Assessing new nuclear power station designs

Generic design assessment of Hitachi-GE Nuclear Energy Limited's UK Advanced Boiling Water Reactor

Consultation document

12 December 2016

We are the Environment Agency. We protect and improve the environment and make it a better place for people and wildlife.

We operate at the place where environmental change has its greatest impact on people's lives. We reduce the risks to people and properties from flooding; make sure there is enough water for people and wildlife; protect and improve air, land and water quality and apply the environmental standards within which industry can operate.

Acting to reduce climate change and helping people and wildlife adapt to its consequences are at the heart of all that we do.

We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

Natural Resources Wales is the largest Welsh government sponsored body, employing 1,900 staff across Wales. We were formed in April 2013, largely taking over the work of the Countryside Council for Wales, Forestry Commission Wales and the Environment Agency in Wales, as well as certain Welsh government functions. Our main roles are:

- Adviser: principal adviser to the Welsh government, adviser to industry and the wider public and voluntary sector, and communicator about issues relating to the environment and its natural resources
- Regulator: protecting people and the environment, including marine, forest and waste industries, and prosecuting those who breach the regulations that we are responsible for
- Designator: for Sites of Special Scientific Interest – areas of particular value for their wildlife or geology, Areas of Outstanding Natural Beauty (AONBs), and National Parks, as well as declaring National Nature Reserves
- Responder: to some 9,000 reported environmental incidents a year as a Category 1 emergency responder
- Statutory consultee: to some 9,000 planning applications a year
- Manager/operator: managing 7% of Wales' land area, including woodlands, National Nature Reserves, water and flood defences, and operating our visitor centres, recreation facilities, hatcheries and a laboratory
- Partner, educator and enabler: working with the public, private and voluntary sectors, providing grant aid, and helping a wide range of people use the environment as a learning resource
- Evidence gatherer: monitoring our environment, commissioning and undertaking research, developing our knowledge, and being a public records body

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Foreword

We, the Environment Agency and Natural Resources Wales, are the independent environmental regulators for England and Wales respectively. We both work to create better places for people and wildlife, and support sustainable development. This includes our regulation of nuclear power stations to minimise environmental impacts.

I am pleased to introduce this generic design assessment (GDA) consultation document inviting your comments on our assessment findings so far. Your comments will help inform our decisions about whether we should issue a Statement of Design Acceptability (SoDA) for Hitachi-GE's UK Advanced Boiling Water Reactor (UK ABWR) design.

GDA is a joint process of the Office for Nuclear Regulation (ONR), the UK regulator for nuclear safety and security, the Environment Agency and Natural Resources Wales. We are working together to ensure that any new nuclear power stations built in the UK meet high standards of safety, security, environmental protection and waste management.

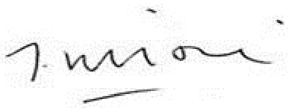
The objectives of our GDA process and assessments are to:

- have an early influence on potential reactor designs that might be built in England and Wales so that we can be confident that they will meet high standards of safety, security, environmental protection and waste management
- provide potential developers and investors in any new nuclear stations with our views about the designs, so reducing the associated regulatory risks
- establish, subject to normal national and commercial security constraints, an open and transparent process of assessment
- build a professional and synergistic working relationship between the nuclear regulators as we work jointly to develop, implement and carry out our GDA process

Hitachi-GE's public comments process has been in place throughout our assessment, which saw Hitachi-GE publish its design information on its website and ask for comments and questions about the UK ABWR. In August 2014, we published our initial assessment of this reactor design and in October 2015 ONR published its Step 3 report on the design.

We have identified some areas where more work is required to provide further information and resolve technical issues. We are confident that these areas can be addressed by the reactor designer during GDA, or by a developer as part of its site-specific applications.

On behalf of the Environment Agency and Natural Resources Wales, we very much welcome your comments on our assessment of the UK ABWR and we look forward to hearing from you.



Toby Willison

Director of Operations, Environment Agency

Tim Jones

Executive Director Operations North & Mid Wales, Natural Resources Wales

This consultation - at a glance

Topic	This consultation is about the Environment Agency's assessment, with Natural Resources Wales, of Hitachi-GE Nuclear Energy's UK Advanced Boiling Water Reactor (UK ABWR) nuclear power station design. It seeks your views on the environmental aspects of the design and on our assessment of those aspects. Our consultation does not relate to a specific site. It is not about the need for nuclear power, the siting of nuclear power stations, nor the safety and security of the design.
Geographical scope	England and Wales only.
Audience	This is aimed at: • members of the public • the energy industry • academics with an interest in nuclear power, energy production or the environment • non-governmental organisations (NGOs) Comments from any other interested parties are also welcome.
Duration	12 weeks. The consultation will close on 3 March 2017.
Contact details	Please complete the online response form Alternatively, you can email your response to: gda@environment-agency.gov.uk Or write to us (for the attention of Declan Roscoe) at: Environment Agency Ghyll Mount Gillan Way Penrith 40 Business Park Penrith Cumbria CA11 9BP If you have any queries, or would like a hard copy of this document, please email us: gda@environment-agency.gov.uk
Next steps	A summary of responses will be published following the closure of the consultation. We will carefully consider all comments made, where relevant to the scope of our assessment, before producing a document that: • sets out our decision whether or not to issue a statement of design acceptability for the UK ABWR • summarises the consultation responses and issues raised • sets out our views on those issues We expect to do this by December 2017.

Future opportunities to have your say	There will be further consultation on any environmental permit applications for the operation of this design on specific sites (see paragraph 44).

Executive summary

About generic design assessment (GDA)

1. The UK government's energy policy (GB Parliament, 2008a) identifies that nuclear power could play a vital role, alongside gas and renewable energy sources, such as wind and solar power, in making sure that the UK has enough low-carbon electricity in the future.

2. As regulators of the nuclear industry, the Office for Nuclear Regulation (ONR), the Environment Agency and Natural Resources Wales, are working together to make sure that any new nuclear power stations built in the UK meet high standards of safety, security, environmental protection and radioactive waste management.

3. The Environment Agency has developed an assessment process - generic design assessment (GDA), which allows us to scrutinise new nuclear power station designs before they are built. It means we can identify early any potential design or technical issues that relate to those aspects of its environmental performance that we regulate. We can then ask the 'requesting party' (the organisation submitting the design for GDA, usually the reactor designer) to address these issues. This process does not relate to a specific location. The ONR has developed a similar process that assesses the safety and security of a design.

4. Natural Resources Wales has been involved in the GDA process for the UK Advanced Boiling Water Reactor (UK ABWR). This has allowed us to reach the preliminary conclusions set out in this document together. We anticipate that we will also reach final conclusions together, so that the GDA outcome will apply both in England and Wales. References to 'we' and 'our', throughout this document refer to both the Environment Agency and Natural Resources Wales, unless specified otherwise.

5. We carry out the GDA process in two stages: initial assessment and detailed assessment.

6. There are 3 possible outcomes for a GDA.

    1. If we are fully content with the environmental aspects of the design, we provide the requesting party with a statement of design acceptability (SoDA). However, there may still be some Assessment Findings that the requesting party or a future operator will need to resolve at a later stage, for example, during procurement or commissioning.
    2. If we are largely content with the environmental aspects of the design, we provide the requesting party with an interim statement of design acceptability (iSoDA) that specifies the outstanding GDA Issues. We will only do this if the requesting party is able to provide a credible resolution plan that identifies how it will address each of the GDA Issues. A full SoDA may replace an iSoDA once we are content that all the GDA Issues have been resolved.
    3. If we are not content with the environmental aspects of the design, we do not provide a SoDA or iSODA to the requesting party.

> A **GDA Issue** is an unresolved issue that is significant, but resolvable, and which requires resolution before nuclear island safety-related construction of the reactor could be considered.
>
> An **Assessment Finding** is an unresolved issue that is not considered critical to the decision to start nuclear island safety-related construction - it will need to be addressed during the design, procurement, construction or commissioning phase of the new build project.

About GDA for Hitachi-GE's UK ABWR design

7. Hitachi-GE submitted its UK ABWR design for GDA in January 2014. It published the submission on its website (www.hitachi-hgne-uk-abwr.co.uk/gda_library.html) and invited people to comment on it. Hitachi-GE has revised the submission during GDA; the current version (Appendix 3) on the website is up to date and is the basis of our detailed assessment.

8. We completed the initial assessment and published our report in August 2014 (www.gov.uk/government/publications/new-nuclear-power-stations-assessment-of-hitachi-ges-uk-abwr-design).

9. Since then, we have been carrying out our detailed assessment. This consultation document summarises our preliminary findings.

Our preliminary view on the UK ABWR design

10. Following our detailed assessment, our preliminary conclusion, pending consultation, is that we could issue an interim statement of design acceptability for the UK ABWR. This is subject to a number of potential GDA Issues being or able to be resolved (potential GDA Issues 1 to 3 below). If there are no outstanding GDA Issues at the end of the generic design assessment process then a statement of design acceptability could be issued.

- **Potential GDA Issue 1** – Decommissioning of the UK ABWR. We require Hitachi-GE to provide sufficient evidence to demonstrate that the UK ABWR has been designed to facilitate decommissioning and hence to minimise associated waste and impacts on people and the environment from decommissioning operations.
- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.
- **Potential GDA Issue 3** – Consideration of 'best available techniques' (BAT) and 'as low as reasonably practicable' (ALARP) in optimisation. We require Hitachi-GE to demonstrate that appropriate consideration has been given to both environmental and safety aspects, in order to achieve an optimised design.

11. At the time of writing this consultation document we consider that work on the potential GDA Issues relating to source term and decommissioning are well advanced and may be resolved before this consultation starts. The potential GDA Issue in relation to BAT and ALARP is also considered to be resolvable and is expected to be resolved before the completion of this GDA process. We expect the publication of the updated pre-construction safety report (PCSR) to align the BAT case and ALARP case. We will continue to assess documentation provided by Hitachi-GE and will publish an update in an addendum to this consultation document if resolution of any potential GDA Issues occurs before consulation begins.

12. We have also identified a number of Assessment Findings:

- **Assessment Finding 1**: A future operator shall provide details of how the proximity principle has been applied in its selection of optimised disposal routes for solid and incinerable liquid wastes prior to active commissioning.
- **Assessment Finding 2**: If appropriate, a future operator shall produce an assessment of best available techniques that covers all of its sites, noting economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes across all of its sites in its application for an environmental permit.
- **Assessment Finding 3**: A future operator shall demonstrate that the UK ABWR will be operated in a manner that represents best available techniques, addressing in particular:
    - fuel selection
    - fuel and core management
    - avoidance of control rod failure in power suppression situations

    - consideration of all normal operational modes and stages of the reactor's lifecycle
    - control of water chemistry
    - selection of demineraliser resins for liquid waste management systems
- **Assessment Finding 4**: A future operator shall review the practicability of techniques for abatement of carbon-14 prior to operation.
- **Assessment Finding 5**: A future operator shall assess the partitioning of carbon-14 between gaseous, aqueous and solid waste streams, during initial operations.
- **Assessment Finding 6**: A future operator shall address the 15 forward actions as identified by Hitachi-GE in the 'Demonstration of best available techniques' submission - GA91-9901-0023-00001 Revision F (July 2016).
- **Assessment Finding 7**: A future operator shall provide an evidence-based definition of the decontamination factors likely to be achieved for aqueous effluent treatment prior to operation and then compare these with the actual decontamination factors achieved during operation. Differences in expected and actual decontamination factors should be explained.
- **Assessment Finding 8**: A future operator shall assess the chemical speciation of radioactivity in aqueous discharges. It shall consider the implications of this for the receiving environment so that discharges are shown to represent best available techniques.
- **Assessment Finding 9**: A future operator shall, before procurement, provide detailed designs for solid radioactive waste management, storage and conditioning facilities that were covered at a conceptual level during generic design assessment, and demonstrate how these represent best available techniques.
- **Assessment Finding 10**: A future operator shall demonstrate optimised management and disposal of solid radioactive wastes from the UK ABWR, addressing in particular:
    - conditioning of higher activity waste arisings to ensure disposability
    - selection of disposal routes for wastes at the low activity waste/high activity waste boundary
    - management of spent nuclear fuel and any associated secondary wastes to ensure disposability
    - selection of disposal routes for low activity waste
- **Assessment Finding 11**: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G (July 2016).
- **Assessment Finding 12**: A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.
- **Assessment Finding 13**: A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.
- **Assessment Finding 14**: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.
- **Assessment Finding 15**: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.
- **Assessment Finding 16**: A future operator shall appropriately characterise all aqueous waste streams in its water discharge activity permit application. This shall include identification of all significant contaminants, including biocides, detergents and metals, the concentrations and volumes being discharged to the environment.
- **Assessment Finding 17**: A future operator shall specify the minimum performance parameters of the combustion plant in its application for a combustion activity permit.

13. We have provided a draft interim statement of design acceptability in Appendix 1 to help inform this consultation.

14. ONR's GDA Step 4 assessment is ongoing (ONR, 2014). This might raise further issues that could affect our conclusions.

Our consultation

15. This consultation seeks your views on our preliminary conclusions and our detailed assessment of the UK ABWR new nuclear power station design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

16. We want to hear from members of the public, the energy industry, academics with an interest in nuclear power, energy or the environment, non-governmental organisations (NGOs) and any other organisation or public body.

17. Details of how you can respond are given in the 'at a glance' section and in Chapter 1.

18. We will publish all responses to our consultation, subject to commercial, sensitive nuclear or personal information content, by 14 April 2017.

What happens next?

19. We will consider all the responses to our consultation, and the outcome of ONR's assessment, before coming to a final decision on the acceptability of the UK ABWR.

20. We will publish our final conclusions in our 'decision document', which we expect to publish in December 2017.

21. If we conclude that we are able to issue a SoDA or iSoDA, we would then expect to receive applications for environmental permits for specific sites. We do, however, recognise that an operator may wish to submit site-specific applications for environmental permits at an appropraite time for its project which may be before the end of the GDA process. To draw significant benefit from GDA, we would not expect site-specific applications to be made until we have, at least, begun this consultation. In determining these site-specific applications, we will take full account of the work we have done during GDA, so that our efforts are focused on operator and site-specific matters, including how the operator has addressed any outstanding GDA Issues or Assessment Findings. We will carry out further public consultation before deciding whether or not to issue operational permits for a specific site.

Contents

1. About this consultation

This consultation document has two main purposes. Firstly, it explains the preliminary conclusions of the Environment Agency and Natural Resources Wales's assessment of the environmental aspects of a new nuclear power station design, Hitachi-GE Nuclear Energy Limited's (the 'requesting party') UK Advanced Boiling Water Reactor (UK ABWR). Secondly, it seeks your views on the environmental aspects of the design and our assessment so far.

The Office for Nuclear Regulation (ONR) is also assessing the UK ABWR from a safety and security viewpoint. Although we work closely with ONR, this consultation is only about the Environment Agency and Natural Resources Wales's assessment and not ONR's. If we receive any consultation responses that raise safety or security issues, we will pass them on to ONR.

This consultation is not about the need for nuclear power or the siting of nuclear power stations.

About this document

22. This document provides:

- an introduction to our role in nuclear regulation and the basis for generic design assessment (GDA) (Chapter 2)
- an outline of the UK ABWR design (Chapter 3)
- a guide to our detailed assessment (Chapter 4)
- our GDA conclusions, with our consultation questions, followed by our detailed assessment (Chapters 5 to 18)
- our overall conclusion (Chapter 19)
- appendices supporting the consultation document (Appendices 1 to 7)

23. There is also a full list of consultation questions at the end of this chapter.

You can obtain a paper copy of this document by emailing us:

gda@environment-agency.gov.uk

Invitation to comment

24. This consultation seeks your views on our preliminary conclusions following our detailed assessment of Hitachi-GE's UK ABWR new nuclear power station design, and on the environmental aspects of the design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

25. We want to hear from all interested parties. When responding, please state whether you are responding as an individual or representing the views of an organisation.

26. This 12 week consultation began on 12 December 2016 and will close on 3 March 2017. Please send your response to arrive by 3 March 2017.

How to respond

27. There are a number of ways you can let us know your views.

Online

28. Visit our website at https://www.gov.uk/government/consultations/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor. We have designed the online consultation to make it easy to submit responses to the questions. We would prefer you to comment online as this will help us to gather and summarise responses quickly and accurately. To do this, you will need to either log in or register a consultee account before providing your comments.

By email or letter

You can also submit a response by email or letter. It would help us if you would send your comments using the form provided in Appendix 7. Send them to:

Email: gda@environment-agency.gov.uk

Post: For the attention of Declan Roscoe

Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria
CA11 9BP

Data protection notice

How we will use your information

We will use your information to help inform our decision on the generic design assessment of the UK ABWR.

We may refer to any comments or issues raised by you in our decision document and in other Environment Agency or Natural Resources Wales documents related to GDA for the UK ABWR, unless you have specifically requested that we keep your response confidential. We may also publish all responses. We will not publish names of individuals who respond. We will publish the name of the organisation for those responses made on behalf of organisations. Please indicate on your response if you want us to treat it as confidential (but see the box below).

We will place your information on our databases, to be accessed by our staff or our agents, as a record of information received. We may send your information to other relevant bodies, including government departments.

We may keep your name and address on our databases so that we can advise you of any further communications relating to GDA or applications for permits for new nuclear power stations, unless you specifically ask us not to do this.

Freedom of Information Act and Environmental Information Regulations

Confidential responses

We may publish or disclose information you provide in your response to this consultation, including personal information, in accordance with the Freedom of Information Act 2000 (FOIA) (GB Parliament, 2000) and the Environmental Information Regulations 2004 (if the Data Protection Act allows).. If you want us to treat the information that you provide as confidential, please be aware that, under the FOIA or EIR, there is a statutory Code of Practice with which public authorities must comply and which deals, amongst other things, with obligations of confidence.

In view of this, it would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request to disclose the information, we will take full account of your explanation, but we cannot give an assurance that we can maintain confidentiality in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, in itself, be regarded as binding on the Environment Agency or Natural Resources Wales.

Consultation events

29. A programme of communications and stakeholder engagement is underway and will continue during the consultation period. We will do our best to attend meetings and other events if requested. Visit our website for our consultation plan https://www.gov.uk/government/consultations/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor

What happens next?

30. We will acknowledge receipt of your response. We will consider carefully all the responses we get. If issues arise that fall outside our responsibilities, we will pass them to the appropriate government department or public body.

31. Your comments, where relevant to the scope of our assessment (see below), will help us decide whether or not to issue a statement of design acceptability for the UK ABWR. We will publish a document that:

- sets out our decision
- summarises the consultation responses and issues raised
- sets out our views on those issues

32. We expect to do this by December 2017.

Consultation principles

33. Government is improving the way it consults by adopting a more proportionate and targeted approach. We are running this consultation in accordance with the government's consultation principles (GB Parliament, 2016).

34. If you have any queries or complaints about the way this consultation has been carried out, please contact:

Emma Hammonds, Consultation Co-ordinator
Environment Agency
Horizon House
Deanery Road
Bristol
BS1 5AH

Email: emma.hammonds@environment-agency.gov.uk

Consultation questions

35. Below is a full list of the questions that we are asking for responses to, as part of this consultation on the UK ABWR design.

Consultation questions

Do you have any views or comments on our preliminary conclusions on:

1. management systems?
2. strategic considerations for radioactive waste management?
3. the process for identifying best available techniques (BAT)?
4. preventing and minimising the creation of radioactive waste?
5. minimising the discharges and impact of gaseous radioactive waste, and our proposed limits and levels?
6. minimising the discharges and impact of aqueous radioactive waste, and our proposed limits and levels?
7. management and disposal of solid radioactive waste and spent fuel?
8. monitoring of discharges and disposals of radioactive waste?
9. the impact of radioactive discharges?
10. radioactive substances permitting?
11. water abstraction?
12. discharges to surface waters and groundwater?
13. operation of installations?
14. the control of major accident hazards?
15. the overall acceptability of the design?

Additionally:

16. do you have any overall views or comments to make on our assessment, not covered by previous questions?

2. Introduction

This chapter describes the Environment Agency's role in nuclear regulation and the development of new nuclear power stations, and how we carry out generic design assessment.

Government policy on nuclear new build - the origins of GDA

The government has outlined its commitment to a significant expansion in new nuclear in the UK, stating that nuclear power, alongside gas and renewable energy sources, will ensure the UK has enough low carbon electricity in the future. It has taken a number of actions to facilitate the development of new nuclear, including asking the regulators (ourselves and ONR) to consider 'pre-authorisation assessments' of new nuclear power stations. In response, the regulators developed GDA, which allows us to assess the safety, security and environmental impacts of new reactor designs at a generic level, before receiving an application to build a particular nuclear power station design at a specific location.

Our role in nuclear regulation

36. The Environment Agency regulates the environmental impacts of nuclear sites in England such as nuclear power stations, nuclear fuel production plant, and plant for reprocessing spent nuclear fuel. We do this through a range of environmental permits. These permits may be needed for one or more of the site preparation, construction, operation and decommissioning phases of the plant's life cycle.

Role of Natural Resources Wales

Since April 2013, Natural Resources Wales has been the environmental regulator for nuclear sites in Wales. As new nuclear power stations may be built in Wales, Natural Resources Wales has participated in our GDA work and we have reached the preliminary conclusions set out in this document together. We anticipate that we will also reach final conclusions together, so that the GDA outcome will apply in both England and Wales. References to 'we', 'our', or similar terms throughout this document refer to both the Environment Agency and Natural Resources Wales, unless specified otherwise.

37. The permits we issue can include conditions and limits. In setting these we take into account all relevant national and international standards, and UK legal and policy requirements, to ensure that people and the environment will be properly protected. These standards and requirements are described in government and Environment Agency guidance available at:

www.gov.uk/government/collections/radioactive-substances-regulation-for-nuclear-sites

www.gov.uk/government/policies/managing-the-use-and-disposal-of-radioactive-and-nuclear-substances-and-waste

38. We inspect sites to check that the operator is complying with the conditions and limits, and that it has arrangements in place to help ensure compliance. We may take enforcement action, for example, issuing an enforcement notice or taking a prosecution if it is not.

39. We regularly review permits, and vary them if necessary, to ensure that the conditions and limits are still effective and appropriate.

40. We work closely with ONR, which regulates the safety and security aspects of nuclear sites.

Our regulatory role in the development of new nuclear power stations

41. As for existing nuclear sites, any new nuclear power station will require environmental permits from us to cover various aspects of site preparation, construction, operation and eventually decommissioning. In the light of government and industry expectation that power stations of almost the same design might be built on a number of sites and potentially be run by different operating companies, we have split our process for assessing and permitting the operational stage of new nuclear power stations into two phases.

First phase: Generic design assessment (GDA)

42. In the first phase, GDA, we carry out assessments of candidate designs and, at the end, provide a statement about the acceptability of the design. There may be GDA Issues and Assessment Findings associated with the statement. For the UK ABWR, we are in this phase now, this consultation document is about our assessment of the UK ABWR design.

> A **GDA Issue** is an unresolved issue considered by regulators (ourselves or ONR) to be significant, but resolvable, and which requires resolution before nuclear island safety-related construction of the reactor could be considered.
>
> An **Assessment Finding** is an unresolved issue of lesser significance, not considered critical to the decision to start nuclear island safety-related construction. In some cases, it will not be resolvable until a later stage such as procurement or commissioning. It will need to be addressed, as normal regulatory business, either by the designer or by a future operator, as appropriate, during the design, procurement, construction or commissioning phase of the new build project. Issue of a final SoDA is, thus, not dependent on clearance of Assessment Findings. We may address Assessment Findings in site-specific permits, by means of pre-operational conditions or improvement and information requirements.

43. During GDA, we work closely with ONR to assess areas where we have complementary regulatory responsibility, including radioactive waste and spent fuel management, and management arrangements for controlling design changes and controlling GDA submission documents. We have established a Joint Programme Office (JPO), which administers the GDA process on behalf of the regulators.

Second phase: Site-specific

44. In the second phase, we receive applications for environmental permits for specific sites. In determining these applications, we take full account of the work we have done during GDA, so that our efforts are focused on operator and site-specific matters, including how the operator has addressed any outstanding GDA Issues (where there is overlap between a site-specific application and completion of GDA) or Assessment Findings. We also carry out further public consultation before deciding whether or not to issue operational permits for a specific site.

> **Our input to the government's facilitative actions on nuclear new build**
>
> In addition to our regulatory role, we have provided specialist advice, where appropriate, and responded to consultations relating to the actions taken by government to:
>
> - reduce the regulatory and planning risks associated with investing in new nuclear power stations

- ensure operators of new nuclear power stations set aside funds to cover the costs of decommissioning and long-term waste management and disposal

These include:

- **Strategic siting assessment** - this work identified those sites that are strategically suitable for the deployment of new nuclear power stations by the end of 2025. The selected sites are listed in the 'National policy statement for nuclear power generation: EN-6' ('NPS EN-6') (GB Parliament, 2011a). This provides the framework for decisions on planning consent (Development Control Orders). Such decisions are taken by the Secretary of State at Department for Business, Energy and Industrial Strategy (BEIS) on the basis of recommendations made by the Planning Inspectorate.
- **Justification** - before any new type of nuclear power station can be built in the UK, it must be 'justified', that is, it must be shown that the net benefits outweigh any health detriment. The government made a decision that the UK ABWR is justified in December 2015 (DECC, 2014b).
- **Funded decommissioning programme** - 'The Energy Act 2008' (GB Parliament, 2008b) requires any operator of a new nuclear power station to have a funded decommissioning programme, approved by the Secretary of State, in place before construction begins and to comply with this programme. The government published funded decommissioning programme guidance in December 2011 (GB Parliament, 2011b).

About generic design assessment (GDA)

45. GDA means that we assess the acceptability of the environmental aspects of an overall reactor design before individual site applications are made. GDA allows us to get involved with designers and potential operators of new nuclear power stations at the earliest stage, where we can have most influence and where lessons can be learned before construction begins. This early involvement also means that designers and potential operators can better understand the regulatory requirements before they make significant investment decisions.

GDA process

46. Our guidance (Environment Agency, 2013) sets out in detail the information that we require and the process that we follow during GDA. Our process generally has 6 main elements, with a seventh when we issue an interim statement of design acceptability (iSoDA).

1. Initiation - we make an agreement with the requesting party under Section 37 of the Environment Act 1995 (GB Parliament, 1995) and provide advice on the development of a submission.

2. Initial assessment - we receive the submission and examine it, at an outline level, to find out if:

a. we need further information
b. there are any matters that are obviously unacceptable
c. any significant design modifications are likely to be needed

3. Detailed assessment - we examine the submission in detail to come to a preliminary view on whether:

d. we might issue a statement of design acceptability (SoDA)
e. we might issue an interim statement of design acceptability (iSoDA) with associated GDA Issues
f. the design is unsuitable and we will not issue a statement

4. Consultation - we consult widely on our preliminary view following detailed assessment. We provide a consultation document explaining the reasons for our preliminary view.

5. Post consultation review - we carefully consider all relevant responses to the consultation and complete our assessments.

6. Decision and statement - we decide whether, or not to issue a SoDA or iSoDA. We publish a decision document explaining the reasons for our decision.

7. Resolving GDA Issues - we assess the further information provided to clear the GDA Issues and, if satisfied, issue a full SoDA.

47. For both initial and detailed assessment, we use a tiered approach for raising concerns or requesting further information that depends on the level of our concern.

- Regulatory Query (RQ) - this is a request for clarification or further information and does not necessarily indicate any perceived shortfall in the design.
- Regulatory Observation (RO) - we raise a RO when we identify a potential shortfall that requires action and new work for it to be addressed. Each RO can have several associated actions.
- Regulatory Issue (RI) - we raise a RI when we identify a serious shortfall that could potentially prevent us issuing a SoDA, and that requires further work. Each RI can have several associated actions.

48. Both ROs and RIs are published on the Joint Regulators' website (http://www.onr.org.uk/new-reactors/uk-abwr/index.htm). It is possible for a RQ to escalate to a RO or RI, and for a RO to escalate to a RI.

Scope of GDA

49. While the regulators require a certain minimum level of detail to complete a GDA, we recognise that full engineering details of the design may not be available at the GDA stage, as it is normal to finalise some of these as part of the procurement and construction programme.

50. The scope of what is included within GDA depends on the information supplied by the requesting party (GDA is a voluntary process). However, the information provided for GDA needs to be sufficient in scope and detail to enable a meaningful assessment of the safety, security and environmental aspects of the design. We will not proceed with an assessment if essential information is left out.

51. The scope of GDA is defined by the totality of the information provided in the submission to the regulators (as recorded in a 'master document submission list'), together with the 'design reference'. The design reference is a list of all the documents that together describe the design of the reactor and associated plant. We expect this to be 'frozen' at a specific date known as the 'design reference point'.

GDA outcomes

52. There can be 3 different outcomes for a GDA:

- If we are fully content with the environmental aspects of the design, we provide the requesting party with a SoDA. However, there may still be some Assessment Findings that the requesting party or a future operator will need to resolve at a later stage, such as those concerning procurement or commissioning. We will not issue a SoDA if ONR cannot issue a 'design acceptance confirmation' (DAC), as any changes ONR needs to be made to the design could affect the environmental aspects of the design.
- If we are largely content with the environmental aspects of the design, we provide the requesting party with an iSoDA that specifies the outstanding GDA Issues. We only do this if the requesting party can provide a realistic plan for addressing each of the GDA Issues. A full SoDA may replace an iSoDA once all the GDA Issues are resolved to the regulators' satisfaction.

- If we are not content with the environmental aspects of the design, we do not provide a SoDA or iSoDA to the requesting party. This would be the case where there is an unacceptable aspect to the design or an unacceptable omission in the information provided in the submission. The requesting party may propose to undertake further work to address the problems and this might mean we can provide a SoDA at some future date.

Regulatory basis for GDA

53. We provide a SoDA as advice to the requesting party, in accordance with Section 37 of the Environment Act 1995 (GB Parliament, 1995). It has no other formal legal status. However, we will take full account of the work that we have done during GDA if we receive applications for environmental permits relating to a design that has been through GDA.

54. We have carried out our assessments using the Environmental Permitting Regulations 2010 (as amended) (GB Parliament 2010) but we recognise that the Environmental Permitting Regulations 2016 (EPR 16) may come into force before the end of this consultation period.

55. A SoDA will, subject to the scope of the GDA and the nature of the design, state our view on the acceptability of the design to be permitted for:

- the disposal of radioactive waste (gaseous, aqueous and solid), under the Environmental Permitting Regulations 2010 (EPR10) (GB Parliament, 2010)
- the discharge of aqueous effluents containing non-radioactive substances to surface waters and groundwater, under EPR10
- the operation of certain conventional plant (for example, combustion plant used as auxiliary boilers), under EPR10
- the disposal or recovery of non-radioactive waste, under EPR10
- the abstraction of water from inland waters or groundwater, under the Water Resources Act 1991 (WRA91) (GB Parliament, 1991)

56. It will also state our view on the acceptability of the design with respect to the environmental requirements of the Control of Major Accident Hazards Regulations 2015 (COMAH15) (GB Parliament, 2015).

57. Our GDA process mainly focuses on matters relevant to the disposal of radioactive waste. This is because:

- the generation of radioactive waste is intrinsically linked to the detailed design of a nuclear reactor and its associated plant
- permitting the disposal and discharge of radioactive wastes has, in the past, been the area of regulation having the longest lead time for our permitting of new nuclear power stations

58. We also address, as far as is practicable at a generic level, aspects of the design related to the other regulatory requirements listed above.

59. New nuclear power stations are likely to need new or enhanced flood defence structures that will require a flood risk activity permit under the Environmental Permitting Regulations 2010. As flood defence is necessarily site-specific, we do not consider this matter during GDA.

GDA for the UK ABWR

Initiation and initial assessment

60. Our process for the first stage of GDA for the UK ABWR is described in our report on our initial assessment (Environment Agency 2014b). It is summarised below.

- We set up an agreement with Hitachi-GE to carry out GDA of the UK ABWR, which came into effect in April 2013.
- The JPO received Hitachi-GE's submission in December 2013.

- With ONR, we launched the 'comments process' in January 2014, enabling the public to view and comment on the submission.
- We carried out our initial assessment and concluded, amongst other things, that we needed more information.
- We published our report on our initial assessment in August 2014 (Environment Agency, 2014b).

Detailed assessment

61. We began our detailed assessment in August 2014. Where practicable at the generic level, our assessment has taken account of the standards and legal and policy issues set out in government and Environment Agency guidance available at: https://www.gov.uk/government/collections/radioactive-substances-regulation-for-nuclear-sites and https://www.gov.uk/government/policies/managing-the-use-and-disposal-of-radioactive-and-nuclear-substances-and-waste.

The submission

62. We carried out our assessment using the information Hitachi-GE provided in the documents listed in Schedule 1 to the draft iSoDA (the 'submission'). The draft iSoDA is set out in Appendix 1. The documents contain the additional information provided in response to 116 Regulatory Queries, 4 Regulatory Observations and one Regulatory Issue that we raised during our detailed assessment up to 5 August 2016.

Scope of the GDA

63. The requesting party notes that the term ‘UK ABWR’ includes not only the reactor itself but also all buildings and connecting tunnels that are dedicated exclusively or mainly to housing systems and equipment related to the nuclear system, or which control access to those pieces of equipment and systems. There are 5 main buildings within the scope of the UK ABWR GDA:

- reactor building (including containment)
- turbine building
- control building
- radioactive waste building
- service building (structure only)

64. GDA has been based on a generic site layout of the above buildings, which may change for site-specific permit applications.

65. The main stack is located on the roof of the reactor building. This is the single release point for gaseous radioactive waste. Non-radioactive gaseous effluents from the emergency diesel generators are released from a separate release point.

66. There is a single discharge point for release of radioactive effluent to the sea.

67. Other minor sources for radioactive waste are excluded from the GDA scope. These include any discharges from:

- the service building
- the low level waste (LLW) management facilities
- the intermediate level waste (ILW) interim store
- the spent fuel (SF) interim store

68. Further details can be found in Hitachi-GE's ‘Generic site description’ submission.

Liaison with ONR and other bodies

69. We have worked closely with ONR throughout GDA. This enables us to achieve a balance between environmental and safety issues in relation to radioactive waste. We have considered its Step 3 reports. ONR has published a summary document of the Step 3 assessment

(www.onr.org.uk/new-reactors/uk-abwr/reports.htm). Should there be any other relevant issues from its ongoing GDA (Step 4), we expect that ONR will inform us during regular meetings.

Comments process

70. There is a separate comments process, which provides the opportunity for people to access information about the UK ABWR, submit comments and receive responses from the requesting party, has remained available throughout the detailed assessment stage.

71. Hitachi-GE's website (www.hitachi-hgne-uk-abwr.co.uk/index.html) contains regularly updated design information, together with all the information provided to the regulators, except that which is commercially confidential or subject to national security restrictions.

72. Where they relate to our areas of interest, our detailed assessment has taken account of comments received up to 8 July 2016, and Hitachi-GE's responses to those comments - see Chapters 5 to 18. We will address any later comments on environmental issues alongside responses to this consultation in our decision document.

73. The public comments process remains available during the consultation period as ONR is still carrying out Step 4 of its assessment. It will continue until a few months before we make our final decision.

Assessment reports

74. We have documented our detailed assessment in a series of Assessment Reports. These are listed in Chapter 4 and summarised in Chapters 5 to 18 of this document.

Draft iSoDA

75. To help the consultation process, we have included in this document (Appendix 1) a draft iSoDA for the UK ABWR, based on our preliminary (before consultation) view.

Consultation

76. We are now in the consultation stage of our process, which runs from 12 December 2016 to 3 March 2017. We are consulting widely so that people can bring any issues to our attention. We have not yet made any final decisions and will not do so until we have carefully considered all the responses to the consultation.

Post consultation review

77. We will acknowledge all responses, but we will not generally enter into further correspondence with those who respond.

78. We will carefully consider each response that we receive. If matters arise that fall outside our responsibilities, we will pass them to the appropriate regulator, government department or public body.

79. We may seek advice from other organisations, such as government departments and public bodies that have expertise in specific topics, for example, the Centre for Radiation, Chemical and Environmental Hazards (part of Public Health England), which is the government's adviser on radiological protection. If necessary, we will also seek further information or clarification from Hitachi-GE.

Decision and statement

80. In the light of all the information obtained, including that which we receive during and after consultation, we will decide whether to issue a statement and, if so, whether any GDA Issues should be attached to it.

81. We will publish a document that:

- sets out the basis for our decision
- summarises the consultation responses and issues raised

- sets out our views on those issues that fall within our responsibilities and how they have informed our decision making. For responses relating to issues falling outside our responsibilities, we will identify which government department or public body we have passed them to

Working with the public and interested groups

82. We have continued to raise awareness of GDA and the opportunity for the public to comment by:

- meeting with stakeholder groups (including non-governmental organisations, local authorities, local community liaison committees/site stakeholder groups for existing nuclear sites)
- targeting nuclear and energy academics and trade unions
- providing media articles and adverts, and publicising our work at national and local events
- carrying out a public dialogue project with Sciencewise to help us understand the needs of the public in relation to engagement in a GDA of a new nuclear power station (www.sciencewise-erc.org.uk/cms/new-nuclear-power-stations-reviewing-how-to-engage-with-members-of-the-public-in-reactor-design-assessments-known-as-the-generic-design-assessment-or-gda)

83. Copies of our stakeholder engagement plan and our consultation plan for GDA of the UK ABWR are available on request or from GOV.UK (www.gov.uk/government/collections/assessing-new-nuclear-power-station-designs) or our joint website (www.onr.org.uk/new-reactors/public-involvement.htm). Feedback on both is welcome.

3. The UK Advanced Boiling Water Reactor design

This chapter provides a brief description of the UK Advanced Boiling Water Reactor (UK ABWR) design and how it is proposed that waste will be created, processed and disposed of.

Outline of design

84. The UK ABWR design is for a single boiling water reactor (BWR) capable of generating 1,350 megawatts (MW) of electricity. In the reactor core, the uranium oxide fuel (enriched to less than 5% by weight of uranium-235) is cooled by water, which also acts as the neutron moderator necessary for a sustained nuclear fission reaction. The water boils, producing steam, which directly drives a turbine-generator to produce electricity. The steam is then condensed, and the condensate returned to the reactor. The system is shown in Figure 3.1 below.

85. The main ancillary facilities include a spent fuel storage pool, spent fuel store (final option to be determined at site-specific stage), water treatment systems for maintaining the chemistry of the water circuit, 2 alternative alternating current (AC) generator systems for providing power in the event of loss of grid supplies, and waste treatment and storage facilities. Turbine condenser cooling water is provided by a once-through system. For GDA, Hitachi-GE proposes seawater for cooling water.

86. The International Atomic Energy Agency (IAEA) Power Reactor Information System (PRIS) database notes that there are 4 units of the ABWR already operating in Japan, with a further 4 units being built in Japan and Taiwan. Nuclear regulators in the USA, Japan and Taiwan have carried out a design assessment of the ABWR design. The design has evolved from earlier Hitachi-GE BWR designs and the Asea Brown Boveri (ABB) design, transferred under licence to Hitachi-GE/Toshiba. The most recent reactor of similar design is the BWR-6. Currently, there are 8 of these units operating around the world.

Figure 3.1 - Diagram of the UK ABWR

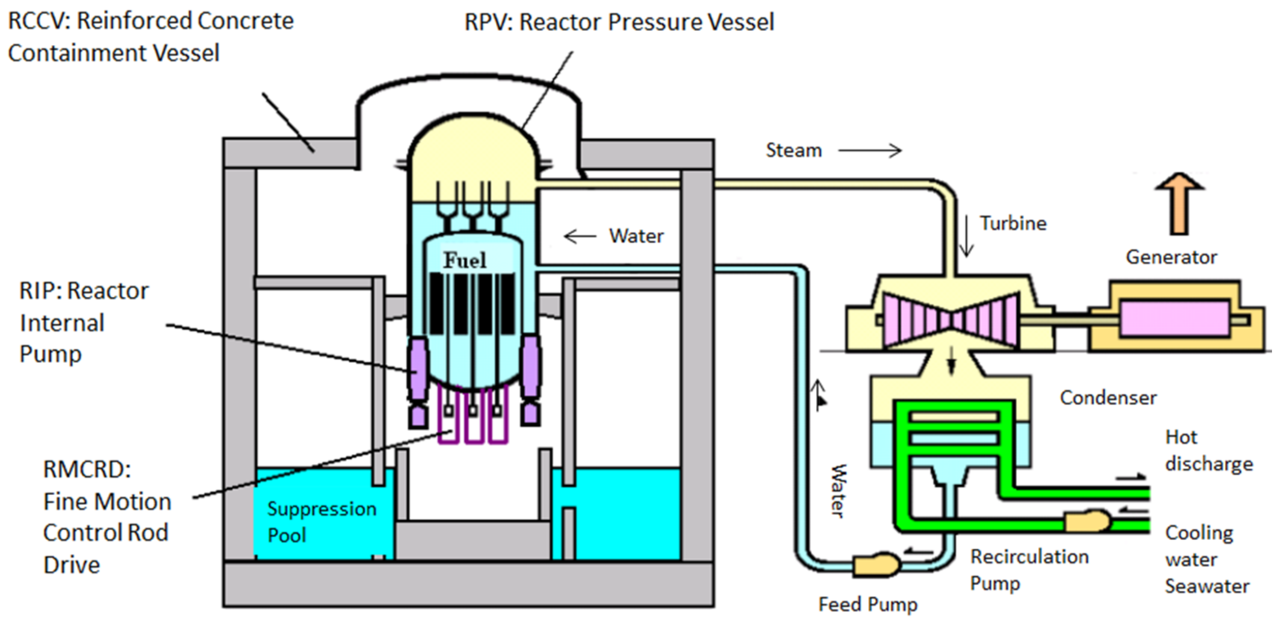


Image courtesy of Hitachi-GE.

Sources, processing and disposal of radioactive waste

87. Radioactive waste is created from activities associated either directly or indirectly with operating and maintaining the reactor, and ultimately, from decommissioning the power station. In particular, operating the UK ABWR generates radioactive waste in the water of the reactor coolant circuit.

88. Liquid radioactive discharges arise mainly from effluents associated with systems for collecting and treating the reactor coolant water. Other sources of effluent include the washings from plant decontamination, drainage from change-rooms and effluent from the active laundry. Liquid effluent treatment facilities include tanks for accumulating, holding up and monitoring wastes, filters, demineraliser ion exchange resin beds and evaporators. Facilities to monitor effluents prior to release are provided.

89. The main source of gaseous radioactive waste is also generated within the reactor coolant circuit. This is collected by the off-gas system (OG) and held for decay storage in the carbon bed delay system. Gaseous activity will also be present in the main process buildings, which are serviced by the heating, ventilation and air-conditioning systems (HVAC). Discharges from these systems are via a high level stack located on the top of the reactor building. There is provision for monitoring these discharges after filtration.

90. Radioactive wastes that are not discharged directly to the environment include spent ion exchange resins, spent filter media, worn-out plant components and parts, contaminated protective clothing and tools, rags and tissues, and potentially contaminated waste oil. Facilities for managing these types of solid waste include resin storage tanks and storage areas for packaged low-level and intermediate-level radioactive waste. Space has been included for treating and packaging solid wastes. All radioactive plant components are likely to become waste when the power station is decommissioned. Similar wastes generated in the UK at present are disposed of at the national Low Level Waste Repository (LLWR) in Cumbria or stored pending disposal at a future deep geological disposal facility (GDF).

91. Spent fuel will be stored under water for several years in the spent fuel storage pool. The design includes providing a store to allow further interim storage prior to final disposal when an appropriate UK facility is available.

Non-radioactive waste

92. Non-radioactive wastes are generated from operating and maintaining the 'conventional' side of the power station. They include:

- combustion gases discharged to air from the auxiliary boilers and back-up generators
- water containing water-treatment chemicals from the turbine-condenser cooling system and other non-active cooling systems, which is discharged to sea
- waste lubricating oils
- debris from the sea inlet screens
- worn-out plant and components and general waste

93. Further information on managing non-radioactive waste will be provided in future submissions from a future operator during site-specific permitting.

94. Non-radioactive substances will also be present in the radioactive wastes and may affect the management or environmental impact of those wastes.

4. Guide to our detailed assessment

This chapter explains where you can find the discussion of specific topics in the rest of this document, and gives some general information about our detailed assessment.

Detailed assessment topics

95. In the following Chapters 5 to 18, we set out our preliminary conclusions and our consultation questions, followed by a summary of our detailed assessment for:

- management systems (Chapter 5)
- radioactive substances regulation topics
    - strategic considerations for radioactive waste management (Chapter 6)
    - process for identifying BAT (Chapter 7)
    - preventing and minimising the creation of radioactive waste (Chapter 8)
    - gaseous radioactive waste (Chapter 9)
    - aqueous radioactive waste (Chapter 10)
    - solid radioactive waste (Chapter 11)
    - monitoring discharges and disposals of radioactive waste (Chapter 12)
    - impact of radioactive discharges (Chapter 13)
- other environmental regulation topics
    - water abstraction (Chapter 15)
    - discharges to surface waters and groundwater (Chapter 16)
    - operation of installations (Chapter 17)
    - control of major accident hazards (Chapter 18)

96. Our preliminary conclusion on the acceptability of the design for radioactive substances permitting is set out in Chapter 14 and that on the overall acceptability of the design in Chapter 19.

97. A full description of our detailed assessment can be found in our separate Assessment Reports:

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

- AR01 - Assessment of management arrangements
- AR02 - Assessment of the strategic approach to waste management
- AR03 - Assessment of best available techniques
- AR04 - Assessment of gaseous radioactive waste disposal and limits
- AR05 - Assessment of aqueous radioactive waste disposal and limits
- AR06 - Assessment of solid radioactive waste and spent fuel
- AR07 - Assessment of sampling and monitoring
- AR08 - Assessment of generic site description
- AR09 - Assessment of radiological impacts on members of the public
- AR10 - Assessment of radiological impacts on non-human species
- AR11 - Assessment of other environmental regulations

About our detailed assessment

98. Our conclusions, all of which should be considered preliminary pending the outcome of this consultation, identify:

- any matters that would be GDA Issues attached to an iSoDA, if we decide to issue one. These GDA Issues may be due to:
    - Hitachi-GE failing to provide enough information for our assessment (for example, because an aspect of the design is not complete)
    - a technical issue raised by our assessment not being fully resolved or confirmed
- any Assessment Findings, which would need to be cleared at an appropriate point during the plant procurement, design development, construction or commissioning programme. These Assessment Findings may relate to:
    - matters that are normally addressed during the construction or commissioning phase (for example, demonstration that as-built plant realises the intended design)
    - matters that depend on site-specific characteristics

5. Management systems

This chapter covers our assessment of Hitachi-GE's management systems. A management system is 'the set of procedures an organisation needs to follow in order to meet its objectives'. It includes identifying the necessary organisational resources, responsibilities and capabilities.

We conclude that Hitachi-GE has an appropriate management system in place that will:

- ensure the design achieves high standards of protection for people and the environment
- support the requirements set out in our process & information document (P&ID) (Environment Agency, 2013)
- control the content and accuracy of the information provided for GDA
- maintain records of design and construction
- control and document modifications to the design
- have adequate suitably qualified staff to support production of the GDA submission

We conclude that Hitachi-GE will have an adequate process in place to:

- inform any operating utility's management system
- transfer knowledge and provide continuing support to any operating utility

We want to ask you:

> Consultation question 1:
>
> Do you have any views or comments on our preliminary conclusions on management systems?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Matters arising from our initial assessment

99. We examined Hitachi-GE’s quality assurance/management system arrangements in some detail during our preliminary assesment in 2013 to 2014 and concluded that it was suitable for controlling the accuracy of the information Hitachi-GE provided to us for GDA.

100. Hitachi-GE describes its management system in its GDA project plan, quality plan, compliance table and GDA specific procedures.

101. We noted that Hitachi-GE management arrangements were certified to ISO 9000, 14000 and 18000 series of standards.

102. We reviewed the Hitachi-GE quality plan and supporting documents, which set out the expectations for quality control requirements for the project. It also identified the requirements for compliance with our P&ID (Environment Agency, 2013) and incorporated required references to our radioactive environmental principles (REPs) (Environment Agency, 2010a).

103. We checked the process documents to ensure they identified the requirements of the P&ID relevant for this stage of the project and our REPs and guidance documents.

104. With ONR, we visited Hitachi-GE's offices in Hitachi City, Japan, for a 4 day joint inspection to see how the management system worked in practice. The inspection objectives were to:

- check that Hitachi-GE has a quality management system (QMS) that provides organisational and procedural arrangements that adequately support production of the submissions
- establish that Hitachi-GE has implemented and continues to review arrangements that adequately control its GDA-related activities
- inform the regulators' assessment of Hitachi-GE's submission

105. Over the 4 days, we examined samples of the QMS procedures and other documentation, and held discussions with relevant staff. Hitachi-GE is certificated to ISO 9001,14001 and 18001, so this inspection concentrated on the processes that will deliver the GDA. These arrangements were generally of a good standard.

106. Our main findings are summarised below:

- Document control arrangements were of a good standard.
- The format and content of documents were suitably specified and arrangements were in place to submit documentation to the Joint Programme Office for assessment by the regulators:
    - We found a number of minor discrepancies.
    - Records were well specified and kept.
    - We judged the document control arrangements to be satisfactory.
- We found the design change control arrangements for developing the UK ABWR reference design from a Japanese reference plant were satisfactory. The level of design review, verification and validation appeared appropriate.
- Arrangements are in place for the review, independent verification and approval of safety and environmental documentation prior to submission to the regulators. We considered these arrangements to be satisfactory.
- Hitachi-GE has arrangements in place for requesting that design changes are included in GDA after the design reference point (DRP) and for receiving regulatory agreement.
- We examined suitably qualified and experienced personnel (SQEP) records for Hitachi-GE personnel, contractors and consultants that demonstrated that the personnel were competent for their roles. SQEP records were of a good standard. We judged this to be satisfactory.
- The control of suppliers included an approved suppliers list, supplier evaluation and a good standard of procurement documentation. Records for supplier evaluations were readily available and complete. We judged these arrangements to be satisfactory.
- Independent assessment of the GDA process consisted of an audit programme. The first part of the programme for ONR's Step 2 and our initial assessment had been completed and all corrective actions carried out and verified. These audits focused on system requirements. We made a recommendation to focus the next round of audits on GDA submissions and supporting documents and to carry out the audits near the start of the next stage of GDA, to allow time for changes to be made.
- During the visit, we held additional meetings to clarify and agree how the UK ABWR reference design will be specified at the DRP and in the master document submission list (MDSL). Hitachi-GE suggested a 'design reference document list' or 'reference plant' document listing approximately 2,000 system descriptions and drawings as the basis for the design reference. This document would also indicate the Japanese reference plant from which the UK systems were developed. We and ONR indicated that we are content with the proposal.
- Hitachi-GE should include the arrangements for controlling the GDA contact list in the document control manual.
- Hitachi-GE should retrospectively add the existing RQs, ROs and other documents, for example management surveillance and quality assurance procedures to the submission tracking sheet and ensure it includes these documents in the future.

107. A joint Environment Agency and ONR RQ was raised with Hitachi-GE to address the main findings of the inspection (RQ-ABWR-0092). This was set out in our Environment Agency preliminary report (Environment Agency, 2014b).

108. We didn't identify any potential GDA Issues or Assessment Findings during our preliminary assesment. However, as discussed above, we did identify some minor areas for improvement:

- Hitachi-GE to improve clarification of responsibilities within the verification process.
- Implement the RQ resolution process.
- Extend Hitachi-GE internal audit programme to cover all aspects of GDA arrangements.
- Hitachi-GE to improve the design review process to clarify how best available techniques (BAT) are discussed and considered during design review meetings and how this is recorded in the minutes.

109. The requirement to record requirements to carry out BAT assessments has now been completed.

110. Radioactive waste advisers (RWAs) had not been appointed at the time of the inspection. However, examination of role profiles indicated that relevant staff had received training on our requirements and the use of BAT. In our view, that was sufficient at that stage of the project. Hitachi-GE has subsequently employed a UK RWA to provide UK legislative advice and to support Horizon Wylfa Ltd staff.

111. Hitachi-GE has acted on our recommendations. We have reviewed this during the detailed assessment stage and are content they have been acted upon.

Other aspects of our detailed assessment

112. During the detailed assessment stage, we continued to communicate regularly with Hitachi-GE via videoconferencing and made several visits to Hitachi works in Japan to gather evidence that changes have been embedded and remain effective.This has enabled us to continue to review Hitachi-GE's progress and provide advice on improvements where necessary. This has been very useful and Hitachi-GE has responded positively.

113. Our review of Hitachi-GE submissions has included how Hitachi-GE has implemented its GDA project plan and the supporting project quality plan (PQP). The PQP describes the arrangements for quality assurance, environmental and safety management activities during the generic design assessment. It includes project instructions and procedures that were specifically developed for the UK ABWR GDA project. These include arrangements for control of documents, data and records, design change, management responsibility, resource management and reporting non-conformances.

114. Hitachi-GE has regularly revised its PQP to reflect developments in the project organisation and associated documents and instructions.

In October 2014, the joint regulators visited Hitachi-GE Japan works offices to review the results of Hitachi-GE internal audits, to discuss updates to the management system and review the implementation of the commitment capture process. We found no significant issues. The visit also included discussions on the requirements for transferring the technology to a future operator. We captured observations made during the visit in a Regulatory Observation (RO ABWR-0057). This was published on the ONR's website (www.onr.org.uk/new-reactors/uk-abwr/ro-res-plan.htm) in June 2015 and the progress is discussed in our assessment report [AR01 - Assessment of management arrangements].

115. The joint regulators carried out a further visit to Hitachi-GE Japan works offices during the detailed assessment stage of GDA in April 2015 to investigate the effectiveness of the training given to support both pre-construction safety report (PCSR) and generic environmental permit (GEP) BAT submissions. The visit included discussing and reviewing processes for recording actions raised as a result of dealing with any RO and RIs raised by all regulators during their assessment of topic areas. The joint regulators concluded that training should take place to improve understanding of UK requirements.

116. A Regulatory Observation (RO-ABWR-0058) was issued and published on the ONR's website (www.onr.org.uk/new-reactors/uk-abwr/ro-res-plan.htm) in June 2015.

117. Hitachi-GE put in place an action plan, which it implemented throughout 2015. It has also carried out an extensive training campaign.

118. The joint regulators visited Japan in April 2016 to discuss progress in training all staff. We noted significant improvement in the number of staff trained by UK specialists since the last inspection. We found the training in UK environmental requirements satisfactory.

119. The visit also included reviewing the implementation of the GDA design review and change processes. We examined examples of how BAT assessments are included in the process and found this to be satisfactory.

120. Hitachi-GE has responded positively to the joint regulators' recommendations and has made changes to its processes.

121. We found no other major areas for improvement other than training, and we remain highly confident in Hitachi-GE's project arrangements.

122. We have met with the Hitachi-GE management systems/quality assurance team throughout the project to review progress on actions from our visits and its own internal audit reviews.

123. We continue to review the development of other processes required to support the provision and control of information to the GDA.

Expectations for the operator's management system

124. During the detailed assessment stage we reviewed the development of the process for technology transfer to licensee and operating regime, which was raised as R0-ABWR-0057 Action 3 (published on ONR's website - www.onr.org.uk/new-reactors/uk-abwr/ro-res-plan.htm).

125. Hitachi-GE proposes to provide a future operator with a suite of documents that will include basic design and construction criteria, technical specifications, equipment manuals (includes surveillance requirements), unit and system operation manuals, incident management arrangements, design control and design authority arrangement. It is our view that this proposal will meet the requirements of the P&ID for informing a future operator's operating instructions.

126. Hitachi-GE has also developed arrangements for identifying the claims, arguments and evidence to help the future operator develop site-specific safety cases and environment cases throughout the life cycle of the plant.

- Claims are clear statements of what will be achieved, and demonstrate compliance with the requirements of the P&ID and those conditions in the generic permit that are subject to the application of BAT.
- Arguments consist of information presented to demonstrate that a claim is valid.
- Evidence is information to support claims and arguments. This may include operating measures and operational requirements.

127. It is our view that this process is well developed and will be used during the detailed assessment process to capture this information as it is identified.

128. We will test these arrangements to ensure the process for technology transfer to a future operator is appropriate and includes environmental requirements.

Our overall conclusions on management systems

129. We conclude that Hitachi-GE has a management system in place that will:

- ensure the design achieves high standards of protection for people and the environment
- control the content and accuracy of the information provided for GDA
- maintain records of design and construction
- control and document modifications to the design

- have enough suitably qualified staff to support production of the GDA BAT case

130. We conclude that Hitachi-GE will have an adequate process in place to:

- inform any operating utility's management system
- transfer knowledge and provide continuing support to any operating utility

You can find more details of our assessment of management arrangements in our report [AR01 - Assessment of management arrangements].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

6. Strategic considerations for radioactive waste management

This chapter covers our assessment of the strategic considerations Hitachi-GE gave to radioactive waste management in developing its design. This includes its general approach to producing and managing radioactive waste and, in particular, the approach to the longer term issues of decommissioning and dealing with spent fuel.

We conclude that:

- Hitachi-GE has provided an acceptable waste strategy for all waste streams that a UK ABWR will typically produce
- Hitachi-GE's Integrated Waste Strategy (IWS), together with its other submissions, will help to protect human health and the environment
- the IWS is consistent with recent government policy statements (DECC, 2014) and current regulatory expectations

We have identified one potential GDA Issue and 2 Assessment Findings:

- **Potential GDA Issue 1** – Decommissioning of the UK ABWR. We require Hitachi-GE to provide sufficient evidence to demonstrate that the UK ABWR has been designed to facilitate decommissioning and hence to minimise associated waste and impacts on people and the environment from decommissioning operations.

- **Assessment Finding 1**: A future operator shall provide details of how the proximity principle has been applied in its selection of optimised disposal routes for solid and incinerable liquid wastes prior to active commissioning.
- **Assessment Finding 2**: If appropriate, a future operator shall produce an assessment of best available techniques that covers all of its sites, noting economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes across all of its sites in its application for an environmental permit.

We want to ask you:

> Consultation question 2:
>
> Do you have any views or comments on our preliminary conclusions on strategic considerations for radioactive waste management?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Overview of the waste management strategy

131. We have carried out a detailed review of Hitachi-GE's integrated waste strategy (IWS) and the documents that support it. The purpose of an IWS is to set the strategy for how wastes will be managed at all stages of a nuclear power station's life cycle, from construction to operation and then to final decommissioning, and also how the plant is designed to minimise the amount of waste generated.

132. The IWS sets out how the requesting party intends to comply with legal obligations and industry good practice for waste management. The strategy considers the requirements of environmental legislation such as the Environmental Permitting Regulations 2010 and industry good practice such as the application of the waste hierarchy.

133. The requesting party's IWS outlines its current strategy for managing radioactive and non-radioactive waste, including spent fuel generated throughout the plant life cycle from constructing, operating and decommissioning the UK ABWR. The strategy is supported by:

- radioactive waste management arrangements
- a decommissioning strategy
- methods for assessing best available techniques (BAT) and defining the approach to optimisation
- impact assessments for humans and wildlife

134. The IWS has been produced for a single reactor unit situated at a generic site. The strategy covers:

- solid radioactive wastes produced during operation and decommissioning
- solid non-radioactive wastes produced during construction, operation and decommissioning
- liquid radioactive wastes produced during operation and decommissioning
- liquid non-radioactive wastes produced during construction, operation and decommissioning
- gaseous radioactive wastes produced during operation and decommissioning
- gaseous non-radioactive wastes produced during construction, operation and decommissioning
- spent fuel, including the final core off-load during decommissioning

135. The first principle of the requesting party's IWS is to apply the waste hierarchy to all wastes and that this should be fundamental when considering subordinate strategies and processes. The IWS also sets out principles that propose to minimise the amount of waste created during construction, operation and decommissioning by using BAT to identify optimised solutions.

136. Although the GDA process allows us to formally ask the requesting party to clarify aspects of its submission, we have not needed to do this during the development of the IWS.

General approach to radioactive waste management

137. Our radioactive substances environmental principles (REPs) (Environment Agency, 2010a), at principle RSMDP1 (Radioactive substances strategy), indicate the matters to be considered at a strategic level.

138. Hitachi-GE's IWS seeks to apply the concentrate and contain principle to individual radioactive waste streams, including the balance between aqueous and gaseous discharges and the generation of solid waste streams. The 'concentrate and contain' option involves trapping the radioactivity in a solid, concentrated form for storage and eventual disposal rather than the 'dilute and disperse' option that involves the direct discharge of gaseous or aqueous liquid radioactivity into the environment (DECC, 2009).

139. Hitachi-GE's IWS summarises how it will manage radioactive waste through operation and decommissioning of the UK ABWR. It also describes how elements of the reactor's design allow

wastes to be managed through their life cycle. We are content that Hitachi-GE has considered gaseous, aqueous, other liquid and solid radioactive wastes and that its approaches for each are technically sound, meet the necessary regulatory requirement and are consistent with current industry good practice.

140. The creation of radioactive waste is minimised in the UK ABWR by maintaining the integrity of the nuclear fuel, minimising materials prone to becoming excessively radioactive in a nuclear reactor, controlling the chemistry of the water coolant; this is known as ‘managing the source term’. A secondary benefit of controlling the chemistry of the water coolant is to minimise corrosion on the inner surfaces of the nuclear reactor plant to prevent the creation of 'mobile' contamination inside the plant.

141. The UK ABWR includes an engineered system for managing and cleaning up the gaseous waste stream prior to its discharge to the environment. This will further reduce the discharge of gaseous radioactivity. We discuss this further in Chapter 9 of this consultation document.

142. There are two main engineered systems that manage aqueous wastes in the UK ABWR. The first is provided to decontaminate and, where possible, recycle aqueous liquids containing radioactivity, while the second system processes aqueous liquid that cannot be recycled by further decontamination before it is discharged to the environment. We discuss this further in Chapter 10 of this document.

143. Hitachi-GE's IWS considers solid radioactive waste according to its categorisation of lower activity waste, higher activity waste or spent fuel. The strategy applies the waste hierarchy, avoiding creating solid waste where possible and minimising radioactive waste at source where this is not possible. The UK ABWR design includes facilities to sort, package and dispatch waste off site where there is currently a disposal route, or to store it on site pending geological disposal. We discuss this further in Chapter 11.

Higher activity waste and spent fuel

144. The government has indicated that new nuclear power stations should proceed on the basis that spent fuel will not be reprocessed, and that both spent fuel and intermediate level radioactive waste (ILW) will be disposed of at a geological disposal facility (GDF) that the government will construct (GB Parliament, 2011b). Since such disposals are unlikely to occur until late this century, this means that the strategy needs to consider on-site storage and management of both ILW and spent fuel for the lifetime of the power station, or an appropriate alternative that is consistent with UK government policy on the long-term management of higher activity radioactive waste (DECC, 2014).

145. The IWS covers segregating and separating higher activity wastes (HAW) and spent fuel. It differentiates between ‘solid HAW’ that would cover metallic and other solid radioactive wastes and ‘wet solid’ HAW that would cover wastes such as contaminated ion exchange resins and process sludges.

146. Solid HAW will be segregated, packaged into a passively safe form and then stored until a GDF is available in the UK. Wet solid HAW will be conditioned by encapsulation in cement also pending the availability of a GDF. The strategy sets out the requirement for inspection and maintenance of both solid and wet solid HAW once it has been conditioned and is being stored on site awaiting final off-site disposal.

147. After an initial period of cooling in the UK ABWR’s spent fuel pool, spent fuel will be treated as if it were waste and will be appropriately packaged and stored awaing disposal to a geological disposal facility, which is consistent with the UK government ‘base case’ (GB Parliament, 2011b).

148. The arrangements set out in the IWS for HAW and spent fuel are consistent with UK government policy, regulatory expectations and industry good practice.

Decommissioning

149. In line with government policy (GB Parliament, 2004), we expect decommissioning of the station to be considered at the design stage, with a view to ensuring that it can readily be carried out, while minimising the volumes of decommissioning wastes and minimising the impacts on people and the environment.

150. Hitachi-GE's IWS summarises the waste management strategy that should be employed when the UK ABWR is decommissioned. It acknowledges that the limits within an environmental permit during the decommissioning phase of a nuclear power station's life are likely to be different from those during operation. It highlights that an operator of a UK ABWR will need to act upon this. It lists which systems will no longer be needed as soon as electricity generation ceases and identifies these as candidates for prompt decommissioning. It also lists the systems that the UK ABWR used during operation which will be critical to sustaining decommissioning activities such as heating, ventilation and air conditioning, liquid effluent systems and solid waste facilities.

151. The IWS provides estimates of waste volumes during decommissioning. This allows the eventual operator to consider waste volumes and costs and to make adequate provision for decommissioning well ahead of the task itself.

152. Although the IWS provides only a summary of the decommissioning strategy, we have reviewed Chapter 31 of the pre-construction safety report (PCSR) where the details that implement the strategy are contained. We have also reviewed Hitachi-GE's radioactive waste management arrangements, which provide greater detail on how decommissioning wastes will be managed.

153. With ONR, we have requested further information from Hitachi-GE on decommissioning to be considered in ONR's Step 4 assessment (RQ-ABWR-0825, RQ-ABWR-0826 RQ-ABWR-0827 and RQ-ABWR-0833). We requested that Hitachi-GE provide further detailed evidence on decommissioning in the GDA to demonstrate that the UK ABWR design has been optimised for decommissioning. We note that this would also help any future operator in providing a decommissioning and waste management plan.

154. A workshop was held with ONR and Hitachi-GE in July 2016 to discuss progress in this area and Hitachi-GE has provided supporting evidence in a series of topic reports (TR):

- TR 1: Decommissioning strategy
- TR 2: Design for decommissioning
- TR 3: Decommissioning plan
- TR 4: Decommissioning techniques
- TR 5: Construction techniques
- TR 6: Decommissioning waste strategy
- TR 7: Decommissioning assessment

155. The Hitachi-GE programme was such that not all documents were available for assessment at the time of our assessment deadline and that several of these are expected to be updated in September 2016 and December 2016. We will, therefore, consider these documents as part of our ongoing assessment and foresee that this potential GDA Issue may be resolved prior to the end of GDA. This is explained further in the Executive Summary (paragraph 11).

156. As Hitachi-GE has yet to provide a complete case to demonstrate that the UK ABWR has been designed for decommissioning, our conclusion is currently subject to the following potential GDA Issue:

- **Potential GDA Issue 1** – Decommissioning of the UK ABWR. We require Hitachi-GE to provide sufficient evidence to demonstrate that the UK ABWR has been designed to facilitate decommissioning and hence to minimise associated waste and impacts on people and the environment from decommissioning operations.

157. The Nuclear Reactors' (Environmental Impact Assessment for Decommissioning) Regulations 1999 (EIADR) cover the environmental impact of decommissioning on habitats. The ONR is responsible for ensuring the requirements of EIADR are followed.

Our overall conclusions on strategic considerations for radioactive waste management

158. Hitachi-GE's IWS is adequate for the purposes of generic design assessment.

159. Hitachi-GE's IWS defines how the waste hierarchy should be applied to wastes generated at all stages of the UK ABWR's life, from construction to operation and decommissioning.

160. The IWS appropriately considers at a strategic level how all radioactive and non-radioactive waste streams will be managed.

161. The IWS does not identify any waste streams for which there is:

- currently no disposal route
- no future disposal route identified

You can find more details of our assessment of strategic considerations in our report [AR02 - Assessment of the strategic approach to waste management].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

7. Process for identifying best available techniques

This chapter covers our assessment of Hitachi-GE's process for identifying best available techniques (BAT). Identifying BAT involves balancing the benefits of minimising the amount of radioactive waste generated and discharged against the costs involved, including non-monetary costs such as any increase in worker dose or reduction in nuclear safety. The results lead to a design that is capable of meeting high environmental standards but where the financial cost of applying techniques is not excessive in relation to the environmental protection they provide.

We conclude that Hitachi-GE has followed an appropriate process for identifying BAT.

We want to ask you:

> Consultation question 3:
>
> Do you have any views or comments on our preliminary conclusions on the process for identifying BAT?

Please read below for a summary of our detailed assessment and links to further supporting documents.

About BAT

162. There is a requirement under EPR10 that we exercise our functions to ensure that all exposures to ionising radiation of any member of the public and of the population as a whole resulting from the disposal of radioactive wastes are kept as low as reasonably achievable, taking into account economic and social factors. We do this by requiring designers and operators to use BAT to:

- prevent and minimise the creation of radioactive waste
- minimise the discharges of gaseous and aqueous radioactive waste to the environment
- minimise the impact of those discharges on people, and adequately protect other species

> **Definition of BAT**
>
> **Best available techniques** means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. In determining whether a

set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to:

- comparable processes, facilities or methods of operation which have recently been successfully tried out
- technological advances and changes in scientific knowledge and understanding
- the economic feasibility of such techniques
- time limits for installation in both new and existing plant
- the nature and volume of the discharges and emissions concerned

Techniques include both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled.

(OSPAR, 1992)

163. BAT is, therefore, a fundamental aspect of radioactive substances regulation, and we expect it to be identified by an appropriate process as described in our REPs (Environment Agency, 2010a) at principle RSMDP4 (methodology for identifying BAT). We refer to BAT as the means an operator of a facility uses to deliver an 'optimised' outcome, to reduce exposures to as low as reasonably achievable (ALARA). Optimisation requires the operator to make judgements about the relative significance of various issues, including:

- the number of people (workers and the public) and other environmental targets that may be exposed to radiological risk
- the likelihood that they could be exposed to radiation, where exposure is not certain to happen
- the magnitude and distribution in time and space of radiation doses that they will or could receive
- nuclear security and safeguards requirements
- issues similar to those above, but relating to non-radiological hazards
- economic, societal and environmental factors
- technical viability
- uncertainties in any of the above

Hitachi-GE's process for identifying BAT

164. We consider Hitachi-GE's approach to optimisation to be a suitable basis from which to identify BAT for the UK ABWR for GDA purposes. The approach is documented in a dedicated Hitachi-GE 'Approach to optimisation' submission. Claims generated as part of this optimisation process are presented along with their accompanying arguments and evidence in the 'Demonstration of BAT' submission.

165. Hitachi-GE has suitably recognised the relevant principles of optimisation and sought to apply these in presenting the GDA case. It has also considered standard environmental permit conditions and our P&ID requirements (Environment Agency, 2013) relating to optimisation.

166. Hitachi-GE has also carried out a number of engineering option selection (referred to as optioneering) exercises to optimise the design of the UK ABWR for GDA purposes. Minimising the amount of radioactive waste generated and discharged has been one factor in these exercises. Overall, we conclude that Hitachi-GE has used optioneering approaches where appropriate, targeting those aspects that are relevant to the UK design and, where prompted, in response to specific regulatory considerations, for example, to justify specific design configurations.

167. Hitachi-GE's approach has been to set out claims, develop arguments in support of these, and to provide the relevant underpinning evidence, where possible (see Appendix 5 for further information). Hitachi-GE provides a specific radionuclide route map in its 'Demonstration of BAT' submission, which indicates how the developed BAT arguments apply to specific radionuclides and, in particular, those that are significant constituents of gaseous and solid discharges.

168. The approach recognises that the UK ABWR is an evolution of earlier BWR technology and reflects on design improvements that are relevant to the BAT claims. We consider this to be a sensible approach and a suitable method by which to convey the 'BAT case' for GDA of the UK ABWR.

169. Hitachi-GE has provided extensive evidence. This is reflected in more than 100 references that support the 'Demonstration of BAT' submission. A large number of Regulatory Queries in relation to BAT aspects have been raised, often jointly with ONR. Hitachi-GE has responded to the Regulatory Queries and, in many cases, the response has subsequently become a supporting reference.

170. Hitachi-GE's approach has also included identifying aspects relating to BAT that any future operators will need to consider (for example, at the detailed design and permitting stage). These aspects have been identified as 'forward actions'. We consider this to be a useful approach and recognise the value of these actions.

171. Overall, we conclude that, in principle, Hitachi-GE has followed an appropriate process for identifying BAT in the design of the UK ABWR. However, demonstrating that BAT has been applied to the design and operation of the UK ABWR requires balancing of relevant factors, including safety aspects. Therefore, optimisation must be based on an overall approach that considers both BAT and ALARP, where appropriate.

172. ONR has raised a number of Regulatory Observations ultimately relating to ALARP considerations for plant systems where BAT is also relevant (radioactive waste management systems). Of particular relevance are: RO-ABWR-0036, 'Demonstration that the approach taken to radioactive waste management reduces risks so far as is reasonably practicable (SFAIRP)', and RO-ABWR-0054, 'UK ABWR – Chemical/process engineering design approach'. We are unaware of any significant impact on the claims, arguments and evidence that Hitachi-GE has made in its 'Demonstration of BAT' submission to date. However, the observations remain open and are yet to be resolved.

173. At this time, and as outlined further below, we have concluded that the UK ABWR design is consistent with BAT in so far as this has been demonstrated and to a level in line with our expectations for GDA. However, ALARP aspects of the design are yet to be fully demonstrated to ONR, as reflected in outstanding Regulatory Observations. In addition, limits and conditions of operation are yet to be fully defined for plant that has an environmental protection function. There remains a possibility, therefore, that design changes in response to ongoing ALARP considerations may impact on the design of plant and how it is to be operated. This may ultimately impact on the BAT case for the UK ABWR.

174. We have concluded that BAT is adequately addressed in Hitachi-GE's design development processes. It is therefore anticipated that any design changes that may result from on-going ALARP considerations will be appropriately assessed in terms of BAT. We will need to revisit our current conclusion pending any design changes to the UK ABWR to ensure ALARP and once any operational limits and conditions are defined. We will continue to liaise with ONR on this as part of the Step 4 assessment, and this work will inform our decision document. Our conclusion is subject to the following potential GDA Issue:

- **Potential GDA Issue 3** – Consideration of 'best available techniques' (BAT) and 'as low as reasonably practicable' (ALARP) in optimisation. We require Hitachi-GE to demonstrate that appropriate consideration has been given to both environmental and safety aspects, in order to achieve an optimised design.

We describe our expectations for resolution of this potential GDA Issue in the executive summary (paragraph 11) of this consultation document.

You can find more details of our assessment of BAT to prevent and minimise the creation of radioactive waste in our report on the assessment of BAT [AR03 - Assessment of best available techniques].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

8. Preventing and minimising the creation of radioactive waste

This chapter covers our assessment of Hitachi-GE's techniques used to prevent and minimise the creation of radioactive waste. We have assessed Hitachi-GE's submission with respect to the:

- sources of radioactivity in the reactor that will eventually become waste, and the techniques used to minimise the amount produced
- containment of radioactive substances in the plant, since losses can result in large volumes of radioactive waste and contamination of land or groundwater
- processing of radioactive substances in the plant and how this affects the distribution of radioactivity between gaseous, aqueous and solid waste streams

We conclude that the UK ABWR uses BAT to:

- prevent and minimise the creation of radioactive waste
- support the principle of 'concentrate and contain'
- minimise the overall impact of discharges to the environment

We have identified 2 potential GDA Issues and 4 Assessment Findings.

- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.
- **Potential GDA Issue 3** – Consideration of 'best available techniques' (BAT) and 'as low as reasonably practicable' (ALARP) in optimisation. We require Hitachi-GE to demonstrate that appropriate consideration has been given to both environmental and safety aspects, in order to achieve an optimised design.

- **Assessment Finding 3**: A future operator shall demonstrate that the UK ABWR will be operated in a manner that represents best available techniques, addressing in particular:
    - fuel selection
    - fuel and core management
    - avoidance of control rod failure in power suppression situations
    - consideration of all normal operational modes and stages of the reactor’s life cycle
    - control of water chemistry
    - selection of demineraliser resins for liquid waste management systems.
- **Assessment Finding 4**: A future operator shall review the practicability of techniques for abatement of carbon-14 prior to operation.
- **Assessment Finding 5**: A future operator shall assess the partitioning of carbon-14 between gaseous, aqueous and solid waste streams, during initial operations.
- **Assessment Finding 6**: A future operator shall address the 15 forward actions as identified by Hitachi-GE in the 'Demonstration of best available techniques' submission - GA91-9901-0023-00001 Revision F (July 2016).

Table 8.1 - Summary of Hitachi-GE's forward actions for a future operator (Assessment Finding 6)

Follow-up actions identified by Hitachi-GE
To support the demonstration that performance of systems deemed to be BAT are as expected and have therefore been optimised.
An assessment shall be undertaken to determine BAT for the selection of demineraliser resins.
Undertake a BAT assessment of carbon-14 abatement techniques using alkaline scrubbing.
Commissioning data shall be provided to support the design basis calculations currently being used to substantiate the argument that the delay period provided by the off-gas delay beds represents BAT.
Undertake a BAT assessment of waste management techniques post-GDA taking into account site-specific factors including the proximity principle.
Undertake a BAT assessment to support the specification and selection of equipment to be used in the radioactive waste management building.
Undertake a BAT assessment of waste management routes taking into account site-specific factors including the proximity principle and other relevant factors to fully substantiate 'Argument 4b'.
The management of waste, the final waste route and the quantity of waste to be consigned will be determined through the application of BAT by a future operator.
A future operator shall select the techniques for environmental sampling and determine the environmental monitoring programme.
A future operator shall assess the cobalt content of steels based on availability and cost from available suppliers.
A future operator shall demonstrate BAT when selecting its plans for packaging, storage and disposal of spent fuel.
A future operator shall determine the optimal stack height.
A future operator shall determine the management and arrangements for aqueous discharges.
A future operator shall assess and define the decay storage timescales.
Management arrangements will be developed to ensure that BAT is considered through the life cycle of the project, from design to decommissioning.

We want to ask you:

Consultation question 4:

Do you have any views or comments on our preliminary conclusions on preventing and minimising the creation of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources and minimisation of radioactivity

175. This section describes the sources of radioactive materials in the UK ABWR that will eventually become waste, and the techniques used to minimise the amount of waste produced.

176. Hitachi-GE provides a diagram of the sources and routings of radioactive wastes within the UK ABWR in Figure 8.1. A summary of the main aspects for the most significant radionuclides contributing to discharges from the UK ABWR design is provided in Tables 8.2 and 8.3. A summary of the projected annual discharges is also provided in Hitach-GE's 'Quantification of discharges and limits' submission. Chapter 11 provides a summary of the solid radioactive waste arisings from the UK ABWR design.

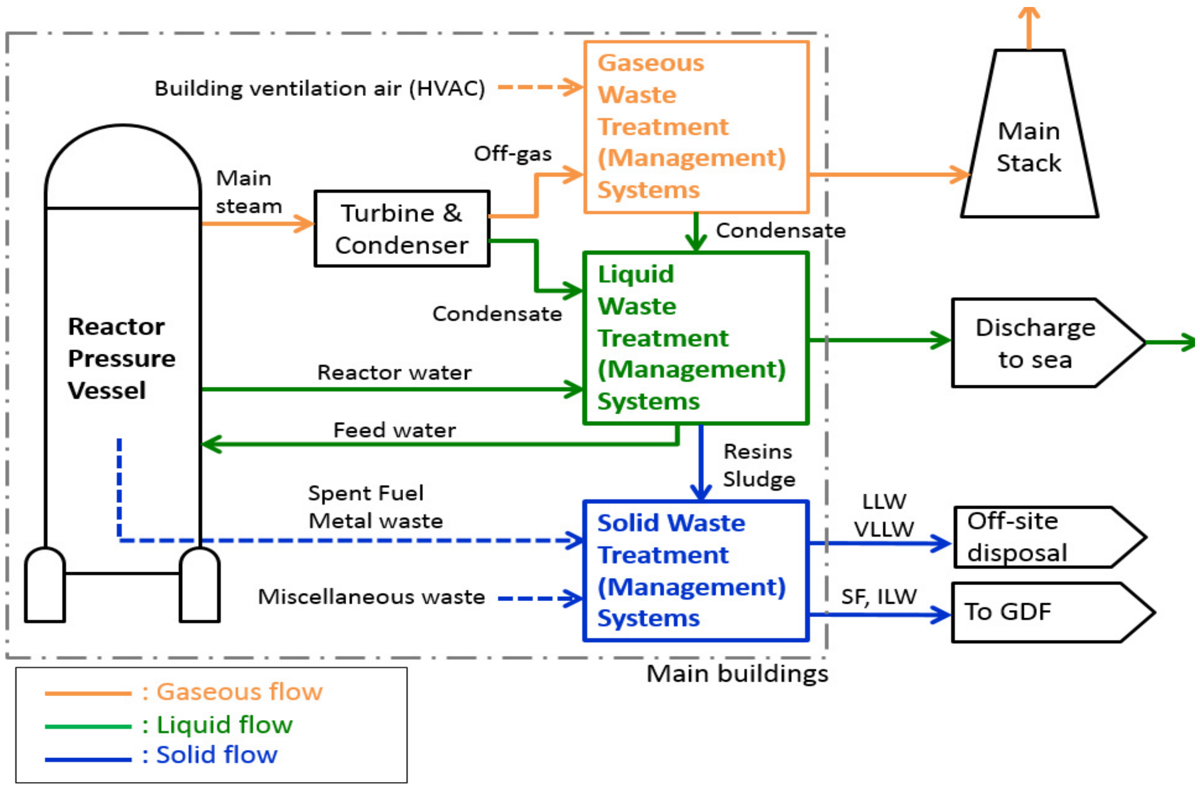


Figure 8.1: Diagram of gaseous, liquid and solid waste arisings within the UK ABWR (from Hitachi-GE's Summary of the Generic Environmental Permit Applications GA91-9901-0019-00001 Revision E).

177. The origins of radioactivity within the UK ABWR are mainly:

(a) Activation of chemical species in the primary reactor coolant (water). Important radionuclides arising in this way are argon-41 and carbon-14, which transfer to the gaseous discharge stream. Other notable activation products include tritium (H-3) and cobalt-60.

(b) Fission products formed in the fuel. These may leak into the primary coolant through any defects in the fuel cladding. Soluble fission products which form ionic species are predominantly accumulated on ion exchange resins and filters and, therefore, arise ultimately as solid waste for disposal. There are very limited liquid discharges from the UK ABWR. Noble gases, including radionuclides of krypton, xenon and argon, are extensively retained on delay beds. Spent fuel is assumed to be waste for GDA purposes and this will contain the majority of radioactivity.

178. Activated and contaminated metals within the plant become solid waste for disposal. Corrosion products from the metal components of the reactor system are also a significant source of waste arisings. Corrosion products entrained within the reactor coolant are activated as they pass through the core of the reactor. In radioactivity terms, the most significant radionuclide arising in

this way is cobalt-60. Corrosion products tend to accumulate on filters and ion exchange media within the liquid system and are largely associated with solid wastes for eventual disposal.

179. Tritium (H-3) arises via a number of mechanisms, including ternary fission in fuel, neutron reactions of boron-10 (a component of some control rods) and from activation of deuterium (H-2).

180. Based on the extensive documentation Hitachi-GE provided we conclude that, at this stage, Hitachi-GE has broadly identified the radionuclides that will contribute significantly to the amount of activity in waste disposals and will result in doses to members of the public. However, sources of radioactivity in the UK ABWR design have been subject to a joint Environment Agency/ONR Regulatory Observation (RO-ABWR-0006) and a subsequent Regulatory Issue (RI-ABWR-0001), 'Definition and Justification for the Radioactive Source Terms in UK ABWR during Normal Operations'.

181. The Environment Agency and ONR raised RO-ABWR-0006 on 28 April 2014. Two of the actions under the RO requested the radiological source terms for the UK ABWR design to be defined and justified. This was raised because Hitachi-GE's GDA submission lacked information regarding radionuclides in the UK ABWR during normal operation. The submission also lacked evidence to support the gaseous and aqueous discharge estimates and proposed limits. We received a resolution plan for this RO on 15 July 2014 and we had regular meetings with Hitachi-GE between July and December 2014. Hitachi-GE submitted 2 reports to us in January 2015, which we and ONR assessed. These reports were intended to address the definition and justification of source terms for the UK ABWR. However, these reports did not meet our expectations, and together with ONR, we provided feedback to Hitachi-GE outlining shortfalls in the reports. We challenged the approach and methodology used to derive the UK ABWR source terms, the limited use of operational experience (OPEX) data from other operating ABWRs and the evidence on which discharge estimates were based.

182. Together with ONR, we escalated the Regulatory Observation to a Regulatory Issue. A workshop was held on 19, 20 and 22 May 2015 at which, we and ONR presented our requirements to Hitachi-GE and gave some examples of source terms that we have assessed for other nuclear power plant designers and operators. RI-ABWR-0001 was raised on 3 June 2015. Regular meetings were held between regulators and Hitachi-GE and have been on-going since June 2015. Hitachi-GE has changed its approach to deriving and justifying source terms for the UK ABWR, using more OPEX data and providing more explanation of the methods used. Between November 2015 and February 2016 we received a number of reports documenting how it had derived and justified the UK ABWR source term. These provided information on the primary source term (radionuclides in the reactor water and steam), process source terms (radionuclides in different downstream systems within the plant) and end-user source terms (which included source term for gaseous and aqueous discharges).

183. At the time of writing this report (5 August 2016), both RI-ABWR-0001 and RO-ABWR-0006 remain open. A workshop was held with ONR and Hitachi-GE between 26 and 29 July 2016 to discuss progress in this area. Our technical assessor and ONR inspectors consider the information Hitachi-GE provided to be adequate.

184. Until the RI and RO are formally closed, there is potential for the estimated gaseous and aqueous radioactive discharges, estimated solid radioactive waste arisings, decommissioning source term and radiological impact assessments to change. This could have an impact on our draft conclusions on the acceptability of the UK ABWR design. However, we now believe there to be a low risk of significant change to the source term. We have raised a number of potential GDA Issues relating to these matters and an explanation of our view on when we expect them to be resolved is included in the executive summary (paragraph 11).

185. As this work has not yet been completed, we have identified the following potential GDA Issue:

- **Potential GDA Issue 2 –** Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

186. From the source term work Hitachi-GE has identified the major radionuclides in gaseous and aqueous discharges. Their sources and minimisation techniques are summarised in the tables below.

Table 8.2 – Major radionuclides in gaseous discharges, approaches and techniques to minimise quantities and impacts

Radionuclide	Sources	Approach and techniques to minimise quantities and impacts
Argon-41	Activation of entrained atmospheric Ar-40 in coolant	Minimisation of leaks (Argument 1j) and the air leakage into the main condenser. Off-gas treatment system charcoal delay beds (Argument 2a and 2b). Discharge at height via main stack (Argument 5a).
Noble gases	Fission products (FP) from fuel and structural uranium. Radioactive noble gases are formed by fission. They are usually confined within the fuel but in the event of fuel leaks, they can pass into the coolant via defects in the fuel cladding. Their presence in the coolant is also due to the occurrence of traces of uranium ('tramp' uranium[1]) on the surface of fuel assemblies following the manufacturing process.	Minimise fuel-cladding failures (grid-to-rod fretting, corrosion and crud, debris, pellet cladding interaction (PCI)) and manufacturing quality assurance (QA) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise 'tramp uranium' (Argument 1a). Minimise crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is provided for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel assemblies used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j). Off-gas treatment system and charcoal delay beds (Argument 2a and 2b). Discharge at height via main stack (Argument 5a).
Iodine-131	FPs from fuel, structural uranium. Iodine isotopes are formed in the fuel by fission and can	Migration into reactor water (direct or through pin fracture) → Partial migration into steam → Separation at condenser →

[1] 'tramp uranium' is any uranium on the external surfaces of the fuel. This has the potential to undergo nuclear fission and to generate fission products that will enter the steam circuit.

Radionuclide	Sources	Approach and techniques to minimise quantities and impacts
	escape into the reactor coolant water via fuel defects. Also, like other FPs, small quantities are produced from uranium contamination on fuel surface ('tramp' uranium) within the reactor which can also be found in the coolant.	Discharge via stack via off-gas (OG) (negligible). Discharge of volatile iodine in aqueous stream via heating, ventilation and air-conditioning (HVAC) system. Minimise fuel cladding failures (grid-to-rod fretting, corrosion and crud, debris, PCI, and manufacturing upsets) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise 'tramp uranium' (Argument 1a). Minimise crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is implemented for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel assemblies used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j).
Strontium-90 **Strontium-89**	FPs from fuel, structural uranium. Isotopes of strontium are formed as a result of fission. They are usually confined in the fuel but, in the event of fuel leaks, they can pass into the coolant via defects in the fuel cladding. Their presence in the coolant is also due to the occurrence of traces of uranium ('tramp' uranium) on new fuel assemblies following the manufacturing process.	Minimise fuel cladding failures (grid-to-rod fretting, corrosion and crud, debris, PCI, and manufacturing upsets) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise 'tramp uranium' (Argument 1a). Minimisation of crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is implemented for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel assemblies used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j). Filters to remove particulate material (Argument 2d).

Radionuclide	Sources	Approach and techniques to minimise quantities and impacts
		Discharge at height via main stack (Argument 5a).
Caesium-137	FPs from fuel, structural uranium.	As for strontium-89 and strontium-90.
Cobalt-60	Cobalt-60 formed from cobalt-59 Activation of reactor components. Activation of insoluble and soluble metal crud and particulate in reactor water.	Minimise crud formation and optimal water chemistry (Argument 1f). Specification of low cobalt content materials (Argument 1g). Minimise leaks (Argument 1j). Filters to remove particulate material (including filters on the HVAC) (Argument 2d). Discharge at height via main stack (Argument 5a).
Tritium	Ternary fission in fuel. Tritium from boron-10 in control rods. Hydrogen-3 produced from hydrogen-2 in reactor water.	No boron usage in the water chemistry (Argument 1b). Use of hafnium control rods (Argument 1b). Use of gadolinium as a burnable poison rather than boron (Argument 1b). Minimise fuel cladding failures (grid-to-rod fretting, corrosion and crud, debris, PCI, and manufacturing upsets) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is implemented for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel assemblies used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j). Gaseous tritium present within the off-gas is removed by the off-gas recombiner and off-gas condenser. The off-gas recombiner recombines hydrogen and oxygen and the off-gas condenser cools and condenses the hydrogen depleted off-gas to separate any moisture and return it to the main condenser.

Radionuclide	Sources	Approach and techniques to minimise quantities and impacts
		Following treatment by these 2 components of the off-gas system the hydrogen concentration is minimised in the off-gas. As tritium is a hydrogen compound, the performance of the off-gas recombiner and off-gas condenser, therefore, also removes tritium from the off-gas. The hydrogen and, therefore, any tritium is converted to water and is returned to the condensate storage tank (CST) where it is reused within the plant. (Argument 2a). Discharge at height via main stack (Argument 5a).
Carbon-14	Neutron activation of nitrogen-14 and oxygen-17 results in carbon-14 both from fuel and reactor water. In another minor mechanism contributing to carbon-14, carbon-13 produces carbon-14, in the presence of dissolved carbon in the coolant.	None. The main source of carbon-14 is the thermal neutron reaction with oxygen-17 in the reactor coolant water (H_2O). Therefore, there are no measures for reducing the generation.

Note to table – please see Appendix 5 for 'arguments' referred to in Table 8.2.

Table 8.3 – Major radionuclides in aqueous discharges, approaches and techniques to minimise quantities and impacts

Radionuclide	Sources and amounts	Approach and techniques to minimise quantities and impacts
Strontium-90 **Strontium-89**	FPs from fuel, structural uranium. Isotopes of strontium are formed as a result of fission. They are usually confined in the fuel but, in the event of fuel leaks, they can pass into the coolant via defects in the fuel cladding. Their presence in the coolant is also due to the occurrence of traces of uranium ('tramp' uranium) that can never be completely removed on new fuel assemblies following the manufacturing process.	Minimise fuel cladding failures (grid-to-rod fretting, corrosion and crud, debris, PCI, and manufacturing upsets) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise 'tramp uranium' (Argument 1a). Minimise crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is implemented for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel assemblies used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j). Reactor water clean-up system (CUW) (Argument 1h). Laundry drain (LD) pre-filter. LD activated carbon adsorption tower activated charcoal. LD filter. High chemical impurities waste (HCW) evaporator. HCW demineraliser. (Argument 2e, Argument 2g and 2h).
Iodine-131	FPs from fuel, structural uranium. Iodine isotopes are formed in the fuel by fission and can escape into the reactor coolant water via fuel defects. Also, like other FPs, small quantities are produced from uranium contamination on fuel surface ('tramp' uranium) within the reactor, which can also be found in the coolant.	As for strontium-89 and strontium-90.

Radionuclide	Sources and amounts	Approach and techniques to minimise quantities and impacts
Caesium-137	FPs from fuel, structural uranium.	As for strontium-89 and strontium-90.
Cobalt-60	Cobalt-60 produced from cobalt-59. Activation of reactor components. Activation of insoluble and soluble metal crud and particulate in reactor water.	Minimise crud formation and optimal water chemistry (Argument 1f). Specification of low cobalt content materials (Argument 1g). Minimise leaks (Argument 1j). CUW system (Argument 1h). LD pre-filter. LD filter. LD activated carbon adsorption tower. HCW evaporator. HCW demineraliser. (Arguments 2e, 2g and 2h).
Tritium	Ternary fission in fuel Tritium produced from boron-10 in control rods. Hydrogen-3 produced from hydrogen-2 in reactor water.	No boron usage in the water chemistry (Argument 1b). Use of hafnium control rods (Argument 1b). Use of gadolinium as a burnable poison rather than boron (Argument 1b). Minimise fuel cladding failures (grid-to-rod fretting, corrosion and crud, debris, PCI and manufacturing upsets) (Argument 1a). High standards of fuel design and fabrication (Argument 1a). Minimise crud formation and optimal water chemistry (Argument 1f). An efficient anti debris device is implemented for fuel assemblies (Argument 1a). The fuel performance - minimising the number of fuel elements used minimises the probability for cladding leakage of FPs into the coolant (Argument 1c). Identifying and isolating fuel leaks (Argument 1d). Minimise leaks (Argument 1j). No abatement (Argument 2e)

Note to table – please see Appendix 5 for ‘arguments’ referred to in Table 8.3.

187. Hitachi-GE claims that the UK ABWR design eliminates or reduces the generation of radioactive waste. It provides claims, arguments and evidence in support of this as part of its ‘Demonstration of BAT’ submission. The arguments Hitachi-GE present and our associated conclusions are

provided in Appendix 5. The developed BAT arguments can be applied to specific radionuclides and, in particular, those that are major consistuents of gaseous and liquid discharges (Tables 8.2 and 8.3 above).

188. We broadly agree with these claims and arguments based on our sampling of the evidence as presented. We note however, and as reflected in our potential GDA Issues, that some aspects are yet to be fully addressed.

189. The UK ABWR design contains a range of features that contribute to eliminating or reducing waste arisings. Hitachi-GE has identified the most significant of these, as follows:

- the design, manufacture and management of nuclear fuel to minimise the potential for a release of fission products (FP) from the fuel into the steam circuit or cooling pool water
- eliminating or reducing materials that are susceptible to activation at all stages of commissioning and operation
- reducing the amount of spent fuel (SF) and higher activity waste (HAW) generated for a given energy output
- reducing the amount of lower activity waste generated for a given energy output
- promptly detecting and managing failed fuel
- introducing techniques to be used during commissioning, start-up and shutdown

190. The UK ABWR design also includes features to minimise the radioactivity in radioactive waste disposed to the environment. Hitachi-GE identifies the most significant of these, as follows:

- providing an off-gas (OG) system that includes processes to reduce radioactivity in the gaseous phase prior to discharge to the environment
- providing off-gas charcoal adsorber within the OG system to abate short lived FPs
- providing a heating, ventilation and air conditioning (HVAC) system that prevents the uncontrolled discharge of radioactive substances
- treatment techniques for aqueous wastes that minimise the discharge of radioactivity to the environment
- decay storage to minimise the radioactivity associated with wastes that require disposal

191. The UK ABWR design also includes features to minimise the volume of radioactive waste disposed of to other premises. Hitachi-GE identifies the most significant of these, as follows:

- design changes that will minimise the volumes of operational and decommissioning waste arisings.
- providing a number of features that will allow future operators to adopt an operating philosophy that will minimise the quantity of solid radioactive waste associated with routine operations and maintenance
- providing dedicated facilities for managing, treating and storing solid radioactive waste
- reducing the quantity of solidified high chemical impurity wastes (HCW) that are generated
- availability of a range of decontamination techniques during decommissioning

We conclude that Hitachi-GE has adequately demonstrated that the UK ABWR design will minimise the amount of of radioactive waste produced. We have identified a number of aspects that we expect any future operators to pursue (please see Appendix 5 for further details).

Containment of radioactive substances

192. Any radioactivity formed in the reactor and not retained in the fuel will inevitably end up as radioactive waste. However, the volume of waste produced can be minimised by containing the radioactivity within those parts of the plant where it is intended to be, and not allowing it to contaminate other parts of the plant, land or groundwater.

193. Hitachi-GE has provided a number of claims, arguments and evidence in support of the containment features of the UK ABWR design. We note the following arguments, presented in Hitachi-GE's 'Demonstration of BAT' submission, as being particularly relevant in this regard:

- Argument 1a: Design, manufacture and management of fuel
- Argument 1d: Detection and management of failed fuel
- Argument 1h: Recycling water to prevent discharges
- Argument 1j: Leak tightness of liquid, gas and mixed phase systems
- Argument 2b: Delay beds for noble gases and iodine
- Argument 2c: Heating, ventilation and air conditioning system
- Argument 2d: Filtration of airborne particulate matter
- Argument 2e: Configuration of liquid management systems
- Argument 2f: Sizing of tanks, vessels and liquid containment systems
- Argument 2g: Demineralisers for distillates from the high chemical impurities
- waste evaporator
- Argument 2h: Evaporation of high chemical impurities waste
- Argument 2i: Radioactive decay of solid and liquid wastes

194. We provide our views on each of these arguments in Appendix 5.

195. We have concluded, at this stage in GDA, that the design of the UK ABWR is suitable to ensure containment of radioactive substances.

Processing radioactive substances in the UK ABWR

196. Once radioactivity is formed in the reactor, its subsequent processing and handling will determine its ultimate distribution between gaseous, aqueous and solid waste streams. We expect the techniques used to be consistent with the principle of the preferred use of 'concentrate and contain' in the management of radioactive waste over 'dilute and disperse' (GB Parliament, 2009a). This means that radioactive waste should preferentially be produced as, or converted to, a solid waste. We also expect BAT to be used to ensure that the distribution of any residual radioactivity between gaseous and aqueous waste streams minimises the overal impact of discharges to the environment.

197. Hitachi-GE has described how radioactive substances will be processed in the UK ABWR to ensure that waste is appropriately managed for disposal. Below, we summarise the design features of the UK ABWR that apply to the processing of gaseous, aqueous, other liquid and solid wastes.

Processing gaseous wastes

198. In broad terms the UK ABWR design aims to avoid and reduce gaseous waste arisings, limit the concentration of radionuclides in gaseous wastes by using delay beds, and to remove particulate material from gaseous wastes using high-efficiency particulate air (HEPA) filtration.

199. The 'off-gas radioactive waste management system' has two main functions:

(i) to safely recombine flammable gases (hydrogen and oxygen), which are generated by radioactive decomposition of reactor cooling water

(ii) to minimise and control the release of small quantities of slightly radioactive gases into the atmosphere by delaying and filtering the OG waste process stream to adequately decay short-lived radioactive isotopes and filter out particulate matter, therefore keeping releases within discharge limits

200. The main features of the design relevant to minimising the impact of gaseous discharges are as follows:

- the design, manufacture and management of nuclear fuel to minimise the potential for a release of fission products (FP) from the fuel into the steam circuit or cooling pool water
- promptly detecting and managing failed fuel
- providing an off-gas (OG) system that includes processes to reduce radioactivity in the gaseous phase prior to discharge to the environment
- providing an off-gas charcoal adsorber within the OG system to abate short lived FPs
- providing a heating, ventilation and air conditioning (HVAC) system that prevents the uncontrolled discharge of radioactive substances

201. Moisture in the gas stream is first condensed, and then the remaining non-condensable gases (principally air with a small amount of radioactive argon, krypton and xenon gas) are extracted and passed through OG charcoal adsorber beds. These adsorbers provide adequate ‘hold-up’ or ‘delay’ to allow time for the radioactive gases to decay to lower activity levels before leaving the system.

202. After this processing step, the treated gaseous waste is monitored and released to the environment through the main stack.

203. The HVAC system is identified as 'building ventilation air' in Figure 8.1. The functions of the HVAC system relevant to managing gaseous radioactive wastes are to limit and contain the possible release of radioactive materials from plant and equipment in an area during normal operation or maintenance or inspection, and, where necessary, filter contaminated air prior to its discharge to atmosphere.

204. The buildings that can potentially generate gaseous radioactive wastes, because of the inventories within them, are the reactor building, the turbine building and the radioactive waste building. Radiologically-controlled area HVAC systems will include high-efficiency particulate air (HEPA) filters on their discharge. Where practicable, and where required to provide adequate dispersion, the HVAC systems will discharge to the environment via the main stack. The HVAC system discharge from the main stack also includes the tank vents and extracts from the various tanks in the radioactive waste building that join the radioactive waste building HVAC system.

205. We observe the following at this stage:

- Using a modern fuel design and further measures to reduce fuel failure rates will help minimise gaseous waste arisings by limiting releases from fuel failure. Measures to detect and manage fuel failure should also prove effective. The regulators will seek to ensure that any future operators develop suitable arrangements to minimise gaseous discharges through appropriate fuel management.
- Using delay bed technology is effective at reducing discharges of noble gases, consistent with the application of BAT for such gases and consistent with approaches adopted in other light water reactors. Delay beds are also effective at reducing the concentration of short-lived iodine radionuclides. We conclude that Hitachi-GE has demonstrated that the quantity of charcoal to enable delay has been optimised in the UK ABWR design.
- The UK ABWR design aims to discharge gases at height via a main stack and this will help to minimise the impacts of those discharges. The stack is located on top of the reactor building, with a height of 57 m.
- No abatement of tritium or carbon-14 is practicable at this time. We agree with Hitachi-GE that future operators should consider if alkaline scrubbing of carbon-14 from gaseous discharges is appropriate in a site-specific context.

206. We conclude that, at this stage, the design of the UK ABWR is suitable for ensuring that BAT can be applied in minimising the impact of gaseous discharges.

207. We discuss gaseous discharges to the environment further in Chapter 9.

Processing aqueous wastes

208. The liquid radioactive waste management system (LWMS) (Figure 1) is designed to control, collect, process, handle, store, and dispose of radioactive waste water generated during operation of the UK ABWR reactor and turbine. All potentially radioactive waste waters are collected in sumps or drain tanks at various locations in the plant and transferred to collection tanks within the radioactive waste building.

209. The LWMS has been designed to recycle as much of the treated waste water back into the reactor cooling water system as possible. An exception is waste water that contains detergent impurities (from the laundry and showers), which are incompatible with the reactor and fuel pool water systems.

210. The LWMS is divided into several sub-systems: the high chemical impurities waste (HCW), the low chemical impurities waste (LCW), laundry drain (LD) and controlled area drain (CAD). The sub-systems segregate waste water with differing characteristics (that is, type of impurity or chemical content), so that it can be treated appropriately and efficiently prior to re-use or eventual disposal. In a situation where the waste water from a treatment system is outside the limits for being re-used or disposed of, the waste water treatment systems can cycle the waste water back through the treatment systems until the relevant parameters or limits are met.

211. Despite the aim to re-use the waste water, there may be times when liquid discharges are necessary when the on-site storage of treated liquid waste reaches full capacity. Hitachi-GE argues that the frequency, volume and contaminant loading of such liquid discharges are reduced to a very low level (Chapter 10). The LWMS normally operates on a batch basis. Provision is made for sampling and analysis at important process points and from the discharge tank to ensure that process parameters and discharge limits are met.

212. Detecting abnormal conditions through alarm systems as well as operational procedures protect against accidental discharges. Tanks, processing equipment, pumps, valves, and instruments that may contain radioactivity are arranged in appropriately shielded, access-controlled containments to minimise plant staff's exposure to radiation and to prevent or minimise radiation dose or release to the environment.

213. During operation, the LWMS will generate solid wastes that include those known as 'cruds or sludges', spent filters and spent ion exchange resins. The solid wastes will be treated and disposed of according to the solid radioactive waste management system (described below and in Chapter 11).

214. At decommissioning, the water within the reactor and fuel pool systems will be treated and discharged using the systems identified above as far as practicable. Redundant items of plant and equipment will be managed according to the solid radioactive waste management system.

215. We conclude that BAT is applied to aqueous radioactive discharges from the UK ABWR. At the current time it is BAT not to abate tritium in aqueous discharges, noting that the dose impact from aqueous discharges from the UK ABWR is very small.

216. We discuss aqueous discharges to the environment further in Chapter 10.

Processing solid wastes

217. Solid radioactive wastes are produced during the operational and decommissioning phases of a power station's life cycle. The UK ABWR design has a waste management strategy and system based on available treatment technologies and current and assumed future disposal facilities (see Chapter 6). The nature of the solid wastes that will arise in the UK ABWR is described further in Chapter 11.

218. A solid radioactive waste management system (SWMS) is designed to control, segregate, collect, handle, process, package and temporarily store wet and dry solid radioactive waste before being dispatched for off-site disposal. Hitachi-GE describes facilities capable of treating, interim and decay storing, where appropriate, and managing the disposal of solid radioactive wastes in accordance with the chosen options for managing these wastes, as described in Hitachi-GE's 'Radioactive waste management arrangements' submission.

Our overall conclusions on preventing and minimising the creation of radioactive waste

219. We conclude that the UK ABWR uses BAT to:

- prevent and minimise the creation of radioactive waste
- support the principle of 'concentrate and contain'
- minimise the overall impact of discharges to the environment

220. We reach this conclusion, at this time, based on our assessment of the design and the supporting claims, arguments and evidence that Hitachi-GE has provided (Appendix 5). We note that there are a number of current Regulatory Observations, and a Regulatory Issue relating to source terms, that may have an impact on our final conclusions.

221. We have identified 4 Assessment Findings, as set out at the beginning of this chapter.

222. BAT aspects of sampling have been considered in Chapter 12.

You can find more details of our assessment of BAT to prevent and minimise the creation of radioactive waste in our report on the assessment of BAT [AR03 - Assessment of best available techniques].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

9. Gaseous discharges of radioactive waste

This chapter covers our assessment of the estimated radioactive gaseous discharges and proposed limits that the UK ABWR should be capable of demonstrating compliance with.

We conclude that:

- **gaseous radioactive discharges arising from all modes of normal operation have been considered**
- **all appropriate radionuclides have been considered in deriving estimated gaseous discharges**
- **the derivation of estimated gaseous discharges is clear and supported by suitable evidence**
- **the selection of significant radionuclides is appropriate**
- **the proposed gaseous discharge limits are of an appropriate order**
- **the gaseous discharges from the UK ABWR will not exceed those of comparable power stations across the world and will be capable of meeting the limits set out below**

Radionuclide or group of radionuclides	Annual limit, GBq
Argon-41 (Ar-41)	5.2E+12
Carbon-14 (C-14)	1.7E+12
Tritium (H-3)	1.0E+13
Noble gases (excluding Argon-41)	2.2E+11

We have identified one potential GDA Issue:

- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

We want to ask you:

> Consultation question 5:
>
> Do you have any views or comments on our preliminary conclusions on the estimated radioactive gaseous discharges and proposed limits?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources of gaseous radioactive waste and proposed limits

224. This assessment considers the estimated discharges of gaseous radioactive waste and proposed gaseous discharge limits Hitachi-GE provided for its UK ABWR design.

225. Information on the sources of gaseous radioactive wastes, the quantification of arisings and discharges, and Hitachi-GE's proposed limits is provided in Hitachi-GE's 'Quantification of discharges and limits' submission.

226. Our assessment considered UK ABWR gaseous radioactive waste that is discharged to the environment via the main stack located on the reactor building. Gaseous discharges arising from all modes of normal operation have been considered. These include start-up, at power, shutdown and outage. Hitachi-GE has also considered discharges resulting from a fuel pin failure, which is reasonably forseeable during the lifetime of the reactor. We are satisfied that all aspects of normal operation have been considered.

227. We conclude that gaseous radioactive discharges arising from all modes of normal operation have been considered.

228. Hitachi-GE has not considered discharges to atmosphere from the service building, the solid LLW facility, the ILW store or the interim spent fuel store. Details of these facilities are at the concept design stage and will not be finalised until site-specific permitting. Hitachi-GE states that the discharges from these facilities are expected to be a small fraction of the overall site discharges. A future operator will need to quantify discharges to atmosphere from these facilities.

229. Radionuclides are produced in the reactor core as:

- fission products produced from fission of tramp uranium or from leakage from fuel pin failure
- activated corrosion products produced from materials dissolved into the reactor water or particulates arising from wear and tear of the reactor
- activation products produced by neutron activation of water

Some radionuclides, which are not contained or abated within the plant, are discharged to the environment.

230. Gaseous discharges reach the main stack by one of 3 routes: via the off-gas system, via the heating, ventilation and air conditioning (HVAC) system or via the turbine gland steam (TGS) system. The off-gas (OG) system contains 4 charcoal beds that delay noble gases and iodine radionuclides, allowing radioactive decay of radionuclides with short half-lives before they are discharged to the environment. Carbon-14 is also discharged via the OG system. The HVAC system contains high efficient particulate air (HEPA) filters that minimise the discharge of radioactive airborne particulates. Iodine radionuclides and tritium are also discharged via the stack from the HVAC system and the turbine gland steam system. There are currently no practicable methods of abating carbon-14 and tritium.

231. Over 600 radionuclides were considered in deriving the source term for the UK ABWR. Those relevant to gaseous discharges were selected based on guidance from the European Commission (EU, 2004) and the Environment Agency (Environment Agency, 2012). We are satisfied that all relevant radionuclides that are likely to be discharged in gaseous form have been considered.

232. We conclude that all appropriate radionuclides have been considered in deriving estimated gaseous discharges.

233. Our guidance for GDA requires quantitative estimates of gaseous and aqueous radioactive wastes that are supported with performance data from similar facilities. The derivation of estimated discharges needs to be appropriate, clear and supported by evidence. Revision B of the generic environmental permit (GEP) submission (submitted by Hitachi-GE in March 2014) contained quantitative estimates of gaseous radioactive wastes, but lacked supporting performance data and explanation of how the discharge estimates had been derived. In April 2014, jointly with ONR, we raised a Regulatory Observation (RO-ABWR-0006) requiring Hitachi-GE to provide definition and justification of the radiological source terms for the UK ABWR design, including the source terms

for gaseous and aqueous discharges, solid radioactive waste arisings, decommissioning and radiation protection. The RO also required Hitachi-GE to use the source term appropriately across the different technical areas for GDA, and to adequately capture the response to the RO in the GDA submission.

234. Documents on the definition and justification of source terms for UK ABWR Hitachi-GE provided in January 2015 did not meet our expectations. We challenged the approach and methodology used to derive the UK ABWR source terms, the limited use of operational experience (OPEX) data from other operating ABWRs and the evidence on which discharge estimates were based. As a result, the aspects of the RO concerned with definition and justification of source terms were escalated to a Regulatory Issue (RI-ABWR-0001). Between November 2015 and June 2016, Hitachi-GE provided a number of documents in response to RI-ABWR-0001. These documents met our expectations and the closure of RI-ABWR-0001 has now been recommended to GDA management. Therefore, it is possible that RI-ABWR-0001 will be closed before our consultation starts. It is likely that RO-ABWR-0006 will still be open. At the time of writing (5 August 2016) both the RI and RO remain open.

235. Until RI-ABWR-0001 and RO-ABWR-0006 are formally closed, it is possible that the estimated gaseous and aqueous radioactive discharges, estimated solid radioactive waste arisings, decommissioning source term and radiological impact assessments may change. We believe that the risk of a significant change to the UK ABWR source term during GDA is small, but we recognise that any such changes may affect our draft conclusions on the acceptability of the UK ABWR design. Our expectations for resolution of this potential GDA Issue are described in the executive summary (paragraph 11) of this consultation document. Therefore, we have identified the following potential GDA Issue:

- **Potential GDA Issue 2** - Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

236. During our assessment of the UK ABWR design, it became apparent that a source of discharges to atmosphere had been omitted from the submission. This source was the turbine gland steam system. Jointly with ONR, we raised RO-ABWR-0071 on 6 June 2016, requesting more information on the turbine gland steam system, including gaseous discharges from this system. We have received documents from Hitachi-GE in response to this RO. Hitachi-GE updated its submission to include estimated discharges from the turbine gland steam system, therefore these discharges are included in the estimated gaseous discharges and proposed limits for UK ABWR assessed for this consultation. ONR is still assessing other documents that Hitachi-GE provided in response to this RO at the time of writing (5 August 2016), and this RO remains open.

237. We conclude that the derivation of estimated gaseous discharges is appropriate, clear and supported by suitable evidence.

238. Hitachi-GE has identified some radionuclides as ‘significant’ for gaseous discharges to the environment and, therefore, important in any future site-specific permitting. Significant radionuclides that may affect people or wildlife are either:

- those discharged in large quantities
- indicators of plant performance
- listed in guidance (EC 2004)

239. Hitachi-GE has identified significant radionuclides based on these criteria, and we are satisfied that the selection of significant radionuclides is appropriate and consistent with our limit setting guidance (Environment Agency, 2012).

240. We conclude that selection of significant radionuclides is appropriate.

241. Hitachi-GE has provided us with proposed limits for discharges of gaseous radioactive waste from UK ABWR (Table 9.1). Limits are proposed for significant radionuclides and are based on discharge estimates for normal operation and includes discharges resulting from fuel pin failure.

Table 9.1: Proposed annual rolling limits for gaseous radioactive waste discharges from UK ABWR

Radionuclide	Proposed annual limit for UK ABWR (Bq)
Argon-41(Ar-41)	5.2E+12
Carbon-14 (C-14)	1.7E+12
Tritium (H-3)	1.0E+13
Noble gases (excluding Argon-41)	2.2E+11

242. The proposed limits include a headroom factor that is applied to the discharges from normal operation. The 'headroom factor' is the difference between the estimated discharges and proposed limits. When permitting a new facility, we recognise that there may be considerable uncertainty regarding the level of discharges to the environment. Therefore, new facilities may have greater headroom than facilities that are already operating.

243. For the UK ABWR, the headroom factor for each radionuclide or radionuclide group has been derived based on the variability of data used to estimate the gaseous discharges. The headroom factors for significant radionuclides range from 1.9 to 3.8. Table 9.2 details annual estimated gaseous discharges and proposed limits for the UK ABWR.

Table 9.2: Estimated annual discharges of significant radionuclides and associated proposed annual limits

Radionuclide	Estimated annual discharge (Bq)	Headroom factor	Discharge from fuel pin failure (Bq)	Proposed annual limit (Bq)
H-3	2.7E+12	3.8	0	1E+13
C-14	9.1E+11	1.9	0	1.7E+12
Ar-41	1.8E+12	2.9	0	5.2E+12
Kr-85	1.0E+08	2.1	1.1E+09	1.3E+09
Kr-85m	2.3E+09		5.5E+09	1.0E+10
Kr-87	2.3E+03		5.0E+03	9.8E+03
Kr-88	1.8E+08		5.5E+08	9.3E+08
Xe-131m	1.4E+08		2.6E+09	2.9E+09
Xe-133	1.0E+10		1.8E+11	2.0E+11
Xe-133m	1.7E+06		1.4E+07	1.8E+07
Xe-135	1.7E-11		3.1E-11	0*
Total for noble gases (excluding Ar-41)				2.2E+11

*Hitachi-GE suggests discharges of Xe-135 do not contribute to the annual limit for noble gases as the discharges of this radionuclide are small.

244. The derivation of proposed gaseous discharge limits for UK ABWR is consistent with our guidance (Environment Agency 2012) and are of an appropriate order.

245. We conclude that the proposed gaseous discharge limits are of the appropriate order.

Comparison of gaseous discharges with similar reactors worldwide

246. Part of our assessment involved gathering information on radioactive gaseous waste produced from predecessor boiling water reactors (BWRs) and comparing this with the estimated discharges of gaseous radioactive waste from the UK ABWR. This is to ensure that discharges from the UK ABWR do not exceed those of comparable power stations across the world.

247. Since the beginning of nuclear power generation, regulators have required operators of nuclear power stations to take samples, carry out measurements and determine radioactivity in discharges.

248. The main radionuclides or radionuclide groups discharged from nuclear power stations as gaseous waste include:

- tritium (H-3) – a low energy beta emitting radionuclide with a half-life of 12.3 years
- carbon-14 (C-14) – a low energy beta emitter with a very long half-life. It can be taken up by crops
- noble gases (isotopes of krypton and xenon, and argon-41) – beta and gamma emitters. Half-lives of noble gases vary from a few minutes to years
- iodine radionuclides – several radionuclides of iodine are formed during nuclear fission. The most important of these is iodine-131 (I-131), a beta and gamma emitter with a relatively short half-life of 8 days. It can be deposited in crops and then ingested, or can be deposited on grass which is grazed by cows and subsequently appears in milk
- particulates – this group includes fission products such as caesium-137 with a half-life of 30 years, and activated corrosion products such as cobalt-60 with a half-life of 5.3 years

249. We commissioned Public Health England to gather data and information on radioactive discharges from comparable BWRs worldwide. The results of this work are published in our report 'Discharges from boiling water reactors - A review of available discharge data' (Environment Agency, 2016). The authors obtained discharge data by contacting the relevant operators and regulators or from publicly available sources. To enable comparison of discharges between different reactors, the report presents discharges having normalised them to gigabecquerels per gigawatt-hour (GBq/GWeh) for actual power output. Data was collected for BWRs in Finland, Germany, Japan, Spain, Sweden, Switzerland and USA. In total, data from 24 BWR stations were collected, although data were not available from all stations on all radionuclides.

250. In order to compare discharges from the UK ABWR to those from other BWRs, the UK ABWR discharges have been normalised to gigabecquerels per gigawatt-hour (GBq/GWeh) for maximum power output. Care must be taken not to draw comparisons too closely, as there are many uncertainties in the datasets, including variation in sampling and monitoring techniques between different power stations.

Tritium (H-3)

251. Annual gaseous tritium discharges from BWRs range from 3.4E-06 to 1.5 GBq/GWeh. The UK ABWR estimated annual gaseous tritium discharge is 2.3E-01 GBq/GWeh. Data are presented in Table 9.3 and Figure 9.1.

Table 9.3: Normalised annual gaseous tritium discharges from BWRs and normalised estimated annual gaseous tritium discharges for UK ABWR

(n=number of plants for which data was obtained)

	Year	Mean gaseous H-3 discharges (GBq/GWeh)			n
		Mean	Minimum	Maximum	
BWR	2005	1.6E-01	6.4E-03	5.0E-01	15
	2006	1.7E-01	2.0E-02	6.7E-01	15
	2007	1.5E-01	1.3E-02	5.6E-01	16
	2008	1.1E-01	1.3E-05	3.7E-01	16
	2009	1.3E-01	2.2E-02	4.0E-01	16
	2010	1.4E-01	1.9E-02	5.6E-01	17
	2011	1.0E-01	3.4E-06	3.8E-01	17
	2012	1.8E-01	1.3E-02	1.5E+00	16
	2013	2.1E-01	2.4E-03	1.5E+00	16
UK ABWR		2.3E-01			

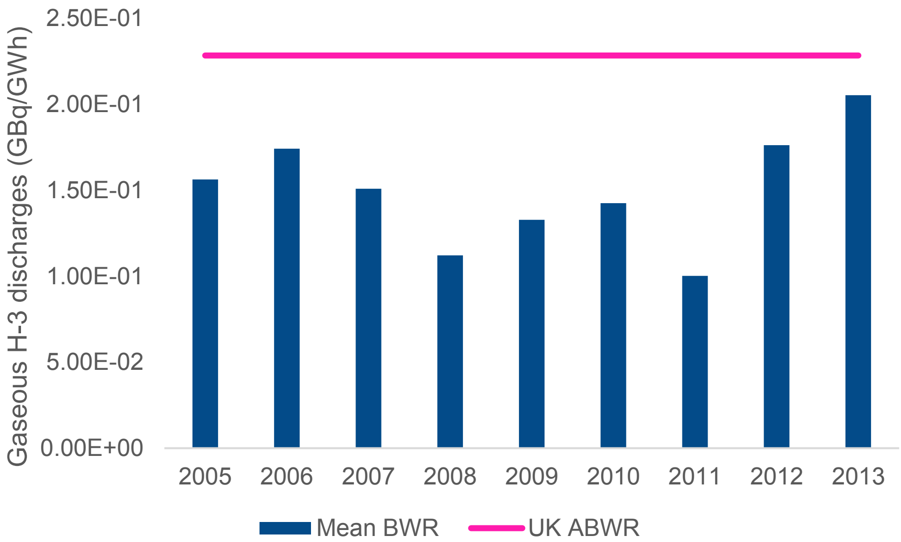


Fig 9.1: Mean normalised annual gaseous tritium discharges for BWRs 2005 – 2013. Pink line shows normalised UK ABWR estimated annual gaseous tritium discharges.

252. Estimated annual discharges of gaseous tritium from the UK ABWR are higher than the mean annual discharges of gaseous tritium from other operating BWRs, but sit within the range of data obtained for operating BWRs. Hitachi-GE suggests that the reason for the apparently high gaseous tritium discharge for the UK ABWR when compared with other reactors is because it has used conservative assumptions when estimating tritium discharges. For tritium discharge estimates, Hitachi-GE has assumed a maximum steam flow rate in the turbine gland steam system that maximises the tritium discharge via this route. However, during operation, the steam flow rate is expected to be lower.

Noble gases

253. Annual noble gas discharges from BWRs range from 4.8E-06 to 7.9 GBq/GWeh. The UK ABWR estimated annual noble gas discharge, with and without fuel pin failure, is 1.7E-01 and 1.5 E-01 GBq/GWeh respectively. Data are presented in Table 9.4 and Figure 9.2.

Table 9.4: Normalised annual noble gas discharges from BWRs and normalised estimated annual noble gas discharges for UK ABWR

(n=number of plants for which data was obtained)

	Year	Mean noble gas discharges (GBq/GWeh)			n
		Mean	Minimum	Maximum	
BWR	2005	1.5E+00	2.7E-02	1.6E+01	15
	2006	1.1E+00	1.0E-05	7.2E+00	17
	2007	1.2E+00	1.4E-02	5.1E+00	15
	2008	8.0E-01	4.8E-06	3.5E+00	15
	2009	1.1E+00	5.8E-03	7.9E+00	14
	2010	6.7E-01	4.8E-03	3.7E+00	19
	2011	7.5E-01	8.1E-04	4.6E+00	18
	2012	8.7E-01	3.3E-03	7.0E+00	15
	2013	7.8E-01	5.9E-04	6.6E+00	16
UK ABWR (no fuel pin failure)		1.5E-01			
UK ABWR (fuel pin failure)		1.7E-01			

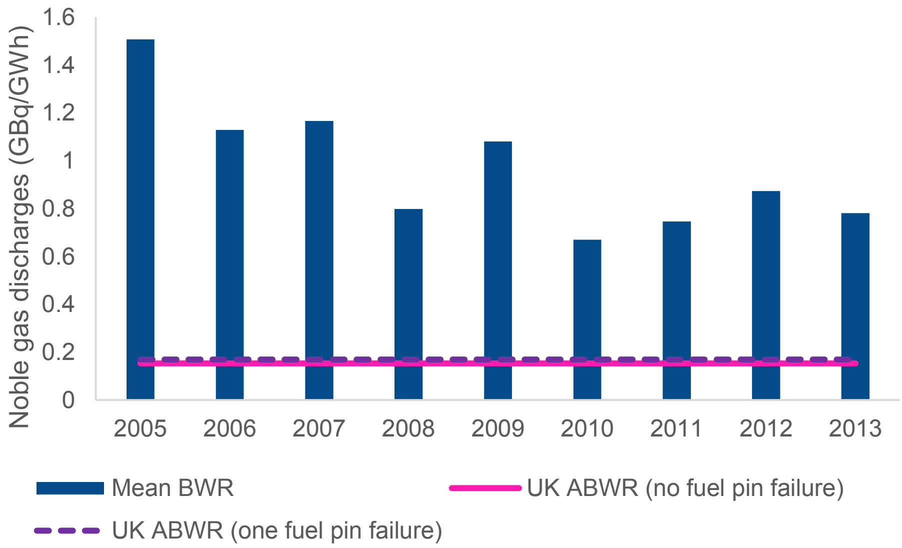


Fig 9.2: Mean normalised annual noble gas discharges from BWRs 2005 – 2013. Solid pink line shows normalised UK ABWR estimated annual noble gas discharges with no fuel pin failure. Dashed line shows normalised UK ABWR estimated annual noble gas discharges with one fuel pin failure.

254. Estimated annual discharges of noble gases from the UK ABWR are lower than the mean annual discharges of noble gases from other operating BWRs and sit at the lower end of the range of data obtained for operating BWRs.

Iodine radionuclides

255. Annual gaseous discharges of iodine radionuclides from BWRs range from 7.3E-11 to 2.1E-02 GBq/GWeh. The UK ABWR estimated annual gaseous discharge of iodine radionuclides is 2.7E-05 GBq/GWeh. Data are presented in Table 9.5 and Figure 9.3.

Table 9.5: Normalised annual gaseous discharges iodine radionuclides from BWRs and normalised estimated annual gaseous discharges of iodine radionuclides for UK ABWR

(n=number of plants for which data was obtained)

	Year	Mean gaseous discharges of iodine radionuclides (GBq/GWeh)			n
		Mean	Minimum	Maximum	
BWR	2005	8.5E-05	7.3E-11	8.0E-04	17
	2006	2.4E-04	1.6E-08	3.0E-03	17
	2007	2.0E-04	4.7E-09	2.3E-03	18
	2008	8.2E-05	1.8E-07	6.6E-04	14
	2009	1.2E-04	7.3E-09	1.2E-03	17
	2010	1.3E-03	1.1E-07	2.1E-02	19
	2011	2.4E-04	6.5E-08	3.0E-03	22
	2012	2.1E-05	1.8E-08	1.2E-04	15
	2013	2.9E-05	1.4E-07	1.3E-04	14
UK ABWR		2.7E-05			

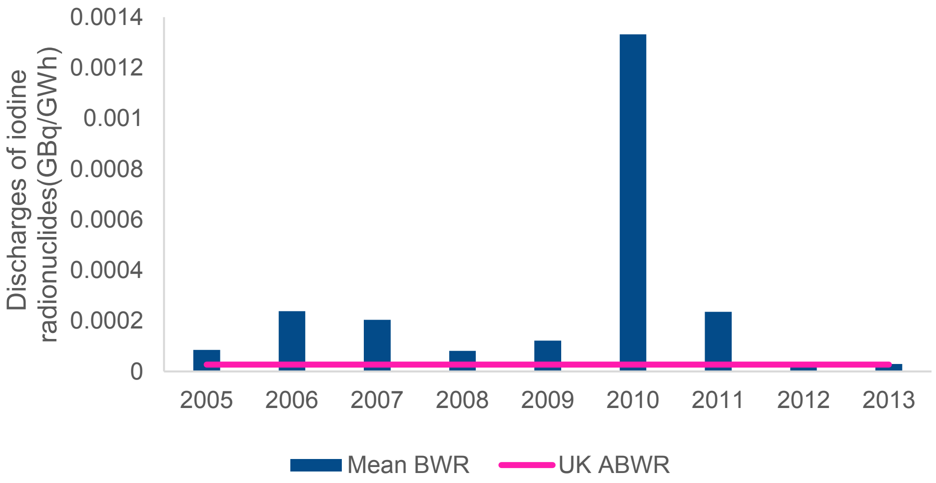


Fig 9.3: Mean normalised annual gaseous discharges of iodine radionuclides from BWRs 2005 – 2013. Pink line shows normalised UK ABWR estimated annual gaseous iodine radionuclides discharges.

256. Estimated annual discharges of gaseous iodine radionuclides from the UK ABWR are lower than the mean annual discharges of gaseous iodine radionuclides from other operating BWRs and sit at the lower end of the range of data obtained for operating BWRs.

Particulates

257. Annual airborne particulate discharges from BWRs range from 2.2E-09 to 1.6E-04 GBq/GWeh. The UK ABWR estimated annual airborne particulate discharge is 2.1E-08 GBq/GWeh. Data are presented in Table 9.6 and Figure 9.4.

Table 9.6: Normalised annual airborne particulate discharges from BWRs and normalised estimated annual airborne particulate discharges for UK ABWR

(n=number of plants for which data was obtained)

	Year	Mean gaseous particulate discharges (GBq/GWeh)			n
		Mean	Minimum	Maximum	
BWR	2005	9.1E-06	1.7E-08	4.8E-05	16
	2006	1.6E-05	2.2E-07	1.6E-04	15
	2007	9.5E-06	2.0E-08	7.9E-05	17
	2008	5.7E-06	3.9E-09	2.7E-05	17
	2009	1.1E-05	2.2E-08	3.4E-05	16
	2010	9.2E-06	6.9E-09	3.6E-05	15
	2011	5.7E-06	5.0E-09	2.2E-05	16
	2012	4.5E-06	1.3E-13	2.3E-05	16
	2013	4.8E-06	2.2E-09	3.1E-05	16
UK ABWR		2.1E-08			

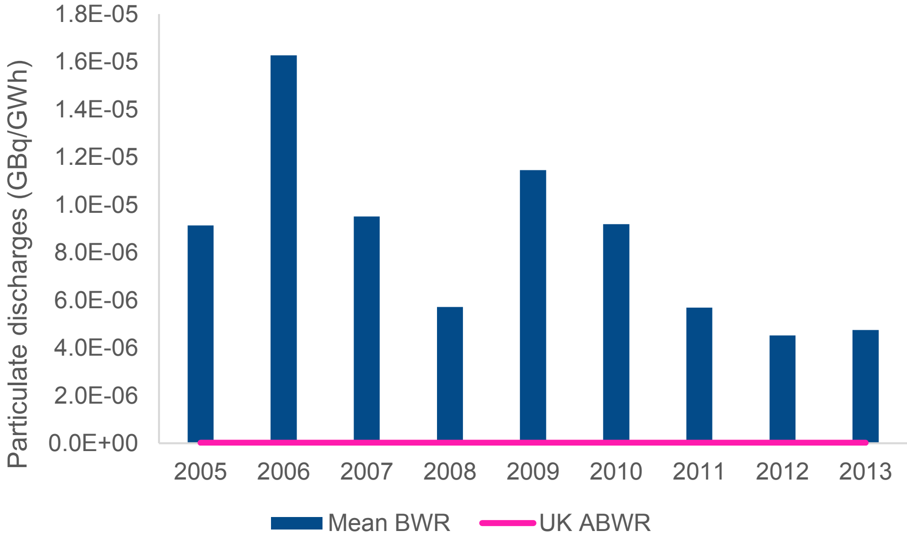


Fig 9.4: Mean normalised annual airborne particulate discharges from BWRs 2005 – 2013. Pink line shows normalised UK ABWR estimated annual airborne particulate discharges.

258. Estimated annual discharges of airborne particulates from the UK ABWR are lower than the mean annual discharges of airborne particulates from other operating BWRs and sit at the lower end of the range of data obtained for operating BWRs.

Carbon-14

259. Annual gaseous carbon-14 discharges from BWRs range from 5.2E-03 to 1.1E-01 GBq/GWeh. The UK ABWR annual gaseous carbon-14 discharge is 7.7E-02 GBq/GWeh. Data are presented in Table 9.7 and Figure 9.5.

Table 9.7: Normalised annual gaseous carbon-14 discharges from BWRs and normalised estimated annual carbon-14 discharges for UK ABWR

(n=number of plants for which data was obtained)

	Year	Mean gaseous carbon-14 discharges (GBq/GWeh)			n
		Mean	Minimum	Maximum	
BWR	2005	5.8E-02	3.1E-02	1.1E-01	5
	2006	4.6E-02	4.1E-03	1.0E-01	5
	2007	7.1E-02	4.2E-02	1.1E-01	6
	2008	5.6E-02	3.4E-02	9.9E-02	6
	2009	5.9E-02	3.7E-02	9.0E-02	6
	2010	5.5E-02	3.6E-02	1.0E-01	17
	2011	6.0E-02	3.4E-02	8.9E-02	17
	2012	5.7E-02	5.2E-03	8.3E-02	16
	2013	6.1E-02	1.4E-02	8.2E-02	16
UK ABWR		7.7E-02			

Fig 9.5: Mean normalised annual gaseous carbon-14 discharges from BWRs 2005 – 2013. Pink line shows normalised UK ABWR estimated annual gaseous carbon-14 discharges.

260. Estimated annual discharges of gaseous carbon-14 from the UK ABWR are higher than the mean annual discharges of gaseous carbon-14 from other operating BWRs but sit within the range of data obtained for operating BWRs. We are requesting further information on this matter and will consider the response when it has been submitted and report on it in our final decision document.

Conclusion of comparison of gaseous discharges with similar reactors worldwide

261. Estimated gaseous discharges of noble gases, iodine radionuclides and airborne particulates from the UK ABWR are lower than mean gaseous discharges for operating BWRs. Gaseous discharges of tritium and carbon-14 from the UK ABWR are higher than the mean discharges from operating BWRs, but still sit within the range of data values obtained. The estimated gaseous discharges for the UK ABWR are derived in a conservative way, and we expect actual UK ABWR discharges to be smaller than these estimates.

262. We conclude that gaseous radioactive discharges from the UK ABWR will not exceed those of comparable power stations across the world.

Our overall conclusions on gaseous radioactive waste

We conclude that:

- gaseous radioactive discharges arising from all modes of normal operation have been considered
- all appropriate radionuclides have been considered in deriving estimated gaseous discharges
- estimated gaseous discharges are clear and supported by suitable evidence
- the selection of significant radionuclides is appropriate
- the proposed gaseous discharge limits are of an appropriate order
- the gaseous discharges from the UK ABWR will not exceed those of comparable power stations across the world and will be capable of meeting the limits set out below

Radionuclide or group of radionuclides	Annual limit, Bq
Argon-41 (Ar-41)	5.2E+12
Carbon-14 (C-14)	1.7E+12
Tritium (H-3)	1.0E+13
Noble gases (excluding Argon-41)	2.2E+11

We have identified one potential GDA Issue:

- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

You can find more details of our assessment of gaseous radioactive waste in our report [AR04 - Assessment of gaseous radioactive waste disposal and limits].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

10. Aqueous discharges of radioactive waste

This chapter covers our assessment of the aqueous discharge limits that the UK ABWR should be able to comply with, and that we might include in any permit issued for a power station of this design.

We conclude that:

- all sources of aqueous radioactive waste have been identified
- the assumed decontamination factors (DF) are appropriate for the abatement technique to which they are applied. However, for site-specific permitting we would expect to see a thorough options study for selecting filter type and ion exchange media
- the appropriate nuclides have been considered for discharges
- the selection of significant radionuclides for aqueous discharge is appropriate
- the proposed aqueous discharge limits are of the appropriate order
- the aqueous discharges from the UK ABWR will not exceed those of comparable power stations across the world and will be capable of meeting the limit set out below

Radionuclide or group of radionuclides	Annual limit, GBq
Tritium (H-3)	760

We have identified one potential GDA Issue and 2 Assessment Findings:

- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

- **Assessment Finding 7**: A future operator shall provide an evidence-based definition of the decontamination factors likely to be achieved for liquid effluent treatment prior to operation and then compare these with the actual decontamination factors achieved during operation. Differences in expected and actual decontamination factors should be explained.
- **Assessment Finding 8**: A future operator shall assess the chemical speciation of radioactivity in liquid discharges. It shall consider the implications of this for the receiving environment so that discharges are shown to represent best available techniques.

We want to ask you:

Consultation question 6:

Do you have any views or comments on our preliminary conclusions on minimising the discharges and impact of aqueous waste, and our proposed limits and levels?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources of aqueous radioactive waste and minimisation of radioactivity in discharges

264. As for gaseous radioactive waste, we expect new nuclear power stations to use BAT to minimise the radioactivity in discharges of aqueous radioactive waste, and to minimise the impact of those discharges on the environment.

265. Information on the sources of aqueous radioactive wastes, the quantification of arisings and discharges, and Hitachi-GE's proposed limits is provided in:

- Hitachi-GE's 'Quantification of discharges and limits' submission
- Sections 5.2.5, 5.2.6, 5.2.7, 5.2.8 and 5.5.2 of Hitachi-GE's 'Demonstration of BAT' submission

266. We carried out our Step 2 initial assessment on Revision D of the GEP submission, which was issued on 6 August 2014. Our initial assessment feedback (Environment Agency, 2014b) noted that some further information would be needed to undertake the detailed assessment, specifically:

- appropriate and robust evidence was required to support the estimates of aqueous (and gaseous) discharges which we raised jointly with ONR in RO-ABWR-0006 and RI-ABWR-0001
- details on the contribution that each constituent of normal operations (such as maintenance and testing) makes to discharges
- demonstration that expected discharges will not exceed those of comparable power stations across the world

267. Ongoing discussion of Revision D of Hitachi-GE's submission resulted in additional RQs relating to discharge variability, monthly discharges and the BAT aspects of the liquid waste management system. The outstanding information has now been provided in response to the RQs.

268. At the time of writing this report (5 August 2016), both RI-ABWR-0001 and RO-ABWR-0006 remain open. A workshop was held between 26 and 29 July 2016 to discuss progress in this area. Hitachi-GE has provided adequate information and our technical assessor and ONR inspectors have now recommended closure of RI-ABWR-0001 to GDA management. Therefore, it is possible that RI-ABWR-0001 may be closed before the start of consultation, although it is likely RO-ABWR-0006 may remain open.

269. However, until the RI and RO are formally closed, there is potential for the estimated gaseous and aqueous radioactive discharges, estimated solid radioactive waste arisings, decommissioning source term and radiological impact assessments to change and impact on our draft conclusions on the acceptability of the UK ABWR design. However, we now believe there to be a low risk of significant change to the source term. Our expectations for resolution of this potential GDA Issue are described in the executive summary (paragraph 11) of this consultation document.

270. As this work has not yet been completed, we have identified the following potential GDA Issue:

- **Potential GDA Issue 2** – Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

Sources of aqueous waste

271. There are 4 aqueous radioactive waste streams:

- low chemical impurity waste (LCW)
- high chemical impurity waste (HCW)
- laundry drain (LD)

- controlled area drain (CAD)

272. Of these 4 aqueous waste management streams only HCW and LD have a route to discharge to the environment. Both types of waste are discharged via the same discharge pipe where it is mixed with the cooling water before being discharged to the marine environment.

273. HCW waste will be recycled where possible and will only be discharged when there is no capacity in the condensate storage tank (CST) where recycled wastes are stored for reuse in the reactor circuit. HCW is treated before being reused or discharged using evaporation to remove insoluble species and demineralisation to remove soluble ionic species. Secondary wastes from this process are transferred to the solid waste management systems. Discharge of HCW is expected to be a maximum volume of 560 m^3/y based on the conservative assumption that all HCW generated will be discharged. We believe that this conservative approach is appropriate for the purposes of GDA and note that the discharges from an operating unit would be expected to be lower than those stated in Hitachi-GE's GDA submission. Therefore, this assumption may need to be reconsidered for site-specific permitting.

274. The LD liquid waste is not suitable for recycling into the reactor circuit and is discharged to the environment following treatment using activated carbon adsorption and filtration. Secondary wastes are transferred to the solid waste management systems. Discharges from LD are expected to be 2240 m^3/y.

275. We conclude all sources of liquid radioactive waste within the scope of GDA have been identified.

276. There are a number of assumptions made in the source term work that are important to the expected liquid discharges. These are:

- tritium partitions within the reactor, 50% each to the steam and water
- tritium is not reduced by any of the abatement techniques employed on the UK ABWR
- 100% of the carbon-14 is partitioned into the gaseous waste stream

277. The assumptions relating to tritium are as expected and the proposed treatments are not effective for tritium abatement. However, the assumption that no carbon-14 enters the aqueous waste streams or adsorbs onto the demineraliser resins is not a conservative assumption as far as aqueous discharges are concerned and may need considering further in the future or validating at an early stage in the operation. This is recorded as an Assessment Finding from the assessment of BAT.

278. Estimated activity concentrations for each waste stream, for relevant nuclides as recommended in the EC recommendation on standardised reporting of discharges from nuclear power stations (EU, 2004) are presented in Hitachi-GE's 'Quantification of discharges and limits' submission (Table 7.2-2).

279. The physico-chemical form of a radionuclide on entering the environment can influence its behaviour and transportation and, therefore, public exposure to radiation. It is noted that the generic environmental permit (GEP) submission contains no discussion on the typical physico-chemical speciation of activity within the aqueous wastes discharged, which may be important to understanding the localised impact at site-specific permitting.

- **Assessment Finding 8**: A future operator shall assess the chemical speciation of radioactivity in aqueous discharges. It shall consider the implications of this for the receiving environment so that discharges are shown to represent best available techniques.

280. Hitachi-GE has not specified a specific filter or ion exchange resins for GDA and notes that the decision will be made by the operator. Therefore, to derive the discharges it needed to make an assumption of the decontamination factor (DF) achieved in abatement. Hitachi-GE has assumed a mixed bed ion exchanger capable of a DF of 100 for soluble species and 10 for insoluble species. Filters are assumed to have DF of 1 for soluble species and 10 for insoluble species as stated in Hitachi-GE's primary source term supporting report (Hitachi-GE, 2016a). The evaporator is expected to achieve a DF of between 1000 and 10,000 as stated in Hitachi-GE's 'Demonstration of BAT' submission.

281. The LD effluent is abated using an activated carbon adsorption tower and filtration. An activated carbon adsorption technique is used due to the organic component of the LD effluent. The activated carbon is assumed to have minimal DF for activity, assuming a DF of 1 for soluble species and 3 for insoluble species (Hitachi-GE's primary source term supporting report - Hitachi-GE, 2016a). That is because the activated carbon tower also acts as a filter, trapping particulates. The pre-filter is assumed to have a DF of 2 for insoluble species and the final filter a DF of 50 for insoluble species. Soluble activity is not removed by the LD abatement system. However, activity concentrations in this waste stream are expected to be very low.

282. We conclude that the proposed abatement techniques are standard abatement techniques in the nuclear industry for treating reactor effluent and are proven technologies.

283. We conclude that the assumed DFs are appropriate for the abatement technique to which they are applied. However, we would expect to see a thorough options selection study for filter type and ion exchange media and an evidence based understanding of what DFs are likely to be achieved .

- **Assessment Finding 7**: A future operator shall provide an evidence-based definition of the decontamination factors likely to be achieved for aqueous effluent treatment prior to operation and then compare these with the actual decontamination factors achieved during operation. Differences in expected and actual decontamination factors should be explained.

Discharges

284. Hitachi-GE presented estimated discharges for each waste stream for relevant nuclides as recommended by the European Commission (EU, 2004) in its ‘Quantification of discharges and limits’ submission (Table 7.2-4).

285. We conclude that the appropriate nuclides have been considered for discharges.

286. The aqueous discharge activity is dominated by tritium (H-3), which is not abated and constitutes over 99.99% of the activity discharged. The second largest contributor of activity to the discharges is iron-55 (Fe-55), which only constitutes 0.0009% of the activity discharged.

Limit setting

287. We expect limits to be set on a 12-month rolling basis and for each nuclide or group of nuclides deemed significant based on the criteria in our guidance (Environment Agency, 2012). Limits set an upper bound on the amount of radioactive waste that an operator may discharge into the environment. The difference between the estimated discharges and proposed limits is referred to as the ‘headroom factor’.

288. For an operating station the headroom factor can be determined by assessing the variability in discharges necessary during normal operations. However, for a new plant this data does not yet exist. Therefore, Hitachi-GE, in its submission, has taken a statistical approach based on the modelling carried out to derive the source term.

289. Hitachi-GE has looked at the data used to derive the primary source term to assess the likely variability of the discharges and, therefore, the likely headroom factor required.

290. There are some important underlying assumptions in this approach:

- the variability in discharges will have a linear relationship to the variability in the primary source term data
- the available OPEX data are normally distributed

291. Hitachi-GE has provided some justification to support these assumptions in response to a Regulatory Query we raised.

292. The headroom factors calculated range from 1.7 to 4.1 and are considered to be reasonable yet conservative, which is acceptable for new build facilities. However, we would expect these to be reviewed during early operation of the plant, with a view to reducing the headroom factors and, therefore, the proposed discharge limits.

293. We conclude that the proposed liquid discharge limits are of the appropriate order of magnitude.

294. The following sections summarise our assessment for individual radionuclides and groups.

Significant nuclides

295. Hitachi-GE has selected significant nuclides based on the appropriate Environment Agency guidance (Environment Agency, 2012).

296. We conclude that the selection of significant radionuclides for liquid discharge is appropriate.

297. Tritium is the only significant nuclide that needs a proposed limit in a future permit. The proposed limit, to be applied on a rolling 12-month basis, is 760 GBq/y.

298. We note that there are no other nuclides identified because the discharges for parameters such as total beta/gamma are too low to monitor using currently available equipment. However, if monitoring technology were to improve or the source term change, we would expect the operator to review this.

Comparing aqueous discharges with similar reactors worldwide

299. Tritium discharges for comparable reactors, normalised for electrical power output, were taken from our report 'Discharges from boiling water reactors - A review of available discharge data' (Environment Agency, 2016).

300. The mean discharges (normalised) were compared to those estimated from the UK ABWR, also normalised for energy output (Table 10.1 and Figure 10.1). You can see that for tritium, the predominant nuclide in aqueous discharges, the UK ABWR estimated discharges are significantly less than those of existing BWRs and ABWRs.

Table10.1 - Normalised annual discharges from BWRs (mean values) and UK ABWR

		Mean aqueous liquid tritium discharges (GBq/GWeh)			
	Year	Mean	Minimum	Maximum	n
BWR	2005	1.2E-01	3.0E-04	5.5E-01	18
	2006	1.0E-01	1.0E-03	5.0E-01	20
	2007	1.3E-01	5.0E-04	6.8E-01	19
	2008	1.1E-01	5.0E-04	4.5E-01	19
	2009	1.1E-01	6.6E-03	3.1E-01	19
	2010	1.0E-01	1.6E-03	4.7E-01	20
	2011	1.2E-01	3.9E-03	3.6E-01	19
	2012	1.5E-01	3.31E-02	5.1E-01	13
	2013	1.3E-01	7.7E-03	2.9E-01	12
UK ABWR		1.7E-02			

(n=number of plants for which data were obtained)

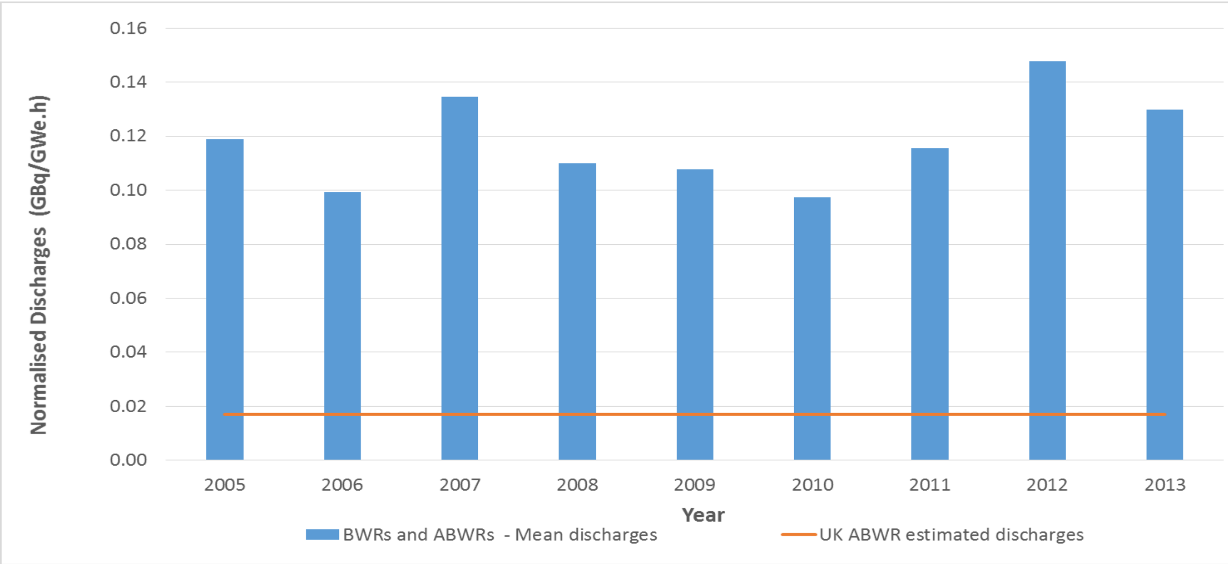


Figure 10.1 – mean normalised discharges from BWRs 2005-2013.

302. We conclude that the aqueous discharges from the UK ABWR will not exceed those of comparable power stations across the world.

Our overall conclusions on aqueous radioactive waste

303. We conclude that:

- all sources of aqueous radioactive waste have been identified
- the assumed DFs are appropriate for the abatement technique to which they are applied. However, for site-specific permitting we would expect to see a thorough options study for selecting filter type and ion exchange media
- the appropriate nuclides have been considered for discharges
- the selection of significant radionuclides for aqueous discharge is appropriate
- the proposed aqueous discharge limits are of the appropriate order
- the aqueous discharges from the UK ABWR will not exceed those of comparable power stations across the world and will be capable of meeting the limit set out below:

Radionuclide or group of radionuclides	Annual limit, GBq
Tritium (H-3)	760

You can find more details of our assessment of aqueous radioactive waste in our report [AR05 - Assessment of aqueous radioactive waste disposal and limits].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

11. Solid radioactive waste

This chapter covers our assessment of:

- the techniques Hitachi-GE proposes to use to minimise the quantity of solid radioactive waste
- the proposed disposal routes for lower activity solid waste
- the management of higher activity solid waste and spent fuel

Minimising the quantity (mass and volume) of solid waste means the limited disposal facilities that are available can be better used. It also minimises the environmental impacts of transporting the waste to those facilities. There are also benefits in terms of use of uranium resources and sustainability.

Currently, there are no final disposal facilities for higher activity wastes (HAW) and spent fuel, but it is expected that these will be disposed of to a geological disposal facility (GDF) that the government intends will be constructed (GB Parliament, 2014). The wastes and spent fuel need to be suitably managed until the GDF is available.

We include non-aqueous liquid wastes, such as oils and solvents, in our assessment of solid wastes, as they need to be managed and disposed of in similar ways.

We conclude that:

- in its submissions, Hitachi-GE describes how solid radioactive waste (low level waste (LLW), intermediate level waste (ILW)) and spent fuel will be generated, managed and disposed of throughout the facility's life cycle at a level of detail in line with our expectations for GDA
- the quantities of solid waste produced by the UK ABWR are comparable to other light water reactor power stations across the world
- the UK ABWR design uses BAT to minimise the quantity (mass and volume) of solid radioactive waste that will need to be disposed of
- solid radioactive waste will be treated and conditioned using proven and recognised techniques
- potential disposal routes have been identified for all LLW solid wastes
- Hitachi-GE has provided information on the fuel composition and characteristics, the expected fuel burn up and the quantities of spent fuel that will be generated and described how spent fuel will be managed and disposed of throughout the life cycle of a UK ABWR at a level of detail in line with our expectations for GDA
- the proposed arrangements for interim management of higher activity solid wastes and spent fuel are unlikely to prevent their ultimate disposal. This conclusion is based on the conceptual options that have been described to date
- Hitachi-GE has obtained a view from Radioactive Waste Management (RWM) Ltd (as the UK authoritative source in providing such advice) on the disposability of ILW and spent fuel, responded to RWM's advice and provided an opinion to the regulators

Further assessment of the solid radioactive waste inventory is on-going in line with the regulatory issue relating to source terms (RI-ABWR-0001). We are not aware at this time that resolving this regulatory issue will have a significant impact on the proposed solid waste management and disposal aspects as described to date. We will consider this further in our consideration of Hitachi-GE’s response to this issue as ONR's Step 4 proceeds.

We will also consider any matters that might arise through resolving other regulatory observations that may have implications in relation to our interests in solid waste aspects.

We have identified one potential GDA Issue and 2 Assessment Findings:

- **Potential GDA Issue 2 –** Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.

- **Assessment Finding 9**: A future operator shall, before procurement, provide detailed designs for solid radioactive waste management, storage and conditioning facilities that were covered at a conceptual level during generic design assessment, and demonstrate how these represent best available techniques.
- **Assessment Finding 10**: A future operator shall demonstrate optimised management and disposal of solid radioactive wastes from the UK ABWR, addressing in particular:
    - conditioning of higher activity waste arisings to ensure disposability
    - selection of disposal routes for wastes at the low activity waste/high activity waste boundary
    - management of spent nuclear fuel and any associated secondary wastes to ensure disposability
    - selection of disposal routes for low activity waste

We want to ask you:

Consultation question 7:

Do you have any views or comments on our preliminary conclusions on the management and disposal of solid radioactive waste and spent fuel?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Sources of solid radioactive waste

304. Hitachi-GE has outlined the sources and quantities of solid radioactive waste that are likely to be generated in its 'Radioactive waste management arrangements' submission. This document also outlines the proposed management arrangements covering the UK ABWR life cycle, including decommissioning. Coverage includes the generation, management and disposal of solid wastes. The solid radioactive waste inventory is presented in Appendix A of Hitachi-GE's 'Radioactive waste management arrangements' submission. More detailed inventory data relating to solid wastes are provided in Hitachi-GE’s reports 'Solid waste generation arising from operation and decommissioning (Hitachi-GE, 2016b) and 'Calculation of radioactive waste end user source term value' (Hitachi-GE, 2016c).

305. Hitachi-GE has identified a wide range of solid waste arisings in its submission and has categorised these according to UK practice and based on physical form and the nature and quantity of radioactivity that they contain, as well as their heat-generating capacity**.** A brief

summary of the solid wastes and their proposed management and disposal routes is provided below.

306. Solid wastes will arise within the nuclear plant and will also be managed, stored and conditioned for eventual disposal in dedicated waste management facilities. The radioactive waste building will house equipment associated with collecting, segregating and treating the liquid and wet solid radioactive waste generated in the plant.

307. Certain waste management facilities are defined only at a conceptual level in GDA, to illustrate the requirements and capabilities that will be needed to enable waste management operations and disposal. Hitachi-GE has identified the following conceptual facilities: wet solid low level waste (WSLLW), dry solid low level waste (SLLW), wet solid intermediate level waste (WILW), solid ILW (SILW) facilities, interim ILW store (ILWS) and a spent fuel interim store (SFIS). It describes these further in its 'Radioactive waste management arrangements' submission.

Very low level waste (VLLW)

308. VLLW is a sub-category of LLW that is suitable for disposal in small volumes with non-radioactive wastes or at permitted landfills for larger volumes (http://ukinventory.nda.gov.uk/about-radioactive-waste/what-is-radioactivity/what-are-the-main-waste-categories/).

309. VLLW will comprise mixed waste that will arise during reactor operations and decommissioning. This waste will consist of contaminated personal protection equipment, monitoring swabs, plastic, equipment, structures and contaminated plant. Different forms of VLLW will require specific removal, handling, sorting and size reduction techniques depending on their physical form and characteristics prior to treatment and disposal.

310. Projected amounts of waste are 14 m^3/year (combustible) and 3 m^3/year (non-combustible) ('Radioactive waste management arrangements' submission). The radionuclide content of such wastes are dependent upon where they are generated but will mainly comprise steel activation products.

311. It is proposed that such wastes will be recycled where practicable (for metals), compacted, incinerated, where possible, or directly disposed of at permitted disposal sites. Any future operators will need to select appropriate disposal routes.

Low level waste (LLW)

312. LLW is defined as waste with a radioactive content not exceeding 4 GBq per tonne of alpha, or 12 GBq per tonne of beta/gamma activity.

313. Hitachi-GE states that operational LLW is mainly lightly contaminated miscellaneous waste, arising from plant maintenance and monitoring. Routine LLW arisings from plant consumables will include HVAC filters, organic bead demineraliser resin and concentrate liquors from the HCW evaporators.

314. Non-combustible wastes are generated through routine operations, maintenance and decommissioning in radioactive areas. These will comprise materials such as metals, concrete, lagging and glass. These types of wastes may include some items that could be dealt with in ways other than being directly disposed of. Hitachi-GE envisages that future operators will apply the requirements of the waste hierarchy to enable appropriate waste routings.

315. Miscellaneous combustible wastes are generated through routine operations, maintenance and decommissioning in radioactive areas. The waste consists mainly of contaminated personal protective equipment, polyethylene (sheet, bag), paper, wood, cloth, rubber gloves, turbine oil waste and spent active carbon filter media. Depending upon use and circuit water quality, LCW spent hollow fibre filter membrane may potentially also demonstrate levels of radioactivity suitable for incineration. Subject to future operators disposing of waste appropriately, it is envisaged that these types of waste will be incinerated at an off-site facility, with the resulting ash disposed of at an appropriate facility.

316. Wastes that are generated as wet material but could be made into solid waste for disposal are known as 'wet-solid' LLW. This includes sludge, ion exchange resin, evaporator concentrates and activated carbon. Subject to appropriate waste routing by future operators it is envisaged that

these types of waste will be solidified by being encapsulated in cement on site for disposal to LLWR.

317. LLW from decommissioning typically includes building materials (concrete), metal plant and equipment. This will comprise large volumes of metal and concrete items. Much of this waste will be very large and need reducing in size. Hitachi-GE recognises that segregating waste based on composition, radioactivity and contamination will be needed and that future operators will need to apply appropriate treatment and disposal strategies.

318. The Hitachi-GE submission broadly categorises LLW into 'dry-solid LLW' and 'wet-solid LLW', and estimates of annual arisings are provided, together with information as to the significant radionuclide inventory components.

319. Total low level waste arisings are envisaged of the order 84 m^3/year, comprising 71 m^3/year dry-solid LLW and 13 m^3/year wet-solid LLW. The most significant volumes are associated with HVAC filters (circa 24 m^3/year), miscellaneous combustible LLW (37 m^3/year) and wet solid LLW (13 m^3/year) ('Radioactive waste management arrangements' submission).

320. Hitachi-GE proposes that, where practicable, LLW will be subject to metals treatment, incineration, super compaction and disposal. This will depend on a future operator applying the waste hierarchy appropriately and the optimal disposal routes.

321. Hitachi-GE observes that specific waste streams are likely to need considering as ‘borderline’ wastes (close to the LLW and ILW categorisation boundary) in the future. Organic bead demineraliser resins used in liquid clean up plant is one example of this type of waste. Any future operators will need to assess borderline wastes using a methodology agreed with the disposal site operators and UK regulators, as appropriate.

Intermediate level waste (ILW)

322. ILW has radioactivity levels that are higher than LLW but do not generate enough heat to require special storage or disposal facilities, such as HLW. The Hitachi-GE submission identifies a range of ILW that will be generated by a UK ABWR. These will broadly comprise 'dry-solid' ILW and 'wet-solid' ILW.

323. Dry-solid ILW comprises activated metals subjected to irradiation to the extent that it becomes significantly active (above LLW levels) within the reactor. These wastes will include control rods and reactor components, such as neutron sources and metallic fuel channels. Metallic components of fuel assemblies are envisaged to be retained and disposed with the associated spent fuel (timescales of up to 140 years are envisaged for spent fuel storage). Although it could potentially be HLW when it is generated, Hitachi-GE expects such dry-solid wastes to be ILW when they are disposed of due to radioactive decay and cooling during storage (timescales of up to 100 years are envisaged). The main radionuclides include cobalt-60, nickel-63 and californium-252 in neutron sources.

324. Wet-solid ILW includes 90 m^3 (per 60 year operational life) of sludge (also referred to as ‘crud’) arising from filtration of water streams and 4.4 m^3/year of powder ion exchange resins (arising from water treatment filter/demineralisers associated with the fuel pool and reactor clean up circuit) ('Radioactive waste management arrangements' submission).

325. Hitachi-GE has identified that some irradiated metals, including control rods and various reactor core components, will be generated as high level waste (that is, having significant heat output). It is assumed that storing this type of waste will mean that it can be treated as ILW when it is disposed of (decay storage is proposed).

326. Hitachi-GE has selected the option of cement encapsulation for solid items and solidification with cement for wet-solid ILW, within unshielded stainless steel containers, as the conditioning option to be adopted for a disposability assessment by RWM. Interim storage for up to 100 years is assumed awaiting disposal to the GDF (see chapter 6 - Strategic considerations for radioactive waste management).

Spent fuel

327. Spent or used fuel is considered as waste in GDA on the basis of an assumed once-through nuclear cycle. This is consistent with the policy, laid out in the government White Paper 'Meeting the energy challenge' (BERR, 2008), that new nuclear power stations should proceed on the basis that spent fuel will not be reprocessed. Hitachi-GE's proposed spent fuel management strategy for the UK ABWR comprises initial pond cooling, followed by dry storage and eventual geological disposal in a GDF (see Chapter 6 - Strategic considerations for radioactive waste management).

328. Hitachi-GE proposes using GE14 fuel in the UK ABWR. This is a modern fuel design that has benefitted from progressive development and optimisation of BWR fuel design (see Claim 1 - in Appendix 5). GE14 fuel consists of a fuel bundle (composed of 92 fuel rods, 2 water rods, spacers and upper and lower tie plates), and a channel that surrounds the fuel bundle. The fuel is in the form of uranium dioxide (UO_2) pellets that are stacked in a zirconium alloy cladding tube to form fuel rods.

329. A GE14 fuel assembly consists of a fuel bundle and a channel that surrounds it. All components of the assembly will become spent fuel waste. It is proposed that the channels that surround each of the fuel element bundles are to remain with the spent fuel to be disposed of together.

330. Significant radioactivity arises in spent fuel within the reactor core by nuclear fission, activation and growth of radionuclides. Much of this activity remains within the fuel, which will contain fission products, activation products and actinides. Approximately 9,600 assemblies are assumed to arise over 60 years' of operation. Interim storage periods of up to 140 years are assumed, awaiting disposal to the GDF.

331. Spent fuel generates considerable radiogenic heat and, therefore, spent fuel management must take account of this. The heat output of fuel is also a consideration in terms of eventual disposal as there are likely to be temperature limits imposed in the waste acceptance criteria of a future GDF. Hitachi-GE proposes to store spent fuel for up to 140 years prior to disposing of it (see Chapter 6 - Strategic considerations for radioactive waste management).

332. For the GDA disposability assessment Hitachi-GE has assumed that spent fuel will be over-packed for disposal, following interim storage. Robust disposal containers manufactured from either copper or steel are considered and each would contain 12 fuel assemblies from a UK ABWR based on the concept design for GDA. The container materials are chosen to be durable and corrosion-resistant, so that they provide long-term containment for the radionuclides within the spent fuel.

Non-aqueous liquid waste

333. Hitachi-GE has concluded that some non-aqueous liquids potentially contaminated with radioactivity will be generated in a UK ABWR. These will be generated from plant operations, such as maintaining pumps and hydraulic equipment. These types of waste may be in liquid form, or associated with materials such as rags, spill kit clean up waste and contaminated plant items. Such wastes are likely to be VLLW or LLW, or could be so lightly contaminated as to be out of scope of the regulations in terms of the definitions of radioactive waste.

334. Hitachi-GE has not quantified the specific nature of such arisings or the associated volumes, as these are particularly difficult to predict. However it is argued based on developed reasoning, that the amounts will be low and that appropriate segregation, characterisation and treatment and disposal options are available for any such waste arisings.

Comparison of arisings with those from comparable stations

335. Hitachi-GE has provided estimates for the annual arisings (during operations and decommissioning) of LLW and ILW. Based on data Hitachi-GE presented in its 'Radioactive waste

management arrangements' submission, the waste arisings are as follows[2]: 73.9 m^3 per year of treated LLW (disposed or stored); 0.8 m^3 per year of conditioned ILW arisings; 23.6 m^3 per year of conditioned wet-solid ILW.

336. The total normalised arisings of LLW (54.7 m^3) and ILW (18.1 m^3) exceed the European Utility Requirement objective of less than 50 m^3 per 1000 MWe plant-year of operation (EUR, 2001). This objective has been used to compare solid waste arisings between different light water reactor designs in GDA[3].

337. In response to RQ-ABWR-0355 'Discharges and waste arisings: comparison with other power stations', Hitachi-GE could not provide detailed comparative data for solid waste arisings (it only provided one data source for solid wastes). An Environment Agency study (Environment Agency, 2016) also had difficulty in benchmarking the solid waste arisings based on internationally available literature sources for BWR.

338. RWM has carried out a comparison of radionuclide inventories for the most active ILW stream and for spent fuel from PWR assessed to date as part of the UK ABWR disposability assessment (RWM Ltd, 2015)[4]. RWM concluded that radionuclides within the decommissioning waste streams are the main source of radioactivity arising in solid waste from the UK ABWR. Comparison with reported activities for similar wastes concluded that radionuclide activity in UK ABWR waste streams is comparable to that for Sizewell B (the UK's only operational PWR).

339. We note that it has been difficult to obtain extensive, relevant data on solid waste arisings to make comparisons. However, it seems reasonable to conclude that the UK ABWR design is not unusual in terms of quantities of solid wastes produced when compared to other modern light water reactor designs.

Minimising the quantity of solid waste

340. Having minimised the overall production of radioactive waste, the use of BAT to minimise the activity in gaseous and aqueous discharges tends to transfer activity to solid waste. This is in line with the principle of preferred use of 'concentrate and contain' over 'dilute and disperse' (GB Parliament, 2009a). There is little opportunity to reduce the activity of this waste, except by decay storage when the waste contains radionuclides with short half-lives. However, the quantity (mass and volume) of waste that needs finally disposing of can be reduced by using techniques such as waste sorting and segregation, compaction, incineration, removal of surface contamination, re-use and recycling.

341. Hitachi-GE has provided a summary in its 'Demonstration of BAT' submission of the techniques to enable minimisation of solid waste arisings. This demonstrates how specific claims and arguments are relevant to particular solid wastes. We note, in particular, that Claim 3 and specific arguments as part of Claim 1 are relevant to minimising solid waste (see Arguments: 1a, 1c, 1e, 1f, 1g, 1j in Appendix 5). We agree that the arguments are valid and are supported by appropriate evidence,

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[2] Treated annual LLW (disposed or stored) 73.9 m^3 (Table A2.3-1); conditioned ILW arisings 0.8 m^3 (Tables A2.4-3 & A2.4-5) and conditioned wet-solid ILW 23.6 m^3 Tables A2.4-1 & A2.4-2 (annual arisings, assuming 25% volume wet-solid ILW). Figures taken from 'Radioactive waste management arrangements' Revision G.
[3] Note that in our earlier GDA assessments of the AP1000 design (a pressurised water reactor) the representative numbers were: 54.7 m^3 LLW per 1000 MWe plant-year of operation; 36.6 m^3 ILW per 1000 MWe plant-year of operation. For the EPR reactor design (a pressurised water reactor) the numbers were: 14.1 m^3 LLW and 26.6 m^3 per 1000 MWe plant-year of operation.
[4] RWM (RWM Ltd, 2015) observes that for UK ABWR and PWRs the overall radionuclide inventories for waste and spent fuel will be broadly similar. This is proven by comparing radionuclide inventories for the most active ILW stream and for spent fuel from the reactor types that RWM has carried out as part of the UK ABWR disposability assessment. These types of waste contain the majority of the radioactivity that arises in solid form. The comparable inventories reflect similar design in terms of fuel types, that is similar enrichment and materials of fabrication.

based on sampling of the evidence provided to us. Our view on each argument is provided in Appendix 5.

342. Overall, at this time, we accept that the UK ABWR design uses BAT to minimise the quantity (mass/volume) of solid radioactive waste that will need to be disposed of.

Disposal of solid wastes

343. Hitachi-GE has sought to demonstrate that solid wastes generated by the UK ABWR design could be disposed of to appropriate routes based on currently established practice and national plans (Chapter 6).

344. We note, in particular, that Hitachi-GE claims in its 'Demonstration of BAT' submission (Claim 4 in Appendix 5), that operators of a future UK ABWR would be able to select the 'optimal disposal routes for wastes transferred to other premises'. The arguments (4a – 4e in the 'Demonstration of BAT' submission) relate to providing waste management facilities, selecting the optimal disposal routes, agreement in principle for lower activity waste disposal routes, disposability assessment for higher activity wastes and compatibility with existing UK waste BAT studies.

345. Hitachi-GE has also performed optioneering studies to identify the best means by which to condition wastes for disposal. For ILW the proposal for GDA is to condition these wastes by cement encapsulation in stainless steel packages. Hitachi-GE outlines a range of spent fuel management options that would be available to any future site operator. However, for the purpose of GDA, it chose to use the KBS-3 disposal canister as RWM understands this package better. Before packaging the fuel for disposal, Hitachi-GE has assumed a dry cask storage system, similar to the Holtec system, for interim storage of spent fuel.

346. We conclude at this stage that Hitachi-GE has appropriately demonstrated that all solid waste arisings from the UK ABWR design would be disposable, in so far as this is possible at this time and to an extent that is in line with our expectations for GDA. We also consider that the proposed waste conditioning options are a suitable basis for assessment at the GDA stage.

347. Any future operators of a UK ABWR would need to demonstrate that waste arisings meet the acceptance criteria for available facilities, determine the optimal disposal routes and waste conditioning approaches at that time.

Management and disposability of higher activity waste and spent fuel

348. The ILW and spent fuel that would arise from a UK ABWR are higher activity waste (HAW). There are currently no final disposal facilities in the UK for HAW. It is expected that HAW, along with spent fuel, will be disposed of to a geological disposal facility (GDF) that the government intends to construct (GB Parliament, 2011b). In the meantime, such wastes need to be managed in a way that adequately protects people and the environment, without compromising their disposability in the GDF.

349. Any future site operator will decide how to manage its wastes and condition them for disposal in line with the appropriate regulations at that time. Hitachi-GE argues in its 'BAT optioneering report' (Hitachi-GE, 2016d) that it has considered the viable options for higher activity wastes in the supporting optioneering for GDA. We are content that it has considered sensible options. We are also content that the options it has chosen demonstrate that the waste produced by the UK ABWR can be disposed of based on the current assessment context.

350. We expect Hitachi-GE to 'obtain a view from the Nuclear Decommissioning Authority, as the UK authoritative source in providing such advice, on the disposability of such wastes and spent fuel' (Environment Agency, 2013). We anticipate that the requesting party will also consider the advice in the case made for GDA and respond to it.

351. The GDA disposability assessment process comprises 3 main components: a review to confirm the waste and spent fuel properties; an assessment of the compatibility of the proposed waste

packages with concepts for geological disposal of higher activity wastes and spent fuel; and identification of the main outstanding uncertainties, and associated research and development needs relating to the future disposal of the wastes and spent fuel.

352. The overall objective of the disposability assessment process, previously called letter of compliance (LoC) assessment process (NDA, 2014), is to give confidence to all stakeholders that the future management and disposal of waste packages has been taken into account as an integral part of their development and manufacture. This is achieved by the site operator working to packaging standards and seeking input from RWM to explicitly demonstrate that the waste packages produced by a proposed packaging process will be compliant with the generic waste package specification and compatible with plans for transport to and emplacement in the planned future GDF.

353. Hitachi-GE has obtained disposability assessment advice from RWM and has responded to this advice. We have considered the submission to RWM, the resulting assessment report and the Hitachi-GE response to the advice.

354. RWM identified 3 key issues for ILW:

- Hitachi-GE's proposed use of 4 m^3 boxes for packaging and disposing of reactor pressure vessel (RPV) decommissioning wastes will need reconsidering because the dose rates will not meet transport regulations. RWM proposes using 3 m^3 boxes.
- Hitachi-GE has proposed disposing of wastes shortly after they arise. For some of the waste streams, this raises concerns about meeting transport limits and operational limits at the GDF. These could be addressed by a period of decay storage for the relevant wastes.
- Control rods disposed of via an ILW route are challenging and will require a period of decay storage prior to Hitachi-GE's proposal for grout encapsulation in 3 m^3 boxes.

355. RWM has also considered a revised waste inventory, which Hitachi-GE submitted following the original submission for RWM's assessment (2014). The latter was produced in response to a changed source term. This was prompted via interactions through the joint Regulatory Observation (RO-ABWR-0006) and the subsequent Regulatory Issue on source term aspects (RI-ABWR-0001, 'Definition and justification for the radioactive source terms in UK ABWR during normal operations').

356. We note that the numerous issues RWM identified are typical of pre-conceptual disposability advice and it is anticipated that such matters could be resolved during any formal disposability assessment process in the future. This is normal practice as the letter of compliance (LoC) process is implemented formally with operators and, therefore, will be undertaken by a future operator.

357. RWM has also confirmed that the changed source term does not impact on the broad conclusions of the assessment report, as issued. We have considered this position and conclude that this seems appropriate at this time. We note, however, that should further work on source terms result in a significant change in inventory, RWM will need to consider any changes for the disposability assessment further. We will review this situation as GDA progresses in ONR's Step 4.

358. Hitachi-GE accept RWM's advice, which a future operator will need to consider further during the site-specific disposability assessment process in support of a conceptual stage disposability assessment. We note, however, that any future site operator will decide how to manage its wastes and condition them for disposal with appropriate regulatory oversight at that time.

359. We see no reason at this stage to believe that any of the ILW or spent fuel from a UK ABWR will not be disposable in a suitably designed and located GDF. We conclude that interactions through the course of the GDA process have identified a range of issues that will need to be addressed in the future programmes of any operators who might wish to pursue the options selected for GDA. We would expect to see more definitive assessments by any future operators to confirm how all of the ILW and spent fuel will be conditioned for disposal, that the selected conditioning methods represent the application of BAT at that time, and that in their conditioned forms the ILW and spent fuel will continue to be disposable.

Our overall conclusions on solid radioactive waste

360. Hitachi-GE has identified the projected solid wastes in terms of their category (HLW, ILW, LLW, VLLW), physico-chemical characteristics and proposed disposal routes. It has quantified the activity of the main individual radionuclides and overall groupings of radionuclides (for example, total beta), together with the likely mass and volume of the waste arisings.

361. Hitachi-GE has identified the solid waste in terms of broad characteristics, quantities and inventory. It has considered this against waste acceptance criteria for current waste routes and against possible disposal routes for the higher activity wastes and spent fuel for which there is currently no disposal route. We conclude at this stage that all wastes arising from the UK ABWR are likely to be disposable.

362. Hitachi-GE has described the conceptual design of waste facilities to manage and treat solid waste arisings. We conclude that appropriate waste treatment and disposal routes have been selected in this context. The proposed disposal routes are consistent with government policy and current UK practices.

363. For spent fuel, Hitachi-GE has identified dry storage in casks as a preferred option to make long-term storage before disposal easier. It describes a spent fuel interim store at a conceptual level for the UK ABWR design. This is broadly consistent with plans for managing existing LWR fuel at Sizewell B, and is argued not to compromise eventual spent fuel disposability. We conclude that the proposed spent fuel management and disposal strategy is reasonable and consistent with the expectations of GDA (see Chapter 6 - Strategic considerations for radioactive waste management).

364. A future operator will need to consider how to ensure the performance of spent fuel during storage so as not to compromise eventual disposal. ONR regulates the storage of waste on nuclear licensed sites. We will seek a view from ONR as it continues to assess conceptual proposals for interim fuel storage. ONR’s advice will help inform our final view on this matter.

365. We conclude that:

- in its submissions, Hitachi-GE describes how solid radioactive waste (LLW, ILW) and spent fuel will be generated, managed and disposed of throughout the facility’s life cycle at a level of detail in line with our expectations for GDA
- the quantities of solid waste produced by the UK ABWR are comparable to other light water reactor power stations across the world, and the UK ABWR design uses BAT to minimise the quantity (mass/volume) of solid radioactive waste that will need to be disposed of
- solid radioactive waste will be treated and conditioned using proven and recognised techniques, and potential disposal routes have been identified for all LLW solid wastes.
- Hitachi-GE has provided information on the fuel composition and characteristics, the expected fuel burn up and the quantities of spent fuel that will arise, and described how spent fuel will be managed and disposed of throughout the life cycle of a UK ABWR at a level of detail in line with our expectations for GDA
- the proposed arrangements for interim management of higher activity solid wastes and spent fuel are unlikely to constrain their ultimate disposal (based on conceptual options developed at this time)
- Hitachi-GE has obtained a view from RWM, as the UK authoritative source in providing such advice, on the disposability of ILW and spent fuel, responded to RWM's advice and provided an opinion to the regulators

366. Our view at this time is that all relevant aspects of the P&ID (Environment Agency, 2013) in relation to solid radioactive waste have been addressed. The case Hitachi-GE has presented is in line with our expectations for GDA.

367. We are, however, investigating further whether the waste inventory has been defined adequately in relation to source terms. We are not aware at this time that resolving this Regulatory Issue will impact significantly on the proposed solid waste management and disposal aspects as described

to date. We will, however, consider this further when we consider Hitachi-GE's response to this issue before we make our final decision. We will also consider any implications for solid waste that might arise through resolving other Regulatory Observations.

368. We have identified one Potential GDA Issues and 2 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter.

You can find more details of our assessment of solid radioactive waste in our report [AR06 - Assessment of solid radioactive waste and spent fuel].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

12. Monitoring of discharges and disposals of radioactive waste

This chapter covers our assessment of Hitachi-GE's proposed techniques to measure and assess discharges of radioactive waste to the environment and the activity content of solid wastes.

This monitoring is necessary to:

- confirm that actual discharges are as predicted by the designer
- assess compliance with discharge limits
- provide good quality data for dose assessments
- characterise solid waste to enable its disposal by optimal routes

We conclude that the UK ABWR uses the best available techniques to monitor discharges and disposals of radioactive waste.

We have identified 5 Assessment Findings.

- **Assessment Finding 11**: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G (July 2016).
- **Assessment Finding 12**: A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.
- **Assessment Finding 13**: A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.
- **Assessment Finding 14**: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.

  Assessment Finding 15: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.

Table 12.1 - Summary of Hitachi-GE forward actions for a future operator (Assessment Finding 11).

Follow up actions identified by Hitachi-GE
Identification of any additional gaseous discharge routes for monitoring (such as the service building and waste processing and storage facilities). **Only main stack of reactor building considered in GDA.**
Review of the main stack sampling design for a site-specific main stack design.
Determination of the main stack platform design.
Recording and reporting of the measurements. Including a recording system for sample collection time.
Ensuring all sampling and monitoring techniques achieve EU2004 detection limits.
Ensuring appropriately accredited laboratories are selected for analysing samples, including MCERTS accreditation where applicable.

Follow up actions identified by Hitachi-GE
Selection of the specific sampling and monitoring equipment for the determination of the discharges. Including consideration of sampling flow rates. **Allowing for technological advances.**
For gaseous sampling the sampling period for each sample collector and the order of sampling will need to be confirmed.
Flow velocity distribution test in the main stack. **Determination of locations of the flow measurement and sampling point in the sampling plane.**
Selection of the type of isokinetic probe for the main stack sampling, for example shrouded or unshrouded.
Define appropriate performance and leak checks to be undertaken after the maintenance and inspection of sampling probes to ensure the correct operation of the probe(s).
Determine the volume of the liquid sample required per unit of volume of discharge to enable analytical requirements to be met.

We want to ask you:

Consultation question 8:

Do you have any views or comments on our preliminary conclusions on monitoring of discharges and disposals of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Monitoring of gaseous waste

369. The monitoring of radioactive gaseous disposals are described in the Hitachi-GE's 'Approach to sampling and monitoring' submission, including considerations of best available techniques (BAT). This includes both the approach to in-process and final discharge monitoring.

370. Hitachi-GE states monitoring and sampling systems will be in place to enable activity concentrations to be determined for total noble gases (krypton-85 and argon-41 will not be measured specifically), particulates excluding iodines (cobalt-60, strontium-90, caesium-137 and total alpha (reported instead of individual alpha emitters)), iodine-131, tritium and carbon-14. Calculations have been performed that indicate that the required values from the EU Commission recommendation 2004/2/Euratom (EU, 2004) for detection limits can be met using currently available systems.

371. The volumetric flow, required to determine the activity concentrations, will be measured continuously using an appropriate MCERTS[5] accredited technique. The exact configuration of the

[5] MCERTS is the Environment Agency's Monitoring Certification Scheme. It provides the framework for businesses to meet our quality requirements.

system will be determined during the commissioning phase following the appropriate ISO standards (ISO10780, 1994 and BS ISO2889, 2010). A sample port on the main stack will also be provided for independent flow measurement. The access port will be consistent with the requirements of our regulatory guidance M1 (Environment Agency, 2010b) and with the provision of 3 standard waterproof sockets of single phase 110 V.

372. There is one gaseous discharge monitoring point proposed on the main stack at a location that will allow for sufficient mixing of the air in the discharge and for the samples collected to be representative of the final discharge. Hitachi-GE is committed to isokinetic sampling consistent with the relevant standard (BS ISO2889:2010). A sampling platform designed to comply with M1 (Environment Agency, 2010b) will be provided to allow workers to have safe access for inspecting and maintaining the sampling equipment, including to the independent port. The final design will depend on the equipment choice and will be made by a future operator.

373. One sampling line from the stack will feed 2 sampling systems. Having 2 sampling systems allows for contingency in the case of failure and for regulatory independent monitoring. The sampling line is being designed to meet the relevant standard, including considering lengths, bends, horizontal runs and temperature control. Modelling work has been undertaken on the penetration factors achievable for different configurations of the sampling line. This indicates that the requirements of BS ISO2889, 2010 can be met. Flexibility has been required as the final positioning of the monitoring room has not been determined. The modelling of penetration factors has been based on the discharge being high efficiency particulate air (HEPA) filtered, so the requirements of the standard (BS ISO2889:2010) can be met. While this is the case for the off-gas and HVAC system, information provided indicated that filtration of the turbine gland steam system (TGS) and mechanical vacuum pump (MVP) lines was not intended and, therefore, they could potentially introduce particulates into the main stack and affect the discharge characteristics. We raised a Regulatory Query around this and Hitachi-GE has committed to installing HEPA filtration (appropriate to the conditions) into the TGS and MVP lines in its response.

374. The sampling systems themselves will be configured so the required nuclides are collected in an order that ensures the best sample is obtained. Particulates (for Co-60, Sr-90, Cs-137 and total alpha analysis) are collected first to minimise losses through plating out. Once particulates have been removed, the sample is passed through an appropriate iodine adsorber, before the sample is passed into the gas chamber for noble gases analysis. Tritium and carbon-14 are collected on a different line.

375. It is good practice to return the sample downstream of the sample extraction point to prevent either double counting or dilution of the sample. However, Hitachi-GE has proposed the sample return line be upstream of the extraction point to save pipework and the amount of potentially contaminated material that needs to be disposed of at the end of the plant life. Given this saving and the fact that the impact of the returning gas would be negligible, due to the very small sample volume being diluted by the large stack flow rate, this approach has been accepted as BAT for the design.

376. We have assessed the information Hitachi-GE provided on the UK ABWR design for the determination of gaseous discharges against the requirements of our technical guidance notes M1 (Environment Agency, 2010b) and M11 (Environment Agency, 1999a) and relevant international and national standards (e.g. BSi, 2010). The assessment also considered the commitment given to our MCERTS (Monitoring Certification) scheme for current in scope standards (Environment Agency, 2011a and 2011b) and flexibility to adopt future standards if nuclear facilities are within scope.

377. We have concluded that:

- BAT has been broadly demonstrated for the UK ABWR gaseous effluent monitoring systems
- appropriate consideration has been given to the sampling line to ensure requirements for sampling can be met (through modelling penetration factors). Final confirmation of the acceptability of the sampling line will be needed once the position of the monitoring room has been finalised

- representative samples will be taken
- appropriate measurement and analysis will be undertaken
- having the return of the sample to the discharge stack upstream of the sample extraction point will have a negligible effect on the discharge monitoring and is acceptable given the saving in pipework
- appropriate provision will be made to allow for independent regulatory verification of the gaseous monitoring and discharge reporting

378. There are a number of areas that a future operator will need to deal with. Hitachi-GE has identified these and they are shown in Table 12.1 at the start of this chapter. We have also recorded an Assessment Finding to ensure these are completed. The most significant ones are recorded as individual Assessment Findings:

- **Assessment Finding 11**: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G (July 2016).
- **Assessment Finding 12**: A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.
- **Assessment Finding 13**: A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.
- **Assessment Finding 14**: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.

Monitoring aqueous wastes

379. The monitoring of radioactive liquid disposals are described in Hitachi-GE's 'Approach to sampling and monitoring' submission, including considerations of best available techniques (BAT). This includes both the approach to in-process and final discharge monitoring.

380. Hitachi-GE's submission states monitoring and sampling systems will be in place to enable activity concentrations to be determined for tritium and other radionuclides (excluding H-3) Co-60, Sr-90, Cs-137 and total alpha (reported instead of individual alpha emitters). Calculations have been made that indicate that the required values from the EU Commission recommendation 2004/2/Euratom (EU, 2004) for detection limits can be met using currently available systems. An exception to this is for alpha emitters, and Hitachi-GE indicate the limit of detection could be achieved using longer count times and these will be required of future operators, if this is the best way to achieve the required limit of detection.

381. For final discharge reporting there will be one sampling location on the final discharge line downstream of the aqueous waste treatment sub-systems. These treatment sub-systems have 2 storage tanks each and when a tank is full it is sealed from additional input and a sample collected once the re-circulation line has agitated that tank. This sample is analysed prior to discharge to confirm the activity is less than the permitted activity. This forms the in-process monitoring. Interlocks are in place to prevent simultaneous discharge and filling of the tank.

382. During discharge the final accountancy samples are taken via a flow proportional sampling system on the final discharge line. This gives an accurate record of what is actually discharged. Hitachi-GE is committed to using MCERTS accredited systems where available. At present pressurised systems are not covered, but are likely to be brought into scope in future. The samples will then be analysed by an accredited laboratory, including for MCERTS where applicable. The discharge flow is also measured at this point using an appropriate MCERTS accredited technique.

383. To provide contingency in the event of equipment failure duplicates of both the flow proportional samplers and flow measurement apparatus will be provided. Providing these duplicate systems also allows for independent verification by the regulator or our representatives.

384. In addition to sample collection, a continuous radiation monitor is provided in the liquid discharge line. If the system detects a high radiation level, it activates an alarm and closes an isolation valve to stop discharge to the environment.

385. We have assessed the information Hitachi-GE provided on the UK ABWR design for the determination of liquid discharges against the requirements of our technical guidance note M12 (Environment Agency, 1999b). The assessment also considered the commitment given to our MCERTS (Monitoring Certification) scheme for current in scope standards (Environment Agency, 2011a and 2014a) and flexibility to adopt future standards if nuclear facilities are within scope.

386. We have concluded that:

- BAT has been demonstrated for the UK ABWR liquid effluent monitoring systems
- representative samples of the final discharge will be taken
- appropriate flow measurement will be undertaken
- appropriate analysis will be undertaken
- appropriate provision will be made to allow for independent regulatory verification of the liquid monitoring and discharge reporting

387. There are some areas that a future operator will need to deal with. Hitachi-GE has identified these and they are itemised in Table 12.1 at the start of this chapter. We have also recorded an Assessment Finding to ensure these are completed. Assessment Finding 14 is also relevant to the monitoring of aqueous wastes:

- **Assessment Finding 11**: A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G (July 2016).
- **Assessment Finding 14**: A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.

Monitoring solid wastes

388. The monitoring of solid waste disposals are outlined in Hitachi-GE's 'Approach to sampling and monitoring' submission, including considerations of best available techniques (BAT). More information is provided in Hitachi-GE's Radioactive solid waste monitoring requirements document (Hitachi-GE, 2016e).

389. The solid waste management system (SWMS) has only been developed at a concept level during GDA, so only an overview of the sampling of solid radioactive wastes has been provided. Hitachi-GE states that solid radioactive waste will be sampled and analysed at each stage to maintain traceability and assure SWMS performance. Prior to dispatch for final disposal, the sample is analysed in order to ensure compliance with the regulatory limit.

390. Information has been provided on the processes that have been considered for the complete waste cycle for the UK ABWR design with account of relevant guidance from the International Atomic Energy Authority (IAEA) and industry (IAEA, 2007, IAEA, 2009 and NICoP, 2012). This gives reassurance that the practices being developed should be appropriate. Examples of typical instruments and equipment have been cited to show proposals are based on current and achievable techniques. Hitachi-GE raises the issue that the UK analytical supply chain may have little experience with the mix of radionuclides in the ABWR waste types and, therefore, method development may be required. It is also recognised that future operators will need to work with the UK supply chain to identify where experienced characterisation capability exists or a development programme may be required.

391. As the monitoring systems for the waste handling facilities have only been developed to concept level these will need to be assessed at a later stage. The assessment will consider the requirements of our P&ID (Environment Agency, 2013) and the relevant guidance such as that referenced above.

392. Our preliminary conclusion is that the practices being developed appear appropriate for monitoring the final disposal of solid wastes, but a full assessment needs to be undertaken when more information has been provided.

393. We, therefore, have the following Assessment Finding:

- **Assessment Finding 15**: A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.

Our overall conclusions on monitoring radioactive wastes

394. We conclude that the UK ABWR uses the best available techniques to monitor discharges and disposals of radioactive waste.

395. We have identified 5 Assessment Findings, as set out in the above paragraphs and at the beginning of this chapter, including a table of follow up actions for the future operator.

You can find more details of our assessment of the monitoring of radioactive waste in our report [AR07 - Approach to sampling and monitoring]. https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

13. Impact of radioactive discharges

This chapter covers our assessment of the impact of the proposed radioactive discharges from the UK ABWR, that is, the radiation doses that people and other species might receive. We compare the calculated doses with national and international limits and standards to confirm that people and the environment will be adequately protected.

Dose calculations rely on models that predict how radioactivity from discharges moves through the environment and causes radiation exposure of people and other species, either externally or by intake of air, water or food. In GDA, we are not dealing with specific sites, so the dose calculations need to be done on the basis of a 'generic site' that has characteristics appropriate to sites in the UK where nuclear power stations might be built. To enable proper comparison with standards and limits, the calculations also take account of the predicted external radiation that comes directly from the nuclear power station, although this is a regulatory matter for ONR rather than the Environment Agency or Natural Resources Wales.

We conclude that, for the operation of a UK ABWR at any coastal site identified as suitable for new nuclear power stations (GB Parliament, 2011a) and with discharges at the annual limits specified in Chapters 10 and 11:

- the radiation dose to people will be below the UK constraint for any single new source of 300 microsieverts per year (μSv/y)
- the radiation dose rates to local wildlife will be below our screening level of 10 micrograys per hour (μGy/h) and so there will not be any significant adverse impact on non-human species

We want to ask you:

> Consultation question 9:
>
> Do you have any views or comments on our preliminary conclusions on the impact of discharges of radioactive waste?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Summary of assessment of impact

396. We have assessed the information Hitachi-GE provided for the UK ABWR relating to the impact on members of the public and non-humans (plants and animals) as a result of the disposal of aqueous and gaseous radioactive waste by discharge to the environment.

397. We conclude that Hitachi-GE has made an adequate assessment of the impact of the gaseous and aqueous liquid discharges to the environment. The assessment assumes that the UK ABWR is located at a coastal location. The estimates of dose to members of the public are well below the

UK constraint for any single new source of 300 μSv/y and also below the dose constraint proposed by Public Health England (HPA, 2009) that recommends that the UK government select a value for the constraint for members of the public from new nuclear power stations to be below 150 μSv/y. We also conclude that the discharges would not adversely affect any conservation sites.

398. This conclusion will need to be confirmed by a detailed site-specific impact assessment that needs to be provided at site-specific permitting. The site-specific assessment will need to be based on the actual environmental characteristics of the proposed site to confirm that doses to members of the public from the UK ABWR at the proposed site will be as low as reasonably achievable (ALARA) and below relevant dose constraint and dose limits.

399. In its assessment of the impact on members of the public, Hitachi-GE carried out a three-stage assessment. This started with a simple and cautious assessment at stage 1, a more refined assessment at stage 2 and a detailed assessment at stage 3. For the stage 3 assessment, the Hitachi-GE estimate of doses was between 14 and 24 μSv/y. This dose was from the operation of a single UK ABWR. Discharges were assumed to be at the annual limits specified above. We were able to verify all stages of the assessment Hitachi-GE produced.

400. Our stage 3 assessment of the doses from the UK ABWR was between 14 and 25 μSv/y. Our assessment was similar to Hitachi-GE's but with some different assumptions about the way the generic site was defined and the dispersion of radionuclides.

401. Hitachi-GE made an assessment of radiation dose rates to wildlife near an operating UK ABWR. It predicts the highest dose rates to be:

- 0.27 μGy/h to a terrestrial organism (bird, mammal and reptile)
- 0.0003 μGy/h to a marine organism (mammal)

402. We have also made our own assessment of radiation dose rates to wildlife near an operating UK ABWR. We predict the highest dose rates to be:

- 0.23 μGy/h to terrestrial organisms (reptile, mammals and birds)
- 0.00039 μGy/h to a marine organism (mammal)

403. These dose rates are well below the 10 μGy/h dose rate criterion that is appropriate to use at generic sites. We conclude that the gaseous and aqueous liquid discharges from a UK ABWR at the generic site are unlikely to pose a risk to wildlife.

Verification of assessment of impact

404. Hitachi-GE has made an assessment of the impact of the discharges of radioactivity from the UK ABWR on the environment. We have reviewed its assessment in detail. Our review involved 3 main processes. Our first process was verifying the assessment Hitachi-GE provided. The verification aimed to reproduce the impacts Hitachi-GE assessed, adopting its model and input data to ensure there were no errors. Our second process was to validate the assessment that Hitachi-GE made to ensure they had adopted an appropriate approach and used best practice and guidance. Our third process was to carry out our own assessment of the impacts using best practice and recommended models and assumptions. These are summarised in Table 13.1 below. We also compared the outputs and approach from our own assessment with those of Hitachi-GE. We followed up any significant discrepancies with Hitachi-GE, where appropriate. These processes helped us to be sure that the assessment of impacts on people and the environment were correct and valid.

Table 13.1 Summary of assessment outputs from the Hitachi-GE assessment of one UK ABWR and our verification for discharges at the proposed annual discharge limit

Assessment	Hitachi-GE calculated dosea μSv/y	Verification of Hitachi-GE assessment	Validation of Hitachi-GE assessment	Our calculated dosea μSv/y
Stage 1	143[(b)]	Vr	Vl	143
Stage 2	24.5[(b)]	Vr	Vl	26
Stage 3	14-24[(b),(c)]	Vr	Vl	14-24[(b),(c)]
Short duration release to atmosphere	0.016-0.019[(d)]	VC	N/A	0.002-0.004[(d)]

[(a)] To groups most exposed to gaseous discharges. Doses from aqueous liquid discharges were very low in the range 0.000005-0.0002μSv/y

[(b)] Sum of doses to the groups most exposed to gaseous and aqueous discharges and direct radiation

[(c)] range of doses for 3 age groups, infants, children and adults. Highest dose to infants

[(d)] Units are μSv per short duration release

Vr – verified – able to reproduce its assessment

VC – validated by comparison between our assessment and Hitachi-GE's

Vl – able to validate the assessment assumptions and approach

Generic site concept

405. At the generic design assessment stage, we have requested an assessment to inform us about the potential impact from an operating UK ABWR. We have also carried out our own assessment of what the impact could be. To make sure that the assessment is realistic, we have asked Hitachi-GE to consider a 'generic site'. The characteristics of the generic site should be appropriate to sites in England and Wales where nuclear power stations could be built. The generic site will define the 'envelope' of applicability (conditions under which the SoDA will be valid) of any statement of design acceptability that we might issue.

406. We asked Hitachi-GE to identify the main factors that will affect the doses received and take them into account when establishing the characteristics of the generic site. The main characteristics that are of interest to us include:

- weather and other factors affecting gaseous dispersion and deposition
- hydrographic and other factors affecting aqueous dispersion
- location of nearest food production, how close people might reasonably live to the site, the location of sensitive habitats and species
- food consumption rates and other human habits data

407. Hitachi-GE provided information on generic site characteristics. It derived its UK ABWR generic site characteristics assuming the UK ABWR will be located at a coastal site with a large amount of coastal water exchange (suitable for seawater cooling). It has chosen these characteristics to provide geographic representation for seawater cooling and represent data for a site where potentially the UK ABWR reactor might be located. We examined Hitachi-GE's generic site description in some detail during our initial assessment (Environment Agency, 2014b) and concluded that the coastal nature of the generic site and the use of once-through direct cooling will

limit the applicability of any future statement of design acceptability (SoDA) to a site with these characteristics.

408. The SoDA or interim statement of design acceptability (iSoDA) will be limited to a site with parameters similar to those set out in the generic site description. Should a site be proposed for a UK ABWR that is not coastal, the assessments required at the permitting stage will need to be based on the appropriate site characteristics.

409. At the detailed assessment stage we noted that the assumptions made in the initial version of the generic site description submission have remained unchanged throughout the issue of the various document revisions.

410. These assumptions represent a simplified representation of a generic UK site, which will have some implications for the impact assessment. However, we note that as a thorough site-specific assessment will be needed to support an application for an environmental permit, we conclude that some simplification is acceptable at the GDA stage.

411. Based on Hitachi-GE's 'Generic site description' submission we have noted the following:

- Hitachi-GE has selected a coastal site to represent the generic site. As government’s National Policy Statement for Nuclear Generation (DECC, 2011a and 2011b) notes that all potential sites for new nuclear power stations are either located on the coast or on large estuaries, we are content that the selection of a coastal site is appropriate for GDA.
- Hitachi-GE has assumed that there is no standing water on the site. This could be considered to be unrealistic for the temperate climate of the UK, but surface water management is a site-specific aspect of design and we consider this to be appropriate for GDA.
- Hitachi-GE has assumed that there are no discharges to freshwaters. This has resulted in it excluding freshwater species from the non-human radiological assessment, but we will expect this to be considered at site-specific environmental permitting, if appropriate.

412. During the time between revisions to Hitach-GE's submissions, a new 'Environmental Risk from Ionising Contaminants: Assessment and Management' (ERICA) tool was released, which resulted in a difference in the reference organisms considered for non-human radiological impact assessment in Revisions D and E of Hitachi-GE's 'Generic site description' submission. We agree that it is appropriate to use the latest version of the ERICA tool available at the time of each document issue.

We conclude that the generic site description is appropriate for the purpose of the GDA.

Our requirements for the assessment of doses to people

413. We required Hitachi-GE to make an assessment of doses to the ‘representative person’. This is the term for those people it is estimated will receive the highest dose overall from gaseous and aqueous liquid discharges and direct radiation. This assessment should use the generic site characteristics, together with agreed or expected levels of discharges, and suitable models to predict the behaviour and concentrations of radionuclides in the environment once they have been discharged. We require allowance for build up in the environment from discharges continuing for 60 years. Hitachi-GE adopted the PC-CREAM 08 system for the stage 3 assessment. PC-CREAM 08 is a software programme that calculates the concentrations of radionuclides in the environment from routine discharges.

414. Doses to members of the public are calculated taking account of the predicted levels of radionuclides in the environment over 60 years and the habits of members of the public near the site. The dose to the representative person is then compared with the dose constraint and dose limit. Doses to members of the public from direct radiation originating from within the site boundary are regulated by ONR. However, for the purposes of comparing doses to the dose constraints, direct radiation has been estimated using data for direct radiation dose rates derived by Hitachi-GE using modelling and measurements. ONR will be making an assessment of Hitachi-GE's proposed direct radiation dose as part of its work in GDA.

415. The assessment approach is designed to make sure that provided the dose to the representative person is below these dose criteria, doses to the public near the site will also be less than the dose criteria. We may also consider doses from aqueous discharges or gaseous discharges separately. Where a separate assessment is made for different types of discharges, the term 'person most exposed to' is used. Doses from the separate assessments may be added together to provide an estimate of total dose from the reactor. However, this is likely to lead to an over-estimate of dose. This is because it is unlikely that any person would have both sets of habits that would lead to most exposure to various types of discharges at the same time. Therefore, the dose to the representative person is calculated using a method that makes realistic combinations of exposures and habits.

416. Hitachi-GE provided information on its assessment of doses to the public in its submission.

Hitachi-GE assessment approach

417. Hitachi-GE carried out a 3-staged approach to its assessment. The first 2 stages followed our initial radiological assessment methodology (Environment Agency, 2006), which allows a conservative assessment of doses to members of the public from discharges of gaseous and aqueous radioactive waste.

- Stage 1 is normally a conservative or bounding assessment that can be used as a screening assessment to identify if a more detailed dose assessment is required. Hitachi-GE used our published dose per unit release factors given in our initial radiological assessment methodology. For gaseous radioactive waste discharges, Hitachi-GE assumed an effective release height at ground level for the stage 1 assessment, which is likely to be the worst case. For aqueous radioactive waste, it was assumed discharges were made into local coastal waters, which then mix with water from elsewhere along the coast at a rate described as the volumetric exchange. The volumetric exchange rate used was 100 m^3/s, which is the conservative value recommended in our initial radiological assessment methodology.
- Stage 2 is a more refined assessment using more realistic main parameters such as stack height and dispersion factors. Hitachi-GE used our published dose per unit release factors in a more realistic way. For gaseous discharges, the effective release height was assumed to be 20 m, which Hitachi-GE considers to be more realistic. The UK ABWR stack protrudes a few metres above the reactor building, which is likely to be around 70 m high and, taking into account potential entrainment of gaseous radioactive waste in the wake of the reactor building, an effective release height of 19 m was considered to be appropriate. For aqueous discharges, the volumetric exchange rate along the coast was unchanged from stage 1 at 100 m^3/s. This is a very conservative value, and typical of a modest estuary. Other coastal locations show exchange rates of up to 3,000 m^3/s. The exchange rate around Wylfa is 1,200 m^3/s, which is where UK ABWRs might be located.

418. For both stage 1 and 2 the methods used calculate doses to the most exposed members of the public for gaseous and aqueous radioactive waste discharges. Doses to the most exposed members of the public were calculated for 4 age groups (infant, child and adult and fetus) for each radionuclide in the discharge. The doses to the age group, which resulted in the highest dose to the most exposed member of the public for each radionuclide, have been used to calculate the total dose to the most exposed members of the public.

419. Hitachi-GE also estimated doses from direct radiation from the UK ABWR in order to predict the dose to the representative person.

420. Stage 3 is a more detailed assessment and is usually carried out where stage 2 outputs are above dose criteria. A stage 3 assessment may also be carried out where additional assurances or more detail is needed about predicted doses.

421. Hitachi-GE carried out stage 3 of the assessment using the PC-CREAM 08 model assessment system. The assessment assumed continuous uniform releases for 60 years at the maximum annual discharge levels for both aqueous and gaseous radioactive waste. The assessment assumed an effective release height of 19 m for gaseous releases. For aqueous discharges, the

volumetric exchange rate along the coast was 1,270 m^3/s. This is a relatively high dispersion rate relative to other sites and so will tend to increase the dispersion and dilution of radionuclides compared with other nuclear sites.

422. The stage 3 assessment takes into account the potential for exposure of members of the public by a combination of internal and external exposures (e.g. ingestion or direct radiation from the ground). For example, Hitachi-GE has assumed that members of the local resident family may also consume seafood at an average rate, and members of the fisherman family may consume food grown on the land, 50% of which is locally sourced. This provides a realistic assessment of dose to the representative person for the UK ABWR.

423. We consider the approach and assumptions Hitachi-GE made in its dose assessment to be reasonable.

Hitachi-GE assessment results

424. Table 13.2 shows the doses Hitachi-GE predicted.

Table 13.2: Hitachi-GE predicted doses for the UK ABWR design for discharges at the proposed annual discharge limit

Pathway	Doses to the public µSv/y		
	Stage 1	Stage 2	Stage 3
Aqueous discharges	0.006	0.0005	0.000001-0.00002
Gaseous discharges	137	22.6	13-24
Direct radiation	1.7	1.7	0.3-0.9
Total dose	139	24	14-24
Short duration release to atmosphere+	N/A	N/A	0.016-0.02[(a),(b)]

[(a)] Assuming discharges are enhanced from fuel pin failure over 24 hours

[(b)] Units are µSv

425. Hitachi-GE's stage 3 assessment resulted in estimated doses to the representative person of the public of 24 µSv/y to an infant (Table 13.2). Doses to other age groups were 15 µSv/y to a child and 14 µSv/y to an adult.

426. The highest contribution to dose was from consuming carbon-14 in milk and milk products, resulting from discharges to atmosphere.

427. From time to time, processes on site may result in additional discharges to atmosphere. These include de-fuelling and coolant purges. The discharges can range from 30 minutes to several hours. Hitachi-GE has made an assessment of a short duration release. Assuming enhanced discharges due to fuel pin failure, one month's discharge is released over 24 hours. These resulted in estimated doses from a UK ABWR to the representative person of the public of **0.02** µSv to an infant, an adult or a child.

428. We conclude that all the doses Hitachi-GE assessed are below the dose constraint for members of the public of 300 µSv/y and the dose constraint recommended by the Health Protection Agency (HPA) for new build of 150 µSv/y.

Our verification of Hitachi-GE assessment results

429. We were able to repeat all 3 stages of the Hitachi-GE dose assessment.

430. We have also carried out our own dose assessment, assuming discharges are made at the permitted discharges. For this, we used the PC-CREAM 08 model and standard approach. We

adopted a slightly different generic site, which took into account coastal situations based on an estuary where seawater cooling may not be possible.

431. Our stage 3 assessment showed the highest estimated dose from a UK ABWR is 25 µSv/y to the representative person , who is most exposed to gaseous discharges (Table 13.3) and received doses from direct radiation and aqueous discharges.

432. The highest doses are from gaseous discharges and the highest contribution was from carbon-14 in milk and milk products.

Table 13.3 Summary of our independent assessment of doses to the representative person from the UK ABWR design in the 3 stages of the assessment at the proposed maximum annual discharge limit

Pathway	Doses to the public µSv/y		
	Stage 1	Stage 2	Stage 3
Aqueous discharges	0.004	0.003	0.000063
Gaseous discharges	143	26	24.1
Direct radiation	N/A	N/A	0.5
Total dose	144	26	24.6

Doses to people - collective dose

433. Collective dose is sometimes used as a measure of the radiation detriment to a population. It is the sum of all the doses received by the members of a population over a specified period of time. Collective doses are assessed in man-sieverts (manSv).

434. Hitachi-GE has provided information on collective dose. It has estimated collective dose to UK, Europe and world populations per year of discharge, for up to 500 years using the PC-CREAM 08 model.

435. Table 13.4 shows the results of Hitachi-GE's collective dose assessment.

Table 13.4 Collective doses estimated by Hitachi-GE per year of discharge from UK ABWR for discharges at the proposed annual discharge limits

Population	Collective dose manSv per year of discharge	Per person dose nano-Sv/y
UK	0.43	7.2
Europe-12	2.6	7.2
Europe-25	2.9	6.3
World	29.9	3.0

Note - Europe-12 and Europe-25 relate to the number of member states of the European Community considered in the collective dose calculation.

436. Hitachi-GE considers that the collective dose to all populations is dominated by releases of carbon-14 in gaseous radioactive waste, in the range 0.4 to 29.9 manSv per year of discharge.

437. Collective doses from aqueous liquid discharges presented by Hitachi-GE are very low, ranging from 0.0000004 to 0.00003 manSv per year of discharge. This is because the radioactivity levels in these discharges are very low.

438. Collective doses were converted to average annual doses.

439. We have also carried out our own calculations of collective dose. We did this for the UK, European and world populations, for up to 500 years, assuming discharges are made at the proposed annual discharge limits for aqueous and gaseous radioactive waste. We used the PC-CREAM 08 software to estimate collective dose. Our results are set out in Table 13.5 below.

Table 13.5 Our estimate of collective doses per year of discharge from UK ABWR for discharges at the proposed annual discharge limits

Population	Collective dose manSv per year of discharge	Per person dose nano-Sv/y
UK	0.8	14
Europe-25	4.5	9.8
World	30.0	3.0

440. Comparing our assessment of collective dose and the assessment Hitachi-GE carried out shows that the results are similar. Our assessment of collective dose similarly showed collective dose to be dominated by gaseous discharges containing carbon-14. Discharges of aqueous radioactive waste are very small and give very small collective doses.

Non-human species

441. We need to know the likely impact of the proposed discharges on non-human species to show that they will be adequately protected and that relevant conservation legislation will be complied with. In a similar way to the assessment of doses to members of the public, models of the behaviour and transfer of radionuclides within ecosystems are used to predict environmental concentrations, from which the radiation doses to reference organisms can be estimated. These doses can then be compared to dose rate criteria to assess the risk to plants and animals. We have adopted a dose criterion of 40 µGy/h as the dose rate below which wildlife is adequately protected. This dose criteria applies to all radiological discharges affecting a protected site. Because non-human species may be affected by radioactive discharges from more than one site, we also use a screening value of 10 µGy/h when considering the impact from a single source, such as in GDA.

442. Hitachi-GE provided information in its submission on assessment of doses to non-human species ('Summary of the generic environmental permit applications' chapter on 'Prospective dose modelling', Section 14). Its approach to assessing the radiological impact on non-human species is as follows:

- Hitachi-GE has assumed that gaseous and aqueous discharges are made at the proposed limits.
- Hitachi-GE has used PC-CREAM 08 (Smith J.G. and Simmonds J.R., 2009) to derive activity concentrations of radionuclides in the environment after 60 years of operation of a UK ABWR unit.
- In its assessment, Hitachi-GE has used the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) integrated approach (Beresford *et al.,* 2007), which is the accepted practice within Europe. This approach aims to ensure that decisions on environmental issues give appropriate weight to the environmental exposure, effects and risks from ionising radiation, with emphasis on ensuring the structure and function of ecosystems.
- To carry out the assessment, Hitachi-GE used the ERICA tool (Brown *et al.,* 2016), which is a software programme that calculates the radiation dose rate that reference organisms are likely to receive from a defined activity concentration of a radionuclide. Reference organisms are used because, given the variation between species, it is not generally possible to develop species-specific assessment systems. Hitachi-GE assumes that the gaseous and aqueous discharges will affect terrestrial and marine environments respectively, and have undertaken assessments of the terrestrial and marine reference organisms in the ERICA tool. Hitachi-GE

has assumed that no discharges are made to freshwater environments, and has not undertaken an assessment of freshwater reference organisms.

- The ERICA tool does not enable the user to assess the impact of noble gas discharges on non-human species. Therefore, to assess the impact of noble gases to non-human species, Hitachi-GE has used the 'Ar-Kr-Xe dose calculator' tool (Vives i Batlle J., *et al*., 2015). This spreadsheet-based tool uses a reference organism approach to calculate dose rates to non-human species in the terrestrial environment from noble gases. The reference organisms in the ERICA tool and the 'Ar-Kr-Xe dose calculator' tool are the same, and, therefore, the dose rates from each tool can be added together to provide an overall dose rate to reference organisms from gaseous discharges.

443. The ERICA integrated approach has a default screening dose rate criterion for all ecosystems of 10 µGy/h. The ERICA integrated approach takes a tiered approach that allows progressively more detailed assessment depending on the magnitude of the dose rates calculated:

- Tier 1 is simple and conservative – it requires a minimal amount of input data, the user can select from a range of radionuclides and calculate the dose rate for the most sensitive combination of reference organisms.
- Tier 2 is more specific and less conservative – the user defines radionuclides of interest and edits transfer parameters. Dose rates are calculated for each reference organism individually.
- Tier 3 is very specific and detailed – used in complex and unique situations and involving a probabilistic risk assessment approach. A tier 3 assessment requires consideration of biological effects data.

444. Results of the assessment carried out by Hitachi-GE:

- Hitachi-GE carried out its assessments at tier 2 and considered the risk to terrestrial reference organisms from gaseous discharges, and marine reference organisms from aqueous discharges, assuming waste was discharged at proposed limits for 60 years of operation.
- The results of its assessment of the impact of gaseous discharges identified that the most exposed reference organisms were birds, large and small mammals and reptiles, which received a dose rate of 6.1 µGy/h. This assessment conservatively assumed that the gaseous discharges are released at ground level. When Hitachi-GE assumed that gaseous discharges were released from a realistic stack height of 57 m, the most exposed reference organisms (bird, large mammal, small mammal and reptile) were exposed to a lower dose rate of 0.27 µGy/h.
- The results of its assessment of the impact of aqueous discharges identified that the most exposed reference organism were mammals with a dose rate of 0.0003 µGy/h.
- The assessments undertaken by Hitachi-GE show that the dose rates to non-human species from gaseous and aqueous discharges are below the screening dose rate criterion of 10 µGy/h. In addition, when gaseous discharges were assumed to be released from a realistic stack height, the assessments show that for each reference organism the probability that the UK ABWR discharges would result in dose rates that exceed the 10 µGy/h screening dose criterion was less than 1%.

445. We carried out 2 evaluations of the assessment undertaken by Hitachi-GE:

- A validation exercise using the ERICA tool to satisfy ourselves that the results of the assessments undertaken by Hitachi-GE could be reproduced.
- An independent assessment using the ERICA tool and the 'Ar-Kr-Xe dose calculator' tool to determine dose rates using discharge data Hitachi-GE provided, and predicted activity concentrations an independent contractor modelled for us. For this assessment, we assumed that gaseous discharges were released at proposed limits and from a realistic stack height.

446. When we used the same input data and parameters, we were able to reproduce the results of the assessments that Hitachi-GE carried out using the ERICA and the 'Ar-Kr-Xe dose calculator' tools.

447. Our independent assessment of gaseous discharges identified that the most exposed reference organisms were birds, reptiles, large mammals and small burrowing mammals, and that they would receive a dose rate of 0.23 µGy/h.

448. Our independent assessment of aqueous discharges identified that the most exposed reference organisms were mammals and that they would receive a dose rate of 0.00039 µGy/h.

Comparison with standards

Source dose constraint

449. There is a dose constraint in the Environmental Permitting Regulations 2010 (EPR 2010) for the maximum dose to people that may result from discharges from a new single source (for example, a new power station). The constraint is 300 µSv/y and it applies to the dose from proposed discharges and direct radiation.

450. As set out above, our independent assessment shows that, for the UK ABWR, the sum of doses to the representative person from the maximum expected discharges and direct radiation is 14-25 µSv/y and is below the source dose constraint.

451. We conclude that the sum of doses to the representative person is below the source dose constraint.

Site dose constraint

452. There is also a dose constraint in EPR 2010 for the maximum dose to people that may result from discharges from a site as a whole. The dose constraint is 500 µSv/y and it applies to the total dose from the discharges, in this case direct radiation is not included, from all sources at a single location, including discharges from any immediately adjacent sites that share a boundary.

453. We consider, in the light of our assessment, that the highest total dose from a reactor is estimated to be 14-25 µSv/y. Although 2 or 3 UK ABWR reactors may be installed in a single power station, it is very unlikely that doses at the site where several UK ABWRs are installed next to an existing nuclear site will exceed the site dose constraint of 500 µSv/y.

454. We conclude that site dose should be re-assessed at site-specific permitting. This should take into account all the reactors installed and any adjacent power stations.

Dose limit

455. There is also a dose limit for the public stated in EPR 2010 for the maximum dose to any member of the public from ionising radiation. The dose limit value is defined in the EC Basic Safety Standards (GB Parliament, 2010) and is 1 mSv/y (1000 µSv/y). The dose limit applies to the total dose from all artificial sources of radioactivity including past discharges, but does not include medical exposure and exposure to radiation from accidents.

456. We consider, in the light of our assessment, that the highest total dose from a reactor is estimated to be 14 to 25 µSv/y. Although 2 or 3 UK ABWR reactors may be installed in a single power station, it is very unlikely that doses at the site where several ABWRs are installed next to an existing nuclear site will exceed the dose limit of 1000 µSv/y.

457. Comparison against the dose limit can be assessed at site-specific permitting when contributions from all sources of radiation can be included.

Effect of short-term releases

458. The assessment of annual doses assumes that discharges are evenly spread throughout the year. However, some discharges may occur intermittently and over a short period. The dose per unit discharge for short-term discharges can be higher than that for continuous discharges, depending on factors such as the time of year, the prevailing weather conditions and the state of nearby pasture or crops. An assessment has been made of potential short duration (up to 24 hours) releases. Hitachi-GE's assessment of short duration releases indicated that the radionuclides expected to be released over a short duration would be noble gases arising from fuel pin damage. The doses from short duration releases are 0.02 µSv per event. Our assessment of the effect of

short duration releases was similar. In the event of a short-term release, this additional dose would not cause the source constraint, site constraint or dose limit to be exceeded.

Collective doses

459. The collective dose from the UK ABWR ranges from 0.4 to 30 manSv per year of discharges. There are no limits or constraints for collective dose. However, the International Atomic Energy Agency (IAEA) has set a level for collective doses of less than 1 manSv per year of discharge below which it is unlikely to be appropriate to undertake detailed option studies.

460. Public Health England provided additional guidance on assessing how important the collective doses are. It advises calculating an average dose to members of the population (per person doses). PHE further advised that if the average per person doses for a population group are only a few nano-sieverts (nSv) per year, we can consider them to be less important. If the per person doses increase above this level, we may need to look more carefully at the discharge options. Dose per person derived from the collective doses are in the range of 3 to 14 nSv/y, which is very low.

Non-human species

461. Our independent assessments also showed that for each reference organism the probability that the UK ABWR discharges would result in dose rates exceeding the 10 µGy/h screening dose rate was less than 1%.

462. A summary of the results of a comparison of the Hitachi-GE assessment with our assessment is set out in Table 13.6 below.

Table 13.6 - Comparison of Hitachi-GE's assessment results with independent assessment results

Assessment types	Data source	Hitachi-GE results	Our results
Terrestrial assessment from gaseous discharges			
ERICA Tier 2	Hitachi-GE (assuming ground level release)	Highest dose rate to any reference organism is 6.09 µGy/h.	Same as Hitachi-GE results.
	Hitachi-GE (assuming release from stack)	Highest dose rate to any reference organism is 0.27 µGy/h.	Same as Hitachi-GE results.
	Independent (assuming release from stack)		Highest dose rate to any reference organism is 0.23 µGy/h.
Ar-Kr-Xe dose calculator	Hitachi-GE	Highest dose rate to any reference organisms is 0.0064 µGy/h.	Same as Hitachi-GE results.
	Independent		Highest dose rate to any reference organism is 0.00024 µGy/h.
Total	Hitachi-GE (assuming ground level release)	Highest dose rate to any reference organism is 6.1 µGy/h.	Same as Hitachi-GE results.
	Independent (assuming release from stack)		Highest dose rate to any reference organism is 0.23 µGy/h.

Marine assessment from aqueous discharges			
ERICA Tier 2	Hitachi-GE	Highest dose rate to any reference organism is 0.0003 µGy/h.	Same as Hitachi-GE results.
	Independent		Highest dose rate to any reference organism is 0.00039 µGy/h.

463. There are some differences between the results of Hitachi-GE's assessments and our independent assessment. Our independent terrestrial assessment of gaseous discharges from UK ABWR showed that non-human biota would be exposed to lower dose rates than those calculated by Hitachi-GE. This variability is due to differences in the assumptions made about the location of non-human receptors: Hitachi-GE calculated terrestrial dose rates to non-human biota at 100 m from the stack whereas our Technical Specialist Contractor (TSC) calculated dose rates at a greater distance of 300 m from the stack. Our independent marine assessment of aqueous liquid discharges from UK ABWR showed that non-human biota would be exposed to slightly higher dose rates than those calculated by Hitachi-GE. This variation is due to differences in the marine dispersion modelling parameters used to calculate concentrations of radionuclides in the sea from UK ABWR discharges. Our TSC used less dispersive parameters resulting in higher concentrations of radionuclides in the marine environment and slightly higher dose rates to marine reference organisms.

464. We consider the assessment that Hitachi-GE carried out to be conservative and reasonable at the GDA stage. We also consider that Hitachi-GE has used an appropriate approach to assessing the radiological impact of the UK ABWR on non-human species. The results of the assessment Hitachi-GE carried out and our independent assessment show that dose rates to non-human species will not exceed the screening dose rate criterion at the generic site.

465. We conclude that at the GDA stage we consider that the gaseous and aqueous discharges from UK ABWR are unlikely to pose a risk to non-human species. We consider that the assessment is suitably conservative at this stage of the process. We recognise that a detailed site-specific assessment of the radiological impact from the UK ABWR will be required for any site where a UK ABWR is proposed.

Our overall conclusions on the impact of radioactive discharges

466. We conclude that, for the operation of a UK ABWR at any coastal site identified as suitable for new nuclear power stations (GB Parliament, 2011a) and with discharges at the annual limits specified in Chapters 10 and 11:

- the radiation dose to people will be below the UK constraint for any single new source of 300 microsieverts per year (µSv/y)
- doses to the public from discharges and radiation from a single ABWR are in the range of 13 to 25 µSv/y. Most of the dose is from gaseous discharges
- doses to the public from aqueous liquid discharges are very low, in the range of 0.004 to 0.005 µSv/y. This is because the discharge of radioactivity is very small, due to the recycling clean up and reuse of waste waters
- most of the dose from gaseous discharges is from carbon-14
- doses from direct radiation makes a contribution of 0.3 to 0.9 µSv/y
- all doses are below the source dose constraint of 300 µSv/y
- gaseous and aqueous discharges from the UK ABWR are unlikely to pose a risk to non-human species as dose rates are below the screening dose rate criterion of 10 µGy/h

467. Our independent assessment considered a more restrictive coastal environment than the one Hitachi-GE used. Our assessment shows that the low levels of radioactivity in aqueous liquid discharges from the UK ABWR leads to low doses to the public in an environment with restricted dispersion.

You can find more details of our assessment of the impact of radioactive discharges in our reports [AR09 - Assessment of radiological impacts on members of the public & AR10 - Assessment of radiological impacts on non-human species].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

14. Our overall conclusion on radioactive substances permitting

We conclude that, subject to the potential GDA Issues and Assessment Findings identified in Chapters 5 to 13, the design is acceptable for permitting for the disposal of radioactive waste at any coastal site listed in NPS EN-6 (GB Parliament, 2011a). We do not believe that any of the potential GDA Issues or Assessment Findings are so fundamental that they are unlikely to be resolved satisfactorily before or during site-specific permitting.

We want to ask you:

> Consultation question 10:
>
> Do you have any views or comments on our preliminary overall conclusion on radioactive substances permitting?

We have assessed the UK ABWR design and set out our findings in Chapters 5 to 13. Our conclusions for these chapters are summarised below:

- **Quality management systems**: Hitachi-GE has a quality management system (QMS) and has developed specific management system arrangements for the GDA project. We are satisfied that Hitachi-GE has developed and implemented a suitable management system for the GDA project**.**
- **Best available techniques (BAT)**: Hitachi-GE has recognised the relevant principles of optimisation and applied these in presenting the GDA case. Its approach has also been guided by considering standard environmental permit conditions and our GDA guidance. Hitachi-GE has also carried out a number of optioneering exercises to identify optimal approaches to the UK ABWR for GDA purposes. Overall, we conclude that Hitachi-GE has followed an appropriate process for identifying BAT in the design of the UK ABWR, to prevent and minimise the creation of radioactive waste, and to minimise the overall impact of discharges to the environment.
- **Gaseous and aqueous radioactive wastes**: We conclude that gaseous and aqueous discharges arising from all modes of normal operation have been considered, including discharges from any events that are expected to occur during the operational life of the UK ABWR. We conclude that all appropriate radionuclides have been considered, and that the selection of significant radionuclides is appropriate. We conclude that the proposed discharge limits are of the appropriate order, and that discharges from the UK ABWR should not exceed those of comparable power stations across the world.
- **Solid radioactive wastes**: We conclude that optimal potential disposal routes have been identified for all lower activity solid wastes, and that all higher activity solid wastes and spent fuel are likely to meet disposability criteria for the proposed national geological disposal facility. We agree the proposed arrangements for interim management of higher activity solid wastes and spent fuel are unlikely to affect their ultimate disposal. We conclude that the quantities of solid waste produced by a UK ABWR are comparable to other light water reactor power stations across the world.

- **Monitoring discharges and disposals**: We conclude that the UK ABWR uses the best available techniques to monitor discharges, but require further detail on monitoring for the disposals of solid radioactive waste following the solid radioactive waste treatment system design at site-specific stage.
- **Impact of radiological discharges**: Doses to the public from discharges and radiation from a single ABWR are in the range of 14 to 25 µSv/y. Doses to the public from aqueous liquid discharges are very low, because the discharge of radioactivity is very small, due to the recycling clean up and reuse of waste waters. Most of the dose is from gaseous discharges, from carbon-14. All doses are below the source dose constraint of 300 µSv/y. The radiological impacts are also below the dose criteria for wildlife of 10 µGy h^{-1}.

Overall, we conclude that, subject to the potential GDA Issues and Assessment Findings identified in Chapters 5 to 13, the design is acceptable for permitting for the disposal of radioactive waste at any coastal site listed in NPS EN-6. We do not believe that any of the potential GDA Issues or Assessment Findings are so fundamental that they are unlikely to be resolved satisfactorily before or during site-specific permitting.

15. Water abstraction

This chapter covers our assessment of water use and abstraction.

Nuclear power stations need fresh water for use in the steam-raising circuits, other process use and domestic purposes, for example, showers, toilets, laundry. They also need fresh or seawater to cool the steam condensers and other plant. Where water supplies are abstracted directly from groundwater, for example, via boreholes, or from inland waters, for example, lakes, rivers or estuaries, a water abstraction licence is required.

We conclude that:

- an abstraction licence is not likely to be required for the cooling water as the proposals are for abstracting water from the open sea only
- the screening on the cooling water abstraction intakes to minimise fish ingress and injury and meet the requirements of the Eels Regulations 2009 (GB Parliament, 2009b) is a site-specific issue and can only be determined once the local environmental conditions are known.

We want to ask you:

> Consultation question 11:
>
> Do you have any views or comments on our preliminary conclusions on water abstraction?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Cooling water

469. Hitachi-GE states that seawater will be used for once-through cooling in the main steam condenser and for cooling other reactor and turbine components ('Other environmental regulations' submission). The seawater cooling system can be divided into 3 systems: the circulating water system (CW), turbine building service water system (TSW) and the reactor building service water system (RSW).

470. Hitachi-GE states that the cooling water flow rate is based on a 12^{o}C increase in the temperature of the intake water at the point of discharge back into the sea. Under normal operation the flow rate for the CW is 184,000 m^3/hour, the flow rate for the TSW is 7,400 m^3/hour and the flow rate for the RSW is 10,800 m^3/hour. The total annual volume of seawater required will be approximately 1.8 billion m^3/year.

471. Abstracting water from the open sea does not require an abstraction licence unless the particular location of the abstraction means that it falls within the definition of inland waters. The generic site for the purposes of GDA is considered a coastal location and, therefore, an abstraction licence is not required. The location of abstraction points for each specific site will need to be assessed individually to determine whether an abstraction licence is required.

472. The abstracted seawater needs screening to remove debris before it can be used. However, screens can trap and damage fish and other invertebrates, so fish deterrent and return systems are needed. Operators abstracting more than 20 m^3/day or discharging water back to any channel sea or bed are subject to the requirements of The Eels (England and Wales) Regulations 2009 and must screen the abstraction or discharge to prevent eels becoming trapped unless an exemption notice has been granted.

473. Hitachi-GE in its 'Other environmental regulations' submission has described the different screens (drum, travelling band, bar) that could be used along with the other types of barriers for capturing and returning fish and eels back to the sea. The location of cooling water abstraction intakes and their design and screening options to minimise fish ingress and injury and meet the requirements of the Eels Regulations 2009 (GB Parliament, 2009b) depends on the local environment and can only be determined at the site-specific stage.

Other water use

474. Hitachi-GE states that the GDA is based on the assumption that the local water company will supply all fresh water requirements and that freshwater abstraction and an abstraction licence will not be required.

475. Hitachi-GE states in its submission that fresh water will be used in different ways:

- for drinking, washing and showering
- within the process
- to supply the demineraliser plant
- to supply fire water

476. The domestic fresh water requirements will depend on the number of people present and will be addressed at the site-specific stage. Hitachi-GE state that the normal amount of fresh water used within the process will be 99.2 m^3/day, increasing to 819.2 m^3/day when intermittent systems are operating.

477. Fresh water is also needed by the purified water treatment facility (PWTF). This is used for reactor water, auxiliary boiler water and boronated water in the standby liquid control system. Hitachi-GE states that the PWTF is expected to use 900 m^3/day when operating at a maximum rate.

478. The UK ABWR will also have a back-up water supply of 10,000 m^3. Fire water supply is 1,000 m^3.

Our overall conclusions on water abstraction

479. We conclude that:

- an abstraction licence is not likely to be required for cooling water where the abstraction is from the open sea
- the screening on the cooling water abstraction intakes to minimise fish ingress and injury and meet the requirements of the Eels Regulations 2009 (GB Parliament, 2009b) is a site-specific issue and can only be determined once the local environmental conditions are known

You can find more details of our assessment of the impact of radioactive discharges in our report [AR11 - Assessment of other environmental regulations].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

16. Discharges to surface waters and groundwater

This chapter covers our assessment of discharges of non-radioactive contaminants to surface waters (for example, lakes, rivers and the sea) and groundwater.

Non-radioactive contaminants include the heat transferred to the cooling water, as well as process and other chemicals. We assess the environmental impact of the discharges by comparing the predicted concentrations of contaminants in the receiving waters against relevant environmental standards.

We conclude that:

- subject to the relevant Assessment Findings set out below, the UK ABWR design is likely to be acceptable for permitting for the discharge of non-radioactive substances to surface waters at any coastal site listed in NPS EN-6 (GB Parliament, 2011a)
- a permit for discharges to groundwater will not be required since there are no proposals for intentional discharges to groundwater (whether direct or indirect), and the design includes all necessary and reasonable measures to prevent and limit unintentional discharges to groundwater of non-radioactive substances

We have identified one Assessment Finding:

- **Assessment Finding 16**: A future operator shall appropriately characterise all aqueous waste streams in its water discharge activity permit application. This shall include identification of all significant contaminants, including biocides, detergents and metals, the concentrations and volumes being discharged to the environment.

We want to ask you:

Consultation question 12:

Do you have any views or comments on our preliminary conclusions on discharges to surface waters and groundwater?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Discharges to surface waters

481. Hitachi-GE has provided the information on surface water discharges in Section 5 of its 'Other environmental regulations' submission.

482. Hitachi-GE states that the aqueous effluent streams generated from the UK ABWR are divided into the following categories:

- discharges from cooling water systems

- discharges from drainage networks in non-radioactive areas
- discharges from the drainage networks in the radioactive areas via the liquid waste management system
- effluent from the boiler blowdown and the purified water treatment facility (PWTF)
- rainwater

483. The original submission did not include sufficient information for some of these aqueous waste streams to enable us to determine whether the likely environmental impact from discharges to surface water would be acceptable from the UK ABWR. We raised a Regulatory Observation (RO-ABWR-0070) requiring Hitachi-GE to provide further information on the contaminants, volumes being discharged, treatments being employed inlcuding assessment of environmental impact for various aqueous waste streams.

Cooling water discharges

484. Discharges from the cooling water systems will consist of once-through seawater cooling used in the CW, TSW and RSW systems. Potential contaminants will be scale washings from the condenser tubes, biocides and potentially iron.

485. Biocides will be used to prevent bio-fouling of the CW system. Hitachi-GE states that sodium hypochlorite is a suitable biocide to use in the UK ABWR. The dosing strategy will be implemented at the site-specific stage but will ensure that the chlorine level (measured as total residual oxidant) will not exceed the environmental quality standard (EQS) of 0.01 µg/l at the edge of the mixing zone. This is expected to result in a discharge concentration of 0.1 µg/l at the cooling water outfall. This level is comparable to a newly permitted nuclear power plant.

486. Iron will be potentially used as a corrosion inhibitor in the heat exchangers in TSW and RSW systems. Usage levels will be 0.03 ppm during commissioning and 0.01 ppm during operations. It is only needed in a specific type of heat exchanger, although the final choice will only be decided at the site-specific stage.

487. Hitachi-GE states that there will be no treatment of the discharges from the cooling water systems. Monitoring will be carried out to ensure the discharge criteria are met.

Non-radioactive area discharges

488. The drainage networks from the non-radioactive areas are the service water storm drain (SWSD) and the non-radioactive storm drain (NSD) and will be free of radioactive contamination.

489. The SWSD discharge consists of seawater used in the heat exchangers as part of the reactor and turbine cooling water systems and should not be contaminated. The volume discharged is expected to be 24 m^3/day, with a maximum of 240 m^3/day during maintenance.

490. The NSD discharge will consist of purified water from the cooling water system used in the anciliary systems in the reactor and turbine buildings. The discharge will contain sodium nitrite, which is used as a corrosion inhibitor (up to 300 ppm). The volume discharged is expected to be 24 m^3/day, with a maximum of 240 m^3/day during maintenance.

491. Hitachi-GE states that there will be no treatment of the SWSW and NSD discharges. A radiation monitor will be installed in the NSD discharge line so the effluent can be transferred to the radioactive waste treatment facility, if necessary. We conclude that given the low levels of contamination, low volumes discharged and the significant volumes of dilution with cooling water, treatment is not necessary.

Radioactive area discharges

492. The drainage networks from the radioactive areas are the controlled area drain (CAD), high chemical impurities waste (HCW) drain, low chemical impurities waste (LCW) drain and laundry drain (LD). Together, these drainage systems make up the liquid waste management system (LWMS). The purpose of the LWMS is to treat the aqueous wastes to enable their reuse in the UK ABWR and minimise discharges to the environment. The exception is aqueous waste from the LD, which cannot be reused because it contains detergents.

493. The CAD discharge is expected to be free from radioactive contamination as it receives drainage from non-radioactive equipment. Potential contaminants will be sodium nitrite (a corrosion inhibitor) at levels of 300 ppm. The expected volume of aqueous waste is 3 m^3/day.

494. This effluent will normally be discharged to sea without treatment, although it will be monitored before being discharged to ensure the discharge criteria are met. If it contains any chemical or radiological contamination the effluent will be transferred to the HCW system for treatment. We conclude that, given the very low levels of sodim nitrite, the minimal volume discharged and the significant volumes of dilution with cooling water, treatment is not necessary.

495. The HCW and LCW drainage systems receive contaminated liquid effluent from within the UK ABWR. The HCW is designed to treat higher levels of chemical and radioactive contaminants than the LCW but lower volumes of effluent. Hitachi-GE states that the treatment will remove the radioactive and chemical contaminants from the aqueous effluent but it has not provided any information on what the contaminants are or the levels expected in the effluent. Discharges to sea can only occur from the HCW.

496. We have raised Assessment Finding 16 to ensure that any future operator identifies all the contaminants within the aqueous effluents in its water discharge activity permit application. This information is essential to assess the full environmental impact from discharges to surface waters and enable a permit to be granted.

497. The HCW effluent is treated using an evaporator to concentrate and remove insoluble impurities followed by a demineraliser using ion-exchange resins to remove soluble impurities. The effluent is sampled following treatment and, if suitable, is reused in the reactor, otherwise it will be recycled through the treatment process. If there is not enough capacity within the reactor system the effluent will be discharged to sea, but only if the discharge criteria are met. Hitachi-GE states that operational Japanese ABWRs are discharging to sea on average 2.5 batches of HCW each year. This is approximately 288 m^3/year, equivalent to 115 m^3 per batch.

498. We conclude that using an evaporator and demineraliser is suitable treatment for the HCW.

499. The LCW effluent is treated using filters to remove insoluble impurities followed by ion-exchange to remove soluble impurities. The effluent is sampled following treatment and, if suitable, is reused in the reactor, otherwise it will be recycled through the treatment process. We conclude that using filtration and a demineraliser is suitable treatment for LCW.

500. The LD receives effluent from the laundry, showers and sinks in the controlled areas. This effluent cannot be reused within the UK ABWR because it contains detergents. Other contaminants in the discharge are suspended solids and organic matter. Hitachi-GE states that for the purposes of GDA an anionic surfactant based detergent will be used.

501. The LD effluent is treated using a combined filtration system to remove suspended solids and organic matter. The filtration system consists of a packed bed pre-filter, followed by an activated charcoal adsorption unit and finally a pre-coat carbon filter. Hitachi-GE states that the filtration system provides a decontamination factor (DF) of 300 for insoluble contaminants. The pre-filter removes coarse solid material. The activated charcoal adsorption unit contains bead activated carbon to adsorb organic impurities and smaller suspended solids that pass through the pre-filter. The pre-coat filters contain cartridges with a fabric sock pre-treated with granular activated carbon to trap small sized suspended solids.

502. We conclude that using filtration and activated carbon is suitable for treating LD aqueous waste.

Boiler blowdown and purified water treatment facility effluent

503. Boiler blowdown (removal of water from the boiler) will be generated when the auxiliary boilers are being used. This will contain low levels of chemical contaminants from the treatment of the boiler feed water. These chemicals have been assumed to be phosphate for pH control, and hydrazine as an oxygen scavenger. The hydrazine will be broken down into ammonia and water. Phosphate is expected to be present in the boiler blowdown at 3 ppm. Hydrazine will be dosed at 0.2 ppm and will produce 0.13 ppm of ammonia if fully degraded. Boiler blowdwon will be 4.3 m^3/day.

504. The purified water treatment facility (PWTF) uses reverse osmosis and electro-deionisation to produce purified water from towns-water. The aqueous waste produced contains the same constituents as towns-water but at double the concentration. The expected volume of aqueous waste discharged is 450 m^3/day.

505. There is no treatment of these effluent streams. Both will be stored prior to batch discharge for mixing with the cooling water discharges. The significant dilution from the cooling water should ensure the levels of contaminants discharged to sea are negligible (see Impact assessment below).

Rainwater

506. Treating rainwater will depend on where it falls within the UK ABWR site. The final strategy for managing rainwater will be site-specific and depend on the site topography, location and layout.

507. For GDA, rainwater within the inner fence is assumed to drain to the seal pit and be discharged with the cooling water. Rainwater from outside the inner fence may go direct to the sea.

508. Hitachi-GE states that drainage systems will have appropriate measures in place to manage spills of chemicals, such as oil interceptors.

Discharge criteria

509. Discharges to the sea of aqueous wastes will be from the cooling water systems (CW, TSW and RSW), NSD, SWSD, CAD, HCW and LD. The cooling water discharges will be continuous, whereas the other discharges will be on an intermittent batch basis. All discharges will be via the seal pit.

510. Hitachi-GE has provided criteria for discharges to sea from the NSD, SWSD, CAD and LD and these are presented in Table 16.1 below. Hitachi-GE states that these are the criteria for the Japanese ABWR and demonstrate the level of control in place for an operational nuclear power plant. The finalised discharge criteria will be determined at the site-specific stage.

Table 16.1 - Discharge criteria provided by Hitachi-GE

Parameter	Level	
pH	5.6 – 8.6	
Chemical oxygen demand (COD)	<30 mg/l	Daily maximum
	<20 mg/l	Daily average
Suspended solids	<20 mg/l	Daily maximum
	<15 mg/l	Daily average
Concentration of normal hexane extract	<3 mg/l	Daily maximum

511. We accept that the final discharge criteria for any discharges to surface water can only be determined at the site-specific stage.

512. The criteria above indicate that the levels of suspended solids and organic material, as measured by COD, in the discharged aqueous waste are low. The pH range is comparable to operational nuclear power plants in the UK. The concentration of normal hexane extract is a measure of the level of oil in the discharge. We would expect any discharge to have no visible oil.

513. Hitachi-GE has also included the acceptance criteria required for the condensate storage tank (CST), which is where the aqueous waste is stored to reuse in the UK ABWR. These acceptance criteria are presented in Table 16.2 below.

514. Hitachi-GE states that the HCW aqueous waste will only be discharged to the sea if there is not enough storage capacity within the CST. This indicates any HCW discharge to the sea meets these acceptance criteria.

Table 16.2 - Acceptance criteria for the condensate storage tank

Parameter	Acceptance threshold
Conductivity	<100 µS/m
pH	5.6 – 8.0
Chloride (Cl-)	<20 ppb
Sulphate (SO42-)	<20 ppb
Total organic carbon (TOC)	<400 ppb

515. The levels of chloride, sulphate and TOC are extremely low, indicating minimal contamination. The pH range is similar to those for operational nuclear power plants within the UK. The conductivity of less than 100 µS/m indicates that there are low levels of ionic species in the HCW aqueous waste.

Impact assessment

516. Hitachi-GE has identified only a limited number of non-radioactive contaminants likely to be in the aqueous waste streams discharged to the sea. These are:

- sodium hypochlorite and degradation products used as a biocide in the cooling water systems
- iron from dosing of the cooling water systems at a maximum concentration of 3 ppm
- nitrite as a corrosion inhibitor in auxiliary equipment cooling systems at concentrations of 300 ppm
- detergents from use in the laundry
- phosphates and ammonia in the boiler blowdown

517. Environmental quality standards (EQS) for discharges into coastal waters are available for iron, ammonia and chlorine as total residual oxidants (TRO).

- Iron – 1 mg/l
- Ammonia – 21 µg/l
- Chlorine (as TRO) – 0.01 mg/l

Hitachi-GE states that there is no EQS for hydrazine. A no observed effect concentration (NOEC) of 0.5 µg/l has been identified in an Environment Agency report on chemical discharges from nuclear power stations. The same report also states the most stringent United States Environmental Protection Agency (USEPA) criterion for phosphate as 10 µg/l.

518. Hitachi-GE has carried out an environmental impact assessment of discharges of iron. The impact assessment follows the Environment Agency H1 guidance methodology by comparing the discharge concentration (DC) and process concentration (PC) of the iron against the relevant environmental quality standard (EQS). The DC is the concentration at the end of pipe before discharge in the environment. The PC is the concentration in the environment following initial dilution. The results are presented in Table 16.3 below.

Table 16.3 - Results of environmental impact assessment for discharges of iron

Chemical	Annual Release (kg)	DC (µg/l)	PC (µg/l)	EQS (µg/l)	DC/EQS (%)	PC/EQS (%)
Iron (0.03 ppm)	4783	2.69	0.54	1000	0.27	0.05

519. The results show that there is minimal environmental impact from the discharge of iron to the sea. The PC and DC are worse case as they are based on discharge volumes of the TSW and RSW and do not take into consideration dilution from the CW discharge.

520. We conclude that the environmental impact of iron discharged to sea via the cooling water from the UK ABWR is likely to be acceptable for permitting.

521. Hitachi-GE has carried out a semi quantitative or qualitative impact assessment on biocides (sodium hypochlorite), phosphate, ammonia and hydrazine and detergent.

522. When injected into water the chlorine in the sodium hypochlorite forms a number of residual oxidising species, including hypochlorous acid (HOCl), free chlorine and small volumes of by-products. These are referred to as total residual oxidants (TRO). The EQS for chlorine (as TRO) in seawater is 0.01 mg/l.

523. Hitachi-GE states that a dosing strategy for the sodium hypochlorite will be designed to ensure that the EQS is not exceeded at the edge of the mixing zone while still ensuring effective bio-fouling treatment. This is expected to result in a concentration of 0.1 mg/l at the cooling water outfall. This is similar to the TRO levels specified for cooling water from a newly permitted nuclear power station. Based on this, we conclude that the environmental impact from sodium hypochlorite dosing in the cooling water for the UK ABWR is likely to be acceptable for permitting.

524. Phosphate is present at a maximum concentration of 3 ppm in the boiler blow-down. Based on a minimum dilution of 9,100 m^3/hour from cooling water (lowest cooling water flow expected during outage), Hitachi-GE states the highest (worse case) predicted concentration of phosphate at the cooling water outfall is 1.5 µg/l. This is below the 10 µg/l USEPA criterion.

525. Ammonia is present at a maximum concentration of 0.13 ppm based on full degradation of hydrazine which is dosed at 0.2 ppm. Based on dilution of 9,100 m^3/hour from cooling water, Hitachi-GE states the highest predicted concentration of ammonia is 0.07 µg/l at the cooling water outfall. This is below the EQS of 21 µg/l.

526. Hydrazine, under a worst-case scenario, could be present at 0.2 ppm if no degradation were to occur. Based on dilution of 9,100 m^3/hour from cooling water, Hitachi-GE states the highest predicted concentration of hydrazine is 0.1 µg/l at the cooling water outfall. This is below the no observed effect concentration (NOEC) level of 0.5 µg/l.

527. Hitachi-GE assumes that an anionic surfactant based detergent will be used. The active ingredient (sodium;1,4-bis(2-ethylhexoxy)-1,4-dioxobutane-2-sulfonate) is present at a concentration of 75% and is reported to have no toxic effects on the environment or aquatic organisms. The annual usage of detergent is estimated to be 750 litres compared to an annual discharge of 2,245 m^3 of aqueous waste from the laundry. This will be significantly diluted by the cooling waste discharge (minimum of 9,100 m^3/hour).

528. We conclude that the environmental impact from the detergents as part of the laundry discharge from the UK ABWR is likely to be acceptable for permitting.

529. Sodium nitrite will be present at a maximum level of 300 ppm in the CAD and NSD aqueous waste streams. Given the minimal volumes discharged (3 m^3/day from the CAD and up to 240 m^3/day from the NSD) and the dilution from the cooling water (minimum of 9,100 m^3/hour), we conclude that the environmental impact from the sodium nitrite corrosion inhibitor discharged from the UK ABWR is likely to be acceptable for permitting.

530. Although Hitachi-GE has not identified the potential contaminants, we conclude that the environmental impact from HCW aqueous waste discharged from the UK ABWR is likely to be acceptable for permitting. This is based on:

- the minimal volume of HCW discharged (288 m^3/year based on Japanese operational experience)
- the very significant dilution from cooling water (typically 203,000 m^3/hour, minimum 9,100 m^3/hour);

- criteria for reusing HCW which infers minimal levels of organic contamination as indicated by a TOC (<400 ppb), minimal levels of ionic species (inorganic/metals) as indicated by conductivity (<100 µS/m) and minimal levels of sulphate (<20 ppb) and chloride (<20 ppb)

531. We conclude that the operator of a UK ABWR will need to ensure it identifies all substances in the aqueous effluents before submitting a water discharge activity permit application. This should include biocides, detergents and metals. The operator will also need to identify expected volumes of the different effluent streams (Assessment Finding 16).

532. The operator of a UK ABWR will also need to carry out an environmental impact assessment for all substances discharged to surface water as part of a water discharge activity permit application.

Impact of thermal discharges

533. Hitachi-GE states that in order to assess the environmental impact of the thermal plume from the cooling water discharge, accurate information is needed on how the receiving surface water behaves with the various substances discharged. This can only be achieved using computational modelling supported by localised monitoring data from the specific site.

534. Hitachi-GE has proposed that no thermal modelling is undertaken at the GDA stage because the thermal impact is site-specific.

535. We accept this proposal and the thermal impact of discharges to surface water has been agreed to be out of scope of GDA.

Discharges to groundwater

536. Hitachi-GE has provided the information on discharges to groundwater in Section 6 of its 'Other environmental regulations' submission.

537. Hitachi-GE’s UK ABWR states that there are no intentional discharges to groundwater.

538. The physical measures taken in the UK design to prevent and minimise unintentional discharges to groundwater are described in Section 6.3 of Hitachi-GE's 'Other environmental regulations' submission. These are:

- tank bunding
- tertiary containment
- hard surfacing areas in spill risk area (for example, loading bays, tanker bays)
- use of interceptors on drainage systems
- provision of spill kits
- a plumbing and drainage system to collect and segregate potential leaked water (for example, fire water run-off)

539. Hitachi-GE states that the following measures will also be implemented to minimise the potential for accidental spills and leaks and limit their impact to land or groundwater:

- staff training
- emergency response exercises
- vehicle routing
- delivery and off-loading procedures
- inspection and preventative maintenance programmes for pollution prevention equipment

540. We believe the pollution prevention measures identified above are suitable for preventing discharges to groundwater.

541. Diesel oil, which will be used in the combustion plant, will be subject to an environmental permit (see Chapter 17 below) and we will ensure that BAT is used to prevent any discharge to groundwater.

542. We will inspect facilities on specific sites during construction to ensure that appropriate pollution prevention measures are in place before operations commence.

Our overall conclusion on discharges to surface waters and groundwater

543. We conclude that:

- the UK ABWR design is likely to be acceptable for permitting for the discharge of non-radioactive substances to surface waters at any coastal site listed in NPS EN-6
- a permit for discharges to groundwater will not be required as there are no proposals for intentional discharges to groundwater (whether direct or indirect), and the design includes all necessary and reasonable measures to prevent and limit unintentional discharges to groundwater of non-radioactive substances

544. We have identified one Assessment Finding, as set out in the above paragraphs and at the beginning of this chapter.

You can find more details of our assessment of the impact of non-radioactive discharges in our report [AR11 - Assessment of other environmental regulations]. https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

17. Operation of installations

This chapter covers our assessment of installations (as defined in Schedule 1 of EPR10). Most nuclear power station designs include conventional combustion plant, of sufficient capacity to require permitting, for standby generation and to use as auxiliary boilers. Other ancillary plant may also meet a description in Schedule 1 and require permitting.

We conclude that:

- the conventional combustion plant is the only ancillary plant meeting a description in Schedule 1 of EPR10
- subject to the relevant Assessment Finding set out below, the conventional combustion plant is likely to be acceptable for permitting:
  - as an installation under EPR10
  - under the 'Greenhouse Gas Emissions Trading Scheme Regulations 2012' (GGETSR12) (GB Parliament, 2012)

We have identified one Assessment Finding.

- **Assessment Finding 17**: A future operator shall specify the minimum performance parameters of the combustion plant in its application for a combustion activity permit.

We want to ask you:

Consultation question 13:

Do you have any views or comments on our preliminary conclusions on operation of installations?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Identification of installations

Combustion plant

546. The conventional combustion plant is specified in Section 7.3 of the 'Other environmental regulations' submission. It will consist of:

- 2 auxiliary boilers, each with a gross rated thermal input of 24.1 *megawatt(thermal)* (MWth)
- 3 emergency diesel generators (EDG), each with a gross rated thermal input of 18 MWth
- 2 diesel driven back-up building generators (BBG), each with a gross rated thermal input of 6.14 MWth
- 1 diverse additional generator (DAG) with a gross rated thermal input of 18 MWth

547. As the total thermal input of the combustion plant exceeds 50 MWth, it is a Part A(1) installation as described in Section 1.1 of Chapter 1 in Part 2 of Schedule 1 in EPR10. This means that it will require an environmental permit from the Environment Agency.

548. As the total thermal input exceeds 20 MWth, the combustion plant is also a 'regulated activity' as defined in GGETSR12 and will require a permit under those regulations.

Other ancillary plant

549. In general, the only other ancillary plant found on a nuclear power station that might need a permit under EPR10 would be an on-site waste incinerator. Hitachi-GE confirms in its 'Other environmetal regulations' submission (Section 7.2) that the design does not include an on-site incinerator.

Combustion plant operations

550. Hitachi-GE states the EDGs, BBGs and DAG are classed as nuclear safety equipment and designed to supply back up emergency electrical power in the highly unlikely event of loss of power on-site. The EDGs and BBGs will operate together if needed. The DAG is there to provide back-up if there is a common cause failure of the EDGs.

551. The EDGs and BBGs will operate during commissioning, routine testing and in the case of a loss of power. A single commissioning test is expected be carried out for each EDG, BBG and the DAG and is expected to last for a few hours. Routine testing is expected to consist of a regular test of 3 hours every 18 months and a monthly surveillance test for one hour. The final commissioning and testing routine is a site-specific issue and will be determined once the EDGs, BBG and DAG have been procured.

552. The auxiliary boilers provide steam to the site during start-up, normal operation and shutdown. Under normal operation both boilers are expected to operate at full load in winter and one boiler at 50% load during the summer, therefore, at least one boiler will be operational during most circumstances.

553. Hitachi-GE states that the final selection of the combustion plant (design of diesel generators and auxiliary boilers) will be carried out at the site-specific stage. This will be based on a review of suitable combustion plant and associated plant available and the selection will be based on the assessment of BAT.

554. The operator of a UK ABWR will need to ensure that it specifies the performance parameters before applying for a permit (Assessment Finding 17).

555. Hitachi-GE has compared the proposed technology in the combustion plant with the combustion sector guidance note and the 'How to comply with your environmental permit' guidance (Environment Agency, 2009). We have reviewed the information submitted and have the following comments:

- The site report is a site-specific issue and cannot be assessed at GDA.
- The EDGs, BBGs and DAG are needed for nuclear safety, are expected to only run for short periods of time and need to respond when required, so we accept that energy efficiency is not a main consideration.
- The main raw materials to be used will be diesel, water and lubrication oil, 22,776 tonnes of diesel oil are estimated to be used in a year based on one boiler operating continuously, and lube oil is estimated to be 5,000 litres/year. Other chemicals used in much lower quantities will be glycol, biocides and boiler water treatment chemicals.
- There will no direct discharges to water from the combustion plant. Boiler blowdown and cooling water discharges will be directed to the wider surface water drainage system within the UK ABWR. These volumes are minimal compared with the surface water discharges associated with the nuclear reactor plant.

- Point source emissions to air will consist mainly of oxides of nitrogen (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM).
    - Using ultra-low sulphur fuel (<0.001% by weight) will minimise emissions of sulphur dioxide. BAT can only be determined at site-specific stage but in principle we accept this as BAT. As part of a permit application a future operator would need to demonstrate that the combustion plant meets the emission limit values (ELVs) that apply to medium combustion plant.
    - Using low NO_x burners will minimise emissions of NO_x from the auxiliary boilers. In principle, we accept this as BAT.
    - Minimising emissions of NO_x from the diesel generators will rely on engine design and will not be finalised until the site-specific stage. Hitachi-GE has quoted a typical discharge concentration of 2216 mg/m^3 for the EDGs. A future operator will need to carry out a BAT options appraisal as part of its permit application to demonstrate that the chosen engine design minimises emissions of NO_x. Improvements are taking place with engine design technology and we expect the operator to review the latest available equipment to identify BAT.
    - Combustion efficiency techniques such as combustion chamber design, optimised fuel and air mixing, and tuning of engines will minimise emissions of carbon monoxide and particulate matter. In principle, we accept this as BAT.

      As part of a permit application the operator will also have to demonstrate that the combustion plant would meet relevant emission limit values (ELVs) for SO_2, NO_x and PM as specified in the Medium Combustion Plant Directive (EC, 2015).

      Note: The EDGs, BBGs and DAG are expected to operate for less than 500 hours per year and are likely to be exempt from the ELVs specified in the Medium Combustion Plant Directive (EC, 2015).
- We are unlikely to require continuous emission monitoring for emissions to air for the combustion plant. The Medium Combustion Plant Directive (EU, 2015) specifies annual monitoring for combustion plants between 20 MW and 50 MW and 3-yearly monitoring for combustion plants between 1 and 20 MW.

  Based on this, the auxiliary boilers will need monitoring annually. The EDGs, BBGs and DAGs will need monitoring every 3 years.
- An assessment against noise, odour and vibration has not been carried out at GDA. This will be required as part of the permit application. Hitachi-GE states that all equipment for the combustion plant will be specified with suitable noise and vibration attenuation where appropriate. Examples are appropriate silencing equipment for generator engine exhausts and pressure relief valves. Hitachi-GE considers that there is unlikely to be any specific measures for odour beyond those indicative measures specified in relevant guidance and we agreed with this.

556. Hitachi-GE carried out an impact assessment of emissions to air from the combustion plant within the UK ABWR to demonstrate that the emissions could be shown as likely to be acceptable for permitting. It carried out the impact assessment in 2 stages:

- A screening assessment of the main process emissions (NO_x,SO_2, CO & PM) using the Environment Agency's H1 environmental risk assessment approach.
- A further screening assessment of the short-term NO_x emissions from the EDGs using the air dispersion model AERMOD (American Meteorological Society/Environmental Protection Agency Regulatory Model).

557. The initial screening assessment was used to assess the ground level concentrations of the combustion plant emissions against the applicable relevant short-term and long-term air quality standards. The assessment was carried out based on the operation of a single EDG, a single BBG and both auxiliary boilers. It was agreed that the DAG did not need to be included in the

assessment as it will only be used as a replacement for an EDG and will, therefore, never operate at the same time. The long-term assessment was based on 20 hours of operation per year each for the EDG and BBG.

558. The initial screening assessment showed that the ground level concentrations of emissions of NO_x, SO_2 and PM from the EDGs and BBGs were significantly below the relevant long-term air quality standards (there is no standard applicable for CO). Long-term emissions from the auxiliary boilers were below air quality standards for SO_2 and PM but nearly 4 times above for NO_x. Short-term emissions were significantly greater than the air quality standard for NO_x from both the EDG and BBG (up to 175 times) and 9 times above from the auxiliary boilers. As a result of the high short-term NO_x emissions, we raised a Regulatory Observation (RO-ABWR-0060) requiring Hitachi-GE to demonstrate that the environmental impact of the emissions to air from the EDGs and BBGs would be acceptable.

559. The second screening assessment was carried out in response to RO-ABWR-0060 to provide a more realistic assessment of the impact of short-term emissions of NO_x from the diesel generators using a more sophisticated dispersion model. The H1 screening tool has limitations, particularly when assessing short-term impacts, and can be over-pessimistic. The original H1 screening tool used an effective stack height of zero in the assessment due to the EDG and BBG having minimal stacks and being located in buildings next to significantly larger buildings. The second assessment was carried out using a variety of stack heights to demonstrate that by increasing the stack height the emissions could be acceptable for permitting. Increasing stack height increases the level of dispersion of any pollutants and, therefore, reduces ground level concentration.

560. The AERMOD screening assessment indicates that increasing the stack heights of the EDG and BBG to around 30 metres will reduce the impact of the short-term emissions of NO_x to acceptable levels. This type of stack height is not unrealistic on a nuclear site.

561. The final stack heights for the combustion plant are site-specific issues for the operator. It is acknowledged that the final plant layout and further detailed dispersion modelling may reduce the final stack heights needed. The purpose of these screening assessments was to show that the impact of emissions from the combustion plant on the UK ABWR could be realistically reduced to acceptable levels to potentially allow a permit to be issued.

562. The operator will have to carry out site-specific air dispersion modelling as part of the permit application to demonstrate compliance with air quality standards and demonstrate that the environmental impact from the combustion plant installation is likely to be acceptable for permitting.

563. As part of the permit application the operator will also need to consider whether there are any designated habitat sites, including Sites of Special Scientific Interest, Marine Conservation Zones, Special Protection Areas, Special Areas of Conservation or Ramsar Conservation sites in the area and, if necessary, carry out a Habitats Regulations assessment.

Combustion plant - greenhouse gas emissions

564. We can only issue a greenhouse gas permit if there are acceptable proposals for monitoring the greenhouse gas emissions.

565. There are different approaches to monitoring greenhouse gas emissions that we have approved. These are based on measuring or calculating the emissions.

566. Hitachi-GE states that the proposed approach to monitoring greenhouse gas emissions will meet the requirements contained in 'General guidance for installations (MRR1)', which provides guidance on how to meet the requirements of the Monitoring and Reporting Regulations for Greenhouse Gas Emissions (EU, 2012). It will follow the standard method used for calculating emissions as outlined in MRR1. This involves measuring fuel inputs and process inputs and applying appropriate emission, process and oxidation factors to calculate the total emissions.

Our overall conclusion on operation of installations

567. We conclude that:

- the conventional combustion plant is the only ancillary plant meeting a description in Schedule 1 of EPR10
- subject to the relevant Assessment Finding set out in the above paragraphs and at the beginning of this chapter, the conventional combustion plant is likely to be acceptable for permitting:
    - as an installation under EPR10
    - as a regulated activity under the EU Regulation on the monitoring and reporting of greenhouse gas emissions

You can find more details of our assessment of the operation of installations in our report [AR11 - Assessment of other environmental regulations].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

18. Control of major accident hazards

This chapter covers our assessment of the applicability and requirements of the Control of Major Accident Hazard (COMAH) Regulations for the UK ABWR. Nuclear power stations may need to store one or more dangerous substances in certain quantities as defined in the regulations. Precautions to prevent a major accident to the environment, therefore, need to be considered.

We conclude that:

- the UK ABWR design involves storing hydrazine in quantities that exceed the upper tier COMAH thresholds during decommissioning activities
- the UK ABWR is likely to be acceptable in terms of the environmental requirements under the COMAH regulations

We want to ask you:

> Consultation question 14:
>
> Do you have any views or comments on our preliminary conclusions on the control of major accident hazards?

Please read below for a summary of our detailed assessment and links to further supporting documents.

Dangerous substances

569. In its submission, Hitachi-GE has estimated the quantities of chemicals that could potentially be stored on the site of a UK ABWR and compared these with the qualifying quantities of named substances to which the COMAH Regulations apply (GB Parliament, 2015). It has determined the quantities of chemicals needed both during operation and commissioning and decommissioning.

570. The following approach has been carried out to determine the quantities of chemicals to be stored at the GDA stage.

- Where the storage capacity of a container (tank or cylinder) for a chemical has been fixed, this has been used as the quantity to be stored in the COMAH assessment.
- Where the storage capacity of a container is not fixed but the safety case sets a quantity of a chemical to be stored, this quantity has been used in the COMAH assessment.
- Where the storage capacity of a container is not fixed, there is no specific safety case requirement but there is information on the usage of a specific chemical, as determined by the operation of the UK ABWR, then 7 days' supply for that chemical is taken to be stored on site for the COMAH assessment.
- Where there is no information available on the quantity of chemicals stored and there is no safety case requirement or usage figure, no COMAH assessment has been made. It is expected that these chemicals will be addressed at the site-specific stage.

571. The most significant chemicals are shown in table 18.1 below:

Table 18.1 - Chemicals identified as being above, or close to, COMAH thresholds

Chemical	Quantity	Lower tier threshold (te)	Upper tier threshold (te)
Chemicals to be used on the UK ABWR during operation			
Diesel	2,419	2,500	25,000
Chemicals to be used on the UK ABWR during decommissioning			
Hydrazine	3.15	0.5	2

572. Hitachi-GE states that the UK ABWR will be an upper tier COMAH establishment only when decommissioning is carried out. This is because the quantity of hydrazine stored (3.15 tonnes) exceeds the upper tier qualifying threshold of 2 tonnes.

573. Significantly lower levels of hydrazine (25 kg/y) are used during operations.

574. The UK ABWR will not be a COMAH establishment during operation as the amount of diesel oil (2,419 tonnes) is just below the lower tier qualifying threshold of 2,500 tonnes.

575. It should be noted, however, that the GDA is based on a generic site with only one reactor unit. It is likely that there will be at least 2 reactor units on each new build site, which would mean the site would be a lower tier COMAH establishment due to the storage of diesel oil during the operational phase.

576. As well as comparing individual named substances against the qualifying thresholds, operators are also required to carry out an assessment of all substances with the same generic hazard classification, in aggregation, to determine whether COMAH applies. The assessment utilises a sum of fraction approach.

577. Hitachi-GE also carried out an assessment of the quantities of chemicals to be stored against the qualifying thresholds of generic categories of dangerous substances. This assessment did not change the COMAH status identified above.

578. At the site-specific stage the operator of a UK ABWR will have to identify all the chemicals that will be used along within their storage quantities and carry out an assessment against the COMAH qualifying thresholds.

579. Operators of upper tier establishments need to notify the competent authority (ONR and us) and prepare a safety report. In the case where an establishment is already operational and falls under the COMAH Regulations due to an increase in the quantity of a chemical already used on site, this should be done 3 months before the increased quantity is brought on site. The operator will also need to demonstrate to the competent authority that all measures necessary have been taken to prevent major accidents and limit their consequences for people or the environment. The notification, safety report and demonstration are site-specific issues for the operator and have not been considered further during the GDA.

Measures to prevent a major accident to the environment

580. Hitachi-GE states that the UK ABWR will have prevention measures in place to avoid releasing hydrazine into the environment to prevent a major accident to the environment (MATTE).

581. Pollution prevention measures will include:

- storing hydrazine in suitable containers such as drums or Intermediate Bulk Containers (IBC) within buildings where possible
- all containers will be stored within suitable secondary containment systems such as bunds or drip trays, which are impermeable to water and attack from hydrazine

- all secondary containment systems will be of a suitable size

582. We accept that the the relatively low levels of hydrazine stored during operations and the immediate dilution with cooling water means that the impact of any spillage to the sea would be limited. The likelihood of any MATTE from an accident involving hydrazine is minimal.

583. Hitachi-GE has also included information on the primary, secondary and tertiary containment measures in place to prevent a MATTE from the bulk storage of diesel oil. This was because a slight increase in the quantity (approximately 80 tonnes) of diesel oil stored on site would bring the UK ABWR into COMAH as a lower tier establishment.

584. Secondary containment measures include ensuring bund capacities are 110% of the largest tank or 25% of the tank rated capacity, whichever is greater; walls, joints and floors must be impervious to hydrocarbons; walls must be capable of withstanding the hydrostatic pressures from a catastrophic tank failure; and concrete bunds must be constructed with reinforced floors and walls to the required standards. Tertiary containment measures will include passive in situ engineered containment systems like bunds and lagoons with active measures such as remotely operated shut-off valves. The final design of the tertiary containment will be a site-specific issue depending upon the site layout.

Hitachi-GE has stated that the secondary and tertiary containment systems will be in accordance with the requirements of the COMAH Competent Authority 'Policy for the bulk storage of hazardous liquids' (HSE, 2008). We will ensure any future storage of diesel oil above the COMAH threshold complies with the COMAH containment policy.

585. We conclude that the UK ABWR design includes appropriate measures to prevent a MATTE.

586. It should be noted that the above conclusions relate only to major accidents to the environment. Our partner in the competent authority for COMAH regulation, ONR, is responsible for assessing matters relating to impacts on people.

Our overall conclusion on COMAH requirements

587. The UK ABWR design involves storing hydrazine in quantities that exceed the upper tier COMAH levels during decommissioning.

588. The UK ABWR is likely to be acceptable in terms of the environmental requirements under COMAH.

You can find more details of our assessment of COMAH requirements in our report [AR11 - Assessment of other environmental regulations].

https://www.gov.uk/government/publications/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor-assessment-reports

19. Our overall conclusion

Our preliminary conclusion is that we could issue an interim statement of design acceptability (iSoDA) for the UK ABWR. This would be subject to the GDA Issues and Assessment Findings identified in the previous chapters and listed in Schedule 2 of the draft iSoDA (Appendix 1) and Appendix 2 respectively. In particular, it would be valid only for a site meeting the identified generic site characteristics.

We will not make a final decision on whether to issue an iSoDA until we have considered all relevant responses to this consultation. If there are no outstanding GDA Issues at the end of the generic design assessment process then a SoDA could be issued.

Expectations for site-specific permitting

We have identified, in Appendix 6, a number of expectations for site-specific permit applications. These are items that have not been addressed or fully addressed in GDA. This list is intended to help prospective operators make a complete application.

We want to ask you:

> Consultation question 15:
>
> Do you have any views or comments on our preliminary overall conclusion on the acceptability of the design?

References

Reference	Author/publication/website
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20. List of abbreviations

Abbreviation	Details
ABB	Asea Brown Boveri
ABWR	Advance Boiling Water Reactor
AC	Alternating current
AGR	Advanced gas-cooled reactor
ALARA	As low as reasonably achievable
ALARP	As low as reasonably practicable
ANOB	Areas of outstanding natural beauty
BAT	Best available techniques
BBG	Back-up building generator
BEIS	(Department for) Business, Energy and Industrial Strategy
BSi	British standards institute
BSS	Basic Safety Standard
BWR	Boiling water reactor
CAD	Controlled area drain
C&I	Control and instrumentation
COD	Chemical oxygen demand
COMAH	Control of Major Accident Hazards
COMAH15	Control of Major Accident Hazards Regulations 2015
CST	Condensate storage tank
CUW	Reactor water clean-up system
CW	Circulating water system
DAG	Diverse additional generator
DC	Discharge concentration
DF	Decontamination factor
DRP	Design reference point
EA 95	Environment Act 1995
EAL	Environmental assessment level
EC	European Commission
EDG	Emergency diesel generator
EIADR	Environmental Impact Assessment for Decommissioning Regulations
ELV	Emission limit value
EPA 90	Environmental Protection Act 1990
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EPR	European pressurised reactor

EPRI	Electrical Power Research Institute – an independent USA organisation
EQS	Environmental quality standard
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
EU	European Union
EUR	European utility requirement
FAPs	Fission and activation products
FOIA	Freedom of Information Act
FP	Fission product
GDA	Generic design assessment
GDF	Geological disposal facility
GEP	Generic environmental permit
GGETSR12	Greenhouse Gas Emissions Trading Scheme Regulations 2012
GW	Gigawatt
GWe	Gigawatt (electrical)
HAW	Higher activity waste
HCW	High chemical impurity waste
HEPA	High efficiency particulate air
HLW	High level waste
HPA-RPD	Health Protection Agency – Radiation Protection Division
HSE	Health and Safety Executive
HVAC	Heating, ventilation and air conditioning system
IAEA	International Atomic Energy Agency
IBC	Intermediate bulk container
ILW	Intermediate level waste
INSA	Independent nuclear safety assessment
ISO	International standard organisation
iSoDA	Interim statement of design acceptability
IWS	Integrated waste strategy
JPO	Joint Programme Office
KBS-3	Kärnbränslesäkerhet-3 (A Swedish waste container type)
LCW	Low chemical impurity waste
LD	Laundry drain
LLW	Low level waste
LLWR	Low level waste repository
LoC	Letter of compliance
LWMS	Liquid radioactive waste management system
LWR	Light water reactor
MATTE	Major accident to the environment

MCERTS	Monitoring certification
MDSL	Master document submission list
MVP	Mechanical vacuum pump
MW	Megawatt
MWe	Megawatt (electrical)
MWth	Megawatt (thermal)
NDA	Nuclear Decommissioning Authority
NGO	Non-governmental organisation
NOEC	No observed effect concentration
NO_x	Nitrogen oxides
NPS EN-6	National policy statement for nuclear power generation
NRW	Natural Resources Wales
NSD	Non-radioactive storm drain
OG	Off-gas system
ONR	Office for Nuclear Regulation
OPEX	Operational experience
P&ID	Process and information document
PCER	Pre-construction environmental report
PC	Process concentration
PCI	Pellet cladding interaction
PCSR	Pre-construction safety report
PHE	Public Health England
PM	Particulate matter
PPC	Pollution prevention and control
PQP	Project quality plan
PRIS	Power reactor information system
PWR	Pressurised water reactor
PWTF	Purified water treatment facility
QA	Quality assurance
QMS	Quality management system
QNL	Quarterly notification level
REPs	(Radioactive substances) regulation environmental principles
RI	Regulatory Issue
RO	Regulatory Observation
RPV	Reactor pressure vessel
RQ	Regulatory Query
RSW	Reactor building service water system
RWA	Radioactive waste adviser

RWM	Radioactive Waste Management (Ltd)
SF	Spent fuel
SFAIRP	So far as is reasonably practicable
SFIS	Spent fuel interim store
SLLW	(dry) solid low level waste
SILW	Solid intermediate level waste
SoDA	Statement of design acceptability
SQEP	Suitable qualified and experienced personnel
SWMS	Solid radioactive waste management system
SWSD	Service water storm drain
TGS	Turbine gland steam system
TOC	Total organic carbon
TRO	Total residual oxidants
TSW	Turbine building service water system
UK	United Kingdom
USEPA	United States Environmental Protection Agency
US NRC	United States Nuclear Regulatory Commission
VLLW	Very low level waste
WRA 91	Water Resources Act 1991
WSLLW	Wet solid low level waste
WSILW	Wet solid intermediate level waste

21. Glossary

Activation product: a material that has been subject to a neutron flux and has been made radioactive as a result.

Alpha activity: some radionuclides decay by emitting alpha particles that consist of 2 neutrons and 2 protons.

Assessment Finding: an unresolved issue of lesser significance than a GDA Issue and not considered critical to the decision to start nuclear island safety-related construction.

Becquerel: the standard international unit of radioactivity equal to one radioactive transformation per second.

- megabecquerel (MBq) – one million transformations per second
- gigabecquerel (GBq) – one thousand million transformations per second
- terabecquerel (TBq) – one million million transformations per second

Best available techniques (BAT): the latest stage of development (state of the art) of processes, of facilities or of methods of operation, which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. In determining whether a set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to:

- comparable processes, facilities or methods of operation which have recently been successfully tried out;
- technological advances and changes in scientific knowledge and understanding;
- the economic feasibility of such techniques;
- time limits for installation in both new and existing plants;
- the nature and volume of the discharges and emissions concerned

Beta activity: some radionuclides decay by emitting a beta particle. This has the same properties as an atomic electron. If the particle carries a positive charge it is known as a 'positron'.

Collective dose: the dose received by a defined population from a particular source of public exposure. This is obtained by adding the dose received by each individual in the population, and is expressed in units of man-sieverts (manSv). Within limits, collective dose can represent the total radiological consequences of the source on the group, over a certain period of time.

Decommissioning: the process of taking a facility, at the end of its life, permanently out of service and making its site available for other purposes.

Direct radiation: radiation that arises directly from processes or operations on premises using radioactive substances such as a nuclear power station, and not as a result of discharges of those substances to the environment.

Discharge: the release of gaseous or aqueous waste to the environment.

Disposal: includes:

- placing solid waste in an authorised land disposal facility without plans to retrieve it at a later time
- releases to the environment (emissions and discharges) of gaseous waste (gases, mists and dusts) and aqueous waste
- transfer of waste, together with responsibility for that waste, to another person

Dose: a general term used as a measure of the radiation received by people and usually measured in sieverts.

Dose constraint: a restriction on annual dose to an individual from a single source, applied at the design and planning stage of any activity. The dose constraint places an upper bound on the outcome of any optimisation study.

Dose limit: the UK legal dose limit for members of the public from all man-made sources of radiation other than from medical exposure is 1 mSv/y.

Final SoDA: the statement of design acceptability provided when all GDA Issues have been addressed to the Environment Agency's satisfaction.

Fission: the splitting of an atomic nucleus into approximately equal parts, either spontaneously or on impact with another particle, usually with an associated release of energy.

Fission products: radionuclides produced as a result of fission.

Gamma radiation: some radionuclides emit gamma radiation when they decay, usually accompanied by emission of an alpha or beta particle. A gamma ray is a discrete quantity of electromagnetic energy without mass or charge.

GDA Issue: an unresolved issue considered by regulators to be significant, but resolvable, and which requires resolution before nuclear island safety-related construction of the reactor could be considered.

GDA submission: the totality of documents presented to regulators in GDA, including the design reference, the GDA safety, security and environmental submissions and related supporting references.

GDA master document submission list: a 'live' document that lists all the individual documents making up the GDA safety, security and environmental submissions and all the supporting documents they reference, and identifies their current revision status.

Generic site envelope: the generic siting characteristics, specified by the requesting party, against which the regulators assess the acceptability of the design safety case. These characteristics, such as seismic hazard, extreme weather events, environmental receptors should, so far as possible, envelop or bound the characteristics of any potential UK site so that the reactors could potentially be built at a number of suitable UK locations.

High level waste (HLW): waste in which the temperature may rise, as a result of its radioactivity, to an extent that it has to be accounted for in designing storage or disposal facilities.

Interim SoDA: an interim statement of design acceptability, issued when there are GDA Issues for which the requesting party has provided a credible resolution plan.

Intermediate level waste (ILW): waste with radioactivity levels exceeding the upper boundaries for low level waste but which does not require heat generation to be accounted for in the design of disposal or storage facilities.

Low level waste (LLW): waste containing levels of radioactivity greater than those acceptable for disposal with normal refuse but not exceeding 4 GBq/tonne alpha-emitting radionuclides or 12 GBq/tonne beta-emitting radionuclides.

MCERTS: the Environment Agency's monitoring certification scheme. It provides the framework for businesses to meet our quality requirements for monitoring, through the use of MCERTS, certified or accredited monitoring techniques, personnel, and so on, where these are available. You can find current MCERTS standards here.

Man-sievert (manSv): a measure of collective dose.

Nuclear safety related construction: relates to construction of the main nuclear island, which includes the main reactor building and nuclear auxiliary buildings such as diesel generator buildings but does not include, for example, sea defences or the cooling water pump houses that are located away from the nuclear island.

Radioactive waste: waste that contains radioactivity above levels specified in the Environmental Permitting Regulations 2010.

Radioactivity: the property of some atomic nuclides to spontaneously disintegrate emitting radiation such as alpha particles, beta particles and gamma rays.

Radiological assessment: an assessment of the radiation dose to members of the public, including that from discharges, which will result from operation or decommissioning of a facility.

Radionuclide: a general term for an unstable atomic nuclide that emits ionising radiation.

Regulatory Issue (RI): a serious regulatory shortfall that is potentially significant enough to prevent provision of a SoDA, and which requires action and new work for it to be addressed.

Regulatory Observation (RO): a potential regulatory shortfall that requires further justification by the requesting party and further assessment by the regulators in the expectation that it can be resolved.

Regulatory Query (RQ): a request for clarification or further information resulting from the assessment process. It may result in an RO or RI being raised if the query cannot be satisfactorily resolved.

Representative person: an individual receiving a dose that is representative of the more highly exposed individuals in the population.

Sievert (Sv): a measure of radiation dose received.

- millisievert (mSv) – one thousandth of a sievert
- microsievert (μSv or microSv) – one millionth of a sievert
- nanosievert (nSv) – one thousandth of one millionth of a sievert.

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

Symbols and units

MW	Megawatt
MWe	megawatt electrical
MWh	megawatt hour
GBq/y	gigabecquerels per year
GWeh	gigawatt per hour electrical
MBq/y	megabecquerels per year
μSv/y	microsievert per year
te	Tonne

Appendix 1 - Draft iSoDA

Environment Agency

Generic assessment of candidate nuclear power plant designs

DRAFT Interim statement of design acceptability for the UK Advanced Boiling Water Reactor design

submitted by

Hitachi-GE Nuclear Energy Limited

The Environment Agency has undertaken a Generic Design Assessment of Hitachi-GE Nuclear Energy Limited's UK Advanced Boiling Water Reactor, during the period January 2013 to <month, year>, using the process set out in the document Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs[1].

The findings of our assessment are summarised in the document:

> Decision Document for the Generic Design Assessment of Hitachi-GE Nuclear Energy Limited's UK Advanced Boiling Water Reactor[2]

The Environment Agency is satisfied that Hitachi-GE Nuclear Energy Limited has demonstrated the acceptability for environmental permitting of the UK Advanced Boiling Water Reactor on the generic site, as defined in Schedule 1, subject to the GDA Issues identified in Schedule 2.

This statement is provided as advice to Hitachi-GE Nuclear Energy Limited, under section 37 of the Environment Act 1995. It does not guarantee that any site-specific applications for environmental permits for the UK Advanced Boiling Water Reactor will be successful.

Name	Date
[name of authorised person]	

Authorised on behalf of the Environment Agency

This statement is endorsed by Natural Resources Wales:

Name	Date
[name of authorised person]	

Authorised on behalf of Natural Resources Wales

References

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Version 2, Environment Agency, March 2013.
   http://webarchive.nationalarchives.gov.uk/20151009003754/https://www.gov.uk/government/publications/assessment-of-candidate-nuclear-power-plant-designs
2. Decision Document for the Generic Design Assessment of Hitachi-GE Nuclear Energy Limited ‘s UK Advanced Boiling Water Reactor, Environment Agency, <month, year>.

Schedule 1 – Scope of the GDA

This statement of design acceptability refers to the UK Advanced Boiling Water Reactor as described in Hitachi-GE Nuclear Power Limited's design reference documentation:

Document reference	Title	Version number
GA91-9901-0017-00001	Definition of Design Reference Point	Rev. B
GA91-1104-0002-00001	Design reference for UK ABWR	Rev. 4
GA91-0011-0003-00001	Master Document Submission List (MDSL)	Rev.8

Schedule 2 – (Potential) GDA issues

Reference	GDA Issue	Resolution plan
Potential GDA Issue 1	Decommissioning of the UK ABWR. We require Hitachi-GE to provide sufficient evidence to demonstrate that the UK ABWR has been designed to facilitate decommissioning and hence to minimise associated waste and impacts on people and the environment from decommissioning operations.	
Potential GDA Issue 2	Source terms for the UK ABWR. We require Hitachi-GE to provide a suitable and sufficient definition and justification for the radioactive source terms in the UK ABWR during normal operations.	
Potential GDA Issue 3	Consideration of 'best available techniques' (BAT) and 'as low as reasonably practicable' (ALARP) in optimisation. We require Hitachi-GE to demonstrate that appropriate consideration has been given to both environmental and safety aspects, in order to achieve an optimised design.	

Appendix 2 - Assessment Findings

Reference	Assessment Finding
Assessment Finding 1	A future operator shall provide details of how the proximity principle has been applied in its selection of optimised disposal routes for solid and incinerable liquid wastes prior to active commissioning.
Assessment Finding 2	If appropriate, a future operator shall produce an assessment of best available techniques that covers all of its sites, noting economies of scale and other efficiencies in disposal of solid and incinerable liquid wastes across all of its sites in its application for an environmental permit.
Assessment Finding 3	A future operator shall demonstrate that the UK ABWR will be operated in a manner that represents best available techniques, addressing in particular: • fuel selection • fuel and core management • avoidance of control rod failure in power suppression situations • consideration of all normal operational modes and stages of the reactor's life cycle • control of water chemistry • selection of demineraliser resins for liquid waste management systems.
Assessment Finding 4	A future operator shall review the practicability of techniques for abatement of carbon-14 prior to operation.
Assessment Finding 5	A future operator shall assess the partitioning of carbon-14 between gaseous, aqueous and solid waste streams, during initial operations.
Assessment Finding 6	A future operator shall address the 15 forward actions as identified by Hitachi-GE in the 'Demonstration of best available techniques' submission - GA91-9901-0023-00001 Revision F (July 2016).
Assessment Finding 7	A future operator shall provide an evidence-based definition of the decontamination factors likely to be achieved for aqueous effluent treatment prior to operation and then compare these with the actual decontamination factors achieved during operation. Differences in expected and actual decontamination factors should be explained.
Assessment Finding 8	A future operator shall assess the chemical speciation of radioactivity in aqueous discharges. It shall consider the implications of this for the

	receiving environment so that discharges are shown to represent best available techniques.
Assessment Finding 9	A future operator shall, before procurement, provide detailed designs for solid radioactive waste management, storage and conditioning facilities that were covered at a conceptual level during generic design assessment, and demonstrate how these represent best available techniques.
Assessment Finding 10	A future operator shall demonstrate optimised management and disposal of solid radioactive wastes from the UK ABWR, addressing in particular: • conditioning of higher activity waste arisings to ensure disposability • selection of disposal routes for wastes at the low activity waste/high activity waste boundary • management of spent nuclear fuel and any associated secondary wastes to ensure disposability • selection of disposal routes for low activity waste
Assessment Finding 11	A future operator shall address the 12 forward actions identified in the 'Approach to sampling and monitoring' submission - GA91-9901-0029-00001 Revision G (July 2016).
Assessment Finding 12	A future operator shall undertake tests to determine the particle concentration profile and whether multi-nozzle probes are required for the main stack sampling.
Assessment Finding 13	A future operator shall demonstrate, prior to reactor commissioning, that the final configuration of the sampling lines and the layout and positioning of the monitoring room are optimised to demonstrate best available techniques.
Assessment Finding 14	A future operator shall demonstrate that, prior to procurement, the specific sampling and monitoring equipment for the determination of the discharges represents best available techniques and enables the EU recommended levels of detection to be met.
Assessment Finding 15	A future operator shall demonstrate that the systems and equipment used for monitoring and sentencing solid waste represent best available techniques.
Assessment Finding 16	A future operator shall appropriately characterise all aqueous waste streams in its water discharge activity permit application. This shall include identification of all significant contaminants (including biocides, detergents and metals), the concentrations and volumes being discharged to the environment.

Assessment Finding 17	A future operator shall specify the minimum performance parameters of the combustion plant in its application for a combustion activity permit.

Appendix 3 - Hitachi-GE submission documents - 'Generic environmental permit'

Document reference	Title	Version number
GA91-9901-0019-00001	Summary of the generic environmental permit applications	Revision G
GA91-9901-0020-00001	Generic site description	Revision E
GA91-9901-0021-00001	Approach to optimisation	Revision E
GA91-9901-0022-00001	Radioactive waste management arrangements	Revision G
GA91-9901-0023-00001	Demonstration of BAT	Revision F
GA91-9901-0025-00001	Quantification of discharges and limits	Revision F
GA91-9901-0026-00001	Prospective dose modelling	Revision F
GA91-9901-0027-00001	Other environmental regulations	Revision F
GA91-9901-0028-00001	Alignment with the Radioactive Substances Regulation environmental principles (REPs)	Revision E
GA91-9901-0029-00001	Approach to sampling and monitoring	Revision G

Appendix 4 - Environment Agency Assessment Reports

Document Reference	Title
AR01	Assessment of management arrangements
AR02	Assessment of the strategic approach to waste management
AR03	Assessment of best available techniques
AR04	Assessment of gaseous radioactive waste disposal and limits
AR05	Assessment of aqueous radioactive waste disposal and limits
AR06	Assessment of solid radioactive waste and spent fuel
AR07	Assessment of sampling and monitoring
AR08	Assessment of generic site description
AR09	Assessment of radiological impacts on members of the public
AR10	Assessment of radiological impacts on non-human species
AR11	Assessment of other environmental regulations
	Generic design assessment of the UK ABWR - Independent dose assessment

Appendix 5 - Summary of the claims, arguments and evidence Hitachi-GE provided

The ‘Demonstration of BAT’ submission includes 5 claims and 35 arguments. We have considered these and sampled the supporting evidence to reach our conclusions at this stage (below). You can find more details of our assessment of BAT, including a summary of our related Regulatory Queries(RQ), Regulatory Observations (RO) and Regulatory Issues (RI) in our report ‘Assessment of best available techniques' (AR03).

Claim 1: Eliminate or reduce the generation of radioactive waste

We expect the best available techniques (BAT) to be used to ensure that production of radioactive waste is prevented. Where that is not practicable, the amount and activity of waste should be minimised (consistent with RSMDP3) (Environment Agency 2010a).

Hitachi-GE claims that the UK ABWR design will eliminate or reduce the amount of radioactive waste generated. This claim is supported by 10 arguments (1a-1j) and extensive evidence. We summarise each argument below and provide our conclusions at this time.

Argument 1a. Design, manufacture and management of fuel

We conclude that the UK ABWR is designed to implement a modern fuel design, to utilise fuel manufactured using appropriate techniques and can, ultimately, be suitably managed to prevent or minimise waste arisings.

Fuel performance has important implications in terms of generating solid, liquid and gaseous wastes that needs disposing of. It is anticipated that the vast majority of radioactivity will remain associated with spent fuel and will, therefore, be disposed of in solid form to a future GDF. However, potentially transferring fission products (FPs) from the fuel to the steam circuit and the spent fuel pond generates waste.

Hitachi-GE has assumed a degree of fuel failure in defining the source term for the UK ABWR. Hitachi-GE argues that only a small number of fuel assemblies may experience failure during normal operations and presents evidence of an overall downward trend in fuel failure rates.

Fuel failure is described as an 'expected event' in terms of estimating waste arisings. For GDA purposes, Hitachi-GE assumes a low but non-zero failure rate, although it has been argued that this is a conservative assumption and is, therefore, tending to overestimate release rates and associated radioactive waste arisings. Evidence from reactor fleet operations has been provided that the total failure rate in modern BWR fuel (such as GE14) due to pellet cladding interaction mechanisms (an important fuel failure mechanism) is less than 4 parts per million. We discuss this aspect further in our assessment report on spent fuel and radioactive waste [AR06 - Assessment of solid radioactive waste and spent fuel].

Hitachi-GE provides evidence that design features in the GE14 fuel, such as debris filtration and zirconium cladding lining, should help to reduce the likelihood of fuel failure and, therefore, reduce the associated waste arisings. Debris filtration and zirconium cladding lining reduces the potential for corrosion degradation of cladding. Hitachi-GE has provided evidence in relation to reduced fuel failure rates through advances in fuel design and reactor operational regimes.

We note that the evidence provided on the basis of BWR fuel experience may not be fully transferable to UK ABWR. This is due to differences in factors such as specific reactor chemistry, fuel burn-up and operational arrangements that may ultimately influence fuel failure rates. It is, however, indicative that low rates of fuel failure are possible and demonstrates an understanding of the underlying mechanisms and technological approaches to improve fuel performance. We anticipate that operational experience from the operational ABWR fleet will usefully inform decisions of future fuel use by UK ABWR operators.

Hitachi-GE recognises 'Manufacturer's guidance on fuel use' and argues that adopting these guidelines will help to reduce fuel failure rates in support of the GDA case. We sought clarity on using manufacturer's guidance in support of BAT arguments. Future operators would ultimately use this guidance, but we see benefit in considering and applying it, where available.

We note that fuel technology is subject to progressive improvement. For example, an advanced fuel design known as GNF2 is currently being developed and progressively deployed in the BWR fleet. Detailed fuel design will need considering further at the site-specific permitting stage, as fuel that offers improved performance may be available at that time. In particular, any design improvements to minimise fuel failure during operation will need to be considered, as this could help minimise waste. We, therefore, identify an Assessment Finding that future operators will need to consider fuel design further.

The detailed operational arrangements for fuel and core management, and how these will be optimised to ensure waste minimisation, will be considered in any site-specific permitting. We note that this is a particular aspect that needs further attention, including any learning from ABWR operational experience, and we identify this as an Assessment Finding.

Argument 1b. Reactivity control

The UK ABWR design enables a range of techniques for reactivity control. These include using hafnium and boron carbide control rods, burnable poisons within the fuel and controlling the flow of water through the core. As an intrinsic feature of the UK ABWR design, there is no requirement to use dissolved boron species in the reactor circuit unlike PWR designs. Therefore, producing tritium in this way is avoided. We conclude that the UK ABWR design appropriately enables reactivity control whilst having associated features that can contribute to minimising waste arisings. We will expect any future operators to optimise reactivity control arrangements to ensure this happens.

We sought clarity on how control rod rupture would be avoided given that this can lead to, arguably small, increases in tritium arisings in the coolant circuit and hence in waste arisings. Overall, we concluded that a future operator will need to fully define the detailed arrangements for using and managing control rods in the reactor core, although we have no reason to doubt that suitable arrangements are possible based on the case provided.

We queried whether irradiation of hafnium control rods would generate any problematic radionuclides in relation to the disposal inventory. The response indicates that this is not the case. We also queried the optimum balance between using boron carbide and hafnium control rods in relation to the associated solid waste arisings. The operational lifetime of boron carbide control rods is significantly less than that of the hafnium rods. Hitachi-GE explained that each type of control rod has different specific functions and provided arguments to suggest that the proposed balance was appropriate in relation to minimising solid waste arisings, which seems reasonable.

We also queried whether using gadolinium as a neutron poison would have any implications for the UK's radioactive waste disposal inventory given its potential chemotoxicity. Only small quantities of residual gadolinium are anticipated in the spent fuel from the UK ABWR. The chemotoxic effects of gadolinium in the UK radioactive waste disposal inventory are yet to be specifically assessed. This is also true of several other potentially toxic components of the UK disposal inventory. The UK ABWR design enables a range of techniques for reactivity control.

Argument 1c: Efficiency of fuel use

We conclude that the UK ABWR design, together with optimised future reactor operations, should mean fuel can be used efficiently, thereby minimising the amount and activity of waste fuel generated. The creation of spent fuel is inevitable but we expect to see optimisation to ensure that spent fuel arisings are minimised.

Hitachi-GE argues that design features of the UK ABWR core and operational regimes based on 'spectral shift operation' minimise the amount of spent fuel created. Spectral shift operation involves exposure of fuel to fast neutrons in the bubble-rich region of the core followed by subsequent burning out of any ingrown fissile plutonium in the core region where water-moderated, thermal neutrons predominate. Essentially this enables a quantity of fertile U-238 to be burnt. We queried the efficacy of this process and argument. 'Spectral shift' can lead to a 2% saving in fuel, reducing the amount of spent fuel waste.

Evidence of improvements in fuel efficiency is provided. It is argued that BWR fuel bundles typically achieved discharge exposures of approximately 20 GWd/t during the 1970s, while more recent BWRs loaded with 10x10 fuel bundles such as GE14 fuel have achieved discharge exposures of 50 GWd/t. We note that Hitachi-GE is proposing average fuel burn-ups of between 50-60 GWd/t for the UK ABWR.

Argument 1d: Detection and management of failed fuel

Hitachi-GE argues that the UK ABWR design includes features which enable the detection of failed fuel and mitigating actions to be taken to essentially isolate such fuel and, therefore, reduce any impacts from it. Hitachi-GE has provided evidence to demonstrate detection of fuel failure by in-line radiation monitoring and proposed arrangements for managing such events, should they happen.

Hitachi-GE argues that inserting control rods around a failed fuel assembly can effectively isolate any detrimental effects and enable operations to continue. This is known as suppression. Suppression of failed fuel by using boron-carbide control rods could potentially result in control rod rupture if not properly managed. This is because boron-carbide control rods can swell when exposed to neutrons in the reactor at power. Any such failure would create more waste, such as increased tritium concentrations in the reactor circuit. Hitachi-GE argues that operational controls during suppression can minimise such failures.

We will expect future operators to define appropriate, optimised arrangements and controls to avoid such failures in power suppression situations. This would prompt any future operators to define appropriate, optimised arrangements for failed fuel detection and management. These will need to be included in detailed specifications, which define the extent of permitted fuel failure in an operational core, together with any operational timeframes and other limits that may be appropriate before shutdown is required. We, therefore, identify an Assessment Finding relating to the need for future operators to define appropriate, optimised arrangements and controls to manage failed fuel and to avoid control rod rupture in power suppression situations.

Argument 1e. Commissioning, start-up, shutdown and outage procedures

Hitachi-GE describes processes that could potentially occur during commissioning, start-up, shutdown and when the reactor is not working that could lead to an increase in the amount of radioactive waste generated. These include mobilisation of corrosion products (CP) that can become activated and increased incidence of stress corrosion cracking, both of which would mean components need replacing, therefore creating more waste. Hitachi-GE describes approaches to mitigate these processes by using chemical treatments such as controls on iron concentration in the reactor circuit, oxygen and zinc injection and through operational arrangements.

We conclude that these measures could be effective in reducing waste arisings when used appropriately within an optimised operational regime. We will expect any future operators to develop optimised arrangements to ensure that they minimise the amount of waste produced by using these approaches, as appropriate, throughout operations. We have identified an Assessment Finding to prompt this.

Argument 1f. Water chemistry

Chemical conditions within the reactor plant have important implications for waste generation. For example, they can affect the mobility of radionuclides and the extent to which corrosion products are produced and ultimately end up as waste. Hitachi-GE describes a range of techniques that can ensure that reactor water chemistry is optimised, which is important in terms of minimising the amount of waste produced. These techniques include the potential for injection of specific reagents and the inclusion of filtration and demineralisation technology.

Hitachi-GE proposes operating the UK ABWR with hydrogen water chemistry and adding noble metal chemicals. This is intended to ensure a reducing chemical environment, which is considered appropriate in terms of minimising corrosion rates. This is in contrast to early BWRs, which used normal water chemistry with no reagent additions. The current Japanese ABWR fleet uses normal water chemistry.

Water chemistry has been subject to a Regulatory Observation (RO-ABWR-0022, 'Demonstration that the primary cooling system operating chemistry reduces risks SFAIRP (so far as is reasonably practicable)', which was closed in October 2015). Compatible materials for deployment in reactor operations has been subject to a joint Environment Agency and ONR Regulatory Observation (RO-ABWR-0006) and a subsequent Regulatory Issue (RI-ABWR-0001), 'Definition and justification for the radioactive source terms in UK ABWR during normal operations'. The Regulatory Issue remains open and may have implications for the results of our final assessment.

We note that the UK ABWR design appears to offer flexibility in terms of water chemistry control. Subject to the Regulatory Issue in GDA being resolved, we will expect any future operators to ensure optimised water chemistry regimes consistent with the relevant GDA outcomes, as this is important in reducing the amount of waste generated. We identify this as an Assessment Finding.

Argument 1g. Specification of materials

Hitachi-GE states it plans to use low cobalt steels and to reduce high cobalt alloys (stellites) used in the UK ABWR design. It also describes using corrosion resistant alloys, which is intended to reduce waste produced from activated corrosion products. It is argued that such measures will reduce waste arisings from activation.

We note that a relevant Regulatory Observation remains open at this time, (RO-ABWR-0035, 'Robust justification for the materials selected for UK ABWR').

We recognise that using low cobalt alloys and corrosion resistant steel helps reduce the amount of waste produced and we will expect any future operator to demonstrate that it has chosen and used the most appropriate low cobalt and corrosion resistant alloys available.

Argument 1h. Recycling of water to prevent discharges

Hitachi-GE describes design features of the UK ABWR that enable water to be recycled in plant systems, including the steam circuit, suppression pool and fuel pool. It is also argued that liquid effluent will be reused during decommissioning activities, for example in aqueous decontamination processes, therefore avoiding generating further liquid wastes. The only proposed liquid discharges from the UK ABWR are from the laundry drain (LD), controlled area drain system (CAD) and occasionally the HCW, as discussed further in our assessment of aqueous radioactive waste report [AR05 - Assessment of aqueous radioactive waste disposal and limits].

Recycling water clearly avoids having to discharge contaminated effluents and can, therefore, potentially reduce the impact on the environment. This is consistent with a 'concentrate and contain' approach, which is aligned with policy for the UK (Defra 2011).

Recycling is possible in the UK ABWR design due to demineraliser technology, which transfers the majority of activity to ion exchange material to eventually be disposed of as solid waste. Thus the use of demineralisers results in solid waste generation whilst reducing the radioactivity disposed in liquid waste discharges. We comment further in the aqueous radioactive waste assessment report on using demineralisers and the implications in terms of solid waste arisings and disposal routes waste in the solid radioactive waste assessment report [AR06 - Assessment of aqueous radioactive waste disposal and limits].

Detailed design of the demineraliser systems will depend upon operator choices and is considered a matter for site-specific permitting. Hitachi-GE has provided us with arguments to demonstrate the possible levels of decontamination based on typical types of ion exchange media used in nuclear applications. A future operator will consider and select appropriate demineraliser resins to minimise the amount of waste produced. We identify this as an Assessment Finding.

The assumption that no carbon-14 enters the liquid waste streams and, therefore, cannot adsorb onto the demineraliser resins or be discharged is not a conservative assumption for liquid discharges and may need considering further in the future or validating at an early stage of operation. We have identified an Assessment Finding relating to this.

Argument 1i. Secondary neutron sources

Hitachi-GE has proposed using californium-252 sources in stainless-steel cladding as secondary neutron sources in the UK ABWR design. An advantage of this type of source is it avoids producing further tritium relative to certain alternatives, such as sources based on antimony-beryllium. Hitachi-GE suggests that there is considerable operational experience to support using californium-252 sources. We agree that the use of neutron sources that do not give rise to additional tritium offers benefits in terms of reduced waste arisings.

Argument 1j. Leak tightness of liquid, gas and mixed phase systems

Hitachi-GE argues that the design of the UK ABWR includes a range of features that will help ensure that radioactive substances that are unavoidably created during operations are contained within designated facilities.

Relevant measures to ensure leak tightness, as described by Hitachi-GE, include reducing the amount of pipework associated with plant operations; improving the performance of welds, seals and connections; including level alarms; including bunding and applying impermeable coatings to the floor and walls in areas where leakage is possible. Hitachi-GE has also defined 'Design policies and principles' that seek to reduce or eliminate leakage, which have been considered in design of the UK ABWR. Specific policies are described for various components of the plant such as the liquid waste system, the off-gas system, the containment vessel, the HVAC system and the fuel pool.

We consider the measures for ensuring leak tightness as defined by Hitachi-GE to be consistent with using BAT as this stage. However, we note that ONR's 'Chemical/process engineering design approach' Regulatory Observation (RO-ABWR-0054) is further assessing relevant aspects. We will consider any outcomes as our assessment progresses in Step 4.

Claim 2: Minimise the radioactivity in radioactive waste disposed to the environment

Hitachi-GE claims that the UK ABWR design will minimise the radioactivity in radioactive waste disposed of to the environment. This claim is supported by 9 arguments (2a-2i) and extensive evidence. We summarise each argument below and provide our conclusions at this time.

Argument 2a. Off-gas waste treatment system (OGWTS)

The major radionuclides in the off-gas stream anticipated in gaseous discharges are the noble gases, carbon-14, tritium and iodine radionuclides. The design of the UK ABWR includes an OGWTS, that collects, conveys, treats and discharges gaseous radioactive waste from the condenser. This gaseous radioactive waste includes radionuclides that are transported with steam but are not condensed along with water in the condenser. The UK ABWR also includes filtration technology to remove particulates from the off-gas stream.

The OGWTS includes columns of activated charcoal to adsorb radioactive species and, therefore, delay discharge in the off-gas flow. During this delay period, short-lived radionuclides decay in situ and, therefore, do not contribute to the radioactivity in the discharge. The term 'delay beds' is used to describe this abatement approach and is common practice in light water reactor technology and recognised as BAT in international literature. Systems based broadly on the same technology are in operation at Sizewell B and are proposed in both the EPR and UK ABWR PWR designs.

Hitachi-GE has provided arguments and evidence that the design of the OGWTS will be effective in removing short-lived radionuclides that are amenable to delay (most noble gases and short-lived radionuclides, including those of iodine).

Hitachi-GE argues that there are no practicable techniques to abate tritium and carbon-14 in the gaseous waste streams at this time. This view is supported by a review of international practice and a range of options that have been considered against recent international guidance. We prompted further consideration of such aspects via a Regulatory Query.

Abating carbon-14 via the OGWTS would require development work on alkaline scrubbing treatment techniques, which would also entail the disposal of secondary solid wastes resulting from the scrubbing process. Hitachi-GE argues that the development costs would be substantial and any benefits marginal in terms of overall impacts. Hitachi-GE has concluded that not abating carbon-14 in the off-gas is BAT at the GDA stage, but identifies that it is suitable for further consideration by any future operators. We agree with this and will expect any future operators to review the practicability of techniques for abating carbon-14 at the site-specific permitting stage. We have raised an Assessment Finding to this effect.

Argument 2b. Delay beds for noble gases and iodine

Hitachi-GE argues that the delays beds that are part of the OGWTS are suitably configured to enable significant delay of noble gases and iodine radionuclides. Supporting evidence substantiates the quantity of charcoal required to accomplish optimised 'delay'. It is also argued that there are benefits in terms of abating iodine radionuclides. We asked Hitachi-GE to clarify how it had produced its delay calculations and related aspects (RQ-ABWR-0240).

Hitachi-GE argues that the proposed delay beds are designed for 60 years of operation without needing to replace the charcoal. This is based on operational experience from 20 operational nuclear power plants.

Argon-41 is a noble gas radionuclide with a relatively long half-life of 1.8 hours. It is not formed from nuclear fission but results from neutron activation of argon-40, which is present in air and entrained in the reactor circuit. The delay bed design in the UK ABWR would result in a significant reduction in argon-41 gaseous discharges (by a concentration factor of 14 it is argued). However, argon-41 abatement is not as extensive as the reduction in other noble gas radionuclides, which will effectively decay in situ within the OGWTS. Hitachi-GE has identified a number of other approaches that could be used to further abate argon-41. It argues however, given that argon-41 only contributes a small amount to projected doses to the public, reducing it would be prohibitively expensive compared to its potential benefit.

We agree with Hitachi-GE that using delay bed technology in the UK ABWR design is consistent with applying BAT.

Argument 2c. Heating, ventilation and air conditioning (HVAC) system

The UK ABWR design includes a HVAC system that aims to maintain environmental conditions within the reactor plant and provide a cascade air flow from areas of low contamination to areas of higher contamination. All HVAC systems discharge gaseous waste via outlets that will require permitting. Other than filtration, there is no abatement on HVAC discharges. Flow through the HVAC system helps to dilute discharges from the OGWTS. The HVAC system for the UK ABWR is segregated into sub-systems according to the principle areas.

HEPA filtration within the HVAC systems aims to ensure that the concentration of particulate matter within the gaseous radioactive waste stream is minimised during normal and accident conditions. The extent of filtration, in terms of the number of filter banks, has been designed to provide the appropriate level of efficiency based on demands from those plant areas. Hitachi-GE observes that each system will include HEPA filters that comply with relevant industry standards. Hitachi-GE has introduced increased HVAC flow rates to the UK ABWR design, mainly to ensure appropriate radiological protection for workers.

Hitachi-GE proposes that HEPA filters will be changed, where practicable, based on performance criteria monitored via continuous measurement of differential pressures, that is the relative pressures upstream and downstream of the filtration. Hitachi-GE notes that under these arrangements filters will be used to their design capacity and not changed at a predefined frequency. This approach can avoid unnecessary amounts of solid waste being generated and needing disposing of.

We agree that this approach will bring benefits. However, we will consider any outcomes from resolving ONR’s Regulatory Observation on 'Nuclear ventilation codes and standards' (RO-ABWR-0017) before making a final decision.

We queried the ability to abate iodine in the HVAC system. This is a reasonable argument and we also note that should higher activity levels be detected in the HVAC, for example in the case of an accident, it would be possible to switch flow through a standby gas treatment system (with charcoal abatement). This aspect is being considered further through GDA before a final decision is made.

Argument 2d. Filtration of airborne particulate matter

Hitachi-GE argues that the UK ABWR will use appropriate filtration techniques to minimise the concentration of particulate matter within the gaseous radioactive waste stream during normal operations and in the event of an accident. Hitachi-GE argues that the UK ABWR has been subject to considerable optimisation, such that the amount of particulate matter that has the potential to become mobilised within the building areas served by the HVAC systems has been minimised. Overall, Hitachi-GE argues that the performance of the filters will exceed that required for normal operations.

We sought clarity on filtration of the turbine gland steam (TGS) and mechanical vacuum pump (MVP). We noted that the TGS and MVP lines could provide potential sources of particulate matter that could then adsorb activity within the system prior to discharge therefore providing a particulate source term in gaseous discharges. The response indicates that Hitachi-GE will install HEPA filtration into the TGS and MVP lines. The benefits in terms of monitoring arrangements are also recognised.

We recognise that demands on the filtration systems for airborne particulate matter extend beyond normal operations. As per our view on Argument 2c, this aspect is also subject to ongoing consideration until we publish our final decision and via RO-ABWR-0017 (which remains open as of 5 August 2016).

Argument 2e. Optimisation of the turbine gland steam system

The turbine gland steam system (TGS) uses water extracted from the condensate storage tank (CST) to produce steam that is used in the turbine gland seal. Hitachi-GE argues that following use in the turbine gland, 98% of the steam is condensed along with the associated tritiated water, and is subsequently returned to the main condenser and is available to be reused.

Steam used in the TGS represents a source of tritium gaseous discharge and this was not considered in early source term work. A regulatory observation (RO-ABWR-0071, 'Turbine gland steam system: Discharges and optimisation') was raised in June 2016 because the TGS was not fully considered in the generic environmental permit (GEP) submission (Revision E) and Pre-construction safety report (PCSR). The RO remains open, but Hitachi-GE has now provided a satisfactory response in relation to the BAT aspects (one of six actions in the RO).

Hitachi-GE argues that using CST water as the supply for the gland steam evaporator rather than purified water allows the operator to manage the water balance of the plant without having to make additional discharges of aqueous radioactive waste. Therefore, small gaseous discharges of tritium are preferable, overall, to further liquid discharges and other associated impacts, including cost and additional decommissioning wastes.

An options assessment has been provided. The assessment explored opportunities to further optimise the TGS. It concluded that the costs in terms of time, effort and financial cost grossly outweigh the benefits in terms of reducing dose and, therefore, that the proposed UK ABWR (baseline) design remains BAT. We agree that the arguments appear reasonable, however, we await further work to close RO-ABWR-0071 until a definitive view can be provided.

Argument 2f. Configuration of the liquid management systems

The design of the UK ABWR includes a liquid management system. This has a series of segregated drains that segregate similar types of waste for subsequent treatment, where practicable. In-process monitoring is used to confirm the relevant characteristics of the liquid waste and to make ensure it is suitable for treatment, reuse or disposal. In many cases aqueous radioactive waste is treated before it is discharged. Treatment techniques include filtration, demineralisation and evaporation that aim to remove radionuclides, and certain other species, to make sure it can be reused and to meet discharge criteria.

The LCW treatment system consists of filters for removing particulates and demineralisers for removing soluble ions. Treated liquids are returned to the CST for recycling rather than discharge.

The HCW includes an evaporator for removing impurities and a demineraliser for removing residual ionic species from the condensate. Treated HCW liquids are either transferred to the CST to be reused or disposed of to the environment in line with permitted limits.

LD waste water streams contain detergent, suspended solids and organic material and low levels of radioactivity, largely as particulate crud. The treatment system comprises collection tanks and filters (LD pre-filter, LD activated carbon adsorption tower and LD filter). Treated waste is disposed of in line with permitted limits.

The CAD system contains a range of liquid wastes generated in the UK ABWR facility's controlled areas, which are not otherwise captured by the HCW and LCW systems. This includes liquid from air-conditioning units and, therefore, the quantity of CAD generation depends on the temperature and the humidity in the building. Wastes from the CAD are discharged to the environment in line with permitted limits. CAD liquid can be treated through the HCW system if any significant radiological contamination is detected.

Hitachi-GE argues that the liquid management systems have been developed based on a set of design policies to prevent leakage of liquid radioactive substances and to prevent their uncontrolled discharge. The LWMS will be designed so that it can be centrally monitored and controlled in the radioactive waste building control room.

Hitachi-GE argues that liquid tritium discharges for the UK ABWR design will be very low and the design allows a considerable amount of this radionuclide to be contained within the reactor water system, including the main steam/condensate circuit and the condensate storage tank. Some tritium will be discharged via evaporation, for example via the HVAC and the TGS steam route. Tritiated water will also be discharged via HCW discharges to maintain the water balance of the plant.

The amount of time of water remains in the condensation system circuit will lead to benefits in terms of decay storage. Hitachi-GE observes that discharges of reactor water will not occur until after 60 to 80 years, which represents more than several half-lives of tritium. This potentially allows appreciable radioactive decay of tritium within the plant.

Hitachi-GE suggests that there are no practicable abatement techniques for liquid tritium and that the low discharge rates and associated impacts do not warrant further development and deployment.

It is notable that liquid radioactive discharges from the UK ABWR are low, in terms of volume, activity and the associated projected dose. Our comparison of relevant reactor discharge data supports this view.

ONR has issued a number of ROs with potential implications for the design of the liquid waste management system, including RO-ABWR-0054 ('Chemical/process engineering design approach') and RO-ABWR-0036 ('Demonstration that the approach taken to radioactive waste management reduces risks SFAIRP'). We will consider any implications resolving these observations could have when we form our final view.

The UK ABWR design benefits from inherent features that enable liquid reuse and this is helped by using appropriate techniques to concentrate and contain waste, where practicable. Overall, at this time, we conclude that the design of the UK ABWR liquid waste management system is consistent with applying BAT at the GDA stage. However, we will continue to review this conclusion in response to the outcomes of the relevant regulatory observations above.

Argument 2g. Sizing of tanks, vessels and liquid containment systems

The UK ABWR design includes tanks to manage the liquid wastes from the segregated drain systems. Hitachi-GE argues that these tanks have been designed to provide enough capacity to store the effluent during treatment and before it is discharged. We queried the definition of these capacities and specifically the definition of the associated margins.

It is argued that the size of the tanks ensures that operators will have enough time to carry out sampling and analysis of wastes before making any decisions to discharge effluent to the environment, or to subject it to additional treatment. All tanks are to be fitted with a series of volume level alarms and with secondary containment in the form of bunding.

We conclude at this time that the approach to sizing of tanks, vessels and liquid containment systems is consistent with applying BAT at the GDA stage. However, we will continue to review this conclusion in response to the outcomes of the relevant Regulatory Observations ONR raised (RO-ABWR-0036, RO-ABWR-0054).

Argument 2h. Demineralisers for distillates from the high chemical impurities waste evaporator

The UK ABWR design includes an evaporator in the HCW system, which is effective at concentrating and containing the majority of the radioactivity from the HCW liquid. It is argued that evaporator liquor is accumulated in a form suitable for conditioning and disposing of as solid waste.

Some of the volatile radionuclides are carried over with the distillate during evaporation and further treatment of the distillate by demineraliser resin is performed. This 'polishing' step further minimises radioactivity in the liquid before the waste is reused, where possible. Where reuse criteria are not met the liquid would be discharged to the environment.

Hitachi-GE has provided evidence of design improvements for treatment of HCW liquids relative to earlier BWR designs. The evaporator has benefited from significant design improvements in relation to operability and recent practice has seen greater throughput treatment and reuse of the floor drain liquid waste arisings.

Overall, we conclude that using an evaporator is consistent with a ‘concentrate and contain’ approach given that a large proportion of the radioactive substances in the HCW stream are concentrated into a solid waste stream. It is also consistent with the waste hierarchy, in terms of potentially allowing liquids that would otherwise need discharging to be reused.

Argument 2i. Evaporation of high chemical impurities waste

Hitachi-GE has included an evaporator in the design of the UK ABWR specifically to treat liquids produced in the HCW system. These liquid wastes are collected in the chemical drain and may contain substances that interfere with waste treatment systems and can cause corrosion of process equipment. Without further treatment these types of wastes could not be reused and would, therefore, have to be disposed of. Residues from the evaporator contain the majority of the radioactivity. Hitachi-GE proposes that these are converted to and disposed of as solid radioactive waste.

We challenged a potential revised design of the HCW liquid waste management system, which would have removed the evaporator from the design. Following further consideration, Hitachi-GE reinstated the evaporator.

Unlike other components of the liquid waste management system the HCW system is linked to a liquid discharge route. The UK ABWR design means that a future operator will only discharge liquid waste to the environment from the HCW route if the water holdings of the plant need to be reduced to maintain water balance and only where sampling and analysis indicate that the waste meets discharge criteria. These discharges would be of very low activity.

We agree with Hitachi-GE that the proposed low frequency of discharges, combined with applying robust treatment technologies, are consistent with applying BAT for the UK ABWR design.

Argument 2j. Radioactive decay of solid and liquid wastes

Hitachi-GE observes that decay storage is a recognised practice in the nuclear industry and is particularly useful in managing short-lived radioactivity. Hitachi-GE argues that there are benefits from decay storage of both solid and liquid wastes and that the design of the UK ABWR and the proposed waste management strategy enables these benefits to be realised.

The design of the UK ABWR includes storage of solid higher activity wastes. Hitachi-GE has assumed storage timescales of up to 100 years pending timescales of future GDF availability. Notably, Hitachi-GE argues that storage of clean-up water resins and fuel pool resins will enable significant decay in storage. Early conditioning of operational waste arisings is proposed and, therefore, storage as solid waste is envisaged. Hitachi-GE has not identified storage capacities for those wastes that may benefit from decay storage, and proposes that these are to be decided by future operators.

Hitachi-GE argues that storage timescales will be long enough to allow decay heat dissipation so that package heat outputs would not hinder disposal to a future GDF. We note, however, that RWM has questioned if certain package types proposed by Hitachi-GE are optimal with regards to package thermal outputs.

Hitachi-GE proposes using 3 m^3 boxes with the same handling features, handling configuration, and transport over-pack as the 3 m^3 drum used for wet ILW wastes. The design of the vault will be considered in future studies.

We recognise that decay storage can minimise the amount of waste that needs disposing of, and is a particularly useful approach for radionuclides with short-half lives. We also support intentions for early waste conditioning, where appropriate, as immobilisation helps to ensure containment and reduce future burdens where it is shown that robust and disposable products can be produced.

Claim 3: Minimise the volume of radioactive waste disposed of to other premises

This claim is supported by 5 arguments (3a-3e) and extensive evidence. We summarise each argument below and provide our conclusions at this time.

Argument 3a. Design to minimise the volumes of operational and decommissioning waste arisings

Hitachi-GE argues that the design of the UK ABWR has evolved to reduce the quantities of solid radioactive waste that will be generated relative to earlier BWR designs. Important features include using internal reactor pumps that avoid extra pipework, improved reactor pressure vessel design that reduces size and eventual waste arisings, reductions in stress corrosion cracking leading to lower replacement frequencies, using hollow fibre filters to reduce filter waste arisings and 10 further minor design changes that are deemed beneficial.

Hitachi-GE identifies only one design change that has increased the amount of waste produced. That is introducing moisture separator reheaters. It is argued that the benefits of this change in terms of improved thermal efficiency are greater than the implications of a small quantity of extra waste.

Argument 3b. Selection of methods to minimise solid waste generation

Hitachi-GE argues that the design of the UK ABWR includes a number of features that will allow any future operator to adopt an operating philosophy that will minimise the quantity of solid radioactive waste associated with routine operations and maintenance. The most important features aspects are ensuring available space for operations in designated areas to help segregate waste, avoiding unnecessary 'office work' in controlled areas and adopting a flexible approach to maintenance where appropriate items can be replaced as needed rather than according to a pre-defined schedule.

We recognise that, on balance, the design of the UK ABWR seeks to minimise waste volumes, where practicable. Through future regulation of any operational UK ABWR plant we will seek to ensure waste minimisation throughout the plant life cycle.

Argument 3c. Application of volume reduction processes for solid waste

Hitachi-GE observes that making efficient use of space in waste containers helps reduce the size of storage facilities, decreases the number of vehicle movements during transportation and minimises the demand on disposal capacity. Reducing the size of used control rods, using 'off-site' incineration facilities, and using shredding and low force compaction as the preferred processing methods for LLW filters and combustible waste are all consistent with this approach.

We recognise these aspects as relevant good practice consistent with applying BAT. We will aim to make sure that any future operators make appropriate use of these approaches.

Argument 3d. Solid waste, minimising the quantity of solidified high chemical impurities waste (HCW)

Hitachi-GE argues that HCW is best treated by a combination of evaporator and demineraliser technology. The evaporator helps to remove impurities that increase the risk of corrosion and the associated generation of corrosion products. These include organic carbon impurities that are difficult to remove by demineralisation approaches. Using evaporation technology helps make it easier to reuse liquids in the condensate circuit, which avoids discharging liquid effluent. Residues from the evaporation process are to be conditioned for eventual disposal.

We conclude that using evaporation technology allows a 'concentrate and contain' approach and can potentially reduce the amount of overall conditioned waste relative to other approaches. It also allows liquids to be reused more within the plant system rather than discharging them (as per Argument 2h). This is consistent with applying BAT.

Argument 3e. Application of decommissioning techniques to reduce the activity and volume of decommissioning waste:

Significant amounts of waste will be generated when a UK ABWR is decommissioned.

Hitachi-GE observes that a future operator will be responsible for decommissioning the UK ABWR and selecting the techniques to do this. Hitachi-GE, therefore, focuses on demonstrating for GDA that, based on current technologies, adequate techniques are available to do this. Hitachi-GE highlights those features relating to system decontamination during decommissioning and approaches to decontamination after dismantling.

We recognise that these approaches, as outlined for GDA, are potentially applicable and effective. We will expect, however, that a future operator develops an optimised and integrated decommissioning plan, which ensures that waste will be appropriately minimised and routed. We recognise that Hitachi-GE have committed to this in their forward action plan which is the subject on an Assessment Finding (Assessment Finding 6).

Claim 4: Selecting the optimal disposal routes for wastes transferred to other premises

This claim is supported by 5 arguments (4a-4e) and extensive evidence. We summarise each argument below and provide our conclusions at this time.

Argument 4a. Provision of waste management facilities

Hitachi-GE argues that the design of the UK ABWR's radioactive waste building includes the space and services needed to install the equipment necessary to characterise, treat and store wastes. This, it argues, will enable a future operator to implement the most appropriate routes for disposing of radioactive solid wastes. Therefore, for GDA, Hitachi-GE has aimed to demonstrate that waste could be disposed of to appropriate routes based on currently established practice and national plans. Future site operators would need to select the actual disposal routes.

Hitachi-GE argues that characterising, sorting, treating and storage facilities will make it easier to consign waste to appropriately permitted routes, including those provided by waste management service providers. To support the GDA arguments, Hitachi-GE has provided evidence of agreement in principle for disposing of lower activity wastes that will be produced during the lifetime of the UK ABWR. Hitachi-GE has also provided disposability assessments for higher activity wastes based on advice received from RWM.

Overall, we recognise that the design does not constrain future operators and conclude that Hitachi-GE has provided a sufficient case in this respect for GDA.

Argument 4b. Optimal disposal route selection

Hitachi-GE argues that wastes arising from a UK ABWR could be disposed of via existing disposal routes and those that could be available in the future, such as a geological disposal facility (GDF). Evidence is provided to support potentially using a range of selected waste management techniques to dispose of appropriate wastes via a range of routes.

We consider the level of detail provided in GDA to be appropriate in this regard. Hitachi-GE has recognised that any future operator will need to carry out further detailed assessment to support this argument in their forward action plan, which is the subject of Assessment Finding 6.

Argument 4c. Agreement in principle for waste routes - lower activity wastes

Hitachi-GE has engaged with the suppliers of waste management services for solid and non-aqueous radioactive waste in the UK. It has obtained agreement in principle to dispose of appropriate compatible wastes in the following ways:

- metallic waste for physical decontamination and recycling
- combustible waste for volume reduction by incineration
- VLLW for disposal at appropriately permitted commercial landfills
- super compaction of compressible lower activity waste followed by disposal in the national LLWR
- disposal of non-compressible lower activity waste in the national LLWR

We consider this 'agreement in principle' to suitably demonstrate waste compatibility with current disposal routes. This is in line with GDA, and is based on high-level descriptions of waste inventory and characteristics. Any future operators would clearly be expected to confirm future compatibility by more detailed assessment against waste acceptance criteria at that time, and therefore to ensure they comply with their environmental permits (see also Environment Agency 2016b).

Argument 4d. Disposability assessments for higher activity wastes

Hitachi-GE has obtained disposability advice from RWM and responded to that advice as part of GDA.

We consider the level of development of the disposability case for higher activity wastes and spent fuel to be in line with GDA expectations. We consider that this fulfils the relevant requirement of the P&ID.

Argument 4e. Compatibility of existing UK waste BAT studies

Hitachi-GE has carried out assessments to find out how much the findings of NDA-led UK waste BAT studies apply to the lower activity wastes that will be generated by the UK ABWR. Assessments have considered metallic wastes (NDA 2009), combustible wastes (LLWR 2008) and wastes with very low levels of radioactivity (LLWR 2009).

The conclusions suggest that the UK BAT studies are applicable to the anticipated UK ABWR lower activity wastes and, therefore, that BAT is demonstrated at a strategic level. We agree that this is a reasonable conclusion at this stage.

Claim 5: Minimise the impacts on the environment and members of the public from radioactive waste that is disposed of to the environment

This claim is supported by 2 arguments (5a-5b) and extensive evidence. We summarise each argument below and provide our conclusions at this time.

Argument 5a. Gaseous discharge system - main stack

Hitachi-GE argues that the location, height and dilution of gaseous discharges in the main stack will help to minimise the dose to members of the public and the environment. Arguments are presented to suggest a generic location of the stack. It is also argued that gaseous waste from the off-gas system will be significantly diluted prior to discharge by the much higher flow rates from the HVAC system, which is likely to contain very low levels of gaseous radioactivity.

Hitachi-GE recognises that any future operators will need to determine the specific stack height as a site-specific activity. We agree that the appropriate location of the main stack will need considering further in relation to minimising public doses. This is a matter to be progressed at the site-specific design stage.

Argument 5b. Liquid effluent system

Hitachi-GE argues that the design of the UK ABWR's liquid effluent management system allows the timing and location of effluent discharges to be controlled.

The UK ABWR's liquid effluent management system also includes sampling arrangements. These are designed to allow the characteristics of the waste to be determined and to demonstrate conformance with any specific limitations and conditions as may be imposed by permitting.

We observe that any future operators will need to determine the timing and location of effluent discharges at the site-specific design stage. We also note that design features enabling controlled discharges and suitable characterisation of liquid effluents are consistent with applying BAT.

Appendix 6 - Expectations for site-specific permitting

Any applications for site-specific permitting that rely on this GDA will also need to address the items specified below:

- how the potential GDA Issues listed in the iSoDA have been, or will be, addressed (if the application is made prior to issue of full SoDA)
- how the Assessment Findings listed in Appendix 2 have been, or will be, addressed
- matters agreed as out of scope of this GDA, including:
    - environmental monitoring programme
    - reporting requirements in addition to those for significant nuclides, for example pollution inventory
    - BAT aspects of radioactive waste management facilities that were considered only to concept level in GDA and that operators need to develop to the detailed design stage
    - impact of thermal discharges to surface waters
    - gaseous and aqueous discharges from the service building, dry solid LLW processing facility, ILW store and interim spent fuel store
    - cooling water abstraction intake screening
    - flood risk activities
    - The operator will need to demonstrate that there is a suitable management system in place for the installation.
- any extension to the scope of GDA, including:
    - provision of more than one reactor
    - non-coastal site
- any changes or developments to the design (as described in the design reference documentation specified in the iSoDA), not addressed by GDA Issues or Assessment Findings, that might affect environmental performance
- operator and site-specific matters including:
    - management arrangements

      site-specific radiological assessments for people and non-human species, reflecting the local environment and the expected discharges taking account of all the matters above

Appendix 7 - Response form

How to respond

Visit our website at https://www.gov.uk/government/consultations/gda-of-hitachi-ge-nuclear-energy-ltds-uk-advanced-boiling-water-reactor. The online consultation has been designed to make it easy to send responses to the questions. We would prefer you to comment online as this will help us to gather and summarise responses quickly and accurately. To do this, you will need to either log in or register a consultee account before providing your comments.

If that is not possible, you can send your response by email, letter or fax. Please use this form when responding. It can be downloaded at https://consult.environment-agency.gov.uk/engagement/consultation-on-gda-of-uk-abwr-design

If you use any additional sheets, please make sure that each page is clearly labelled and numbered.

Please send your response to arrive by 3 March 2017.

Please read the notices below before sending your response to:

Email: gda@environment-agency.gov.uk

Post: For the attention of Declan Roscoe

Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria
CA11 9BP

Data protection notice

How we will use your information

We will use your information to help inform our decision on the generic design assessment of the UK ABWR.

We may refer to any comments or issues you raised in our decision document and in other Environment Agency documents related to GDA for the UK ABWR, unless you have specifically requested that we keep your response confidential. We may also publish all responses. We will not publish names of individuals who respond. We will publish the name of the organisation for those responses made on behalf of organisations. Please indicate on your response if you want us to treat it as confidential (but see the box below).

We will place your information on our databases, to be accessed by our staff or our agents, as a record of information received. We may send your information to other relevant bodies, including government departments.

We may keep your name and address on our databases so that we can advise you of any further communications relating to GDA or applications for permits for new nuclear power stations, unless you specifically ask us not to do this.

Freedom of Information Act and Environment Information Regulations

Confidential responses

We may publish or disclose information you provide in your response to this consultation, including personal information, in accordance with the Freedom of Information Act 2000 (FOIA) and the Environmental Information Regulations 2004 (if the Data Protection Act allows). If you want us to treat the information that you provide as confidential, please be aware that, under the FOIA or EIR, there is a statutory Code of Practice with which public authorities must comply and which deals, among other things, with obligations of confidence.

In view of this, it would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request to disclose the information, we will take full account of your explanation, but we cannot give an assurance that we can maintain confidentiality in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, in itself, be regarded as binding on the Environment Agency.

About you

Name

Organisation

(if relevant)

Job title

(if relevant)

Address

(including postcode)

Email

Telephone

Fax

Response

Q1: Do you have any views or comments on our preliminary conclusions on management systems? If so, please use the box below to provide any details.

Q2: Do you have any views or comments on our preliminary conclusions on strategic considerations for radioactive waste management? If so, please use the box below to provide any details.

Q3: Do you have any views or comments on our preliminary conclusions on the process for identifying best available techniques (BAT)? If so, please use the box below to provide any details

Q4: Do you have any views or comments on our preliminary conclusions on preventing and minimising the creation of radioactive waste? If so, please use the box below to provide any details.

Q5: Do you have any views or comments on our preliminary conclusions on minimising the discharges and impact of gaseous radioactive waste, and our proposed limits and levels? If so, please use the box below to provide any details.

Q6: Do you have any views or comments on our preliminary conclusions on minimising the discharges and impact of aqueous radioactive waste, and our proposed limits and levels? If so, please use the box below to provide any details

Q7: Do you have any views or comments on our preliminary conclusions on the management and disposal of solid radioactive waste and spent fuel? If so, please use the box below to provide any details.

Q8: Do you have any views or comments on our preliminary conclusions on the monitoring of discharges and disposals of radioactive waste? If so, please use the box below to provide any details

Q9: Do you have any views or comments on our preliminary conclusions on the impact of radioactive discharges? If so, please use the box below to provide any details.

Q10: Do you have any views or comments on our preliminary conclusions on radioactive substances permitting? If so, please use the box below to provide any details.

Q11: Do you have any views or comments on our preliminary conclusions on water abstraction? If so, please use the box below to provide any details.

Q12: Do you have any views or comments on our preliminary conclusions on discharges to surface waters and groundwater? If so, please use the box below to provide any details

Q13: Do you have any views or comments on our preliminary conclusions on the operation of installations? If so, please use the box below to provide any details.

Q14: Do you have any views or comments on our preliminary conclusions on the control of major accident hazards? If so, please use the box below to provide any details.

Q15: Do you have any views or comments on our preliminary conclusions on the overall acceptability of the design? If so, please use the box below to provide any details.

Q16: Do you have any overall views or comments on our assessment, not covered by previous questions? If so, please use the box below to provide any details.

Confidentiality

Please identify any parts of your response that you consider to be confidential:

And provide your reasons:

Decision document

Would you like to receive a copy of our decision document when it is available?

Yes

No

Natural Resources Wales Customer Care Centre 0300 065 3000 (Mon-Fri, 9am-5pm)

Our Customer Care Centre handles everything from general enquiries to more complex questions about registering for various permits and can provide information about the following topics:

- water and waste exemptions
- lower and upper tier carrier and broker registrations
- hazardous waste registrations
- fish net licences
- cockling licences
- water resources permit applications
- waste permit applications
- water quality permit applications
- permit applications for installations
- marine licence applications
- planning applications
- publications

Email

enquiries@naturalresourceswales.gov.uk

By post

Natural Resources Wales
c/o Customer Care Centre
Ty Cambria
29 Newport Rd
Cardiff
CF24 0TP

Incident Hotline 0800 80 70 60 (24 hour service)

You should use the Incident Hotline to report incidents such as pollution. You can see a full list of the incidents we deal with on our report it page.

Floodline 0345 988 1188 (24 hour service)

Contact Floodline for information about flooding.
Floodline Type Talk: 0345 602 6340 (for hard of hearing customers).

Would you like to find out more about us or about your environment?

Then call us on
03708 506 506 (Monday to Friday, 8am to 6pm)

email
enquiries@environment-agency.gov.uk

or visit our website
www.gov.uk/environment-agency

incident hotline 0800 807060 (24 hours)
floodline 0345 988 1188 (24 hours)

Find out about call charges: www.gov.uk/call-charges

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