2 to fully assess against this principle in this discipline assessment. I will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.
ECV.6 Monitoring devices	Suitable and sufficient monitoring devices with alarms should be provided to detect and assess	This principle sets an expectation that device and alarms should monitor the physical and environmental conditions important to safety	Not discussed in Section 4 of this report. There was insufficient information in Ref. 2 to fully assess against this principle in this discipline assessment. I

	changes in the materials and substances held within the containment.		will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.
ECV.7 Leakage monitoring	Appropriate sampling and monitoring systems should be provided outside the containment to detect, locate, quantify and monitor for leakages and escape of radioactive material from the containment boundaries.	No additional explanation required	Not discussed in Section 4 of this report. There was insufficient information in Ref. 2 to fully assess against this principle in this discipline assessment. I will engage with other discipline specialists on this SAP as it relates to this topic area during future GDA Steps.