Environment Agency

Generic design assessment

UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA

Consultation document

We are the Environment Agency. It's our job to look after your environment and make it **a better place** - for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

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Foreword

I'm pleased to introduce this consultation document inviting your comments on EDF and AREVA's UK EPR reactor design and the views that we have formed of it so far during our Generic Design Assessment (GDA) programme. Your comments will help inform our decisions about whether we should issue a Statement of Design Acceptability and, if so, what its caveats should be. We have also published the equivalent document and begun consulting on the AP1000 design, the other reactor design in the GDA programme submitted by Westinghouse.

We and the Health and Safety Executive are independent regulators conducting robust assessments. When we jointly developed the GDA process and started these assessments about three years ago, our key objectives were:

- to have early influence on potential reactor designs that might be built in the UK so that we could be confident that they would meet the high standards that we require of safety, security, environment protection and waste management;
- to provide potential developers and investors in any new nuclear stations with our views about the designs, so reducing the associated regulatory risks;
- by assessing and influencing designs early, to help to ensure that any developments can achieve their project timescales and costs because they would be more fully specified before significant construction;
- to establish, subject to normal national and commercial security constraints, an open and transparent process of assessment; and
- to build a professional and synergistic working relationship between the nuclear regulators as we worked jointly to develop, implement and carry out our GDA process.

So far, the GDA programme has been successful and we are making very good and timely progress towards these objectives. In March 2008 we and HSE jointly published our preliminary assessment of the reactor designs. We also established our public involvement process so that questions about the designs could be posed to and answered by the reactor designers. We see both questions and answers and can use these to help inform our assessments. In November 2009 HSE published its "Step 3" reports on the UK EPR and AP1000 designs. We also publish joint quarterly reports on our assessment progress indicating any concerns we have.

Publishing this document and consulting on the Environment Agency findings so far continues this good progress. In our assessments, we have identified some areas where more work is required by the reactor designers to provide further information and resolve technical issues. We are confident that these areas are resolvable and that they 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 we very much welcome your comments on both reactors and we look forward to hearing from you.

David Jordan

Director of Operations, Environment Agency, June 2010

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Executive summary

Introduction to GDA

1 As the leading organisation working to protect the environment, it is the Environment Agency's role to regulate discharges and waste disposals from nuclear power stations in England and Wales and ensure their impact on air, water and land is minimised.

2 In response to growing interest in nuclear power and potential applications to build new nuclear power stations in England and Wales, we have been working on a new approach, Generic Design Assessment (GDA), for assessing the environmental impacts of new reactor designs. GDA means that we assess the acceptability of the generic environmental aspects and the nuclear reactor design before individual site applications are made. This approach allows us to get involved at the earliest stage where we can have most influence and where lessons can be learned for site specific applications. It also gives us additional time to address regulatory and technical issues with designers and potential operators.

3 The new GDA approach has given us the opportunity to work more closely with the Health and Safety Executive (HSE), providing effectively a 'one-stop-shop' for nuclear regulation. The process is allowing a rigorous and structured examination of detailed environmental, safety and security aspects of the reactor designs over approximately four years. We believe that GDA is improving efficiency both for the Regulators and the nuclear industry, and delivering greater protection for both people and the environment. GDA cannot provide a complete assessment of a final "site-specific" design as there will be other issues, operator specific or site related, that we would expect to be considered during the environmental permitting and site licensing stages.

4 We are conducting our GDA work in an open and clear way and will communicate with industry, academics, trade unions, non-Governmental Organisations and other interested groups and individuals throughout the process.

5 GDA is in two stages: the preliminary assessment and detailed assessment. We completed the preliminary assessment and published our findings in March 2008.

6 Electricité de France SA and AREVA NP SAS (EDF and AREVA) submitted their UK EPR nuclear power plant design for generic design assessment in August 2007. They published the submission on their website (http://www.epr-reactor.co.uk) and invited people to comment. The submission has been revised during GDA, the current version on the website is up to date and is the basis of our detailed assessment.

7 Based on our past experience, authorising the disposal and discharge of radioactive waste is the area of regulation that has the highest profile; the greatest perceived uncertainties and the longest lead-time for our permitting of new nuclear power stations. For those reasons, our GDA focuses mainly on radioactive waste issues, although we have also looked at aspects of the design that relate to other areas such as abstraction and discharges to water, pollution control issues, as well as management of non-radioactive waste.

8 This consultation document summarises our detailed assessment findings so far on environmental aspects of the UK EPR nuclear power plant design. Our output from the GDA will be a public statement of our conclusions. If we are content with the environmental aspects of the design, that it should meet the high standards we expect, we will issue an Environment Agency statement of design acceptability (SODA). If we are not content we will not issue a SODA. We will use the comments and issues raised in this consultation to help inform our decisions.

9 When we issued our guidance on GDA in 2007, we envisaged that when we came to a decision on the acceptability of a reactor design, we may need to attach caveats. Previous experience in similar projects has also shown that it is not unusual for industry to take significant time to completely resolve some of the technical issues raised by regulators, in view of the need for new analysis, tests or research, etc., to be carried out or for the design detail to be completed. Also, there will be some

requirements for commissioning tests, maintenance schedule, and operating rules, etc., that can only be fully addressed by a future operator. In these instances, a ‘satisfactory’ response to a technical issue for the GDA could be one where the matter is not fully resolved or confirmed If any of the issues are considered by regulators to be particularly significant, but still resolvable, then these would be identified as GDA Issues. In these cases the Statement of Design Acceptability would be labelled as ‘Interim’, and we will expect the Requesting Parties to produce a Resolution Plan that identifies how the Issue would be addressed and closed out. At this stage of consultation, Resolution Plans have not been prepared.

10 We have also identified in our consultation document any other issues and assessment findings that we would expect to be addressed during site permitting and licensing, reactor procurement, design development, construction, or commissioning.

11 When all GDA Issues have been addressed to our satisfaction then the Interim status of the GDA outcomes would be reviewed and, if appropriate, a final Statement of Design Acceptability would be provided, together with a report describing the basis of the GDA Issue resolution. Only when all GDA Issues related to the SODA have been addressed to our satisfaction will we confirm to HSE that we are content it considers providing Consent to start nuclear safety related construction of the reactor.

12 Should a SODA be issued, the design and safety case will continue to evolve as the detailed design progresses and site-specific applications are developed. We would expect that the generic reactor design submitted for GDA and the SODA will be used to underpin the permissions to construct a fleet of reactors identical except for site-specific requirements and the requirements of different operators.

Our findings so far, pending consultation

13 We have now carried out a detailed assessment of EDF and AREVA’s submission for the UK EPR nuclear power plant design and our conclusion, pending consultation, is that we could issue an interim statement of design acceptability for the UK EPR. This is subject to a number of potential GDA Issues covering the following areas:

Potential GDA Issues

a) Decommissioning of the UK EPR.

b) Disposability of spent fuel following longer term interim storage pending disposal.

14 From our assessment so far, we have also identified other issues covering the following areas:

Other issues

a) The changes to the ‘reference case’ for the site-specific strategy and evidence that the site-specific strategy achieves the same objectives shall be provided at site-specific permitting.

b) Zinc injection as an option for the UK EPR to aid corrosion control.

c) Assessment of the removal of secondary neutron sources (to further minimise creation of tritium) when EPR operational information becomes available.

d) Review of the Best Available Techniques (BAT) assessment on the minimisation of the production of activated corrosion products, where possible improvements were identified in the PCER.

e) Providing the design of certain discharge tanks with associated demonstration of BAT for size and leak-tight construction.

f) Providing a BAT assessment to demonstrate that controls on the fuel pool minimise the discharge of tritium to air.

g) The sizing of filters and the demineralisation system in the liquid waste processing system.

h) Disposability of intermediate level radioactive waste (ILW) following longer term interim storage pending disposal.

i) If smelting of any low level waste (LLW) is pursued at site-specific permitting, demonstrating that the conditions of acceptance of any available smelting facilities can be met.

j) If incineration is pursued at site-specific permitting for certain waste streams, demonstrating that the conditions of acceptance of any available incineration facilities can be met.

k) Evidence at site-specific permitting that specific arrangements for minimising low and intermediate level radioactive waste (LLW and ILW) exist.

l) The monitoring of gaseous, aqueous and solid discharges and disposals of radioactive waste.

15 We have provided a draft interim statement of design acceptability in Annex 1 to help inform this consultation. We also seek views on our proposed limits for radioactive waste discharges.

16 Some of our GDA Issues and other issues are the subject of ongoing assessment by HSE in its GDA Step 4 assessment, which may raise further issues that could affect our conclusions.

<u>What next?</u>

17 This consultation seeks your views on our preliminary conclusions following our detailed assessment so far of the EDF and AREVA UK EPR new nuclear plant design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

18 We want to hear from members of the public, industry, non-Governmental organisations (NGOs) or any other organisation or public body.

19 This 16 week consultation began on 28 June 2010 and will close on 18 October 2010. Please send your response to arrive by 18 October 2010.

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

Online Visit our website at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda.

21 You can also submit a response by email, letter or fax. It would help us if you would send your comments using the form provided in Annex 8 of the main consultation document. Send them to:

Email: gda@environment-agency.gov.uk

Post: Sue Riley
Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria CA11 9BP

Fax: 01768 865606

22 We will publish all responses to our consultation before the end of 2010 and summarise our progress with HSE in our quarterly reports, which we will continue to place on our joint website (www.hse.gov.uk/newreactors).

23 We will consider all the responses to our consultation and HSE's assessment before coming to a final decision on the acceptability of the UK EPR. We will publish our final conclusions, having carefully considered all comments received, in our decision document that we intend to publish in June 2011.

1 About this consultation

24 The purpose of this consultation document is to:

a) explain the pre-consultation findings of the Environment Agency's assessment of a new nuclear power plant design, the UK EPR, by Electricité de France SA and AREVA NP SAS (EDF and AREVA) (the 'requesting party');

b) seek your views on the design and our assessment so far of the design.

25 The Health and Safety Executive (HSE) is also assessing the UK EPR, from a safety and security viewpoint. Although we work closely with HSE, this consultation is only about the Environment Agency's assessment and not HSE's. If we receive any consultation responses that raise safety or security issues, we will pass them to HSE.

1.1 About this document

26 This document provides:

a) An introduction to our role in nuclear regulation and the basis for GDA (chapter 3);

b) An outline of the UK EPR design (chapter 4);

c) A guide to our detailed assessment (chapter 5)

d) Our GDA conclusions with our consultation questions, followed by our detailed assessment (chapters 6 to 15);

e) Our overall conclusion (chapter 16)

f) Annexes supporting the consultation document (Annexes 1 to 8).

27 A full list of consultation questions is found in chapter 2 as well as throughout the individual chapters.

1.2 Invitation to comment

28 This consultation seeks your views on our preliminary conclusions following our detailed assessment of the EDF and AREVA UK EPR new nuclear plant design. We will carefully consider your views in reaching our decision on whether to issue a statement of design acceptability.

29 We want to hear from members of the public, industry, non-Governmental organisations (NGOs) or any other organisation or public body.

30 When responding please state whether you are responding as an individual or representing the views of an organisation.

31 This 16 week consultation began on 28 June 2010 and will close on 18 October 2010. Please send your response to arrive by 18 October 2010.

1.3 How to respond

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

Online

33 Visit our website at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda. The online consultation has been designed to make it easy to submit responses to the questions. We would like you to register so you can respond online. This will help us to gather and summarise responses quickly and accurately. To do this you must first log in or register if you have not yet done so already.

By email, letter or fax

34 You can also submit a response by email, letter or fax. It would help us if you would send your comments using the form provided in Annex 8. Send them to:

Email: gda@environment-agency.gov.uk

Post: Sue Riley
Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria CA11 9BP

Fax: 01768 865606

Timescale

35 This 16-week consultation began on 28 June 2010 and will close on 18 October 2010. Please send your response to arrive by 18 October 2010.

1.4 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 EPR.

We may refer to any comments / issues raised by you in our decision document and in other Environment Agency documents related to GDA for the UK EPR, unless you have specifically requested that we keep your response confidential. We may also publish all responses after the consultation has closed. 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 (see 1.5 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.

1.5 Freedom of Information Act

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). If you want us to treat the information that you provide as confidential, please be aware that, under the FOIA, 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.

1.6 Consultation events

36 A stakeholder seminar is due to be held on 6 July 2010 to share our findings and preliminary views from our assessment and seek feedback. A programme of communications and stakeholder engagement is underway and will continue during the consultation period. We will do our best to respond positively to requests to attend meetings and other events.

1.7 What happens next?

37 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.

38 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 EPR. We will publish a document that:

a) sets out our decision;

b) summarises the consultation responses and issues raised;

c) sets out our views on those issues.

We expect to do this by June 2011.

1.8 Consultation Code of Practice

39 We are running this consultation in accordance with the criteria set out in the Government's Code of Practice on Consultation (see Annex 6).

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

Cath Beaver, Consultation Co-ordinator
Environment Agency, Rio House
Waterside Drive, Aztec West
Almondsbury, Bristol BS32 4UD
Email: cath.beaver@environment-agency.gov.uk

2 Consultation questions

41 Below is a list of questions that we are asking for responses to as part of this consultation on the UK EPR design:

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

1. management systems?
2. the radioactive waste and spent fuel strategy?
3. best available techniques to minimise the production of radioactive waste?

4a. best available techniques to minimise the gaseous discharge of radioactive waste?

4b. our proposed annual disposal limits?

4c. our proposed gaseous quarterly notification levels?

5a. best available techniques to minimise the aqueous discharge of radioactive waste?

5b. our proposed annual disposal limits?

5c. our proposed aqueous quarterly notification levels?

6. solid radioactive waste?
7. spent fuel?
8. monitoring of disposals of radioactive waste?
9. the impact of radioactive discharges?
10. the abstraction of water?
11. discharges of non-radioactive substances to water?
12. pollution prevention for non-radioactive substances?
13. Environmental Permitting Regulations 2010 (EPR 10) Schedule 1 activities?
14. non-radioactive waste?
15. Control of Major Accident Hazards (COMAH) substances?
16. the acceptability of the design?
17. Do you have any overall views or comments to make on our assessment, not covered by previous questions?

3 Introduction

3.1 The Environment Agency

43 Our corporate strategy **Creating a better place 2010-2015** (Environment Agency, 2009b) sets out our aims and describes the role we will play in being part of the solution to the environmental challenges society faces.

44 Our strategy aims to create a better place by securing positive outcomes for people and wildlife, in five key areas. We will:

a) act to reduce climate change and its consequences;

b) protect and improve water, land and air;

c) work with people and communities to create better places;

d) work with businesses and other organisations to use resources wisely;

e) be the best we can.

3.2 Our role in nuclear regulation

45 We regulate the environmental impacts of nuclear sites (such as nuclear power stations, nuclear fuel production plants, plants for reprocessing spent nuclear fuel) 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 lifecycle.

46 The permits we issue can include conditions and limits. In setting these, we take into account all relevant national and international standards and legal 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:

http://www.defra.gov.uk/environment/policy/permits/index.htm

http://www.environment-agency.gov.uk/business/topics/permitting/32320.aspx

http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/government/legislation/legislation.aspx

http://www.environment-agency.gov.uk/business/sectors/32533.aspx

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

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

49 We work closely with the Health and Safety Executive (HSE), which regulates the safety and security aspects of nuclear sites.

3.3 Our regulatory role in the development of new nuclear power stations

50 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 plants 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.

51 In the first phase, generic design assessment (GDA), we carry out detailed assessments of candidate designs and, at the end, provide a statement about the acceptability of the design. We may attach caveats to the statement. We are in this phase now – this consultation document is about our assessment of the UK EPR design.

52 In the second phase, we would receive applications for environmental permits for specific sites. In determining these applications, we will take full account of the work we have done during GDA, so that our efforts will be focussed on operator and site-specific matters, including how the operator has addressed any caveats attached to the statement of acceptability.

53 For GDA, we have worked closely with HSE to assess areas where we have overlapping regulatory responsibility, including radioactive waste and spent fuel management, and management arrangements for control of design changes, and control of GDA submission documents.

3.4 Our input to the Government's facilitative actions on nuclear new build

54 We have provided specialist advice, where appropriate, and responded to consultations relating to the actions taken by Government to:

a) reduce the regulatory and planning risks associated with investing in new nuclear power stations;

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

55 These include:

a) **Strategic siting assessment** – this aims to identify those sites that are strategically suitable for the deployment of new nuclear power stations by the end of 2025. The selected sites would be listed in the Nuclear National Policy Statement (NNPS) (DECC, 2009b). This would provide the framework for decisions on planning consent (Development Control Orders) by the new Infrastructure Planning Commission[1]. At the time of writing, the Government has consulted on a draft NNPS.

b) **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. At the time of writing, the Government has consulted on its proposed decision that the AP1000 and UK EPR power stations are justified (DECC, 2009c).

c) **Funded decommissioning programme** – *The Energy Act 2008* 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. At the time of writing, the Government has consulted on draft funded decommissioning programme guidance (BERR, 2008b).

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[1] In the Coalition Agreement following the May 2010 General Election, the Government stated it will "abolish the unelected Infrastructure Planning Commission and replace it with an efficient and democratically accountable system that provides a fast-track process for major infrastructure projects." See http://www.cabinetoffice.gov.uk/media/409088/pfg_coalition.pdf

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3.5 About Generic Design Assessment (GDA)

56 GDA means that we assess the acceptability of the environmental aspects of an overall 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.

57 Our guidance (Environment Agency, 2007) sets out in detail the process that we follow during generic design assessment. It has six main elements:

a) **Initiation** – we make an agreement with the requesting party under section 37 of the Environment Act 1995 and receive a submission.

b) **Preliminary assessment** – we make an outline examination of the submission to find out if:

   i) we need further information;

   ii) there are any issues that are obviously unacceptable;

   iii) any significant design modifications are likely to be needed.

c) **Detailed assessment** – we examine the submission in detail to decide initially if we might issue a statement of design acceptability.

d) **Consultation** – we consult widely on our initial view. We produce a consultation document explaining our view and, if we consider that we might issue a statement of design acceptability, we may set out a draft template permit appropriate to the design.

e) **Post consultation review** – we carefully consider all relevant responses to the consultation.

f) **Decision and statement** – we decide whether we should issue a statement of design acceptability and, if so, what GDA Issues, if any, we should attach to it. We publish a document that provides the background to and basis for our findings.

58 The remainder of this chapter describes how we have applied this process, so far, to the UK EPR in GDA.

3.5.1 Initiation and preliminary assessment

59 Our process for the first stage of GDA for the UK EPR is described in our report on our preliminary assessment (Environment Agency, 2008a). In summary:

a) We set up an agreement with Electricité de France SA and AREVA NP SAS (EDF and AREVA) to carry out GDA of the UK EPR, which came into effect in July 2007.

b) The Joint Programme Office (JPO) received the EDF and AREVA submission in August 2007.

c) With HSE, we launched the 'public involvement process' in September 2007. This enabled the public to view and comment on this and three other submissions. (See: http://www.hse.gov.uk/newreactors/publicinvolvement.htm)

d) We carried out our preliminary assessment and concluded that we needed further information.

e) We raised a Regulatory Issue on EDF and AREVA in February 2008 setting out the further information that we needed.

f) We published our report on our preliminary assessment in March 2008.

g) EDF and AREVA completely revised their submission during 2008 and provided a Pre-construction environmental report (PCER) with supporting documents. They reviewed and updated the PCER in March 2010.

3.5.2 Detailed assessment

60 We began our detailed assessment in June 2008.

3.5.2.1 The submission

61 We have carried out our assessment using the information EDF and AREVA provided in the documents listed in Annex 5 (the 'submission'). These contain the additional information provided in response to our Regulatory Issue and in response to 31 Technical Queries and 4 Regulatory Observations that we raised during our detailed assessment.

3.5.2.2 Liaison with HSE (and other bodies)

62 We have worked closely with HSE throughout GDA. This enables us to achieve the right balance between environmental and safety issues in relation to radioactive waste. We have considered its Step 3 reports (available at http://www.hse.gov.uk/newreactors/reports.htm). Should any [further] relevant issues arise from its ongoing GDA (Step 4), we expect that HSE will identify them in its response to this consultation.

63 We have also liaised with the Food Standards Agency and the Health Protection Agency on matters relating to the assessment of doses to members of the public. We have maintained contact with Natural England in light of its interest in the assessment of the impact on non human species and with the Nuclear Decommissioning Authority in light of its interest in the disposability of solid radioactive waste. We will also be consulting with these organisations as part of GDA.

3.5.2.3 Public involvement process

64 The opportunity for the public to access information about the UK EPR, submit comments and receive responses from the requesting parties, has remained available throughout the detailed assessment stage.

65 We have encouraged the requesting parties to make it easier for people to access their design information. EDF and AREVA relaunched their website in Autumn 2009. The design information on their website has been updated at intervals and contains all the information provided to the Regulators except that which is commercially confidential or subject to national security restrictions.

66 We have continued to raise awareness of GDA and the opportunity for the public to comment through:

a) relaunch of the Regulators' website (www.hse.gov.uk/newreactors) in March 2009, providing more information in a more user-friendly way;

b) meeting with or holding events for key stakeholder groups (including non-governmental organisations, local authorities, local community liaison committees / site stakeholder groups for existing nuclear sites);

c) attending stakeholder events organised by the Department of Energy and Climate Change (DECC) as part of its consultation on the draft Nuclear National Policy Statement;

d) targeting nuclear and energy academics and trade unions;

e) providing media articles and adverts, and publicising our work at national and local events.

67 Where they relate to our areas of interest, our detailed assessment has taken account of comments received up to 1 April 2010, and EDF and AREVA's responses to those

comments – see Chapters 6 - 15. We will address any comments on environmental issues we receive after this date alongside responses to this consultation.

68 Comments received about the public involvement process itself are addressed in a report published at the end of 'Step 3' of HSE's assessment (HSE, 2009b). A similar report will be published at the end of 'Step 4'. The public involvement process remains available during the consultation period as HSE are still carrying out 'Step 4' of its assessment.

69 Copies of our stakeholder engagement strategy for nuclear new build and our national and local stakeholder engagement plans for the generic design assessment are available on request or from our joint website www.hse.gov.uk/newreactors/publicinvolvement.htm. Feedback on both is welcome.

3.5.2.4 Assessment reports

70 We have documented our detailed assessment in a series of assessment reports, which are listed in Annex 1 (Schedule 3). These are summarised in Chapters 6 – 15 of this document.

3.5.2.5 Draft statement of design acceptability

71 To help the consultation process, we have also included in this document (Annex 1) a draft statement of design acceptability for the UK EPR based on our initial (that is, before consultation) view.

72 Enough information needs to be submitted so that the Regulators can fully assess the design against our Radioactive Substances Regulation Environmental Principles and the HSE’s Safety Assessment Principles.

73 We acknowledge that some of the reactor designs that are taken through GDA may not be fully complete. This could mean that, after any GDA statement of design acceptability (SODA) or HSE design acceptance confirmation (DAC) are issued, parts of the design may continue to be developed and technical issues could arise that need to be addressed.

74 If a SODA or DAC are to be issued, the Regulators’ preference is to close-out all generic issues during the GDA detailed assessment steps so they can issue these ‘clean’ and without caveats.

75 Any of the design and environment / safety case details that are not supplied by the Requesting Parties (RPs), have to be considered as ‘out of scope’ for GDA. However, if we believe that this information should have been supplied as part of GDA, as it forms part of the requirements specified in our guidance documents (Environment Agency, 2007, HSE, 2008, and OCNS, 2007), then either we will not issue a SODA / DAC, or we may choose to identify this information as a GDA Issue to an Interim SODA / DAC (GDA Issues are discussed below).

76 It is important to note that our assessment can only be on the documentation that is provided and is, therefore, ‘within scope’ for GDA. The scope of what is included within GDA will be defined by the set of documents that form the GDA design reference. It is expected that, at the very least, the design reference information will match that which has to be submitted for GDA as set out in our guidance documents (Environment Agency, 2007, HSE, 2008, and OCNS, 2007).

3.5.3 Consultation

77 We are now in the consultation stage of our process, which runs from 28 June 2010 to 18 October 2010. We are consulting widely so that people can bring any issues to our attention. Before this consultation, we have not made any final decisions and will not do so until we have carefully considered all the responses.

3.5.4 Post consultation review

78 We will acknowledge all responses (see "How to respond" in chapter 1.3), but we will not generally enter into further correspondence with those who respond.

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

80 Where we need advice from other organisations that have expertise on specific topics, we will seek the expert views of the Government department or official public body concerned, for example, the Radiation Protection Division of the Health Protection Agency – the Government's adviser on radiological protection. Similarly, if necessary, we will seek further information or clarification from the Requesting Party.

3.5.5 Decision and statement

81 In the light of all the information obtained, including that received during and after consultation, we will decide whether to issue a statement of design acceptability and what GDA Issues should be attached to it.

82 We will publish a document that:

a) sets out the basis for our decision;

b) summarises the consultation responses and issues raised;

c) sets out our views on those issues and how they have informed our decision making. Where specific input is not taken on, we will identify why.

3.6 End of GDA detailed assessment steps

83 The output from the GDA detailed assessment steps will be a public statement from the Regulators on their conclusions. For the Environment Agency, this will be a decision document following our consultation.

84 There could be three different outcomes:

a) If we are fully content with the environmental aspects of the design safety case then we will provide the RP with an Environment Agency Statement of Design Acceptability (SODA). However, there may still be other issues arising from our assessment that need to be carried forward for future resolution in later safety case submissions.

b) If we are largely content with the environmental aspects of the design then we will provide the RP with an Environment Agency Interim Statement of Design Acceptability and identify the outstanding GDA Issues. These outstanding GDA Issues need to be cleared before a final Statement of Design Acceptability can be provided.

c) If we are not content with the environmental aspects of the design then no Statement of Design Acceptability will be provided to the RP. This would be the case where we judge that there is an unacceptable shortfall in the design or safety submissions (i.e. where the issues are very significant). However, the RP could still propose to undertake subsequent additional work to address the shortfalls and this might allow a Statement of Design Acceptability to be provided at some future date.

85 If our assessment of the design is generally positive but some environmental concerns remain, these will be identified when we issue the SODA. The concerns will be identified and we are calling them GDA Issues to the SODA. The RPs can make sure that they minimise the number of Issues by supplying quality and detailed GDA submissions, along with timely and full responses to the issues we raise.

86 The Regulators have recently issued further guidance on the Management of GDA Outcomes (including GDA scope, our SODA, HSE's Design Acceptance Confirmation (DAC) and GDA Issues) and this is available on the joint regulators website: www.hse.gov.uk/newreactors (Joint Regulators, 2010).

3.6.1 Environment Agency statement of design acceptability

87 Our statement of design acceptability will state our view on the acceptability of the design to be permitted, under the relevant environmental legislation, for:

a) the disposal of radioactive waste (gaseous, aqueous and solid);

b) the discharge of non-radioactive substances to water;

c) the operation of conventional plant (for example, combustion plant used as auxiliary boilers), where applicable;

d) the disposal or recovery of non-radioactive waste, where applicable;

e) the abstraction of water from inland waters or groundwater, where applicable.

88 Our view on the acceptability of the design with respect to the environmental requirements of the COMAH regulations will also be stated.

89 If we provide an Interim Statement of Design Acceptability, it will still mean that we are confident that the design is capable of being built and operated in the UK in a way that is environmentally acceptable, but that there are some GDA Issues that we want to see further progressed before HSE consideration be given to providing Consent[2] to start nuclear safety related construction of the reactor.

90 The Statement of Design Acceptability will refer to the Final GDA Submission (environment submissions and the Design Reference) as the basis of what has been included within the scope of GDA.

3.6.1.1 GDA Issues

91 The ultimate output from the GDA assessment will be our Decision Document following consultation and, if appropriate, a Statement of Design Acceptability.

92 Previous experience in similar projects has shown that it is not unusual for industry to take significant time to completely resolve some of the technical issues raised by regulators, in view of the need for new analysis, tests or research, etc., to be carried out or for the design detail to be completed. Also, there will be some requirements for commissioning tests, maintenance schedule, and operating rules, etc., that can only be fully addressed by a future operator. In these instances, a 'satisfactory' response to a technical issue for the GDA could be one where the matter is not fully resolved or confirmed, but regulators judge it is acceptable for it to be carried forward for future resolution.

93 It might then be appropriate for us to allow the project to proceed in a controlled manner, If any of the issues are considered by regulators to be particularly significant, but still resolvable, then these would be identified as GDA Issues. In these cases the Statement of Design Acceptability would be labelled as 'Interim', and we will expect the Requesting Parties to produce a Resolution Plan that identifies how the Issue would be addressed and closed out. At this stage of consultation, Resolution Plans have not been prepared.

94 We have also identified in our consultation document any other issues and assessment findings that we would expect to be addressed during site permitting and

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[2] A Consent is required before the nuclear site licensee can carry out certain activities identified in the licence or other activities which HSE has the power to specify. For example, a Consent from HSE is required before a reactor is allowed to be started up again following a periodic shutdown. In order to secure a Consent the licensee must satisfy HSE that the proposed action is safe and that all procedures necessary for control are in place. See http://www.hse.gov.uk/nuclear/silicon.pdf

licensing, reactor procurement, design development, construction, or commissioning. Following review in the light of relevant consultation responses, these would also be identified in our Decision Document at the end of GDA, together with an indication of the point before which they will need to be cleared during the reactor procurement, design development or construction programme.

95 Any issues identified will not come as a surprise to the RP. The subject areas in which they might arise will be discussed with the RP during our assessment and every opportunity given for them to be cleared at an early stage. For additional transparency, we will identify the most significant issues within our public quarterly joint progress reports.

96 When all GDA Issues have been addressed to our satisfaction then the Interim status of the GDA outcomes would be reviewed and, if appropriate, a final Statement of Design Acceptability would be provided, together with reports describing the basis of the GDA Issue resolution. As noted above, only when all GDA Issues have been addressed to the satisfaction of HSE and Environment Agency will consideration be given to providing Consent to start nuclear safety related construction of the reactor.

3.7 Regulatory basis for GDA

97 The SODA is provided as advice to the RP, in accordance with section 37 of the Environment Act 1995, and 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.

98 The Environment Agency regulates several aspects of the operation of nuclear power stations in England and Wales. Previously, this was done under a number of regulatory regimes, but many of these have now been drawn together into a single permitting and compliance system known as 'Environmental Permitting'. (Further information on the environmental permitting programme is available on the Defra website, http://www.defra.gov.uk/environment/policy/permits/index.htm).

a) The disposal of radioactive waste requires a permit under *The Environmental Permitting (England and Wales) Regulations 2010* (EPR 10) (previously, an authorisation under *The Radioactive Substances Act 1993* (RSA 93) was required).

b) The discharge of aqueous effluents (such as from cooling or dewatering during construction) requires a permit under EPR 10 (previously, a consent under *The Water Resources Act 1991* (WRA 91) was required).

c) Some conventional plant (for example, combustion plant used as auxiliary boilers and emergency standby power supplies, and incinerators used to dispose of combustible waste) may require a permit under EPR 10 (before 1 April 2008, a permit under *The Pollution Prevention and Control Regulations 2000*, Statutory Instrument 2000 No. 1973 (PPC 00) may have been required).

d) The disposal of waste by depositing on or into land, including excavation materials from construction, and other waste operations may require a permit under EPR10 (before 1 April 2008, a permit under PPC 00 or a licence under part II of *The Environmental Protection Act 1990* may have been required).

99 The abstraction of water (for example for cooling or process use) from inland waters or groundwater, except in some specific circumstances, requires a licence under WRA 91. Inland waters include rivers, ponds, estuaries and docks, amongst others.

100 The Environment Agency and HSE together form the competent authority for *The Control of Major Accident Hazards Regulations 1999*, Statutory Instrument 1999 No. 743 (COMAH 99). On-site storage of certain substances in large quantities may fall under these regulations.

101 Based on our past experience, permitting the disposal of radioactive waste is the area of regulation that has the highest profile, the greatest perceived uncertainties and the longest lead-time for our permitting of new nuclear power stations. For those reasons, our GDA focuses mainly on radioactive waste issues, although we also look at aspects of the design that relate to other regulatory issues.

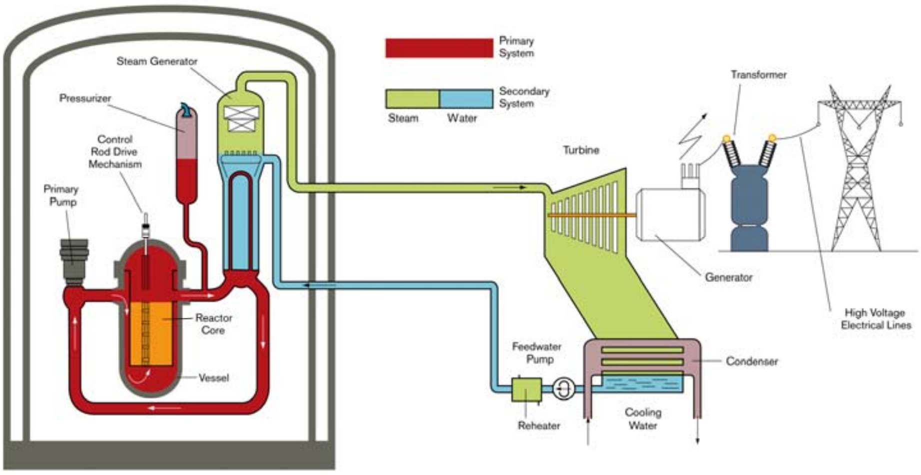
102 New nuclear power stations are likely to need new or enhanced flood defence structures. A flood defence consent will be needed to construct these but, as flood defence is necessarily site-specific, we have not considered this matter during GDA. HSE also considers flooding when assessing the safety of a nuclear reactor against external hazards.

4 The UK EPR design

103 This section provides a brief outline of the UK EPR design and how it is proposed that waste will be created, processed and disposed of.

4.1 Outline of design

104 The UK EPR design is for a single, pressurised water reactor (PWR) capable of generating in total 1735 megawatts (MWe) of electricity and providing 1630 MWe of this to the national grid. In the reactor core, the uranium oxide fuel (enriched up to 5 per cent of uranium-235) is cooled by water in a pressurised circuit, the primary circuit. This water also acts as the neutron moderator necessary for a sustained nuclear fission reaction. The primary circuit includes four steam generators where heat is transferred from the primary circuit to an isolated secondary circuit, producing steam. This steam then drives a turbine-generator to produce electricity, is condensed, and the condensate returned to the steam generators.



Simplified schematic of the EPR™ reactor (source AREVA)

105 The main ancillary facilities include a spent fuel pool, water treatment systems for maintaining the chemistry of the primary and secondary water circuits, standby diesel generators for providing power in the event of loss of grid supplies, and waste treatment and storage facilities. For GDA purposes, turbine condenser cooling water is provided by a once-through system using seawater.

106 The UK EPR design has evolved from combining experience from earlier separate PWR designs operating in France and Germany (77 operational plants). The most recent French design was the N4, brought into commercial operation in 1996 (Chooz B1). The most recent German design was the KONVOI, brought into commercial operation in 1989 (GKN-2). The EPR™ has undergone design assessment by the nuclear Regulators in Finland and France and has obtained construction licences. Four EPR™ plants are already being built: one at Olkiluoto in Finland; another one at Flamanville in France; and two at Taishan, China. Certification of the EPR™ reactor design is currently underway in the USA, where a number of power companies have chosen the EPR™ reactor for their new generation construction projects.

4.2 Sources, processing and disposal of radioactive waste

107 Radioactive waste would be produced by activities associated either directly or indirectly with operating and maintaining the reactor, and ultimately, from decommissioning the plant. In particular, operating a PWR generates radioactive substances in the water of the primary coolant circuit, which subsequently become waste.

108 Discharges of radioactive waste dissolved or carried in water (aqueous discharges) are produced mainly from effluents associated with systems for treating the primary circuit water or with drain systems. Other sources of effluent include the fuel pool purification system and washings from plant decontamination. Effluent treatment facilities include accumulation, hold up and monitoring tanks; filters; evaporation; degassing and demineraliser ion exchange resin beds. Facilities to sample and monitor aqueous waste before it is released are provided. Final discharge is to the sea combined with the cooling water.

109 The main source of gaseous radioactive discharges is from degassing the water in the primary circuit. This is directed to the gaseous effluent treatment system where waste gas is dried then passed through a line of three activated carbon delay beds (to allow noble gases to decay). After primary filtration, the waste gas is further filtered through high efficiency particulate air (HEPA) filters before being discharged after sampling and monitoring.

110 Gaseous activity will also be present in the main process buildings, which are serviced by the heating, ventilation and air-conditioning (HVAC) systems. Extracted air is passed through HEPA filtration systems and, if necessary, iodine traps before being discharged. There is also the possibility of radioactivity, particularly tritium, reaching the secondary circuit due to minor leaks from the primary circuit. Gases collected in the condenser vacuum system of the secondary circuit are directed to the HVAC system for HEPA filtration. All gaseous waste streams are collected for discharge through a common stack. Stack height is based on site-specific factors to give good dispersion, as a minimum it will be at the height of the reactor building (60 m). There is provision for sampling and monitoring gaseous wastes at various points in the treatment systems as well as at the final combined discharge stack.

111 Other radioactive waste created by the UK EPR includes spent ion exchange resins; spent filter media; worn-out plant components and parts; contaminated protective clothing and tools; rags and tissues and waste oil. These are collected in the solid waste treatment plant where basic conditioning is carried out so they can be disposed of off-site. Intermediate level waste (ILW) will need to be stored until disposal facilities are available.

112 EDF and AREVA do not expect that the UK EPR plants will generate any novel solid waste streams. Solid low level radioactive waste (LLW) from its operation will be suitable for disposal at the UK national LLW repository near Drigg in Cumbria.

113 Most radioactive plant components are likely to become waste when the plant is decommissioned. The strategy for disposing of decommissioning waste is described later in this document.

114 Spent fuel will be stored under water in the spent fuel pool for about 10 years. The options for longer term management are described later in this document.

4.3 Non-radioactive waste

115 Non-radioactive waste is produced from operating and maintaining the plant. It includes:

a) combustion gases discharged to air from the diesel generators;

b) water containing water-treatment chemicals from the turbine-condenser cooling system; other non-active cooling systems and the secondary circuit purge, which is discharged to the sea;

c) waste lubricating oils;

d) screenings from sea inlet filters;

e) worn-out plant and components and general rubbish.

116 Non-radioactive substances will also be present in the radioactive waste and may affect how that waste is managed or the impact it has on the environment. For example, aqueous radioactive discharges will contain boron compounds. Boron (a neutron absorber) is added to the primary coolant circuit to help control reactivity in the core.

5 Guide to our detailed assessment

117 In the following chapters 6 to 15 we set out our preliminary conclusions, subject to the outcome of this consultation, and our consultation questions followed by our detailed assessment for:

a) Management Systems (chapter 6);

b) Radioactive Substances Regulation:

   i) Integrated Waste Strategy (chapter 7)

   ii) Best Available Techniques to minimise production of radioactive waste (chapter 8)

   iii) gaseous radioactive waste disposal and limits (chapter 9)

   iv) aqueous radioactive waste disposal and limits (chapter 10)

   v) solid radioactive waste (chapter 11)

   vi) spent fuel (chapter 12)

   vii) monitoring of radioactive disposals (chapter 13)

   viii) impact of radioactive discharges (chapter 14)

c) other environmental regulations (chapter 15).

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

a) identify any matters that would be GDA Issues attached to our statement of design acceptability, if we decide to issue one. These GDA Issues may be due to:

   i) EDF and AREVA failing to provide enough information for our assessment (for example, because an aspect of the design is not complete);

   ii) a technical issue raised by our assessment not being fully resolved or confirmed.

b) identify any other issues that would need to be cleared at an appropriate point during the reactor procurement, design development or construction programme. The other issues may relate to:

   i) matters that are normally addressed during the construction or commissioning phase of a plant (for example, demonstration that as-built plant realises the intended design);

   ii) matters that depend on site-specific characteristics.

119 Our detailed assessment took account of the legal and policy issues set out in our considerations document (Environment Agency, 2009c), where practicable at the generic level. Our considerations document was superseded with the introduction of the Environmental Permitting Regulations (EPR 10) in April 2010 and the issue of related guidance documents. We will review our assessment against the EPR 10 guidance before we publish our final decision in June 2011.

120 As part of our agreed GDA process with the Requesting Parties, we agreed a mechanism for raising concerns and / or requesting further information. This mechanism works on a tiered approach depending on the severity of our concern:

a) **Technical Query** (TQ): A request for clarification or further information resulting from the inspection / assessment process. A Technical Query is not a Regulatory Observation or a Regulatory Issue, but may result in an Observation or Issue being raised by the Regulators to the Requesting Party where the query cannot be satisfactorily resolved.

b) **Regulatory Observation** (RO): An assessment finding that requires further justification by and / or discussion with the Requesting Party and further assessment by the Regulators in the expectation that it can be resolved to the satisfaction of the Regulators. A Regulatory Observation that has not been satisfactorily resolved may, at the discretion of a regulator, be converted to a Regulatory Issue (RI).

c) **Regulatory Issue** (RI): In the judgement of the Regulators a finding or concern for which, for the design submitted and the mode of operation proposed, the Requesting Party has not demonstrated (or may not be able to demonstrate) that risks will be reduced as low as reasonably practicable (ALARP), or that regulatory requirements are met, or that the best available techniques (BAT) will be used to minimise the arisings and impact of conventional and radioactive waste, and which is important enough that it would prevent GDA being successfully completed or lead to a GDA Issue.

121 We found that the initial submission did not contain the level of information we needed to carry out a detailed assessment. We raised a Regulatory Issue on EDF and AREVA and they committed to providing further information. In fact, they provided a completely revised submission, their 'Pre-construction environmental report' (PCER) with supporting documents. They have published the PCER and other documents on their website (http://www.epr-reactor.co.uk).

122 During our assessment of the PCER, we had some concerns and needed some additional information. We raised 4 ROs and 31 TQs on EDF and AREVA. The responses to these ROs and TQs were incorporated into revisions of the PCER and some additional supporting documents, as now available on the website noted above.

123 We are now consulting on the outcome of our detailed assessment of the information contained in the revised submission. The documents comprising the submission are listed in Annex 5. We reference most frequently to the following documents:

a) Pre-construction environmental report (PCER);

b) Pre-construction safety report (PCSR);

c) GDA UK EPR integrated waste strategy document (IWS);

d) GDA UK EPR BAT demonstration (EPRB);

e) UK EPR solid radioactive waste strategy report (SRWSR).

124 More details of our assessment can be found in our assessment reports. These are listed in Annex 1 (Schedule 3).

125 The White Paper on Nuclear Power (BERR, 2008a, paragraph 2.87) states that:

> ‘The environment agencies will ensure that radiation exposure of members of the public from disposals of radioactive waste, including discharges, are as low as reasonably achievable (ALARA) by requiring new nuclear installations to use the best available techniques (BAT) to meet high environmental standards. This will help ensure that radioactive wastes created and discharges from any new UK nuclear power stations are minimised and do not exceed those of comparable power stations across the world.’

126 Annex 3 of this Consultation Document presents an analysis of discharge data from predecessor nuclear power stations, so that we can make a comparison with the predicted discharges from the UK EPR. However, it is important not to draw comparisons too closely as there are many uncertainties in the datasets. For example, the published results:

a) Are the results of measurement - albeit to differing standards, or are derived from calculations of predicted discharges;

b) treat limits of detection in different ways;

c) are taken from reports to differing formats; and,

d) should not be compared with other data without establishing how those were obtained and reported e.g. Germany only requires the measuring and reporting of carbon-14 in CO_2 form.

127 The public involvement process has been available throughout our assessment. We addressed those comments we received before 4 January 2008 in our preliminary assessment report. We have considered comments we received since then during our detailed assessment, and refer to these in the relevant sections of chapters 6 – 15.

128 We set out our overall preliminary conclusion on design acceptability in chapter 16.

6 Management systems

129 We conclude that EDF and AREVA have an appropriate management system in place to:

a) control the content and accuracy of the information provided for GDA;

b) maintain records of design and construction;

c) control and document modifications to the design.

130 We conclude that EDF and AREVA have adequately specified:

a) its expectations for any operating utility's management system;

b) how it expects to transfer knowledge and provide continuing support to any operating utility.

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

6.1 EDF and AREVA's management system

131 We examined EDF and AREVA's management system in some detail during our preliminary assessment in 2007-8 and concluded that it was suitable for controlling the content and accuracy of the information EDF and AREVA have provided to us for GDA (Environment Agency, 2008a). There were, however, some matters that we felt could be improved and we made recommendations for improvement during our joint Regulators' inspection in 2007 for EDF and AREVA to consider.

132 EDF and AREVA responded positively to the recommendations of the joint Regulators' inspection of December 2007. EDF and AREVA's progress in implementing the recommendations was discussed during the joint Regulators' inspection in April 2009. EDF and AREVA advised the joint Regulators of appropriate changes to the project organisation and supporting instructions and procedures:

a) The role of the GDA steering committee in providing governance to the GDA committee was presented by EDF and AREVA, and discussed during the joint Regulators' inspection in April 2009. PCER Sub-Chapter 2.1, Project Organisation, describes the role of the steering committee and shows the interfaces in relation to the project organisation.

b) The EDF and AREVA project team considered the formal tracking of regulatory issues. The project instruction for management of regulatory issues for the UK EPR GDA project has been regularly reviewed and updated, and outlines roles and responsibilities for responding to and progressing Regulatory Issues.

133 Our conclusion is that EDF and AREVA responded positively to the joint Regulators' inspection recommendations and have implemented changes to reflect the suggested improvements.

134 During the detailed assessment stage, we have kept EDF and AREVA's management arrangements under review. Our assessment of management arrangements has involved reviewing EDF and AREVA's GDA submissions and arrangements for quality management, in particular the overarching project quality assurance plan. A significant part of our assessment activity has involved inspection to review the application of EDF and AREVA's arrangements to the UK GDA project, and to identify evidence that it has effectively implemented arrangements.

135 Our review of EDF and AREVA's GDA submissions included the overarching project quality assurance plan (PQAP) produced by the joint project team, established by the two co-applicants EDF and AREVA. The PQAP describes the detailed arrangements in place to produce the GDA submissions for the UK EPR design, including the PCER and PCSR, and for the development of responses to Regulatory Issues, Regulatory Observations and Technical Queries issued by the Regulators, and for responding to the public involvement process.

136 The PQAP is supported by the quality and environment management systems of the co-applicants and their sub-contractors. The management systems comply with internationally recognised standards and are externally audited. The PQAP is supported by a number of joint project instructions and procedures that were specifically developed for the UK EPR GDA project. These include arrangements for control of documents, data and records, design change, management responsibility, and resource management. The PQAP was revised in November 2008 to reflect developments in the project organisation and associated documents and instructions.

137 The joint Regulators carried out a further inspection during the detailed assessment stage of GDA in April 2009. This was followed by a quality assurance topic specific meeting in July 2009. The inspection focused on and re-examined the arrangements for controlling modifications to the UK EPR design; configuration control for GDA submission documents and arrangements for transmitting submission documents to the Regulators, internal, external and third party certification audits; learning from experience; and procurement arrangements.

138 The joint Regulators made a number of recommendations that they discussed with EDF and AREVA during the 2009 inspection. The joint Regulators' inspection report was published in 2009 and can be found at http://www.hse.gov.uk/newreactors/reports.htm.

139 The joint Regulators' conclusion from the inspection was that:

a) EDF and AREVA continue to manage and operate joint activities in support of GDA in a professional way.

b) These joint activities are defined in the UK EPR project quality plan and are implemented through the related procedures.

c) The joint project arrangements are supported by well-established quality management systems operated separately by EDF and AREVA.

d) There were no major issues identified during the joint inspection and so the joint Regulators have confidence in EDF and AREVA GDA project arrangements.

140 We issued two ROs following our April 2009 inspection. We raised a number of aspects for EDF and AREVA to consider, including clarifying the role of the independent nuclear safety assessment process (INSA) as applied to design changes, and its application to environmental aspects of the design (RO-EPR-34). The inspection suggested that EDF and AREVA should consider extending auditing programmes to cover all UK GDA support contractors. The joint inspection team also suggested that both EDF and AREVA should consider reviewing their current arrangements for managing and tracking non-conformances from their auditing activities. The joint Regulators consider it would be beneficial to develop integrated systems:

a) for capturing non-compliances;

b) for tracking processes that would provide improved management information to support close outs and system improvements and strengthen the well being of the management system.

The joint inspection identified that further discussions were needed on issues including submission tracking sheets, design change controls and INSA arrangements (RO-EPR-31).

141 The joint Regulators and EDF and AREVA held a quality assurance topic specific meeting in July 2009. There was further discussion on the inspection recommendations including RO-EPR-31 and RO-EPR-34 and the proposed responses from EDF and AREVA. Further teleconference discussions were also held regarding these matters.

142 In regard to RO-EPR-31, the evidence provided and discussions held satisfied the Regulators that AREVA has an integrated oversight and review process in place for its quality assurance audit activities. EDF gave commitments to complete further actions in auditing arrangements and implementing associated learning by the end of 2009. This is an area that HSE will examine again in Step 4 during a planned inspection. We will continue to work closely with the HSE and will use this information to inform our decision document for GDA.

143 The Regulators considered the responses from EDF and AREVA provided enough information and were satisfactory. The closure of RO-EPR-31 on arrangements for tracking and closure of non-conformances from audits was agreed between the Regulators and EDF and AREVA in September 2009.

144 RO-EPR-34 on INSA was discussed in the quality assurance topic meeting. The rationale has been to only apply INSA to parts of the submission produced uniquely for UK GDA. It was confirmed, as understood by the joint Regulators' inspection of December 2007, that INSA was applied to Volume 1 of the Safety Security and Environment Report; that is the initial GDA submission made in 2007, specifically Chapter G on Environment.

145 We have assurance from evidence reviewed and discussions held in July 2009 that an independent peer review process has been applied to producing the PCER. A number of report reviews related to the PCER were requested and examined during the July meeting. EDF and AREVA formally responded to provide a summary of information discussed at the July meeting, and proposals for application of independent peer review for future PCER submissions made during GDA. The Regulators were satisfied with the review arrangements that had previously been applied to GDA documents on the basis of evidence seen in the inspection, and further topic meeting. The Regulators were also satisfied with the plans for future reviews that were formally documented in revised versions of project instructions.

146 EDF and AREVA have responded to those recommendations that were raised following the joint Regulators' inspection in April 2009. We are satisfied that their responses fully address the issues we raised. The implementation of EDF and AREVA's responses to the inspection recommendations will be examined during HSE's planned Step 4 inspection. One outstanding matter remains with regard to EDF's integrated oversight of issues arising from audits, and this will be examined during a planned inspection by HSE during its Step 4. We will continue to work with HSE on this matter and this will inform our decision document and statement of design acceptability in June 2011.

6.2 Expectations for the operator's management system

147 Before a site-specific application for a UK EPR can be made, the potential operator will need to begin establishing its management system, including organisational structure and resources, and there will need to be considerable knowledge transfer about the design. We, therefore, need a Requesting Party to address, in its GDA submission, the implications of the design for the potential operator's management system, and how it intends to transfer the necessary information and provide ongoing support to the potential operator.

148 Reference 1.1 of Table 1 of the process and information document (Environment Agency, 2007) requires EDF and AREVA to set out their expectations of the operator's management system to cover the reactor's operations throughout its lifecycle. The

Regulators asked EDF and AREVA in TQ-EPR-253 to address, in their GDA submission, the implications of the UK EPR design for the potential operator's management system. In particular, how AREVA and EDF intend to transfer the necessary information about the UK EPR design, and the arrangements to provide ongoing support to the potential operator. The EDF and AREVA submission addresses these matters in the PCER at sub-chapter 2.1 'Project Organisation'.

149 The operator is required to establish a design authority, with arrangements in place to make sure that enough information and knowledge about the design is transferred from EDF and AREVA, as the design organisation, to the operator so that it can act as an effective design authority. EDF and AREVA are a unique requesting party in GDA as co-applicants; AREVA as the vendor and EDF as the operator.

150 PCERsc2.1s3 sets out the expectations of the post GDA organisation. This is defined according to the plant owner or operator, the architect engineer and suppliers. It is recognised in the submission document that the plant owner (operator) will have safety and environmental responsibilities in relation to plant operation, waste and effluent management.

151 EDF and AREVA set out a number of possible approaches to transferring knowledge and developing an 'intelligent operator' (we use the term to describe the capability of an operator to have a clear understanding and knowledge of the reactor design being supplied), given that, at this stage, the future operating organisation is not known.

152 EDF's approach is to include the co-designer, the architect engineer and the future operator within the same company. This approach will help to transfer knowledge and information.

153 In developing 'intelligent operator' capability, EDF participates in a knowledge transfer programme, which takes account of EDF operating experience feedback. EDF is the world's largest nuclear operator, and currently operates 58 nuclear power plants (CEA Nuclear Power Plants in the World 2008 Edition). The operator will be integrated into the engineering design, operation and procurement processes with specific responsibilities for specifying UK requirements, and the final stage of design reference and safety case.

154 AREVA's approach as the vendor, to help transfer knowledge and provide ongoing support to the potential operator, will depend upon the future owner / operator organisation. AREVA sets out its expectations and how they can be achieved. AREVA will use its knowledge, based on 35 years experience in building nuclear power plants and organising the associated transfer of knowledge to the plant owner and operator, to allow the plant to operate safely and efficiently.

155 AREVA indicated that several utilities were integrated in the EPR basic design phase, participating in technical and project working groups. In addition, studies were carried out under the responsibility of the utilities in areas such as overall operation policy, and availability and maintenance analysis. AREVA also references the European Utility Requirements (EUR) document, specifically the EPR sub-set to illustrate the ongoing utility-vendor interface for the EPR.

156 AREVA recognises that transferring knowledge to operators is important to ensure that the future owner / operator can secure and maintain the safety and environmental performance for the EPR. AREVA organises workshops and seminars with potential utility customers to provide technical information on the EPR design and to exchange information on the technical scope, and knowledge transfer.

157 The knowledge transfer stage includes both handing over technical data and information, and also training programmes. Interfaces with sub-contractors and utilities are detailed in configuration and design change management procedures for each project. AREVA also sets out its training programme information to help develop the knowledge, skills and behaviours needed to safely operate the EPR. The owners'

group has arrangements in place to help share feedback experience from operating plants between the utility and the vendor.

158 We consider that AREVA and EDF have demonstrated that they understand the requirement to establish arrangements to maintain design integrity, and to preserve the necessary detailed and specialised knowledge generated over the plant's operational life for the UK EPR. AREVA has arrangements in place to help transfer the necessary knowledge and information, and to fully support the plant owner / operator at all phases of the nuclear new build project, by providing training programmes and transferring data and document and technical information.

7 Integrated waste strategy

159 We have concluded that:

a) EDF and AREVA have provided a reasonable waste and spent fuel strategy for all waste streams that a UK EPR will typically produce.

b) The radioactive waste and spent fuel strategy is consistent with recent government statements (BERR, 2008a).

160 However, our conclusion is subject to the following:

Potential GDA Issue:

a) Decommissioning of the UK EPR (UK EPR-I1)

Other issue

b) The changes to the 'reference case' for the site-specific strategy and evidence that the site-specific strategy achieves the same objectives shall be provided at site-specific permitting. (UK EPR-OI01)

Consultation question 2: Do you have any views or comments on our preliminary conclusions on the radioactive waste and spent fuel strategy?

161 We expect new nuclear power plant designs to be developed in line with a radioactive waste and spent fuel strategy that seeks to:

a) minimise the production of radioactive waste;

b) manage unavoidable waste and spent fuel to achieve an optimal level of protection for people and the environment.

162 Our radioactive substances regulation environmental principles (REPs) (Environment Agency, 2010c) set out the issues that this type of strategy should take into account. For new nuclear power plant designs, the strategy also needs to be consistent with recent government statements (BERR, 2008a) that:

a) the disposal of intermediate level radioactive waste (ILW) to a future geological repository, from any new nuclear power stations, is unlikely to occur until late this century;

b) any nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed.

7.1 EDF and AREVA's integrated waste strategy

163 EDF and AREVA's integrated waste strategy (IWS) outlines their current strategy for managing radioactive and non-radioactive waste, including spent fuel arising from the construction, operation and decommissioning of the UK EPR. The strategy is supported by:

a) a BAT assessment in the PCER (Chapter 8);

b) radionuclide specific BAT assessment reports in the EPRB;

c) impact assessments in the PCER (Chapters 11 and 12).

164 EDF and AREVA present a 'reference case' solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR at Flamanville 3. In addition, since potential UK EPR operators may wish to adopt alternative spent fuel and waste management

arrangements, other possible options to the reference case are presented in a solid radioactive waste strategy report (SRWSR). EDF and AREVA state in the IWS that the SRWSR does not provide respective BAT assessments for the options, but they have a high degree of confidence that such cases can be made by potential UK EPR operators.

165 EDF and AREVA claim in their IWS that there is a management strategy for all waste streams produced by the UK EPR and that their proposals minimise the amount of waste produced by adhering to the waste hierarchy and BAT. They also claim that there are adequate controls to manage unavoidable waste and spent fuel to achieve an optimal level of protection for people and the environment. EDF and AREVA claim that all waste that cannot be reused or recycled is disposable.

166 EDF and AREVA state in their IWS that when considering the options for treatment of individual waste steams, the preferred approach used for the UK EPR design involved considering the balance between gaseous and aqueous discharges, and the generation of solid waste, while favouring a strategy of 'concentrate and contain'. (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 radioactivity into the environment (DECC, 2009a)).

167 In 2006, the Government's response to recommendations by the Committee on Radioactive Waste Management (CoRWM), established that, in England and Wales, deep geological disposal is the preferred route for the long-term management of radioactive waste that is not suitable for near-surface disposal. It also gave the responsibility for implementing the programme for a deep geological repository to the Nuclear Decommissioning Authority (NDA). To take this into account, HSE, the Environment Agency and the Scottish Environment Protection Agency (SEPA) have developed a series of joint guidance documents on the management of higher activity radioactive waste (available at http://www.hse.gov.uk/nuclear/wastemanage.htm). These specify the production, content, maintenance and review of radioactive waste management cases (RWMCs). The RWMC should demonstrate the long-term safety and environmental performance of the management of higher activity radioactive waste from generation to conditioning into a form that will be suitable for storage and eventual disposal. EDF and AREVA have provided a mapping document that they claim identifies how their existing documentation forms the basis of a RWMC for the UK EPR.

168 EDF and AREVA state in their IWS that solid radioactive waste will be optimised and this waste will be disposed of as soon as practicable where an appropriate disposal route is available. EDF and AREVA will dispose of LLW to the low level waste repository (LLWR) and ILW to the geological disposal facility (GDF) when it is available. In the interim, ILW will be stored on site in a dedicated building(s).

169 EDF and AREVA state in their IWS that their strategy for the management of aqueous radioactive waste for the reference case is based on:

a) minimising the production of effluents at source;

b) optimum use of segregation and effluent treatment systems;

c) optimum use of suitable storage systems for the site.

170 EDF and AREVA state in their IWS that their management strategy to limit radioactive gaseous discharges from the operating activities of the UK EPR is based on the design of the plant and the operational practices to be implemented. They claim that they will use BAT to minimise gaseous discharges at source and similarly in abatement plant, and balance worker doses and costs incurred during treatment in the plant with public doses from discharges.

171 The IWS is consistent with recent government statements (BERR, 2008a) as EDF and AREVA have made provision in the design for ILW to be stored on site until the GDF is available for its disposal.

172 The IWS takes into account statutory guidance concerning the regulation of radioactive discharges into the environment (DECC, 2009a). In particular, as EDF and AREVA have used the principle of 'concentrate and contain' in their UK EPR design.

173 **We have concluded that:**

a) **EDF and AREVA have provided a reasonable radioactive waste strategy for all waste streams that a UK EPR will typically produce.**

b) **The radioactive waste strategy is consistent with recent government statements. (BERR, 2008a)**

174 **The radioactive waste strategy is a 'reference case' based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. The reference case is reasonable, however we expect changes to the 'reference case' for the site-specific strategy and evidence that the site-specific strategy achieves the same objectives to be provided at site-specific permitting (other issue UK EPR-OI01).**

7.2 Spent fuel specifics

175 EDF and AREVA's integrated waste strategy (IWS) states there is a spent fuel interim store to store all spent fuel assemblies generated by the reactor for about 100 years before final disposal. The design of the store will provide adequate space and handling for safe operation, and monitoring of the condition of the spent fuel. The store is designed to be maintained or replaced to last for at least 100 years from when spent fuel is first emplaced in the store.

176 Interim storage may be required potentially beyond 100 years to cover the lifetime of reactor operations (including the final emplacement of fuel to interim storage, following an initial cooling period in a pool after reactor operations cease), the time to reduce the heat generation of the fuel, and the potential for refurbishment of the store(s).

177 The Regulators requested further information about long-term storage. EDF and AREVA provided detailed response information in March 2010, and whilst our views are presented in this consultation document we note HSE is continuing to review this information in its Step 4 assessment. We will continue to work closely with HSE on this, and this work will inform our decision document.

178 EDF and AREVA take account of Government policy in their IWS, noting that spent fuel will be declared as waste and will not be reprocessed, and that spent fuel will be stored on site and then disposed of to the geological disposal facility. The IWS indicates that the UK EPR design allows for spent fuel to be stored in an on site fuel store designed to accommodate the lifetime arisings of spent fuel from the nuclear power station. PCERsc6.2s3.4.2 notes one or more options for spent fuel storage, including an on site interim storage facility and / or construction and operation of an interim spent fuel storage facility shared between several sites.

179 EDF and AREVA provided information on the measures incorporated in the design and the use of fuel materials, and reactor controls in order to retain activity in the fuel.

180 EDF and AREVA produced the RWMC evidence report to demonstrate how they could meet regulatory expectations, and identified the information required to produce the RWMC for spent fuel. The RWMC demonstrates the longer term safety and environmental performance of waste for the planned management from generation to conditioning to a form which will be suitable for storage and eventual disposal. The evidence report identifies the existing documents that form the basis of the RWMC, and maps the RWMC requirements against specific submission document sections. It covers spent fuel generated throughout the reactor lifecycle from operation, maintenance, and decommissioning stages.

181 EDF and AREVA present a 'reference case' solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. Other possible options to the reference case for spent fuel strategy are presented in a solid radioactive waste strategy report (SRWSR).

182 Five interim storage solutions are identified in the solid radioactive waste strategy report, SRWSR, including underwater long-term pool storage and four types of dry storage. Wet storage is usual practice in nuclear power plants and is used for initial cooling, and subsequently may be used for interim storage, before final disposal. Dry interim storage for spent fuel is used in Europe and the USA.

183 Of the five options, one wet pool storage, and two dry storage solutions were identified and assessed in more detail for the UK EPR. EDF and AREVA considered the regulatory requirements for interim storage facilities and in particular Environment Agency requirements in relation to BAT and our radioactive substances environmental principles (REPs).

184 EDF and AREVA considered three spent fuel storage technologies, based on available and proven technologies:

a) wet interim pool storage - fuel assemblies stored in a pool;

b) dry interim cask storage - fuel assemblies stored in metal casks;

c) dry interim storage in purpose designed stores - fuel assemblies stored in vault type storage.

185 The dry interim storage facility uses metallic storage flasks technology; the TN-DUO flask which is designed for both transport and storage. Information is provided on the building layout and safety features in the SRWSR. The storage facility is designed to operate for 100 years. Visual surveillance is carried out as part of a maintenance programme for flasks in the interim storage facility. A permanent check system is implemented which monitors any pressure drop in the interspace between the primary and secondary lid of the TN-DUO flask.

186 The dry storage vault involves placing fuel assemblies into canisters when they are received. The stainless steel canisters contain aluminium partitions to house fuel assemblies and ensure heat dissipation. Details are provided on the building layout and safety features.

187 These designs allow for retrieval and inspection of the fuel, and for refurbishment. Further information on wet interim storage is provided in chapter 12.

188 The IWS is consistent with recent government statements (BERR, 2008a) as EDF and AREVA have made the following assumptions:

a) Spent fuel will be declared as waste and will not be reprocessed.

b) Spent fuel will be stored on site followed by disposal to a geological disposal facility (GDF) at the appropriate time.

189 **We have concluded that:**

a) **EDF and AREVA have provided a reasonable strategy for spent fuel that will be produced by the UK EPR.**

b) **The spent fuel strategy is consistent with recent government statements (BERR, 2008a), and our REPs (Environment Agency, 2010c).**

190 **The radioactive waste strategy is a 'reference case' based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. The reference case is reasonable, however we expect changes to the 'reference case' for the site-specific strategy and evidence that the site-specific strategy achieves the same objectives to be provided at site-specific permitting (other issue UK EPR-OI01).**

7.3 Decommissioning specifics

191 In line with government policy (DTI, 2004), we expect:

a) the radioactive waste and spent fuel strategy to address decommissioning;

b) the design to use the best available techniques to:

   i) facilitate decommissioning;

   ii) minimise decommissioning waste;

   iii) minimise the impacts on people and the environment of decommissioning operations and the management of decommissioning waste.

192 EDF and AREVA's UK EPR decommissioning strategy is described in Chapter 5 of the PCER. This chapter includes the measures adopted at the design stage to facilitate decommissioning. Further detailed information on decommissioning, including dismantling methodologies considered for the UK EPR and decontamination techniques, are in the solid radioactive waste strategy report (SRWSR).

193 The SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to the workers and minimise radioactive waste generation. The SRWSR discusses the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials;

194 With HSE, we have recently requested further information from EDF and AREVA on decommissioning for consideration in HSE's Step 4 assessment. We also expect further detailed evidence to be provided in GDA on decommissioning, as this would assist any future operator in providing a Decommissioning and Waste Management Plan for agreement by the Department of Energy and Climate Change (DECC) Secretary of State. (see BERR 2008b).

195 **We conclude that we require further detailed evidence on how the UK EPR is designed to facilitate decommissioning, minimise decommissioning waste and minimise the impacts on people and the environment of decommissioning operations. We will continue to work with HSE on this as part of its Step 4 assessment, and this work will inform our decision document. Therefore, our conclusion is subject to the following potential GDA Issue:**

a) **Decommissioning of the UK EPR (GDA Issue UK EPR-I1)**

8 Best available techniques (BAT) to minimise production of radioactive waste

196 We conclude that overall the UK EPR utilises the best available techniques (BAT) to prevent and minimise production of gaseous and aqueous radioactive waste:

a) during routine operations and maintenance;

b) from anticipated operational events.

197 However, our conclusion is subject to four other issues, which will need to be addressed during site-specific permitting.

198 <u>Other issues</u>:

a) Zinc injection as an option for the UK EPR to aid corrosion control. (UK EPR-OI02)

b) Assessment of the removal of secondary neutron sources (to further minimise creation of tritium) when EPR operational information becomes available. (UK EPR-OI03)

c) Review of the BAT assessment on minimising the production of activated corrosion products for the following matters, where possible improvements were identified in the PCER (UK EPR-OI04):

   i) corrosion resistance of steam generator tubes;

   ii) electro-polishing of steam generator channel heads;

   iii) specification of lower cobalt content reactor system construction materials;

   iv) further reducing use of stellites in reactor components, in particular the coolant pump;

   and incorporation of the improvements into the design where appropriate.

d) Providing the design of the discharge tanks (LRMDS, ExLWDS and CILWDS tanks) with associated demonstration of BAT for size and leak-tight construction. (UK EPR-OI05)

Consultation Question 3: Do you have any views or comments on our preliminary conclusions on best available techniques to minimise the production of radioactive waste?

199 In minimising and managing radioactive waste, we require that best available techniques (BAT) are applied so that new nuclear power station designs are capable of meeting high environmental standards (DECC, 2009a). BAT replaces, and is expected to provide the same level of environment protection as, the previously used concepts of best practicable environmental option (BPEO) and best practicable means (BPM).

200 Identifying BAT is the result of a process of optimisation where minimising the generation and discharge of radioactive waste is balanced against the cost and benefits of further reductions. This process is not restricted to radioactive substances and their resulting doses, but also concerns:

a) safety considerations (for example, protecting workers) and security;

b) wider environmental considerations (for example, using energy and other resources, generating and disposing of conventional waste);

c) social and economic considerations.

This optimisation approach ensures that the cost of applying techniques is not excessive in relation to the environmental protection they provide.

201 BAT needs to be used throughout a design and over many aspects. We have assessed BAT starting at the source of radioactivity (the reactor), the way in which radioactivity is processed into gaseous, aqueous and solid waste streams and how each of those streams is reduced and disposed of.

202 We will set disposal limits based on the use of BAT. The limits will be set at the minimum levels to permit normal operation and will include contingencies to allow for maintenance and relevant operational fluctuations, trends and events that are expected to occur over the likely lifetime of the plant. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP12)

8.1 Sources of radioactivity

203 This section describes the sources of radioactive materials in the UK EPR that will eventually become waste, and the techniques used to minimise the amount produced. We expect new nuclear power plants to be designed to use BAT to prevent radioactive waste being produced unnecessarily. Where waste is produced, we expect BAT to be used to minimise the amount generated. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP3)

204 EDF and AREVA say that the origins of radioactive materials within the UK EPR are mainly (PCERsc6.1):

a) activation of chemical species in the primary reactor coolant (the coolant is essentially water with low levels of some chemicals added);

b) corrosion products from the metal components of the reactor system present in the reactor coolant and activated as they pass through the core of the reactor;

c) fission products formed in the fuel. These may leak into the primary coolant through any defects in the fuel cladding.

205 EDF and AREVA provide information in the PCER on the following radionuclides or groups of radionuclides:

a) tritium;

b) carbon-14;

c) noble gases;

d) iodine radionuclides;

e) other radionuclides that can be produced by activation of non-radioactive materials or by fission in fuel. EDF and AREVA group these together as their discharges tend to be minimised by the same techniques (for example, filtration or ion exchange) and they are usually measured as a group using a gross activity method. The most important of these are:

   i) cobalt-60

   ii) caesium-134 and caesium-137

   iii) strontium-89 and strontium-90

   iv) a number of other activated corrosion products can also be produced in less significant amounts. These radionuclides include maganese-54, iron-59, chromium-51, nickel-63, silver-110m, antimony-122, antimony-124 and antimony-125.

206 We have provided a guide on how radioactivity is formed in a nuclear reactor and the nature and properties of the significant radionuclides in Annex 4.

207 We conclude that EDF and AREVA have identified those radionuclides which either:

a) contribute significantly to the amount of activity (Becquerel - Bq) in waste disposals;

b) contribute significantly to potential doses to members of the public;

c) indicate plant performance, for example where the levels of a radionuclide might increase in the event of a deviation from normal plant operation.

208 We summarise below the information presented in the PCER on the sources of specific radionuclides and their minimisation and provide our assessment.

8.1.1 Tritium

209 Tritium is produced by three main mechanisms and initially contained within the reactor coolant (see PCERsc6.2s1.2.1, PCERsc6.3s6.2.1 and EPRBs3.3s2):

a) activation of boron (present as boric acid) in the reactor coolant. Boron (in particular the isotope boron-10 making up 20 per cent of natural boron) is used to control the reactivity of the reactor. The UK EPR uses boric acid with the boron-10 content enriched to 37 per cent. EDF and AREVA claim that the quantity of boron needed in the reactor coolant has been reduced in the UK EPR by using a burnable poison – gadolinium oxide – within some of the fuel. They claim this has reduced the production of tritium by the UK EPR from this source compared to predecessor reactors despite an increase in power, but they do not quantify the reduction as this depends on the fuel management approach adopted;

b) activation of the lithium-6 content (approximately 7.5 per cent of natural lithium) of the lithium hydroxide used for chemical control of the reactor coolant to offset the corrosive effect of boric acid. The amount of boric acid needed has been reduced by the use of a burnable poison – see above – and also by using boric acid with an enriched boron-10 (the important neutron absorber) content. This reduces the quantity of lithium hydroxide needed. The UK EPR will also use hydroxide containing less than 0.1 per cent lithium-6 to reduce tritium production. EDF and AREVA state that with natural lithium, tritium production would be 1-2 TBq day^{-1}, the use of low lithium-6 hydroxide will achieve 'expected performance' disposals of less than 0.16 TBq day^{-1};

c) activation of beryllium (initially to lithium-6 then to tritium) in the secondary neutron sources. These antimony / beryllium sources are used to demonstrate the function of neutron measurement equipment, an essential safety feature for plant start-up, and are cased in stainless steel that is permeable to tritium. The PCER states that production from this source is 9 TBq y^{-1}. The PCER discusses options to remove these sources or to use an impermeable zirconium-based alloy for the cladding, but information from an operational EPR is needed before removal can be assessed. Therefore, a change in cladding is discarded as this would be a departure from a proven design and require more frequent change of sources, which may increase occupational radiation exposure and generate more solid waste.

210 The production of tritium (excluding the contribution from the secondary neutron sources) is directly related to power output of the reactor. EDF and AREVA claim that the above measures mean that the UK EPR will release only 4 per cent more tritium than the predecessor 1300 MWe reactor, while its power output is some 25 per cent greater. The predicted production rate is 52 TBq y^{-1}. The majority of tritium produced will be in the form of tritiated water.

211 There are some other sources of tritium:

a) activation of deuterium in the reactor coolant (deuterium is naturally present in water at 0.015 per cent);

b) ternary fission products, normally contained within the fuel cladding;

c) activation of helium pressurising the fuel pins, normally contained within the fuel cladding.

212 More information on these sources is presented in the PCERsc6.3s6.2.1.2. We do not consider these sources are significant as regards discharges. We have not specifically assessed BAT for these sources, but activation of deuterium is unavoidable and fuel cladding integrity is assessed below under noble gases.

213 **We conclude that EDF and AREVA have demonstrated that BAT is used to minimise the production of tritium in the UK EPR at this time. For the secondary sources:**

a) **we accept that a cladding change should not be pursued at this time;**

b) **we expect EDF and AREVA to assess removing these sources and present information when operational experience is available during site-specific permitting. (other issue UK EPR-OI03)**

8.1.2 Carbon-14

214 Carbon-14 is produced mainly by two mechanisms within the reactor coolant (PCERsc6.3s6.3.1, PCERsc6.3sc7.3.1 and EPRBs3.2):

a) activation of oxygen-17, a naturally occurring stable isotope of oxygen as part of the water molecules making up the reactor coolant. The annual production of carbon-14 from oxygen-17 is calculated as 401 GBq. There is no practicable way to avoid this formation route;

b) activation of nitrogen-14. Nitrogen is used as a cover gas in the system that treats reactor coolant, a certain portion will dissolve in the coolant. The annual production of carbon-14 from nitrogen-14 depends on the dissolved concentration of nitrogen, calculations presented by EDF and AREVA predict 43 GBq at 10 ppm (expected) to 219 GBq at 52 ppm (extreme maximum). EDF and AREVA claim using nitrogen as a cover gas (as used in the predecessor KONVOI design) instead of hydrogen is a safety feature as it reduces risk of hydrogen / air combustion. This offsets the possible 10 - 50 per cent increase in carbon-14 production.

215 EDF and AREVA use 440 GBq y^{-1} as their base value for production of carbon-14. We accept that there are no techniques that can be used to minimise production of carbon-14 from oxygen-17. Management of operational dissolved nitrogen levels is critical to minimise production of carbon-14 from nitrogen-14, this will be reflected in our disposal limits.

216 Other minor mechanisms contribute to carbon-14 discharge:

a) a trace of dissolved carbon can be present in the coolant – this can be activated to carbon-14 (PCER6.3s6.3.1.1);

b) nitrogen impurities and oxygen within the fuel can be activated to carbon-14 but the carbon-14 will normally be contained within the fuel cladding (EPRBs3.2);

c) the 'aeroball' system used to measure neutron flux within the reactor is driven by nitrogen, the nitrogen can be activated to carbon-14 but production estimates give a maximum of 1.5 GBq y^{-1} (PCERsc6.3s7.3.1.1);

d) the air within the reactor pit contains oxygen and nitrogen that can be activated to carbon-14, the maximum production is estimated as 1 GBq y^{-1} (PCERsc6.3s7.3.1.2).

We do not consider it necessary or proportionate to assess BAT for these sources as they represent less than 1 per cent of the total carbon-14 discharge.

217 **We conclude that BAT is used in the design of the UK EPR to minimise production of carbon-14 provided that dissolved nitrogen concentrations are minimised by operational controls.**

8.1.3 Noble gases

218 Noble gases are a range of xenon and krypton radionuclides, in particular xenon-133, xenon-135 and krypton-85, these are fission products and are produced by the burn-up of the uranium in the fuel. They are normally contained within the fuel cladding. If there are any fuel defects these gases can pass into the primary reactor coolant. (EPRBs3.5)

219 Traces of uranium contamination can occur on the outside of new fuel assemblies (known as 'tramp uranium') and its fission can also contribute to the presence of noble gas radionuclides in the coolant. EDF and AREVA claim fuel is '*manufactured to stringent specifications and is subject to rigorous inspection*'. They claim that 'tramp uranium' cannot be totally avoided, but is only present in trace amounts. (EPRBs3.5ss3)

220 In normal operation, a portion of the coolant is passed through the chemical and volume control system (CVCS). If removal of dissolved noble gases from the coolant is required, the CVCS sends the coolant through a degasification system where gases are removed and sent to the gaseous waste processing system (GWPS). Following treatment, the GWPS vents gaseous waste to the main stack. The level of noble gases at the main stack is a reflection of the failure of fuel cladding. (PCERsc6.3s7.4.2.1)

221 EDF and AREVA claim that the amount of fission products reaching the coolant through fuel defects can be minimised at source by '*high standards of fuel design and fabrication*'. For example, there is '*clear separation between the 'controlled' areas where pellets are manufactured and introduced in the cladding tubes which are decontaminated before sealing, and the 'non-controlled' areas in which only sealed rods are handled. The surface contamination level is then checked for each fuel assembly'.* They claim there will only be a small number of pins with minute defects (the 'failed fuel fraction').

222 They claim that AREVA's PWR assemblies have '*exhibited consistently high operational reliability with an average annual fuel failure rate of approximately* 10^{-5}' and that this rate is '*less than half of the failure rate at the end of the 1980s*'. The failure rate is the ratio of number of failed fuel pins discharged divided by the number of fuel pins in reactors that have been refuelled during the considered year, 10^{-5} means 10 in a million. (EPRBs3.5ss1.1 and PCERsc6.1s6.1.2)

223 EDF and AREVA state that the most common causes of fuel failures in operation are grid-to-rod fretting, corrosion and crud, debris, pellet cladding interaction and manufacturing upsets. They participate and contribute in the EPRI (Electrical Power Research Institute – an independent USA organisation) Fuel Reliability Action Plan. The UK EPR design minimises such failures by: (EPRBs3.5ss1.1)

a) minimising initial surface contamination of fuel by best practice in manufacture;

b) minimising crud formation by control of primary circuit chemistry;

c) defining appropriate criteria for fuel design to prevent cladding failure;

d) incorporating an efficient anti-debris device in the fuel assemblies.

224 EDF and AREVA say that any leaking fuel pins will be identified during refuelling and not reused. (EPRBs3.5ss3)

225 There are no techniques to prevent the production of xenons and kryptons within the fuel pins as they are fission products; their production is related to power output. The main factor in minimising discharges of noble gases is the reliability of fuel.

226 **We conclude that the average fuel failure rate quoted by EDF and AREVA is indicative of use of BAT to minimise the release of noble gases from the fuel in the UK EPR. Fuel integrity will be reflected in the disposal limits we set for noble gases.**

227 **Argon-41** can be formed by activation of the natural argon content of air near the reactor. It can be collected by ventilation systems – although the reactor building is not ventilated in normal operation – and discharged through the main stack. (PCERsc6.3s7.4.2.1)

228 A small amount of argon-41 may also be produced from the argon in air dissolved in the reactor coolant - mostly after a shutdown. (PCERsc6.1s2.4)

229 PCERsc6.3s7.4.2.1 indicates that argon-41 will form 2.9 per cent of the 'expected performance' of total noble gas discharges (23.2 GBq y^{-1} argon-41). The discharge of argon-41 should not increase when discharges of noble gases increase in the event of any fuel defects. However, EDF and AREVA chose to use a discharge value of 2.9 per cent of the 'maximum' for noble gases (653 GBq argon-41) to predict a pessimistic impact for argon-41. The radiological impact from the annual disposal of 653 GBq of argon-41 to air is stated as a dose to adults of 0.014 μSv y^{-1}, to children of 0.0083 μSv y^{-1} and infants of 0.0065 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

230 The half-life of argon-41 is under two hours and the UK EPR discharge has little environmental impact, 0.0005 μSv y^{-1} to an adult at the 'expected performance' discharge. Argon-41 discharges from PWRs are less than 1 per cent of those from the UK Advanced Gas-cooled Reactors (AGRs) and less than 0.1 per cent of those from Magnox reactors.

231 **We conclude that it is not proportionate to assess BAT in detail for argon-41 discharge but it will be monitored and included within the noble gases total discharge at the main stack**.

8.1.4 Iodine radionuclides

232 Iodine radionuclides, in particular iodine-131 and iodine-135, are produced by fission in the uranium in the fuel or in 'tramp uranium' – as described in the noble gases section above. However, iodine radionuclides tend to remain in the liquid phase in the chemical and volume control system (CVCS) as they are readily soluble. Residual gaseous iodine radionuclides will pass through the gaseous waste processing system to the main stack. The UK EPR design also allows for any trace leakage from systems containing primary coolant, the ventilation over such systems can be sent to 'iodine traps' if iodine radionuclides are detected (automatic systems). (PCERsc6.2s1.2.1)

233 We accept that there are no techniques to prevent the production of iodine radionuclides within the fuel pins. The fuel cladding should prevent leakage into the reactor coolant. The integrity of the cladding is discussed above under noble gases, and will be reflected in the disposal limits we set.

234 **We conclude that BAT is used to minimise the release of iodine radionuclides from the fuel in the UK EPR.**

8.1.5 Other radionuclides

235 **Activated corrosion products -** the components of the reactor system are made of various metals and alloys and are in contact with the reactor coolant. The coolant contains chemicals such as boric acid. The coolant can cause erosion and corrosion of the surfaces it contacts and this gives both soluble and insoluble (particles) corrosion products. Radionuclides can be produced by activation of these corrosion products as they pass through the reactor core within the coolant. Activation products

can also be formed in structural reactor components, most of the radioactivity produced will remain within the components (a matter for decommissioning) but some can be released by corrosion and erosion. PCERsc6.1s2.6 lists the most significant radionuclides produced (see also PCERsc6.2s1.1.1, PCERsc8.2s3.3.1 and EPRBs3.4).

236 **Manganese-54** from the activation of the iron-54 content of all metallic materials used in the reactor system, no minimisation is practicable.

237 **Cobalt-58** from the activation of nickel-58, a major constituent of nickel based alloys (for example, the 690 alloy used in the steam generator tubes). EDF and AREVA say that:

a) constant improvements are being made to the corrosion resistance of steam generator (SG) tubes (PCERsc8.2s3.3.1.1.3);

b) they are evaluating electro-polishing of SG channel heads to reduce erosion and corrosion potential (PCERsc8.2s3.3.1.1.5).

The above options would reduce nickel-58 corrosion products entering the coolant. We will require an updated BAT assessment against these options at, or before, the site-specific permitting stage.

238 **Iron-59** from the activation of the iron-58 content of all metallic materials used in the reactor system, no minimisation is practicable.

239 **Cobalt-60** from the activation of cobalt-59, a major constituent of steels and, in particular, 'hard' high cobalt alloys, for example, stellites used in valve seats. EDF and AREVA propose to minimise the amount of cobalt in contact with the reactor coolant in the UK EPR (PCERsc8.2s3.3.1.1.1 and EPRBs3.4):

a) by excluding stellites from valves used in the reactor coolant systems. This is estimated to reduce the total dose predicted for the UK EPR by 8 per cent;

b) by reducing the use of stellites in other reactor components. But the programme is not complete, for example, EDF and AREVA say that: '*stellite parts of reactor coolant pumps to be assessed*'. (PCERsc8.2s3.3.1.1.1);

c) EDF and AREVA say they are making '*constant improvements*' to the specification of lower cobalt contents of stainless steels, welding materials and steam generator tubing used in the construction of the UK EPR. (EPRBs3.4ss3.1.2, PCERsc8.2s3.3.1.1.2)

240 We will require an update to the BAT case to show that cobalt use in the UK EPR has been minimised at, or before, the site-specific permitting stage.

241 **Chromium-51** from activation of chromium-50, an essential part of stainless steels, no minimisation is practicable.

242 **Nickel-63** from activation of nickel-62 present in structural materials, in particular alloy 690, no minimisation is practicable.

243 **Silver-110m** from activation of silver-109 contained in control rods and helicoflex seals. EDF and AREVA state that the UK EPR will:

a) reduce the use of helicoflex seals in favour of graphite seals; but

b) control rods cannot be modified.

244 **Antimony-122 and antimony-124** from the activation of other stable antimony isotopes used as a base for alloys used in some seals and pump bearings. EDF and AREVA state that the UK EPR will reduce the use of bearings containing antimony.

245 **Antimony-125** from the activation of antimony-124 produced as described above. This will be reduced as the production of antimony-124 is reduced.

246 **Corrosion control** - The reduction of corrosion is important to reduce the level of corrosion products. EDF and AREVA state that the UK EPR will:

a) use a programme to produce an oxide layer on reactor circuit components before beginning power operation. This layer reduces the potential for corrosion products to form (PCERsc8.2s3.3.1.1.4);

b) apply a reactor chemistry regime to minimise formation of corrosion products (PCERsc8.2s3.3.1.2).

247 **We conclude that the two corrosion control techniques proposed above are BAT. However, EDF and AREVA present some information on using zinc injection to control corrosion – PCERsc8.2s3.3.12.1.2. We received additional information on this topic too late to assess for this consultation, also HSE has ongoing assessment in this area. We have, therefore, identified this as another issue at this time (other issue UK EPR-OI02)**.

248 **Nitrogen-16 and nitrogen-17** are produced by activation of oxygen-16 and oxygen-17 in the reactor coolant. There is no practicable way to reduce them forming. However, their short half-lives, 7.3 and 4.2 seconds, mean that discharges to the environment will be insignificant. We do not consider them further in our assessment. (PCERsc6.1s2.1, 2.2)

249 **Caesium-134, caesium-136, caesium-137 and caesium-138** are fission products normally contained within the fuel cladding. If there are any fuel defects, caesium radionuclides can pass into the primary reactor coolant. We accept that caesium radionuclides production cannot be minimised at source but should be contained. We have commented on the integrity of the cladding above under 'noble gases'. Caesium radionuclides are highly soluble and, if released from the fuel, will be treated in the liquid waste processing system (LWPS). Detecting caesium radionuclides in aqueous radioactive waste disposals is an indicator of fuel failures.

250 **Strontium-89 and strontium-90** are fission products normally contained within the fuel cladding. If there are any fuel defects, strontium radionuclides can pass into the primary reactor coolant but strontium is less mobile than caesium. We accept that strontium radionuclide production cannot be minimised at source but should be contained. We have commented on the integrity of the cladding above under 'noble gases'. Any released strontium radionuclides should remain in the aqueous effluent and be effectively removed by the filters and demineralisers in the LWPS. EDF and AREVA claim that strontium radionuclides cannot be detected in releases from currently operating nuclear power plants in France (PCERsc8.4s5.1). We consider strontium radionuclide discharges to the environment will be insignificant and do not consider them further in our assessment.

251 **We conclude that the UK EPR uses BAT to minimise the production of other radionuclides but expect a review of the BAT assessment on minimising the production of activated corrosion products for the following matters where possible improvements were identified in the PCER, see above:**

a) **corrosion resistance of steam generator tubes;**

b) **electro-polishing of steam generator channel heads;**

c) **specification of lower cobalt content reactor system construction materials;**

d) **further reducing use of stellites in reactor components, in particular the coolant pump;**

and incorporation of the improvements into the design where appropriate (other issue UK EPR-OI04).

8.1.6 Radioactive actinides

252 Radioactive actinides (in particular plutonium, americium, curium and uranium) are formed by a series of activations of uranium (see annex 4) (PCERsc6.1s6.1.2):

a) in the fuel but will only appear in the coolant if there are fuel defects;

b) in any trace surface contamination of the fuel pins by fuel (called 'tramp uranium');

c) in impurities in the fuel cladding and in other materials.

They are potentially significant to the impact of disposals as they are alpha emitters.

253 EDF and AREVA claim that the sources of actinides from surface contamination or impurities are not significant compared to the potential for release through fuel defects.

254 EDF and AREVA claim that improvements in fuel reliability through design and quality manufacture minimise fuel leaks and, therefore, the potential for actinide discharges. They also claim high removal efficiencies for actinide particulates in the filters in the coolant purification system of the chemical and volume control system.

255 EDF and AREVA provided us with an internal report examining data about alpha emitters in a number of operating plants with cladding defects. The report confirms the high removal efficiencies claimed. EDF and AREVA claim that their operational experience shows that even with fuel defects they have not been able to detect alpha emitters at the points of discharge for predecessor plants to the UK EPR. They will install alpha detectors (to give an alarm at level of detection) on both gaseous and aqueous discharge points, but otherwise do not provide discharge estimates and do not consider disposal limits are required.

256 **We conclude that radioactive actinides will not contribute significantly to discharges or radiological impacts. We do not consider it proportionate to assess actinides in detail and will not consider them in limit setting. The presence of actinides in discharges will be detected by the various monitoring arrangements.**

8.2 Processing of radioactive materials in the UK EPR

257 This section describes how radioactive materials are processed and handled in the UK EPR. We expect the options chosen for a new nuclear power plant to minimise the overall impact of their discharges on people and the environment. (Statutory Guidance (DECC, 2009a) and our REPS (Environment Agency, 2010c) RSMDP7)

258 The majority of radioactive materials that will form waste are initially contained within the reactor coolant. Therefore, the options used to treat coolant are important factors that determine the form of radioactive waste and its ultimate disposal to solid, aqueous and gaseous waste routes.

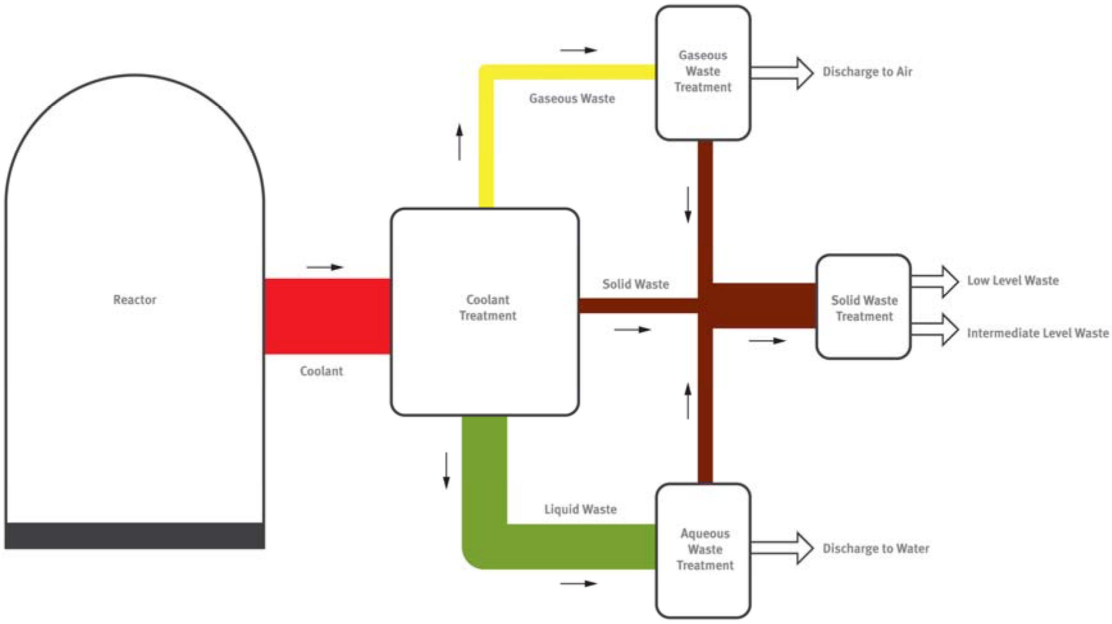


Figure 8-1 Conceptual waste flow diagram for a PWR

259 Gaseous radioactivity from radiologically controlled areas within the UK EPR is removed by ventilation systems to reduce occupational exposure. The ventilation systems discharge into the main stack.

8.2.1 Primary circuit – the reactor coolant system (RCS)

260 The reactor coolant system (the RCS) includes the reactor, four steam generators and a pressuriser and contains the coolant. The coolant is essentially water with certain chemicals added for control purposes. To maintain this control, a small flow of coolant from the RCS is sent to the chemical and volume control system (CVCS). The CVCS purifies and degasifies the coolant and then adjusts chemistry by adding or removing chemicals, in particular boron. The coolant is pumped back into the RCS at a rate to maintain the contained volume. (PCERsc1.2s4.2.8)(Flow diagram - PCSRsc9.3s9.3.2 Figure 1)

261 The coolant purification system (CPS) takes coolant from the CVCS and passes it through a filter to remove particles and demineralisers (ion exchange resins) to remove soluble metal compounds. The filter will remove 99.9 per cent of particles sized at 1 micron or above. The CPS removes material that could be made radioactive by activation and also material that has been activated, therefore

minimising radioactivity in the coolant. This is important both for protecting workers from radiation and to minimise activity in aqueous radioactive waste produced. EDF and AREVA claim that using filters below 1 micron adds to generation of solid waste (spent filter cartridges) for minimal reduction in the radioactivity of the coolant. The filter elements and spent demineraliser resins need to be replaced at intervals and become solid radioactive wastes that are usually intermediate level waste (ILW). We consider using filters and demineralisers in this system in the UK EPR is BAT to minimise discharges to the environment and is consistent with the principle of 'concentrate and contain'. (EPRBs3.4)

262 Coolant from the CVCS can be sent to a degasifier if required. This is mainly used before a shut-down or if noble gases are detected (loss of fuel integrity) in the coolant during operation. The gases removed from the coolant are sent to the gaseous waste processing system (GWPS). The gases need to be removed to avoid build-up of radioactivity in the coolant both for protecting workers from radiation and to avoid a surge in discharged activity at shut-downs. We consider availability of the degasifier and the GWPS in the UK EPR as BAT to control the radioactivity of gaseous wastes and minimise peaks of discharge. (PCERsc6.2s1.2.2.1)

263 The CVCS can send coolant to the reactor boron and water makeup system (RBWMS). The boron concentration in the coolant is used to control reactivity in the reactor and is generally reduced over a power cycle (the time before refuelling – usually 18 months for the UK EPR). The RBWMS contains an evaporator that separates coolant into water that can be recycled back into the RCS and a boron concentrate that can be reused. We accept that the RBWMS within the UK EPR is BAT, as recycling and reuse of water and boron will minimise the generation of aqueous waste. (PCERsc6.2s2.2.2.5)

264 A coolant storage and treatment system (CSTS) is associated with the CVCS. This contains six tanks that can store water and boron solution for use in the RCS. The tanks help reuse and recycling, accepting input from the RBWMS and the nuclear drain system. There is a route to bleed coolant to the LWPS when necessary to control tritium and carbon-14 content. Coolant volume can be made-up by adding demineralised water. Water is passed through a demineraliser and filter before transfer to the RCS by the CVCS. We consider that the UK EPR uses BAT to reuse and recycle liquids where possible to reduce aqueous effluent volume. (PCERsc6.2s1.1.2.1)

265 The degree of recycling of effluents in the UK EPR design increases degassing. This has the effect of transferring the maximum amount of carbon-14 into the gaseous effluent. EDF and AREVA claim this is BAT, as the impact from gaseous disposal is less than that of aqueous disposal (0.008 µSv GBq^{-1} carbon-14 for gaseous is quoted against 0.15 for aqueous). We accept this claim. (EPRBs3.2)

266 The final element of the CVCS is a volume control tank (VCT) with a nitrogen filled headspace. Dissolved gases, particularly noble gases, in the coolant will degas into the VCT headspace. The CVCS in the UK EPR is a closed system (similar to the KONVOI design). This is claimed as minimising the source of tritium to gaseous discharges from the reactor coolant system (PCERsc6.3s7.2.1). There is a purge from the VCT to the gaseous waste processing system. The GWPS normally recycles the purge gas. This allows decay of shorter-lived noble gases before discharge. During plant start-up or shut-down, a portion of the purge gas passes through driers to remove water vapour before entering three delay beds. The driers will act to reduce discharges of tritiated water to air. PCERsc8.2 Table 8 claims a reduction of 60 per cent in gaseous tritium discharges compared to predecessor 1300 MWe plant. We accept that the UK EPR design uses BAT to minimise gaseous discharge of tritium from the RCS.

267 Any leakage from pipes or equipment containing reactor coolant could:

a) cause aerosols containing corrosion products, these would be collected by the ventilation systems and contribute to gaseous radioactive waste;

b) contribute to aqueous radioactive waste by way of the drain systems.

268 EDF and AREVA claim 'reinforced leak-tightness requirements for active parts (pumps and valves) and the recovery of primary coolant leaks'. Recovery is demonstrated (PCERsc6.2s1.1.2.1) and PCERsc8.2s3.3.1 lists techniques used in the UK EPR to minimise leaks:

a) bellows seals;

b) reduced numbers of welds;

c) double barriers made of a ring joint with a blocked port between the two rings;

d) leak-off lines: pipes placed on valves to enable connection directly to drain system;

e) double packing pressure seals.

We conclude BAT is used on the UK EPR to minimise leaks and, therefore, minimise the potential for producing wastes.

269 There is a system to collect effluents produced in the UK EPR (PCERsc6.2s1.1.2.1). This is part of the nuclear island vent and drain system (NVDS). Effluents from the RCS are collected separately, unless potentially chemically polluted, and recycled into the coolant storage and treatment system for treatment and reuse as coolant. We see this as BAT to minimise the volume of aqueous waste requiring disposal.

270 The NVDS collects all other aqueous effluents in a number of drains but maintains segregation to allow the most appropriate treatment before disposal. PCERsc6.4s2.1 Figure 2 shows the principle of routing of effluents. Choices can be made at effluent collection sumps as to route, with uncontaminated effluent sent directly to a discharge tank or contaminated effluent to an appropriate tank at the front end of the liquid waste processing system. Again, we see this as BAT as it allows the most effective treatments to be applied to minimise activity on disposal.

8.2.2 Secondary circuit

271 The secondary circuit contains boiler quality water that is made into steam in the steam generators (SGs). The steam drives turbines that generate electricity. The steam is condensed after the turbines and the condensate water reused. In the event of any tube leaks in the SGs, the secondary circuit water could be contaminated with radioactivity, in particular tritium. There is a blowdown (bleed) from the secondary circuit used to control the solids content of the water. This is normally passed through a filter and demineraliser and recycled. If the blowdown cannot be recycled, it is sent to a discharge tank for monitoring before disposal without further treatment. SG construction has been improved to minimise potential for leaks. There is no additional generation of tritium by this route. We accept the improvements to the SG construction as BAT to minimise the potential for a radioactive discharge by this route. (PCERsc6.2s1.1.2.3)

8.2.3 Ventilation systems

272 We require BAT to be used in the design of ventilation systems. Systems should include appropriate treatment systems to remove and collect airborne radioactive substances before they are discharged to the air. (Our REPS (Environment Agency, 2010c) ENDP16)

273 All radiation controlled areas within the UK EPR are served by ventilation systems (PCERsc6.2s1.2.3.2). This is considered to be ALARP to minimise radiation exposure to the workforce. Radioactive materials can occur in the ventilation air from trace

leakage from active systems, EDF and AREVA claim '*reinforced leak-tightness requirements*' (PCERsc8.2s3.3.1), see section 8.2.1 above.

274 The UK EPR design has minimised the potential for radioactivity to enter ventilation systems or the air by:

a) removing air operated valves from the reactor building (RB). This means that there is no excess air entering the RB and no need to vent this during the power cycle. This removes a possible source of gaseous radioactive waste;

b) installing a metal skin inside the reactor building to prevent leakage of radioactive gases.

275 The main source of tritium for gaseous disposal is tritiated water evaporating from the surface of fuel pools and entering the ventilation systems. Disposal is to the main stack.

8.3 Containment of radioactive liquids in the UK EPR

276 Radioactive liquids will be produced in the UK EPR. We expect these liquids to be contained within the facility to prevent contamination of land or groundwater under normal conditions. Under fault conditions, we expect a design to use BAT to minimise the probability of contamination occurring and the extent of contamination. (Our REPS (Environment Agency, 2010c) RSMDP10 and CLDP1)

277 Under the Environmental Permitting Regulations 2010 (EPR 10), a permit is required for the deliberate discharge of certain substances, including radioactive substances, to groundwater, with the aim of preventing or limiting pollution of groundwater.

278 EDF and AREVA claim that there is no likelihood of direct or indirect discharges of radioactive substances to groundwater. In that case, a UK EPR should not need to be permitted by us for a discharge to groundwater under EPR 10.

279 EDF and AREVA claim that the UK EPR has several levels of techniques to contain liquids within the nuclear island and prevent contamination of groundwater (PCER sc8.3s3):

a) primary containment:

   i) metallic components are designed, manufactured and erected to ensure they remain leak-tight over the lifetime of the facility (see PCSRsc3.2s1 and Table 3, PCERsc8.2s3.3.1);

   ii) concrete pools, tanks and sumps that will hold liquids will be fitted with a metallic liner.

b) secondary containment: any leaks that do occur will be contained inside buildings or piping galleries:

   i) buildings are erected on a concrete raft with floor and part of walls coated to contain spills;

   ii) pipes that run outside buildings will be in leak-tight concrete galleries that can be inspected.

c) valves are installed on liquid circuits to allow isolation of any section with a leak;

d) leak collection systems operate in the nuclear island and the turbine hall. The sumps of these systems are fitted with systems to warn the operator, through the main control and instrumentation (C&I) system, of massive liquid inlet. An alarm is also given in the event of excessive sump pump run time, which could indicate a continuous smaller leak;

e) drains that pass through the base concrete are of a double wall construction, the inner pipe carrying effluent is within a larger outer pipe. When drain pipes enter sumps, a special receptacle is placed to collect any leakage in the outer pipe and give a visual indication of a leak in the inner pipe;

f) sumps are fitted with visual inspection tubes so that any leakage from the liner into the concrete pit can be seen;

g) monitoring throughout the life of the plant:

   i) inspection of equipment during maintenance;

   ii) monitoring of groundwater.

280 EDF and AREVA state that concrete pools, in particular the spent fuel pool, and tanks in the nuclear island are fitted with a system to detect, locate and drain leaks from the liner of the concrete tanks.

281 EDF and AREVA claim that concrete tanks in the nuclear island are oversized to reduce the risk of overflow.

282 Effluents are collected at the front end of the liquid waste processing system (LWPS) by tanks. EDF and AREVA claim that these, together with the discharge tanks, are sized to offer substantial hold up capacity to cover all reactor operating scenarios and represent BAT for storage of effluents on the UK EPR. (PCERsc8.2s3.3.4 and PCERsc6.4s1.1)

a) Floor drain storage – 2 x 75 m^3 steel tanks;

b) Process drain storage – 2 x 100 m^3 steel tanks;

c) Chemical drain storage – 2 x 160 m^3 steel tanks;

d) Distillates storage – 2 x 100 m^3 steel tanks.

283 EDF and AREVA provided us with a document that gives design information for these tanks. The tanks are:

a) of stainless steel to design standard EN 14015;

b) have high level alarms;

c) are within a concrete bund of 440 m^3 available volume (our requirement is greater than 110 per cent volume of largest tank, that is greater than 176 m^3).

We conclude that the UK EPR design, in terms of LWPS front end tank design and bunding, uses BAT.

284 EDF and AREVA state that the tank volumes were determined using operational feedback data from predecessor plants. They predict total volume of effluent for the UK EPR as 12,000 $m^3\ y^{-1}$. The tanks are operated in pairs, with one filling while the contents of the other are processed through the LWPS. EDF and AREVA claim that the emptying period is designed to be shorter than the filling period, allowing for operational fluctuations in effluent produced, therefore contingency capacity is not required. There is the possibility to transfer effluent to the reserve ExLWDS tanks (see next paragraph) in the event of any problems. The length of fill periods will be variable depending on operational factors. EDF and AREVA are still carrying out studies to define UK EPR fill period ranges.

285 The UK EPR will have a set of discharge tanks outside the nuclear island:

a) LRMDS tanks – collecting effluent from the LWPS with a peak maximum radioactivity concentration (based on predecessor plant experience) of 7 MBq l^{-1}, mostly tritium. This would not represent discharge concentrations, effluent can be recycled through the LWPS until acceptable for discharge.

b) ExLWDS tanks – reserve in case of LWPS or outfall problems, normally empty;

c) CILWDS tanks – collecting effluent from radiologically uncontrolled areas, usually uncontaminated. Tritium contamination is possible in the event of leaks from the primary to secondary systems with an expected maximum level of 1.9 MBq l^{-1}.

286 EDF and AREVA say that discharge tank design will need to take account of site-specific factors. They provide information from the Flamanville site (comprising two existing 1300MWe reactors, one EPR in construction and another possible EPR in the future) where tanks will be:

a) 6 LRMDS tanks, 3 ExLWDS tanks and 4 CILWDS tanks, each of 750 m^3 capacity (the number of tanks will be a site-specific matter);

b) of concrete construction with a leak tight, reinforced liner;

c) fitted with high level alarms;

d) fitted with overflow pipes to the other discharge tanks.

287 We require the tank design to be BAT to contain the low activity level liquid effluents. We would not require additional containment such as bunding, but will require details of construction techniques and liner specification at site-specific permitting. We would inspect tanks during construction and would expect to see the operator implement a test and maintenance programme to ensure the tanks remain leak tight.

288 EDF and AREVA will recommend that operators implement procedures for inspecting equipment through the life of a UK EPR to ensure it remains leak tight. These should include:

a) condition of pipework (lagging to be removed where necessary);

b) mechanical damage;

c) operation and integrity of pipe supports;

d) indication of leaks;

e) defects in threaded connections, measuring devices and impulse lines;

f) vibration, excessive noise.

289 EDF and AREVA will recommend that operators of a UK EPR should establish a network of boreholes for sampling groundwater during construction. The network should remain in place during operation and be used to monitor groundwater quality and detect any contaminants that inadvertently reach the water table. We commend this as good practice for reassurance, and recommend that operators contact us at the early stages of site-specific designs so that we can advise on the appropriate location and construction of boreholes. Operators should also develop a conceptual site model for each specific site to help location of boreholes.

290 **We conclude at this stage that the UK EPR uses BAT to contain liquids and prevent contamination of groundwater in normal operation. The techniques used should also minimise contamination under fault conditions. However, the design of the discharge tanks needs to be resolved at the site-specific stage, with an associated demonstration of BAT for size (enough capacity to cover all reactor operating scenarios) and leak-tight construction.**

9 Gaseous radioactive waste disposal and limits

291 We conclude that overall the UK EPR utilises the best available techniques (BAT) to minimise discharges of gaseous radioactive waste:

a) during routine operations and maintenance;

b) from anticipated operational events.

292 However, our conclusion is subject to one other issue, which will need to be addressed during site-specific permitting (UK EPR-OI06):

a) Providing a BAT assessment to demonstrate that controls on the fuel pool minimise the discharge of tritium to air.

293 We conclude that the gaseous discharges from the UK EPR should not exceed those of comparable power stations across the world.

294 We conclude that the UK EPR should comply with the limits and levels set out below for the disposal of gaseous radioactive waste to air.

Radionuclides or group of radionuclides	Annual limit GBq	Quarterly notification level GBq
Tritium	3000	150
Carbon-14	700	100
Iodine-131	0.4	0.04
Noble gases	22500	2250
All other radionuclides (excepting tritium, carbon-14, iodine radionuclides and noble gases)	0.05	0.027

295 As part of GDA, we are proposing both annual discharge limits and quarterly notification levels (QNLs). Annual limits will probably be expressed as a 12-month rolling average in any permit we may issue. The general principles and methodology for limit setting are set out in our guidance (Environment Agency, 2005), and are consistent with the Government discharge strategy which states '*in setting discharge limits, the Regulators will have regard to the application of best available techniques (BAT)*'. (DECC, 2009a).

296 Normally, we would use operational experience from a reactor in setting QNLs, but as the UK EPR is not yet operating anywhere in the world, we do not have that information. Therefore, we have used EDF and AREVA's 'expected performance' as a basis to set the QNLs. These will be challenging for a new reactor as we wish to assure ourselves that BAT is being used to minimise discharges (in accordance with Government expectations (BERR, 2008a). It is possible that with early operational feedback from reactors now under construction we may need to review and revise the QNLs at the site permitting stage.

Consultation Question 4: Do you have any views or comments on our preliminary conclusions on:

a. best available techniques to minimise the gaseous discharge of radioactive waste;

b. our proposed annual disposal limits;

c. our proposed quarterly notification levels?

297 In addition to using BAT to prevent and, where that is not practicable, minimise the creation of radioactive waste (as discussed above), we also expect new nuclear power plant to use BAT to minimise the radioactivity of discharges of gaseous radioactive waste and to minimise the impact of those discharges on the environment.

298 The PCERsc3.3s4.1.1.1 describes three origins of gaseous radioactive waste:

a) degassing associated with the primary circuit. This waste will contain the radioactive gaseous products of fission and activation and will enter the gaseous waste processing system (GWPS). The GWPS treats gaseous effluents from the systems serving the reactor coolant system:

   i) the purge system keeps a nitrogen flow through the free volumes of tanks and vessels. The nitrogen purge gas is mostly recovered by the GWPS and reused. During plant start-up or shut-down a portion of the purge gas is sent to a dryer and then three activated carbon delay beds in series before discharge;

   ii) the degasification system may be used to treat coolant at shut-down and its waste gases sent to the delay system. (PCERsc6.2s1.2.3.1, diagram PCERsc6.4s3 Figure 1 (page 80)).

b) the ventilation of buildings within the UK EPR that may be contaminated with radioactivity, in particular the nuclear auxiliary building and the fuel building. Ventilation air that may contain radioactive particulates and gases, in particular iodine radionuclides (iodine-131 and iodine-133), is passed through filters and, if iodine detected, iodine traps before discharge;

c) gaseous effluent from the secondary circuit. This would be mainly air collected in the condenser vacuum system that could be contaminated with radioactivity, particularly tritium, in the event of a minor tube leak in the steam generators. The collected gases are filtered before discharge.

299 The box at the end of PCERsc8.2s3.4.6 summarises the EDF and AREVA BAT assessment for gaseous radioactive discharges. The UK EPR design has:

a) provided absorbent charcoal delay beds to reduce the activity of short lived radioactive gases such as xenon and krypton;

b) included dry high efficiency particulate air (HEPA) filters (efficiency 99.97 per cent) on ventilation discharges;

c) used carbon adsorption to reduce discharges of iodine radionuclides whenever detected in ventilation discharges;

d) used a semi-closed loop system for the treatment of aerated effluents, its advantages are listed in PCERsc6.3s7.4.1.

300 EDF and AREVA claim that, depending on the level of primary coolant activity, gaseous radioactive discharges from the UK EPR can be reduced by 20 per cent for noble gases and iodine radionuclides and by 15 per cent for other fission and

activation products as compared to the predecessor 1300 MWe design allowing for the increase in energy production. (PCERsc6.3s7.4.1).

301 PCERsc3.3s4.1.2 Table 4 states that the UK EPR will make radioactive discharges to air through the main stack as given in the table below. We have added to that table our proposed disposal limits, which are explained further later in our document.

Category	Annual expected performance excluding contingency (GBq)	Maximum annual gaseous radioactive discharge (GBq)	Proposed Environment Agency annual limits (GBq)	Proposed Environment Agency QNL (GBq)
Tritium	500	3000	3000	150
Carbon-14	350	700	700	100
Iodine-131	0.0228	0.18	0.4	0.04
Total iodine radionuclides	0.05	0.4	None	
Noble gases	800	22500	22500	2250
All other radionuclides (excepting tritium, carbon-14, iodine radionuclides and noble gases)	0.004	0.12	0.05	0.027

302 The above estimates are expanded into individual radionuclides in the PCERsc3.3s4.1.2 Table 5. We are content that these represent the significant radionuclides potentially discharged to the air.

303 We will set limits and levels on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment. We have assessed the information within the PCER against the criteria in our limit setting guidance (Environment Agency, 2005) as follows:

a) critical group dose greater than 1 μSv y^{-1}: carbon-14 at 5.6 μSv y^{-1};

b) discharge exceeds 1 TBq y^{-1}: tritium and noble gases;

c) indicator of plant performance:

   i) iodine radionuclides for fuel pin failures, we will use iodine-131 as an indicator;

   ii) 'all other radionuclides' to be monitored as particulates will confirm performance of filters in the ventilation systems.

304 We have set out our proposed disposal limits for tritium, carbon-14, noble gases, iodine-131 and other radionuclides in the table above. The definition of 'all other radionuclides' will be specified more completely in our permit with reference to the monitoring technique to be used.

305 PCERsc6.3s7.2 to s7.5 quantifies disposals, these are given as 'expected performance' that has no allowance for any contingencies and 'maximum' (we have taken as the proposed disposal limit) that allows for contingencies to cover situations foreseeable in normal operations but not any incidents. The PCERsc6.2s1.2.2 covers the nature and treatment of the gaseous disposals. We have summarised the PCER and EPRB information below for individual radionuclides and groups and detailed our limit proposals.

9.1 Tritium

306 The main sources of tritium for gaseous disposal are tritiated water evaporating from the surface of the in-containment refuelling storage water tank (IRWST) and the spent fuel pool which are collected by the ventilation systems. EDF and AREVA claim maximum losses by evaporation are 350 GBq y^{-1} from the pool and 500 GBq y^{-1} from the IRWST, with realistic values below these figures. Disposal is to the main stack.

307 EDF and AREVA claim that ventilation system design reduces evaporation of tritium but fail to provide evidence or quantification of this.

308 EDF and AREVA say that evaporation of tritium from the pool and the IRWST depends on the ambient temperature and hygrometry. Operating conditions need to be optimised by the operator at the site-specific stage between the health and safety of workers in the building and reduction of evaporation of tritium.

309 We will require a BAT case for controlling tritium resulting from evaporation in the UK EPR in applications for site-specific permitting.

310 Tritium will also be present in the gaseous effluent from the primary coolant treatment systems. This effluent is processed in the gaseous waste processing system. We have noted above that the GWPS minimises discharge of tritium to air.

311 Another possible source of tritium is in the event of leaks between the primary and secondary circuits in the steam generators. The steam in the secondary circuit may then contain some tritium, the steam is condensed after passing through the turbines and the condenser off-gas is collected and feeds into the ventilation systems.

312 EDF and AREVA review gaseous abatement techniques (EPRBs3.3) but do not consider any represent BAT:

a) decay by delay is not an option as the half-life of tritium is 12 years;

b) filtration does not affect tritium in gaseous effluent;

c) oxidising the gaseous effluent and then adsorption of the tritiated water produced on molecular sieve is possible. The sieve could be disposed of as solid waste or the tritiated water desorbed by heat and discharged as aqueous effluent;

d) scrubbing with chilled water will move tritium to aqueous effluent. The low level of tritium in the gaseous route (2 - 3 per cent of UK EPR total) and inefficiency of the scrubbing process mean any cost would be disproportionate to the benefit in reducing the gaseous impact.

313 Tritium discharges have a relatively low impact on the environment (see below - 0.26 μSv y^{-1} to an infant). We, therefore, agree that using any of the gaseous abatement techniques considered is disproportionate for the UK EPR.

314 **We conclude that the UK EPR uses BAT to minimise discharges of gaseous tritium, although we expect the operator to demonstrate that controls on the fuel pool are BAT to minimise the discharge of tritium to air at the site-specific stage (other issue UK EPR-OI06).**

315 EDF and AREVA estimated the expected performance value of 500 GBq y^{-1} using operational feedback from currently operating similar reactors, allowing for differences in pool surface area.

316 EDF and AREVA cited current limits for similar but smaller plants and operational experience of an annual maximum reaching 1000 GBq to propose a maximum annual disposal for the UK EPR of 3000 GBq.

317 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of tritium is 100 to 3600 GBq per year (GBq y^{-1}) for a 1000 MWe power station (see Annex 3). We conclude that the gaseous discharge of tritium from UK

EPR at the 'expected performance' of 500 GBq (290 GBq normalised to 1000 MWe) is comparable to other power stations across the world.

318 The monthly disposal profile is stated as unlikely to present major fluctuations. Values at 10 per cent of the annual are quoted: 50 GBq/month 'expected performance' and 300 GBq/month 'maximum'.

319 The radiological impact from the 'maximum' disposal of tritium to air is stated as a dose to adults and children of 0.14 μSv y^{-1} and infants of 0.26 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

320 EDF and AREVA propose a gaseous disposal limit for tritium of 3000 GBq y^{-1}. They state that as a new design there are some uncertainties as to the actual evaporation rates leading to tritium disposals and that an improved monitoring method for tritium may report higher values than historic data from existing reactors. Therefore, the headroom of 2500 GBq above the 500 GBq 'expected performance' is proposed until operational experience of an EPR is available.

321 We have provisionally accepted above that the UK EPR uses BAT to minimise the gaseous discharge of tritium with an 'expected performance' value of 500 GBq y^{-1}. The limit set should allow some headroom above this value to allow for foreseeable contingencies. We have considered the operational data presented in PCERsc6.3 Appendix A-24 and A-25 for previous similar plant and have taken 1000 GBq y^{-1} as a worst-case operational estimate. Allowing for the larger size of the UK EPR and a contingency factor, we will accept the proposal to set the annual disposal limit at 3000 GBq.

322 We consider that a quarterly notification level based on the 'expected performance' (500 GBq y^{-1}) and the stated monthly estimate of 10 per cent of annual should be set. That is 3 x 50 = 150 GBq/quarter. This should highlight adverse trends in disposals and require an operator to demonstrate that BAT is still being applied if a QNL is exceeded.

9.2 Carbon-14

323 As described above, the main source of carbon-14 is the activation of oxygen and nitrogen in the reactor coolant. The carbon-14 is mainly present as the dissolved gases methane (CH_4 – about 80 per cent) and carbon dioxide (CO_2 - 20 per cent). A portion of the coolant continually passes through the chemical and volume control system where dissolved gases are sent to the gaseous waste processing system. The GWPS does not remove any carbon-14. EDF and AREVA state that 80 – 95 per cent of the carbon-14 in the coolant will discharge as a gas with 5 - 20 per cent remaining in aqueous or solid waste. (PCERsc6.3s7.3.1.3)

324 EDF and AREVA have considered techniques to minimise the gaseous discharge of carbon-14 (EPRBs3.2), in particular:

a) decay by delay is not an option as the half-life of carbon-14 is 5710 years;

b) thermal oxidation to ensure all carbon-14 is converted to carbon dioxide (CO_2) followed by scrubbing, for example, with sodium hydroxide solution, to remove the CO_2 as a carbonate. The carbonate can be converted to a solid waste for disposal;

c) thermal oxidation, as above, followed by CO_2 absorption in a cooled fluorocarbon or ethanolamine solvent. The issue of dealing with the absorbed CO_2 is not resolved;

d) thermal oxidation, as above, followed by CO_2 adsorption on molecular sieve. The issue of dealing with the molecular sieve after saturation is not resolved;

e) thermal oxidation, as above, followed by freezing out the CO_2. The issue of dealing with the removed CO_2 is not resolved.

325 EDF and AREVA state that while there are potential techniques for reducing carbon-14 in gaseous effluents, none are currently used on operational power reactors and they do not, therefore, represent world best practice. Also, some are not technically developed enough to be used in a PWR. They cite the IAEA Technical report 421 that concludes that carbon-14 removal methods are costly and require high energy consumption, but do not provide any cost or energy estimates for applying any techniques to the UK EPR. EDF and AREVA consider that the impact from the gaseous disposal of carbon-14 is low (a maximum of 5.6 μSv y^{-1} for an infant) and conclude that no technique is BAT for use in the UK EPR.

326 **We agree that no techniques appear to be BAT at this time for reducing carbon-14 in gaseous discharges from a PWR. We conclude that the UK EPR uses BAT to minimise the discharge of carbon-14 to air.**

327 EDF and AREVA predict an 'expected performance' value of 350 GBq y^{-1} based on the 444 GBq y^{-1} source term, assuming some 80 per cent of carbon-14 produced goes to air. They state that the split of carbon-14 between solid / aqueous and gas is uncertain. Also the level of dissolved nitrogen in the coolant may increase from 10 ppm (value used for source term). Therefore, they propose a maximum annual disposal for the UK EPR of 700 GBq. This value is supported by operational data from predecessor KONVOI reactors.

328 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of carbon-14 is 40 to 350 GBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' gaseous discharge of carbon-14 from UK EPR at 350 GBq (203 GBq normalised to 1000 MWe) is within this range. We conclude that gaseous discharge of carbon-14 is comparable to other power stations across the world.

329 EDF and AREVA were unable to provide a monthly discharge profile but did provide quarterly data based on operational feedback (PCERsc6.3s7.3.3). Discharges are affected by power output and factors such as shut-downs. They are variable and a significant portion of annual discharge can occur in one quarter. Values of 100 GBq/quarter 'expected performance' and 300 GBq/quarter 'maximum' are quoted.

330 The radiological impact from the 'maximum' disposal of carbon-14 to air is stated as a dose to adults of 2.9 μSv y^{-1}, to children of 3.2 μSv y^{-1} and infants of 5.6 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D, corrected from 900 to 700 GBq y^{-1}.

331 We accepted above that the UK EPR uses BAT to minimise the gaseous discharge of carbon-14, with an 'expected performance' value of 350 GBq y^{-1}. We accept the headroom proposed of 350 GBq y^{-1} to allow for the uncertainty of split between gas and liquid and level of nitrogen in the coolant. We will set the annual disposal limit at 700 GBq.

332 We consider that a quarterly notification level based on the 'expected quarterly performance' of 100 GBq should be set.

9.3 Noble gases

333 Significant quantities of xenon-133, xenon-135 and krypton-85 should only reach the gaseous waste processing system (GWPS) in the event of defects in fuel cladding (discussed above). The GWPS is designed to minimise the impact of noble gases by delaying their discharge using activated charcoal beds. The noble gases are initially adsorbed but are gradually moved forward by fresh purge gas passing through the beds. The delay allows the radioactivity to decay (PCERsc6.3s7.4.2.1). Xenon is delayed by 40 days – for xenon-131 with a half-life of 5.25 days this will reduce radioactivity to less than 0.5 per cent of the value entering the GWPS (reduction factor of 200). Krypton is delayed by at least 40 hours giving effective decay of the short-lived radionuclides krypton-85m (reduction factor of 500 claimed), krypton-87 and

krypton-88 but not krypton-85 with a half life of 10.72 years. There is a gas drier before the delay beds to optimise their performance and a filter after to prevent any dust from the beds escaping to the air. The gaseous effluent from the GWPS is discharged to the main stack through HEPA filters located in the nuclear auxiliary building. (PCERsc6.2s1.2.3.1)

334 EDF and AREVA provided us with their design calculations, confirming that the activated charcoal in the three beds would achieve the delays promised above, but did not provide a full BAT options appraisal of alternative techniques or bed sizing.

335 **We accept the delay calculations and that delay beds are current good practice. Further, that the impact from noble gases is slight (0.047 μSv y^{-1}) so that a full BAT assessment would be disproportionate. We conclude that the UK EPR uses BAT to minimise the discharge of noble gases.**

336 PCERsc6.3s7.4.2.1 Table 16 gives the expected distribution of noble gas radionuclides based on data from similar predecessor reactors:

Radionuclide	Percentage of total noble gas activity discharged
Krypton-85	13.9
Xenon-133	63.1
Xenon-135	19.8
Argon-41	2.9
Xenon-131m	0.3

337 Argon-41 is discussed above, its source is activation of naturally occurring argon-40 in the air around the reactor and it is sent to the main stack by the ventilation systems. It does not pass through the GWPS but is monitored in the stack before discharge.

338 EDF and AREVA estimated their 'expected performance' value of 800 GBq y^{-1} using operational feedback data from predecessor reactors. This value can only be achieved if there are no fuel cladding failures and a subsequent need to degas the reactor coolant during a reporting year. The operational data is highly variable showing dependency on fuel reliability. EDF and AREVA say that a sizable contingency is needed to allow for continued operation with even a very low level of fuel failure. They propose a 'maximum' of 22,500 GBq y^{-1} – the same as the current limit in France for the 1300 MWe reactor. As the UK EPR will generate 25 per cent more energy, this is effectively a 25 per cent lower limit and reflects the better performance expected of fuel today. (PCERsc6.3s7.4.2.1, s7.4.2.2.1)

339 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of noble gases is 100 to 10,000 GBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' gaseous discharge of noble gases from UK EPR at 800 GBq (460 GBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of noble gases is comparable to other power stations across the world.

340 EDF and AREVA say that in normal operation (without fuel leaks or degassing before shutdown) monthly discharges could be below detectable quantities. Monitoring systems would report at detection thresholds and this could be 400 GBq/month. However, with fuel leaks and if the reactor coolant is degassed the monthly discharge could reach 5000 GBq. (PCERsc6.3s7.4.2.2)

341 The radiological impact from the 'maximum' disposal of noble gases to air is stated as a dose to adults of 0.047 µSv y^{-1}, to children of 0.029 µSv y^{-1} and infants of 0.023 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

342 We have provisionally accepted above that the UK EPR uses BAT to minimise the gaseous discharge of noble gases with an 'expected performance' value of 800 GBq y^{-1}. EDF and AREVA propose a headroom of 21,700 GBq to allow for some level of fuel cladding failure. In setting limits we accept that predicting an allowance for fuel leaks is difficult. Reactors are designed to run until their next refuelling shutdown with a small number of fuel leaks, and we do not wish to constrain operations when noble gas discharges have so little impact. We stated our range above as up to 10,000 GBq y^{-1} and, using this as a base value, we need to add some contingency to set a limit and to allow for the increased size of the UK EPR. On that basis, we consider the EDF and AREVA proposal reasonable and we will set the annual disposal limit at 22,500 GBq.

343 We consider that a quarterly notification level should be set to give us early indications of fuel cladding failures. Based on our regulatory experience, we will set the QNL at 10 per cent of the disposal limit - 2250 GBq.

9.4 Iodine radionuclides

344 As described above iodine radionuclides are formed by fission in the fuel and are normally contained within the fuel cladding. PCERsc6.3s7.4.3.1 says that most of the iodine radionuclides are retained within the liquids going to the liquid waste processing system. Gaseous iodines will enter the gaseous waste processing system (GWPS) with the noble gases as described above. The recirculation of purge gas in the GWPS will allow decay of shorter-lived iodine radionuclides such as iodine-132 and iodine-134. When purge gas is bled off, it passes through delay beds before discharge. While these beds are not targeted at iodine radionuclides, EDF and AREVA claim a delay of 40 days in the delay beds for iodine radionuclides. Iodine-131 has a half-life of 8 days, so a reduction to around 3 per cent of the input value should take place.

345 The effluent gas from the GWPS is passed to HEPA filters before discharge from the main stack. There is a detection system to pass the gas through activated charcoal iodine traps if high iodine radioactivity is detected. EDF and AREVA claim a decontamination factor of 100 for the iodine traps in systems that operate during fault conditions and 10 for others. (PCERsc6.2s1.2.3.2.1)

346 Any iodine radionuclides coming from leaks in the primary coolant circuit will enter the ventilation systems. These systems will send ventilation air to activated charcoal iodine traps if high iodine radioactivity is detected or as a precaution during certain operations or in case of accidents. (PCERsc6.3s7.4.3.1 Figure 16)

347 **EDF and AREVA have not presented evidence that the techniques described above for minimising iodine radionuclides discharged are BAT. However, we do accept using activated charcoal as current good practice for minimising the discharge of iodine radionuclides. As the level of discharge (50 MBq y^{-1}) and subsequent impact (maximum 0.32 µSv y^{-1}) are low, we accept that a detailed BAT assessment would be disproportionate. We conclude that the UK EPR uses BAT to minimise the discharge of iodine radionuclides to air.**

348 EDF and AREVA calculated an 'expected performance' value of 50 MBq y^{-1} using operational feedback data from predecessor reactors. This may be high as much data showed 'below detection limit'. This value can only be achieved if there are no fuel cladding failures and subsequent release of iodine radionuclides. The operational data for 'maximums' is highly variable, showing dependency on fuel reliability. EDF and AREVA say that a sizable contingency is needed to allow for continued operation with even a very low level of fuel failure. They propose 400 MBq y^{-1} – the same as the current limit in France for the 1300 MWe reactor. As the UK EPR will deliver 25 per

cent more energy, this is effectively a 25 per cent lower limit and reflects the better performance expected of fuel today and the improvements made to the GWPS.

349 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of iodine radionuclides is 1 to 2000 MBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' gaseous discharge of iodine radionuclides from UK EPR at 50 MBq (29 MBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of iodine radionuclides is comparable to other power stations across the world.

350 EDF and AREVA claim that in normal operation (without fuel leaks) and without shut-downs or maintenance activities, monthly discharges are very low and could be below detectable quantities; a value of 20 MBq is proposed. However, most iodine radionuclides discharges are expected during shut-downs or maintenance activities when large volumes can be processed through the GWPS. If this also happens when there are fuel leaks, the discharge could reach 75 per cent of the maximum annual discharge so the proposed maximum monthly discharge is 300 MBq.

351 The radiological impact from the 'maximum' disposal of iodine radionuclides to air is stated as a dose to adults of 0.039 μSv y^{-1}, to children of 0.078 μSv y^{-1} and infants of 0.32 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D.

352 We have provisionally accepted above that the UK EPR uses BAT to minimise the gaseous discharge of iodine radionuclides with an 'expected performance' value of 50 MBq y^{-1}. The headroom proposed allows for some level of fuel cladding failure – the PCER says past operational experience has seen discharge levels increase by a factor of up to 10 following fuel leaks. We noted above that we would only set a limit against iodine-131 as it has the greatest individual impact of the iodine radionuclides. Also, the impact of iodine radionuclides is low and we wish to provide adequate headroom to avoid constraining operations, so we propose to set the annual disposal limit for iodine-131 at 400 MBq.

353 We consider that a quarterly notification level should be set to give us early indications of fuel cladding failures. Based on our regulatory experience, we will set the QNL at 10 per cent of the disposal limit - 40 MBq.

9.5 Other radionuclides

354 EDF and AREVA say in PCER sc6.3s7.4.4.1 that other fission and activation products (FAPs) are present in the reactor coolant and can be in aerosols (a dispersion of solid or liquid particles in a gas) produced from equipment leaks or as the coolant is treated in the chemical and volume control system (CVCS). Most FAPs remain in the liquid phase. Aerosols from equipment leaks are picked up by the ventilation systems, these systems have HEPA filters that should effectively remove the aerosols before discharge to the main stack. FAPs can be in the gaseous effluent from the CVCS to the gaseous waste processing system (GWPS). The gaseous effluent from the GWPS passes through HEPA filters before discharge to the main stack.

355 **We conclude that using HEPA filters in the UK EPR on all gaseous discharges that may contain fission and activation products is BAT.**

356 PCERsc6.3s7.4.4.1 Table 17 gives the distribution of the main fission and activation product radionuclides expected to be found as particulates in the gaseous discharge:

Radionuclide	Percentage of activity in discharged FAPs
Cobalt-58	25.5
Cobalt-60	30.1
Caesium-134	23.4
Caesium-137	21.0

357 Caesium is a fission product and should only be detected on fuel cladding failures, cobalt is an activated corrosion product and can be present in trace quantities. Discharges are often below the threshold of detection of monitoring equipment.

358 EDF and AREVA calculated an 'expected performance' value of 4 MBq y^{-1} using operational feedback from predecessor reactors. Values of FAPs were below the detection limits of monitoring equipment and the 4 MBq is in essence a threshold of detection value. Peaks of discharge can be seen, however, during shut-downs and maintenance activity and significant contingency should be allowed to cover these operations. EDF and AREVA used the current limit value for their predecessor 1300 MWe reactors of 400 MBq y^{-1} as a start point for proposing the 'maximum' discharge. They claim that the UK EPR has improvements over the 1300 MWe reactor with improved HEPA filtration and the source of cobalt has been minimised by using low cobalt content material. The 'maximum' proposed is 120 MBq y^{-1} – less than 25 per cent of the 1300 MWe reactors if the increased power of the UK EPR is taken into account.

359 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to atmosphere of fission and activation products is 1 to 1000 MBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' gaseous discharge of FAPs from UK EPR at 4 MBq (2.3 MBq normalised to 1000 MWe) is well within this range. We conclude that gaseous discharge of FAPs is comparable to other power stations across the world.

360 EDF and AREVA claim that in normal operation (without fuel leaks to contribute caesium) and without shut-downs or maintenance activities monthly discharges are very low and could be below detectable quantities, the 'expected performance' value of 0.8 MBq is proposed. However, in a month before shut-down or when maintenance is carried out and allowing for some fuel leaks combined with any treatment failures a much higher value is required for the monthly 'maximum'. Up to 50 per cent of the annual discharge could occur in a month – 60 MBq is proposed.

361 The radiological impact from the 'maximum' disposal of other FAPs to air is stated as a dose to adults of 0.018 μSv y^{-1}, to children of 0.01 μSv y^{-1} and infants of 0.009 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables B, C and D, corrected from previous maximum of 340 to 120 MBq y^{-1}.

362 We have accepted above that the UK EPR uses BAT to minimise the gaseous discharge of other FAPs with an 'expected performance' value of 4 MBq y^{-1}. As well as comparing their 'maximum' with current limits, EDF and AREVA say that the headroom of an additional 116 MBq y^{-1} allows for a combination of fuel leaks, maintenance operation and a failure of HEPA filtration systems that could increase discharge by 10 to 50 times. (PCERsc6.3s7.4.4.3)

363 We do not consider this approach justified, in particular when operational data provided in the PCERsc6.3 Appendices A-55 and A-56 is taken into account. The highest discharge reported in the six years from 2002 to 2007 was less than 6 MBq y^{-1}. The values reported are often less than 1 per cent of limits. We note that some higher levels, up to 50 MBq y^{-1}, are reported in the PCER but without the context to these numbers we cannot assess whether they represent normal operational variance or events. We set limits to ensure BAT is used. While we allow for contingencies, we believe that, using BAT, a failure of HEPA filtration should be rapidly detected and any ventilation involved should be diverted to functioning equipment quickly. Further, operations that may cause high discharges should not be carried out when key equipment such as HEPA filters are unavailable. Our normal methodology is to take the worst-case discharge from operational experience and then add an appropriate contingency. We have considered the data provided and taken 25 MBq y^{-1} as a worse-case normal operational discharge. We have applied a x2 factor (Environment Agency, 2005) and propose to set 50 MBq y^{-1} as the annual disposal limit.

364 We consider that a quarterly notification level should be set to give us early indications of any issues. We will allow one month at 50 per cent of the disposal limit and two months at the 'expected performance' of 0.8 MBq/month and round up to give a QNL of 27 MBq.

9.6 Gaseous radioactive waste disposal to the environment

365 We are satisfied that all significant gaseous radioactive wastes from the UK EPR are collected into the main stack for discharge. The stack will be fitted with continuous monitoring equipment to measure radioactive materials entering the air.

366 The PCER has assumed an 'effective' stack height of 20 m for GDA. The effective stack height allows for factors such as the effect of nearby large buildings causing downwash, which results in discharges reaching the ground closer to the point of discharge than in an open area. The effective height is much less than the actual height - the initial estimate for the UK EPR stack is 60 metres. Dispersion modelling for the generic site gives an annual dose from the 'maximum' gaseous discharge of 4 μSv for an adult or child and 7.8 μSv for an infant (PCERsc11.1s1.3.2.2). The doses are low enough that we accept that the (GDA) stack is BAT to reduce impact to a minimum. The operator for each specific site will need to demonstrate by modelling that the stack height proposed will be BAT for adequate dispersion allowing for topography (the surface features of the local land area surrounding the site).

10 Aqueous radioactive waste disposal and limits

367 We conclude that overall the UK EPR utilises the best available techniques (BAT) to minimise discharges of aqueous radioactive waste:

a) during routine operations and maintenance;

b) from anticipated operational events.

368 However, our conclusion is subject to one other issue:

a) the sizing of filters and the demineralisation system in the liquid waste processing system (UK EPR-OI07).

369 We conclude that the aqueous discharges from the UK EPR should not exceed those of comparable power stations across the world.

370 We conclude that the UK EPR should comply with the limits and levels set out below for the disposal of aqueous radioactive waste to the marine environment.

Radionuclides or group of radionuclides	Annual limit GBq	Quarterly notification level GBq
Tritium	75,000	45,000
Carbon-14	95	9
Cobalt-60	1.5	0.12
Caesium-137	0.5	0.04
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)	3	0.24

Consultation Question 5: Do you have any views or comments on our preliminary conclusions on:

a. best available techniques to minimise the aqueous discharge of radioactive waste;

b. our proposed annual disposal limits;

c. our proposed quarterly notification levels?

371 In addition to using BAT to prevent and, where that is not practicable, minimise the creation of radioactive waste (as discussed above), we also expect new nuclear power plant to use BAT to minimise the radioactivity of discharges of aqueous waste and to minimise the impact of those discharges on the environment.

372 The PCERsc3.4s5.2.2 describes three categories of aqueous radioactive effluent:

a) liquid associated with the reactor coolant, not chemically polluted;

b) spent liquid comprising polluted reactor coolant, chemical effluent and floor drainage;

c) drainage water from the turbine hall including blowdown from the secondary circuit.

373 The PCERsc6.2s1.1.1 gives more detail on the collection of effluents into 3 drain systems:

a) process drain (PD): collects polluted primary coolant that cannot be recycled;

b) chemical drain (CD): collects chemically polluted water from the nuclear auxiliary building, reactor building and fuel building;

c) floor drains (FD) of 3 types:

i) FD1: collects potentially contaminated leaks and floor washings from controlled areas;

ii) FD2: collects normally uncontaminated leaks and floor washings from controlled areas;

iii) FD3: normally uncontaminated leaks and floor washings from outside controlled areas. FD3 is normally sent directly to a discharge tank for non-radioactive wastes (in the conventional island liquid waste discharge system (CILWDS)).

374 The effluents from the PD, CD, FD1 and FD2 are collected in separate buffer tanks before treatment in the liquid waste processing system (LWPS). Effluent from the LWPS is collected in disposal tanks (the LRMDS tanks). The contents of these tanks are analysed before disposal to the sea is allowed under a managed procedure.

375 Drainage from the turbine halls is normally sent to the CILWDS except for blowdown water from the secondary circuit. This is normally recycled after treatment, but, if recycling is not possible, blowdown is sent to the LRMDS tanks.

376 The UK EPR uses filtration and / or demineralisation and/or evaporation in the LWPS to minimise discharges of aqueous radioactive waste. These techniques are specifically targeted at reducing fission and activation products and are assessed below.

377 PCERsc3.4s5.2.4 Table 1 states that the UK EPR will make radioactive discharges to the sea as given in the table below. We have added to that table our proposed annual disposal limits and QNLs, which are explained later in our document.

Category	Annual expected performance excluding contingency GBq	Maximum annual liquid radioactive discharge GBq	Proposed Environment Agency disposal limits GBq	Proposed Environment Agency QNL GBq
Tritium	52,000	75,000	75,000	45,000
Carbon-14	23	95	95	9
Iodine radionuclides	0.007	0.05	None	None
Cobalt-60	0.18	3	1.5	0.12
Caesium-137	0.0567	0.945	0.5	0.04
All other radionuclides[1]	0.4	6	3	0.24

[1] (excepting tritium, carbon-14, cobalt-60 and caesium-137)

378 PCERsc3.4s5.2.4 Table 2 gives the distribution of fission and activation products in radionuclides discharged as aqueous waste. The most significant are cobalt-60 and

cobalt-58. We are content that this lists the significant individual radionuclides that need to be considered.

379 We will set limits and levels on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment. We have assessed the information within the PCER against the criteria in our limit setting guidance (Environment Agency, 2005) as follows:

a) critical group dose greater than 1 μSv y^{-1}: carbon-14 at 14 μSv y^{-1} and 'all other radionuclides' at 3.27 μSv y^{-1} (total including cobalt-60 and caesium-137);

b) discharge exceeds 1 TBq y^{-1}: tritium;

c) indicator of plant performance:

   i) cobalt-60 indicates effectiveness of corrosion controls and the filter and demineralisation system in the liquid waste processing system;

   ii) caesium-137 is an indicator of fuel cladding failures.

380 We have set out our proposed disposal limits for tritium, carbon-14, cobalt-60, caesium-137 and other radionuclides in the table above. 'All other radionuclides' will be more completely defined in any permit we issue, for example, '*All other radionuclides means the sum of all radionuclides as measured by the methods defined in this permit except those specified individually in the table*'. We do not consider it proportionate to set a limit for iodine radionuclides as discharge levels and impact are low and measured levels may well be below detection thresholds of monitoring methods.

381 EDF and AREVA state that alpha-emitting radionuclides should not be present in detectable amounts in the aqueous discharge and that in-line detectors will operate to prevent any such discharge. We will not include alpha-emitters as a category for disposal limits.

382 PCERsc6.3s6.2 to s6.5 quantifies disposals, these are given as 'expected performance' that has no allowance for any contingencies and 'maximum' (we have taken as proposed disposal limit) that allows for contingencies to cover situations foreseeable in normal operations but not any incidents. The PCERsc6.2s1.2.2 covers the nature and treatment of the aqueous disposals. We have summarised the PCER information below.

10.1 Tritium

383 Tritium is present as tritiated water in the reactor coolant. EDF and AREVA state there are currently no available techniques to remove tritium from the reactor coolant. Therefore, to avoid the build up of tritium in the coolant (to reduce radiological hazard), a portion of the coolant must be discharged (and replaced). This is the main source of tritium for aqueous discharge.

384 Tritium can also be found in the water contained in the secondary circuit if there are leaks in the steam generators. Any water drained from the circuit will enter the LWPS and be contained in storage tanks before monitoring and discharge. This discharge route does not affect the overall discharge of tritium.

385 EDF and AREVA review aqueous abatement techniques (EPRBs3.3) but do not consider any represent BAT:

a) decay by delay is not an option as the half-life of tritium is 12 years;

b) filtration has no effect on tritium in aqueous effluents;

c) evaporation is not an option as tritiated water would carry over to the condensate, leaving little in the concentrate for treatment and disposal as solid waste;

d) EDF and AREVA refer to IAEA technical report No. 421 that lists some theoretical techniques that may potentially be used in the future, but none are currently technically developed for PWRs;

e) tritiated water could be collected and cemented to solid waste. This would produce large volumes of solid waste for disposal (probably ILW) and the tritium may not be immobilised effectively;

f) isotopic retention is an undeveloped technique.

386 **Tritium discharges have a low impact on the environment (see below: 0.018 µSv y^{-1} to an adult). Therefore, we agree that using any of the aqueous abatement techniques considered is not proportionate for the UK EPR, we conclude that the UK EPR uses BAT to minimise the discharge of aqueous tritium.**

387 The 'expected performance value' of 52 TBq y^{-1} and 'maximum' of 75 TBq y^{-1} were taken from calculations assuming 91 per cent or 100 per cent power production respectively and various reactor chemistry options (PCERsc6.3s6.2.1.4). EDF and AREVA then reviewed operational experience of predecessor plant to validate the calculations.

388 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to water of tritium is 2 to 30 TBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' aqueous discharge of tritium from UK EPR is 52 TBq (30 TBq normalised to 1000 MWe). While the UK EPR is at the top of our range, we noted above in section 8.2.1 that the UK EPR minimises gaseous discharge of tritium and this does affect aqueous discharges. We conclude that aqueous discharge of tritium is comparable to other power stations across the world.

389 EDF and AREVA state that monthly discharges are related to the time in the generation cycle. Also contingency is needed to allow operational flexibility to delay discharges for a period to allow for maintenance or faults in the LWPS. Values at 25 per cent of the annual are quoted: 13 TBq/month 'expected performance' and 18.75 TBq/month 'maximum'.

390 The radiological impact from the 'maximum' disposal of tritium to the sea is stated as a dose to adults of 0.018 µSv y^{-1}, to children of 0.0049 µSv y^{-1} and infants of 0.0017 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

391 EDF and AREVA propose an aqueous disposal limit for tritium of 75 TBq y^{-1}. The headroom over the 'expected performance' of 52 TBq y^{-1} allows for up to 100 per cent production or other management options that may affect tritium discharges. (PCERsc6.3s6.2.2.2)

392 We have accepted above that the UK EPR uses BAT to minimise the n discharge of tritium with an 'expected performance' value of 52 TBq y^{-1}. We accept the headroom proposed by EDF and AREVA as a reasonable contingency factor and we will set the annual disposal limit at 75 TBq.

393 As tritium production depends on power production rather than abatement techniques we consider that a quarterly notification level based on the maximum disposal (75 TBq y^{-1}) is appropriate in this case. We will take the stated maximum monthly estimate of 25 per cent of annual (18.75 TBq) and add two months at the 'expected' level of 13 TBq to give (rounded up) 45 TBq/quarter. This should highlight adverse trends in disposals and require an operator to demonstrate that BAT is still being applied if a QNL is exceeded.

10.2 Carbon-14

394 As described above, 5 - 20 per cent of carbon-14 produced (444 GBq y^{-1}) will be present in the aqueous or solid waste. (PCERsc6.3s6.3.1)

395 EDF and AREVA propose no specific techniques for carbon-14 reduction in aqueous waste from the UK EPR but have considered (EPRBs3.2):

a) decay by delayed discharge is not an option as the half-life of carbon-14 is 5710 years;

b) filters and demineralisers do remove some carbon-14 but this depends on the form of the carbon-14 and these items are optimised for corrosion products removal. Further treatment may be possible by filters and demineralisers but reductions are difficult to calculate and may only affect carbon-14 in inorganic forms while much may be organic. Further, increasing carbon-14 content on filter media and resins can give issues for solid waste disposal (current disposal facilities have a strict acceptance criterion for carbon-14). Further treatments by these techniques are not proposed;

c) evaporation of some aqueous effluent is carried out in the UK EPR. Evaporation of all aqueous effluent is possible but would require '*significant amounts of additional energy* [for example, 13 GWh to evaporate the 19000 m^3 of aqueous effluents from Flamanville units 1 and 2], *while conversion* [of the concentrate] *to solid waste would produce large volumes of solid waste*'. Further, past operational experience has shown that while much carbon-14 would be retained in concentrates, there is still significant carbon-14 activity in distillates and these must be discharged (in GDA to the sea). EDF and AREVA do not intend to perform additional evaporation for the UK EPR but offer no formal options assessment.

396 **EDF and AREVA claim that while techniques have been used in the UK EPR to minimise the presence of carbon-14 in aqueous waste (see section 8.2.1 above), there are no techniques that are BAT for reducing the carbon-14 content of that waste. We conclude that, at this time, the UK EPR uses BAT to reduce the discharge of carbon-14 to the sea as there are no applicable reduction techniques available.**

397 The 'expected performance' value of 23 GBq y^{-1} was estimated from the basic source term of 444 GBq y^{-1} applying operational feedback experience from the predecessor 1300 MWe reactors. This is also about 5 per cent of the source term, so equates well to the expected distribution. (PCERsc6.3s6.3.2.1)

398 EDF and AREVA propose a 'maximum' value of 95 GBq y^{-1}. This is because:

a) the 444 GBq y^{-1} term was based on reactor availability of 91 per cent, and it is hoped the UK EPR will exceed this value;

b) the distribution of carbon-14 between gas and liquid in the UK EPR could be different to existing reactors, operational experience of an EPR is needed to confirm performance;

c) the 444 GBq y^{-1} source term assumed a coolant nitrogen content of 10 ppm (parts per million), if a higher content is found in operation then the nitrogen source term will increase.

399 We have limited information about discharges of carbon-14 to water from PWRs operating over the last 10 to 15 years, but we consider that the range of discharge to water of carbon-14 is 3 to 45 GBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' aqueous discharge of carbon-14 from UK EPR is 23 GBq (13.3 GBq normalised to 1000 MWe), well within this range. We conclude that aqueous discharge of carbon-14 from the UK EPR is comparable to other power stations across the world.

400 EDF and AREVA state that monthly discharges of carbon-14 are very dependent on power produced and generally unaffected by operating contingencies. However, operational management of aqueous discharges, as noted for tritium above, may affect the level of discharge in any month. A 'maximum' monthly discharge of 24 GBq is proposed based on 25 per cent of the annual 'maximum'.

401 The radiological impact from the 'maximum' disposal of carbon-14 to the sea is stated as a dose to adults of 14 μSv y^{-1}, to children of 4.2 μSv y^{-1} and infants of 1.4 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

402 We have accepted that the UK EPR uses BAT to minimise the aqueous discharge of carbon-14 with an 'expected performance' value of 23 GBq y^{-1}. While the level of headroom proposed is high, an additional 72 GBq y^{-1} to allow for the uncertainty of split between gas and liquid and level of nitrogen in the coolant, we do recognise the uncertainties at this time and will set an indicative annual disposal limit at 95 GBq, this gives a pessimistic impact assessment. We will review this limit at the earliest opportunity once operational experience is available.

403 We will set a quarterly notification level based on the 'expected performance' to give us an early indication if this performance cannot be met in operation. We have allowed for 25 per cent of annual discharge in one month (say 6 GBq) and average discharge (say 1.5 GBq) for two months. This gives a QNL of 9 GBq.

10.3 Iodine radionuclides

404 As described above, iodine radionuclides are formed in the fuel and are only present in the coolant in the event of fuel cladding defects. Iodines tend to dissolve and are, therefore, mostly found in aqueous effluents. While it is not their main function, the demineralisers in the coolant purification system do absorb significant amounts of iodines. Also effluents are held up in tanks in the liquid waste processing system awaiting treatment or discharge, the delays will allow the shorter half-life iodine radionuclides to decay. (PCERsc6.3s6.4.1.1 and EPRBs3.6)

405 The EDF and AREVA BAT case for iodine radionuclides relies on:

a) improved fuel integrity;

b) removal in the demineralisers.

406 **We conclude that the very low levels of discharge and impact (see below) support the case that BAT is employed without a detailed assessment.**

407 The 'expected performance' is stated as 7 MBq y^{-1}. This is supported by operational feedback from predecessor reactors, but results of measurements are often below detection thresholds, so that the 7 MBq value is actually a 'limit of detection' value.

408 The 'maximum' value proposed is 50 MBq y^{-1}. This allows for some 40 MBq headroom over the 'expected value' and relates to operational experience of predecessor reactors when this value was achieved on rare occasions. The headroom allows for contingencies of fuel and treatment system failure. (PCERsc6.3s6.4.1.3)

409 We have limited information about the discharge to water of iodine radionuclides from PWRs operating over the last 10 to 15 years, but we consider that the range of discharge to water of iodine radionuclides is 10 to 30 MBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' aqueous discharge of iodine radionuclides from UK EPR is 7 MBq (4 MBq normalised to 1000 MWe), below this range. We conclude that aqueous discharge of iodine radionuclides from the UK EPR is comparable to other power stations across the world.

410 Monthly discharges in normal operation are stated as being at detection threshold and equivalent to 0.7 MBq. However a worst-case scenario could see almost all the 'maximum' annual discharge in one month – the 'maximum' monthly discharge value is quoted as 50 MBq.

411 The radiological impact from the 'maximum' disposal of iodine radionuclides to the sea is stated as a dose to adults of 7.6×10^{-5} (0.000076) μSv y^{-1}, to children of 3.8×10^{-5} μSv y^{-1} and infants of 2.2×10^{-5} μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G.

412 We have accepted that BAT is used to minimise the discharge of iodine radionuclides to the sea with a 'predicted performance' of 7 MBq y^{-1}. We have decided that, at this level of discharge, and bearing in mind the very low impact, it is not proportionate to set a limit or quarterly notification level for the discharge of iodine radionuclides to the sea.

10.4 Other radionuclides

413 Aqueous waste can contain other radionuclides in addition to those specifically considered above. These are both particulate and dissolved activated corrosion products (particularly cobalt-58 and cobalt-60) and fission products (particularly caesium-134 and caesium-137). (PCERsc6.3s6.4.2.1) The main source of these is the coolant. The coolant is recycled through filters and demineralisers in the chemical and volume control system (CVCS) where high decontamination factors are achieved (see section 8.2.1 above). EDF and AREVA say they rely on these systems for primary reduction of these other radionuclides. However, low concentrations are still found in managed discharges and minor leaks of coolant reaching the liquid waste processing system (LWPS).

414 PCERsc8.2s3.3.3 lists some available techniques to treat aqueous effluents:

a) chemical precipitation;

b) hydro-cyclone centrifuging;

c) cross-flow filtration;

d) ion exchange (demineralisation);

e) reverse osmosis;

f) evaporation.

415 PCERsc8.2s3.3.3.4 discusses some techniques being developed that could potentially be used to treat UK EPR effluents:

a) membrane technologies such as cross-flow, micro- and ultra-filtration might be used to retain particles down to 0.01 micron size;

b) reverse osmosis might be suitable to remove dissolved substances from effluent;

c) electrolysis might be used to remove electro-active materials such as corrosion products;

d) isotopic retention is an electrochemical process using a metallic catalyst that can reduce the concentration of some radionuclides.

416 EDF and AREVA claim that only the following techniques are BAT for use in the UK EPR:

a) filtration for removing particulate matter;

b) ion exchange systems for removing dissolved active materials;

c) evaporation for effluents which are incompatible with ion exchange resins, the concentrate is treated for disposal [as solid radioactive waste].

417 EDF and AREVA argue that other techniques are not currently developed for use in PWRs, while those chosen are in standard use. Further, the chosen techniques are adequate to optimise discharges.

418 **We conclude that, at this time, filtration by cartridge filter, ion exchange and, for effluents incompatible with ion exchange, evaporation are BAT for use in the UK EPR.**

419 A diagram of the LWPS is provided as Figure 5 in the IWSp37 and more detailed descriptions are in PCERsc6.2s1.1.3. Effluents are collected at the front end of the LWPS by tanks. Tank contents, depending on their analysis, may be treated by filtration, filtration and ion exchange and / or by evaporation. After treatment, the contents are pumped by way of a final filter to a set of discharge tanks.

420 In the UK EPR, single use cartridge filters are available to select as required by operations in the LWPS. We have not found a BAT case to support the filter pass size chosen: (PCERsc8.2s3.3.3.1)

a) floor drain system – 25 micron;

b) process drain system – 25 followed by 5 micron before demineraliser, 25 micron after (to remove any resin particles);

c) chemical drain system – 25 micron;

d) final filter before discharge tanks – 5 micron.

421 All filters are fitted with instruments to measure the pressure difference over the filter element. The pressure will increase as filters are used and retain particles. EDF and AREVA say that they will only change filter elements when a set pressure is exceeded. We accept that this is BAT to minimise the volume of solid waste arisings from use of filters.

422 The process drain system contains a demineralisation system with three beds which can be filled with (PCERsc8.2s3.3.3.2):

a) strong high-capacity anionic or macro-porous resins;

b) strong high-capacity gel-type cationic resins;

c) mixed-bed-type.

EDF and AREVA state that: '*The initial choice retained for the UK EPR is one high-capacity cationic bed and one mixed bed. The third space is left empty and is used if deemed necessary by the operator, for example if there is a problem with one of the beds (filling the third space will allow for maintenance to be carried out on the bed, without interruption of the filtering process); it also allows flexibility in dealing with specific pollutants (silver, tritium…), as it can be used for a specific treatment if necessary*.'

EDF and AREVA have not provided a BAT case to support the design of the demineralisation system.

423 The chemical drain system has an evaporator available. This separates chemically polluted effluents into a distillate (only weakly active / polluted) and a concentrate containing most of the activity / pollution. The distillate is sent to the discharge tanks after monitoring. The concentrate is sent to the solid effluent treatment unit for treatment before disposal. We conclude that providing the evaporator on the UK EPR is BAT to treat otherwise untreatable aqueous waste.

424 **We conclude that, in principle, the liquid waste processing system of the UK EPR is BAT for minimising the discharge of fission and activation products. However, as the impact of other radionuclides is greater than 1 μSv y^{--1}, we require a complete formal BAT assessment to confirm that the sizing of filters and the demineralisation system is, in fact, BAT to minimise the discharge to sea of other radionuclides before or during site-specific permitting.**

425 EDF and AREVA claim that the 'expected performance' for discharge of other radionuclides (the total including cobalt-60 and caesium-137) is 0.6 GBq y^{-1}. This value is supported by operational data from predecessor reactors with an allowance

426 EDF and AREVA propose a 'maximum' annual disposal of 10 GBq. The headroom above 'expected performance' is not specifically quantified, but allows for contingencies such as fuel cladding defects combined with failure or unavailability of liquid treatment systems. (PCERsc6.3s6.4.2.3)

427 We examined historic discharges (where available) from European and US PWRs operating over the last 10 to 15 years and consider that the range of discharges to water of fission and activation products is 1 to 15 GBq y^{-1} for a 1000 MWe power station (see Annex 3). The 'expected performance' aqueous discharge of other radionuclides from UK EPR is 0.6 GBq (0.35 GBq normalised to 1000 MWe), well below this range. We conclude that the aqueous discharge of other radionuclides from the UK EPR is comparable to other power stations across the world.

428 EDF and AREVA say that monthly discharges are difficult to predict, as they depend on effluent management policy adopted and operational conditions. The monthly discharge during shutdown could be six times higher than other months. In normal operating conditions, monthly discharge could be up to 0.3 GBq. In extreme circumstances, the whole of the 'maximum' detailed above, 10 GBq, could be discharged in one month.

429 The radiological impact from the 'maximum' disposal of other radionuclides to the sea is stated as a dose to adults of 3.27 µSv y^{-1}, to children of 0.53 µSv y^{-1} and to infants of 0.06 µSv y^{-1}– from PCERsc11.1 Annex 3 Tables E, F and G. The greatest part of the dose is attributable to cobalt-60.

430 We have provisionally accepted above that the UK EPR uses BAT to minimise the discharge to sea of other radionuclides with an 'expected performance' of 0.6 GBq y^{-1}. We set disposal limits based on BAT with minimum headroom to cover expected operational events. We believe that equipment failures should be rectified promptly and should not have a significant impact on annual discharges. We do not accept the EDF and AREVA proposal for 'maximum' annual disposal. We have considered past operational data and will allocate an additional 2 GBq y^{-1} above the 'expected performance' to allow for increased discharges due to fuel cladding defects or other contingencies. Our predicted maximum is, therefore, 2.6 GBq y^{-1}, and we will apply a x2 factor to set a disposal limit of 5 GBq y^{-1}. We wish to set limits separately for cobalt-60 and caesium-137, so will allocate the total 5 GBq as:

a) cobalt-60 – 1.5 GBq y^{-1};

b) caesium-137 – 0.5 GBq y^{-1};

c) other radionuclides not specifically limited – 3 GBq y^{-1}.

431 We wish to set a quarterly notification level based on the 'expected performance' to give us early indication if performance cannot be met in operation. We have allowed for 0.3 GBq in one month and average discharge for two months (say 0.05 GBq). This gives a QNL of 0.4 GBq for a total including cobalt-60 and caesium-137. We have apportioned this as follows:

a) cobalt-60 – 0.12 GBq;

b) caesium-137 – 0.04 GBq;

c) other radionuclides not specifically limited – 0.24 GBq.

10.5 Aqueous waste disposal to the environment

432 We have identified three effluent release points for the UK EPR and allocated references as below (diagram PCERsc6.4s2.3 Figure 1 (page 84)):

a) W1 – combined discharge line from two sets of tanks:

   i) from the LRMDS tanks in the liquid radwaste monitoring and discharge system (LRMDS). [6 tanks of 750 m^3] capacity collect effluent treated by the liquid waste processing system (LWPS).

   ii) from the ExLWDS tanks in the additional liquid waste discharge system (ExLWDS). [3 tanks of 750 m^3] capacity kept in reserve in case of issues with the LWPS or the LRMDS. The contents of these tanks can be sent back into the LWPS for treatment or discharged, as appropriate.

b) W2 – discharge line from the CILWDS tanks in the conventional island liquid waste discharge system (CILWDS). [4 tanks of 750 m^3] capacity collect effluent from radiologically uncontrolled areas such as the turbine hall. In normal operation effluents collected by this system are uncontaminated but may show low levels of tritium in the event of any leaks from the primary to the secondary systems.

c) W3 – return line of circulating seawater cooling system. The seawater should be uncontaminated in normal operation. The seawater system serves various systems, each of which should have internal sample points for detection of contamination at point of return to the main system (PCERsc3.4s3.1.1):

   i) circulating water system to main condenser;

   ii) essential services water system;

   iii) service water circuit for conventional auxiliaries;

   iv) ultimate cooling system.

433 EDF and AREVA say that number and sizing of the LRMDS, ExLWDS and CILWDS tanks is a site-specific issue depending on number of reactors on a site and any discharge timing restrictions. The sizes and number of tanks above is from the Flamanville site where 6 LRMDS, 3 ExLWDS and 4 CILWDS tanks will serve two existing 1300 MWe reactors, one EPR in construction and possibly another EPR in the future. We consider that the size of discharge tanks is an important BAT issue. We need to see that enough capacity is available not only to cope with normal operations but also to cope with foreseeable events such as equipment failures. We will not comment on tank sizes at GDA but will expect site-specific applications to provide a formal BAT case, justifying the number and volumes of discharge tanks proposed.

434 Our permit will allow discharge of aqueous radioactive waste through points W1 and W2 under specific disposal limits and conditions. Discharges will not be continuous but on a tank by tank basis. When a tank needs to be discharged, its contents will be sampled and analysed. Data on the volume to be discharged and its radioactivity will be used within a management procedure to authorise the time and rate of discharge to ensure compliance with permit conditions. All discharge authorisations will need to be recorded as operational records – a permit condition. We will require the discharge lines to be fitted with MCERTS (our certification system for measuring equipment) flowmeters and flow proportional samplers at points W1 and W2 to provide permit compliance data.

435 The returning seawater should be uncontaminated. We will not require flow metering of this, flow will be directly related to pumps in service. We will not require continuous sampling as we consider risk of contamination is very low. However, we will require safe and permanent access to the return flow at point W3 for spot sampling to confirm no radioactive contamination or other contamination such as oil or chemicals.

436 The disposal route from points W1 and W2 is initially to join the high volume direct sea water cooling flow (67 $m^3\ s^{-1}$) at the discharge pond. The combined flow is then sent

to an outfall discharging some distance out from the shore. Once radioactive discharges have been minimised by other techniques, pre-dilution in a large flow before discharge to the environment is desirable to reduce initial concentrations before dispersion in the receiving waters.

437 We have not considered at GDA other site aqueous discharges such as surface water. The design of such systems will be site-specific and there should be no contamination in normal operation. We will review site drainage at site-specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling.

438 For GDA, EDF and AREVA selected Irish Sea / Cumbrian waters for predicting dispersion of aqueous radioactive discharges using the model PC Cream. They said this would give pessimistic results for the dose impact calculations. The calculated total annual dose impact to the most exposed members of the public from 'maximum' discharges was 17 μSv for an adult, 4.7 μSv for a child and 1.5 μSv for an infant. Dose was largely due to eating seafood. The doses are low enough that we conclude that dispersion under GDA conditions is BAT.

439 The design and location of outfalls will be a highly site-specific issue. The operator for each specific site will need to demonstrate, by modelling, that the outfall proposed will be BAT for adequate dispersion in local waters.

11 Solid radioactive waste

440 We conclude that:

a) In their submission, EDF and AREVA describe how low level waste (LLW) and intermediate level waste (ILW) will be generated, managed and disposed of throughout the facility's lifecycle.

b) EDF and AREVA have identified all LLW and ILW waste streams that a UK EPR will typically produce.

c) Waste will be treated and conditioned using proven and recognised techniques. However, HSE will be looking at EDF and AREVA's plans for the conditioning of waste produced by a UK EPR in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.

d) The design is not expected to produce LLW or ILW for which there is no foreseeable disposal route. However, the Regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. EDF and AREVA provided information in February and March 2010, and whilst our views are presented in this consultation document, we note HSE is continuing to review this information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document.

e) EDF and AREVA have provided estimates for the annual arisings (during operations and decommissioning) of LLW and ILW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009).

f) EDF and AREVA have provided basic evidence of how they will minimise the disposal of LLW and ILW.

441 However, our conclusion is subject to the following four other issues:

a) Disposability of ILW following longer term interim storage pending disposal. (UK EPR-OI08)

b) If smelting of any LLW is pursued at site-specific permitting, demonstrate that the conditions of acceptance of any available smelting facilities can be met. (UK EPR-OI09)

c) If incineration is pursued at site-specific permitting for SGBS ion-exchange resins (without regeneration), evaporator concentrates, pre-compacted operational waste and operational waste, demonstrate that the conditions of acceptance of any available incineration facilities can be met. (UK EPR-OI10)

d) Provide evidence at site-specific permitting that the specific arrangements for minimising the disposals of LLW and ILW for each site represents BAT. (UK EPR-OI11)

Consultation Question 6: Do you have any views or comments on our preliminary conclusions on solid radioactive waste?

11.1 Creation of solid waste

442 EDF and AREVA identify and quantify the solid radioactive waste that will arise during the operational phase (PCERsc3.3). They state that solid radioactive waste resulting from normal operation (including maintenance) arises either in the nuclear island or in the waste treatment building (ETB). They say that the UK EPR will produce three types of solid radioactive waste (PCERsc6.2):

a) waste known as 'process' waste, associated with generating power. This results from treating fluids, in order:

   i) to limit the contamination and reduce its activity, so that workers are not exposed to radiation;

   ii) to reduce the activity of discharged effluent, whether aqueous or gaseous.

   The process waste from treating gaseous effluent is made up of mainly filters and iodine traps. From aqueous waste treatment, the process waste consists of filters, concentrates and ion-exchange resins.

b) dry active waste from maintenance work (mending faults, repairs, replacement of radioactive equipment, etc.). It comprises mainly of compactable materials, such as vinyl, gloves, adhesive tape, papers, trunking for exhaust fans, etc.

c) other waste, generally from so called sundry incidents (for example, contaminated oils).

443 Additionally, during the operation of the UK EPR, some core components used to control or measure neutron activity may need to be replaced during outages. These include neutron absorber rods and rod cluster control assemblies.

444 In the PCER and supporting documentation, the types of solid radioactive waste are described as shown in the table below:

	Types of waste
Process waste	Ion-exchange resins from the nuclear island
	Low activity steam generator blow down system (SGBS) ion-exchange resins (without regeneration)
	Wet sludges (sumps, tanks)
	Water filters from effluent treatment
	Evaporator concentrates
	Air and water filters
Operational waste	Pre-compacted and non compactable dry active waste (DAW)
	Oils (and solvents)
	Scraps
	Operational waste

445 EDF and AREVA state that the volume of solid radioactive waste depends on the process and on the management of the systems by the operator. PCERsc3.3 Table 2 and PCERsc6.3 Table 1 provide, by volume, the annual estimated production of raw waste (before conditioning) for each type of waste for one UK EPR unit. PCERsc6.3 Table 5 gives the distribution of LLW and ILW in terms of volume of packages to be disposed of or stored per year. This shows that the volume of conditioned LLW to be disposed of per year is 24.5 m^3, which, assuming the UK EPR design is for a single, pressurised water reactor (PWR) capable of generating in total 1735 MWe of

electricity, is equivalent to 14.1 m^3 per 1000 MWe plant-year of operation. This table also shows that the volume of conditioned ILW to be disposed of per year is 46.2 m^3, which is equivalent to 26.6 m^3 per 1000 MWe plant-year of operation.

446 Further information is given in PCERsc6.3. This includes the characteristics of the reference case packaged wastes. Additionally, waste stream datasheets for ion exchange resins, spent filters, dry active waste, tank sludges, evaporator concentrates, low activity resins, air and water filters, oils and metal maintenance waste are given in EDF and AREVA's solid radioactive waste strategy report (SRWSR). These list data on waste origin, waste physical description, nature of radioactive material, annual arising, total arising, waste classification at time of generation, main radionuclides and hazardous substances.

447 EDF and AREVA have estimated the volume of solid radioactive decommissioning waste to be expected after a designed service life of 60 years. An estimated volume of conditioned low level waste (LLW) and very low level waste (VLLW) from decommissioning is around 25,000 m^3 (PCERsc5.2s4.4). The waste is from the following sources:

a) primary circuit;

b) nuclear steam supply system equipment;

c) balance of nuclear island (BNI) equipment;

d) concrete due to clean up of BNI.

448 Estimated volumes of ILW from decommissioning are given in PCER chapter 5 and the SRWSR. Contaminated ILW, which consists of ion-exchange resins used during the full decontamination of the primary circuit, amounts to around 30 to 40 m^3. Activated ILW consisting of metallic and concrete waste from the dismantling of the activated components near the reactor core amount to approximately 450 te of raw solid metallic waste and 180 te of concrete. An estimated volume of conditioned ILW from decommissioning is around 1400 m^3 (PCERsc5.2s4.4). The ILW waste is from the following sources:

a) primary circuit;

b) decontamination.

449 The estimates for operational waste in EDF and AREVA's submission for the volumes of operational LLW and ILW appear to be reasonable for the UK EPR. These estimates were derived by EDF and AREVA using 15 years worth of waste arisings data from across the whole French fleet. The estimates used data from the EDF tracking system which records the characteristics of every solid waste package produced on the 19 sites in France. (PCERsc6.3s3.1)

11.2 Management and disposal of low level waste

450 In this section we cover our assessment of the management and disposal of low level radioactive wastes (LLW). LLW is defined in the UK as 'solid radioactive waste having a radioactive content not exceeding 4 GBq per tonne (GBq/te) of alpha or 12 GBq/te of beta / gamma activity', but we also consider here some liquid waste such as contaminated oils. These types of low level waste are usually suitable for disposal at the low level waste repository (LLWR) near Drigg, disposal by on or off-site incineration, or transfer off-site for recovery (for example, of metals).

451 Having minimised the overall production of radioactive waste, the application of BAT to minimise the activity in gaseous and aqueous discharges tends to transfer activity to low (and intermediate – see below) level solid waste. This is in line with the principle of preferred use of 'concentrate and contain' over 'dilute and disperse' (DECC, 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 volume of

LLW requiring final disposal can be reduced by using techniques such as waste sorting and segregation, compaction, incineration, removal of surface contamination, re-use and recycling.

452 EDF and AREVA state in PCERsc6.2 that solid radioactive waste is segregated at source in each area as it arises, both in terms of activity and its chemical and physical characteristics (for example, combustible, compactable and non-combustible / non-compactable). Activity assessment is determined by measuring with handheld monitors and applying a nuclide fingerprint applicable for the source.

453 For the reference case, the treatment of solid radioactive waste will be carried out by two solid radioactive waste treatment systems; the TES unit system and the 8TES system located in the UK EPR waste treatment building (ETB). The TES unit system will handle the filter replacement and the transfer of resins from the nuclear auxiliary building (NAB) to the ETB. A filter handling machine will remove the used filters and place them in a concrete enclosure. Spent resins will be pumped to the 8TES storage tanks of the ETB by the 8TES handling system. The 8TES system will comprise of effluent storage facilities for the resins and evaporator concentrates and conditioning facilities for the raw solid radioactive waste from the nuclear island and the ETB that results from normal operation. Resins, filter contents, evaporator concentrates and other operational radioactive waste will be encapsulated in concrete enclosures and there will be an installation for compacting low-activity operational waste. All conditioned waste will then be kept on site for interim storage before being sent off site to a final storage location or to a treatment plant for additional processing (for example, incineration, smelting etc). The treatments, conditioning and packaging of operational solid radioactive waste is presented in PCERsc6.3 Table 3 and detailed in PCERsc6.4. EDF and AREVA provide further information on other potential waste management arrangements in the ETB in the SRWSR to accommodate different operators.

454 The following packaging will be used for LLW:

a) metallic drum 200 litres: These drums will mainly be used for the packaging of LLW to be shipped directly to the LLWR;

b) plastic drum 200 litres: These drums have been developed specifically for the incineration process and they are directly introduced to the furnace;

c) metallic boxes 1 m^3: These boxes will be used to collect and ship metallic waste and cut scraps for melting.

455 EDF and AREVA claim that the storage capacity of the reference ETB is enough to ensure buffer storage of LLW for more than one year of operating, including maintenance operations, even in the case that two UK EPR units share the ETB. (PCERsc6.4s4.2.4.1.5).

456 EDF and AREVA state in PCERsc6.5 and in the SRWSR that during the timescale for disposal of ILW to a disposal facility, it is possible that some waste may decay below the ILW threshold limits. Although initially stored as ILW, these waste streams can be re-categorised, removed from the interim storage facility and shipped as LLW.

457 Disposability of operational LLW is discussed in PCERsc6.5 of the PCER. EDF and AREVA will dispose of LLW promptly after it has been generated to the low level waste repository (LLWR). EDF and AREVA have completed LLWR form D1s (Request for agreement in principle to dispose of radioactive waste at the low level waste repository) for each of the UK EPR LLW streams (except waste oils). These forms describe the nature of the process producing the waste, the type of radioactive waste generated and the physical and chemical form of the waste and its radiological characteristics.

458 Although D1 forms have been completed for all UK EPR operational LLW (except waste oils), EDF and AREVA have identified waste streams that are likely to be suitable for incineration and smelting to minimise the waste sent to the LLWR.

459 EDF and AREVA have provided us with signed form D1s from the LLWR, giving agreement in principle for the treatment / disposal of the following LLW:

a) ion exchange resin;

b) ion exchange beads;

c) spent filter cartridges;

d) air filters and water filters;

e) maintenance and operational very low level waste;

f) stainless steel waste;

g) maintenance and operational low level waste;

h) sludges;

i) concentrates.

460 The LLWR recognises that EDF and AREVA's form D1 applications represent assumed waste disposals at some point in the future and, as such, it cannot guarantee future capacity today. However, the LLWR has assessed EDF and AREVA's application against their current arrangements and can give agreement in principle on the basis that this waste would be suitable for treatment / disposal against their current arrangements.

461 EDF and AREVA state that contaminated waste oils and oily, solvent or greasy rags produced by maintenance will be incinerated. They provide evidence that this waste will meet the conditions for acceptance at the Centraco facility in France. They also provide confidence that these types of waste would be accepted at the Tradebe incinerator in the UK. (PCERsc6.2s3.4.1.2)

462 Smelting is also considered for LLW metals as described in PCERsc6.3. However, EDF and AREVA have not carried out a review of this waste stream against the conditions of acceptance of any available smelting facilities to show that they can be met (other issue UK EPR-OI09).

463 Incineration is also considered for SGBS ion-exchange resins (without regeneration), evaporator concentrates, pre-compacted operational waste and operational waste as mentioned in PCERsc6.3. However, EDF and AREVA have not carried out a review of this waste stream against the conditions of acceptance of any available incineration facilities to show that they can be met (other issue UK EPR-OI10).

464 EDF and AREVA have considered the treatment and disposal of large, one-off solid radioactive waste items that could need replacing during the operation of the UK EPR. They consider steam generators and reactor pressure vessel heads. EDF and AREVA state that these items will be LLW and that one method of treatment and disposal will be to cut them into pieces, place pieces in containers and send containers for disposal at the LLWR. (PCERsc6.3s3.2.6)

465 EDF and AREVA expect decommissioning waste will produce similar waste types as the operational phase and, therefore, assume it will be compliant with the LLWR acceptance criteria. The SRWSR assumes that the LLW produced during the dismantling of a reactor is conditioned by packing in half height ISO (HHISO) containers. EDF and AREVA provided a document detailing their decommissioning waste inventory evaluation (ELIDC0801302A).

466 EDF and AREVA state in PCERsc6.3 that they currently envisage reducing the sources of solid waste volume compared with the existing plants' feedback as follows:

a) designation at the design stage of clean-waste zoning, enabling sorting of waste at source and segregating of conventional waste from non-contaminating work in the restricted area;

b) better control of source term through carefully selecting materials in contact with the primary coolant, which then leads to reduced production of corrosion products (a reduction in cobalt 60 activity in particular);

c) optimisation of the chemical treatment of primary coolant;

d) a greater surface area on the chemical and volume control system (CVCS) purification filters than on the 1300 MWe and N4 units (predecessor to the UK EPR), through using multi-cartridge baskets and not single cartridge.

467 EDF and AREVA state that it should be noted that the volume of solid waste depends on the balance between environmental discharges and packaged waste generation in managing the installation, and may, therefore, change according to the various effluent treatment methods.

468 EDF and AREVA state in PCERsc6.5 that in order to minimise the inventory of waste consigned to LLWR, where the characteristics of LLW streams or packages are such that they could be treated as VLLW, LLWR have confirmed that they will offer services to dispose of such waste.

469 EDF and AREVA state in PCERsc8.2 that an 'EPR environment' design review took place in October 2004. One recommendation from this was to reduce the volume of solid waste, in particular by optimising the room zoning and a detailed analysis of the operating procedures and waste inventory of the existing units. They claim that they will reduce the volume of solid waste by ensuring waste is segregated as it is generated, mainly during maintenance operations in the nuclear buildings. (PCERsc8.2s2.3)

470 In PCERsc8.2, EDF and AREVA describe how they consider that BAT has been applied to each significant waste steam. EDF and AREVA claim in their BAT demonstration report (EPRB) that BAT is being applied in the design of the UK EPR to minimise radioactive waste at source and to minimise the impacts of the disposal of waste into the environment.

471 The SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to workers and minimise the amount of radioactive waste generated. The SRWSR discusses the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials.

472 EDF and AREVA claim that improvements and provision are included in the UK EPR design based on feedback experience, in order to avoid replacing during the UK EPR's 60 years of operation large one-off items such as reactor pressure vessel heads and steam generators. They also claim that good chemistry management during operation should prevent the build up of crud and activity due to contamination in the steam generators over their operating life. (PCERsc6.3s3.2.6)

473 **Our conclusions:**

a) **In their submission, EDF and AREVA describe how LLW will be generated, managed and disposed of throughout the facility's lifecycle.**

b) **EDF and AREVA have identified all LLW waste streams that a UK EPR will typically produce.**

c) **Waste will be treated and conditioned using proven and recognised techniques. However, HSE will be looking at EDF and AREVA's plans for the conditioning of waste produced by a UK EPR in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.**

d) **The design is not expected to produce LLW for which there is no foreseeable disposal route. EDF and AREVA have demonstrated that the waste steams would meet the criteria for disposal in a LLW facility. If smelting of LLW is pursued at site-specific permitting, then we require demonstration that the conditions of acceptance of any available smelting facilities can be met. If incineration is pursued at site-specific permitting for SGBS ion-exchange resins (without regeneration), evaporator concentrates, pre-compacted operational waste and operational waste, then we require demonstration that the conditions of acceptance of any available incineration facilities can be met (other issues UK EPR-OI09 and UK EPR-OI10).**

e) **EDF and AREVA have provided estimates for the annual arisings (during operations and decommissioning) of LLW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009). The arisings of LLW are below the European Utility Requirement (European Utility Requirements for LWR Nuclear Power Plants Rev C Apr 2001 (Volume 2 chapter 2, section 5.2)) objective of less than 50 m^3 per 1000 MWe plant-year of operation.**

f) **EDF and AREVA have provided basic evidence of how they will minimise the disposal of LLW. This includes appropriate characterisation and segregation. Further evidence is required at site-specific permitting that specific arrangements for minimising the disposals of LLW for each site represents BAT (other issue UK EPR-OI11).**

11.3 Management and disposal of intermediate level waste

474 In this section we cover our assessment of the management of intermediate level radioactive waste (ILW). ILW is waste with activity 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. There are currently no final disposal facilities for ILW in the UK. However, the Government has stated (BERR, 2008a) that it is satisfied that:

a) a geological disposal facility would provide a possible and desirable mechanism for disposing of higher level waste (both from a new nuclear programme and existing legacy waste);

b) there are feasible and long-term mechanisms through the Managing Radioactive Waste Safely (MRWS) (Defra et al 2008) programme for identifying a suitable site and for constructing a geological disposal facility.

475 Although a permit for final disposal may not be required for a considerable time, we expect EDF and AREVA to show now whether the waste is:

a) likely to be suitable for disposal in a geological repository;

b) will be appropriately managed in the interim, so as not to prejudice its ultimate disposal.

476 EDF and AREVA state in PCERsc6.2 that solid radioactive waste is segregated at source in each area as it arises, both in terms of activity and its chemical and physical characteristics (such as combustible, compactable and non-combustible / non-compactable).

477 For the reference case, the treatment of solid radioactive waste will be carried out by two solid radioactive waste treatment systems; the TES unit system and the 8TES system located in the UK EPR waste treatment building (ETB). The TES unit system will handle the filter replacement and the transfer of resins from the NAB to the ETB. A filter handling machine will remove the used filters and place them in a concrete enclosure. Spent resins will be pumped to the 8TES storage tanks of the ETB by the 8TES handling system. The 8TES system will comprise effluent storage facilities for the resins and evaporator concentrates and conditioning facilities for the raw solid radioactive waste from the nuclear island and the ETB that results from normal operation. Resins, filter contents, evaporator concentrates and other operational radioactive waste will be encapsulated in concrete enclosures and there will be an installation for compacting low-activity operational waste. Conditioned waste will then be kept on site for interim storage before being sent off site to a final storage location. The treatments, conditioning and packaging of operational solid radioactive waste is presented in PCERsc6.3 Table 3 and detailed in PCERsc6.4. EDF and AREVA provide further information on other potential waste management arrangements in the ETB in the SRWSR to accommodate different operators.

478 The characteristics of decommissioning conditioned waste are given in PCER chapter 5 and in the SRWSRs.

479 C1 and C4 concrete containers (these containers are 15 cm thick and have the physical capability to last and confine radioactivity for more than 300 years) are used for packaging ILW in the reference case (PCERsc6.3). Other options for packaging ILW in stainless steel and cast iron containers for disposal are mentioned in the SRWSRs7.4.2.

480 ILW will be stored on the UK EPR sites in dedicated building(s) until a final disposal site for ILW is opened in the UK. The radioactive decay during interim storage of ILW due to its composition of short-lived radionuclides can reduce the final quantities of ILW to be disposed of. Some of this waste could be reclassified as LLW. The ILW interim storage facility will be designed to be in operation for up to 100 years after first fuel loading.

481 Design information on possible option(s) regarding interim storage facilities for ILW is provided in PCERsc6.5 and in the SRWSR. Designs for two ILW storage options are described. These can be adapted to store additional ILW that is generated during decommissioning.

482 EDF and AREVA's proposals for storage of ILW are based on current practice. However, the Regulators have requested further information about the proposed storage facilities to support the long-term safe storage of ILW and to ensure ILW does not degrade over the long storage period.

483 Disposability of operational ILW is discussed in PCERsc6.5. In order to assess the disposability of ILW, EDF and AREVA provided the Nuclear Decommissioning Authority (NDA) with a datasheet for each of the UK EPR waste streams. Each datasheet included information on the nature of the waste stream, rate of arising, proposed matrix, package type, physical and chemical composition and radionuclide inventory, package heat output and external dose rate. EDF and AREVA have provided us with datasheets for the following operational waste types:

a) spent resins (ILW) raw waste;

b) spent cartridge filters (LLW + ILW);

c) operational waste (LLW + ILW);

d) wet sludges (LLW + ILW);

e) evaporator concentrates (LLW + ILW).

484 EDF and AREVA have provided us with datasheets for the following decommissioning waste types:

a) lower internals from EPR pressure vessel: heavy reflector, lower support plate, lower heavy reflector support;

b) upper internals: upper support columns and upper core plate. Lower internals: core barrel, flow distribution device;

c) reactor vessel: parts from the reactor vessel near the core.

485 EDF and AREVA have obtained and provided a view from the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of their proposed arisings of ILW. RWMD concluded that compared with legacy waste, no new issues arise that challenge the fundamental disposability of the waste expected to arise from operation of the UK EPR (see Annex 5). EDF and AREVA also provided the regulators with their critique of the RWMD disposability assessment, which considered the impact of RWMD's disposability assessment on their plans for conditioning, storing and dispatching the waste to a repository.

486 The Regulators requested further information on the volume and radionuclides / activity for waste, including rod cluster control assemblies (RCCAs); redundant irradiated control rods; neutron source assembly and poison rod assemblies, including evidence that they will be disposable. EDF and AREVA confirmed that they consider RCCAs and redundant irradiated control rods to be the same and would be ILW, and that poison rod assemblies are not used. Burnable poison, gadolinium, is mixed with uranium dioxide in some fuel assembly rods with low uranium 235 enrichment. EDF and AREVA provided information on the volume and radionuclides / activity, and on interim storage proposals and packaging for disposal. EDF and AREVA claim this waste will be disposable in a geological disposal facility.

487 The Regulators requested EDF and AREVA to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in their critique of RWMD’s Disposability Assessment will be addressed.

b) How the issues in Appendix B of RWMD's Disposability Assessment will be addressed.

c) How they will manage any risks associated with these issues.

488 EDF and AREVA provided information in February and March 2010. We note in particular that EDF and AREVA have consulted with RWMD specifically on the stages in the Letter of Compliance (LoC) process at which they would expect issues to be addressed. We recognise that, in most cases, these issues will need to be addressed by future operators of UK EPRs, rather than by EDF and AREVA, and we understand that EDF and AREVA have also discussed the timing of resolution of these issues with the potential UK EPR operator.

489 In general, we consider the plans proposed by EDF and AREVA to address – or, more commonly, for future licensees to address – outstanding disposability issues to be adequate at this stage. We will expect these plans to be periodically refined and updated in future to reflect developments.

490 We note that EDF and AREVA have produced a 'mapping document', intended to indicate where the information that will be needed for future Radioactive Waste management Cases (RWMCs) will come from, and when. This document gives us some assurance at this stage that RWMCs can be compiled at relevant stages in the development of a UK EPR fleet, which is sufficient at this stage of the GDA process. We note, however, that the mapping document in its current form would not yet fully meet our expectations for the format and content of a RWMC.

491 HSE is reviewing information on long term storage of ILW in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document.

492 EDF and AREVA state in PCERsc6.3 that they currently envisage reducing the sources of solid waste volume compared to feedback experience as follows:

a) designation at the design stage of clean-waste zoning, enabling sorting of waste at source and segregating conventional waste from non-contaminating work in the restricted area;

b) better control of source term through carefully selecting materials in contact with the primary coolant, which then leads to reduced production of corrosion products (a reduction in cobalt-60 activity in particular);

c) optimisation of the chemical treatment of primary coolant;

d) a greater surface area on the CVCS purification filters than on the 1300 MWe and N4 units (predecessors to the UK EPR), through using multi-cartridge baskets and not single cartridge.

493 EDF and AREVA state that it should be noted that the volume of solid waste depends on the balance between environmental discharges and packaged waste generation in managing the installation and may, therefore, change according to the various effluent treatment methods.

494 EDF and AREVA state in PCERsc8.2 that an 'EPR environment' design review took place in October 2004. One recommendation from this was to reduce the volume of solid waste, in particular by optimising the room zoning and a detailed analysis of the operating procedures and waste inventory of the existing units. They claim that they will reduce the volume of solid waste by ensuring waste is segregated as it is generated, mainly during maintenance operations in the nuclear buildings. (PCERsc8.2s2.3)

495 In PCERsc8.2, EDF and AREVA describe how they consider that BAT has been applied to each significant waste steam. EDF and AREVA claim in their BAT demonstration report (EPRB) that BAT is being applied in the design of the UK EPR to

minimise radioactive waste at source and to minimise the impacts of the disposal of waste into the environment.

496 PCER chapter 5 and the SRWSR states that the UK EPR design will enable decommissioning to be performed to minimise radiation doses to workers and minimise radioactive waste generation. They discuss the following features that have been incorporated into the design:

a) choice of materials of construction to minimise activation;

b) optimisation of neutron shielding;

c) optimisation of access routes to nuclear areas;

d) reactor systems design;

e) ease of removal of major process components;

f) submerged disassembly of reactor pressure vessel;

g) modular thermal insulation;

h) fuel cladding integrity;

i) design for decontamination;

j) prevention of contamination spread;

k) minimisation of hazardous materials.

497 EDF and AREVA claim that improvements and provision are included in the UK EPR design based on feedback experience, in order to avoid replacing during the UK EPR's 60 years of operation large one-off items such as reactor pressure vessel heads and steam generators. They also claim that good chemistry management during operation should prevent the build up of crud and activity due to contamination inside the tubes, over the steam generators' operating life. (PCERsc6.3s3.2.6)

498 Comments on ILW received from the public involvement process relating to the UK EPR design by 4 January 2008 were addressed in our preliminary assessment report (Environment Agency, 2008a). One comment on this subject was received during our detailed assessment stage. The comment asked whether the UK EPR design adequately caters for the encapsulation, storage and disposal of ILW. EDF and AREVA responded with information that is available in their submission, that is that ILW is encapsulated in concrete containers and that final ILW packages will be placed in an interim storage facility before their disposal in the proposed GDF.

499 **We conclude that:**

a) **In their submission, EDF and AREVA describe how intermediate level waste (ILW) will be generated, managed and disposed of throughout the facility's lifecycle.**

b) **EDF and AREVA have identified all ILW waste streams that a UK EPR will typically produce.**

c) **Waste will be treated and conditioned using proven and recognised techniques. However, HSE will be looking at EDF and AREVA's plans for the conditioning of waste produced by a UK EPR in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.**

d) **The design is not expected to produce ILW for which there is no foreseeable disposal route. However, the Regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. EDF and AREVA provided information in February and March 2010, and whilst our views are presented in this consultation document, we note HSE is reviewing this information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document. Therefore, the disposability of ILW following**

longer term interim storage pending disposal is an issue that continues to need addressing (other issue UK EPR-OI08).

e) **EDF and AREVA have provided estimates for the annual arisings (during operations and decommissioning) of ILW. These arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009). The arisings of ILW are below the European Utility Requirement (European Utility Requirements for LWR Nuclear Power Plants Rev C Apr 2001 (Volume 2 chapter 2, section 5.2)) objective of less than or equal to 50 m^3 per 1000 MWe plant-year of operation.**

f) **EDF and AREVA have provided basic evidence of how they will minimise the disposal of ILW. This includes appropriate characterisation and segregation. Further detailed evidence is required at site-specific permitting that specific arrangements for minimising the disposals of ILW for each site represents BAT (other issue UK EPR-OI011).**

12 Spent fuel

500 We conclude that in their submission, EDF and AREVA describe how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. EDF and AREVA provide information on the fuel composition and characteristics, and expected fuel burn up, and quantities of spent fuel that will arise. Information is provided in the submission and supporting documents on short and long-term management proposals for spent fuel. EDF and AREVA have obtained a view from the RWMD of the NDA on the disposability of the fuel and have provided their critique to the Regulators.

501 EDF and AREVA provided detailed responses in regard to storage and disposability in February and March 2010, and whilst our views are presented in this consultation document, we note HSE is reviewing this information in its Step 4 assessment.

502 We will continue to work with HSE on this, and this work will inform our decision document. Therefore, our conclusion is subject to the potential GDA Issue:

a) Disposability of spent fuel following longer term interim storage pending disposal (UK EPR-I2).

Consultation question 7: Do you have any views or comments on our preliminary conclusions on spent fuel?

503 In this section we cover our assessment of the creation and management of spent fuel. There are currently no final disposal facilities for spent fuel in the UK. However, the Government has stated (BERR, 2008a) that it is satisfied that:

a) a geological disposal facility would provide a possible and desirable mechanism for disposing of higher level wastes (both from a new nuclear programme and existing legacy waste);

b) there are feasible and long-term mechanisms through the MRWS (Defra et al 2008) programme for identifying a suitable site and for constructing a geological disposal facility.

504 Although a permit for final disposal may not be required for a considerable time, we expect EDF and AREVA to show now whether spent fuel:

a) is likely to be suitable for disposal in a geological repository;

b) will be appropriately managed in the interim, so as not to prejudice their ultimate disposal.

12.1 Creation of spent fuel

505 The UK EPR reactor core comprises 241 fuel assemblies that contain bundles of fuel rods held in place by space grips and top and bottom fittings. The fuel assembly is a 17x17 square array comprising 265 fuel rods and 24 guide thimbles. The thimbles are joined to the grids and the top and bottom nozzles. The thimbles may also hold rod cluster control assembles (RCCAs) which are used to control the reactivity of the core and power distribution, and for reactor shutdown, and neutron source rods, or in core instrumentation. 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. Some fuel assemblies also include a neutron poison, gadolinium oxide, which is mixed with the fuel and depletes slowly with burn up. It is also possible to use mixed oxide (MOX) fuel pellets in the EPR but this is not proposed for the UK EPR in GDA.

506 The initial enrichment of new fuel is up to 5 per cent in weight uranium 235 in order to sustain the nuclear fission reaction. The UK EPR is designed for an operational life of 60 years during which time the operational reactor will contain around 127 tonnes of enriched uranium fuel. Reactor refuelling takes place at the end of each reactor fuel cycle. The UK EPR fuel cycle lasts from 12-22 months depending on the fuel management regime adopted by the future operator. At the end of the fuel cycle, approximately one third of the 241 fuel assemblies are replaced by new fuel assemblies. The isotopic composition of the spent fuel depends on the initial enrichment, the uranium source and the fuel management conditions in the reactor. The average core region fuel burn up is less than 65,000 MWd tU^{-1}, which is the maximum burn up proposed.

507 Both new fuel and spent fuel are stored on the reactor site in the fuel building. PCERsc1.2 describes the fuel building, which includes the spent fuel pool, the loading pit for casks, the transfer station, and storage and inspection compartments for new fuel assemblies. It also includes filtration units to filter air escaping in accident conditions and ventilation systems. The roof of the fuel building supports the evacuation stack for discharge of gaseous effluent from the nuclear auxiliary building.

12.2 Management and disposal of spent fuel

508 In PCERsc6.2, EDF and AREVA provide information on radioactive waste and spent fuel produced by the UK EPR. A fuel assembly is spent and must be discharged after producing energy in the reactor for a period of 3 to 5.5 years depending on the fuel cycle adopted by the operator. The fuel assembly is then transferred from the reactor building to the fuel building through the containment penetration formed by the fuel transfer tube. The UK EPR spent fuel reactor pool and transfer facility are described in PCSR chapter 9.1. Decay heat generated from the irradiated fuel assemblies is removed by the fuel pool cooling system.

509 Spent fuel assemblies are discharged from the reactor and placed into the spent fuel pool to cool and decay for a period of approximately 10 years before being moved to an interim storage facility. The UK EPR design allows a storage capacity in the fuel pool for 10 years electricity generation.

510 The quantities of spent fuel discharged from the reactor during refuelling can be up to 80 spent fuel assemblies each refuelling operation. A bounding value for the total number of spent fuel assemblies produced at the end of reactor life is set to 3400 units.

511 Core components used to control or measure neutron activity such as rod cluster control assemblies (RCCAs) and in core instrumentation (aeroball finger tubes) may be replaced during outages. The components are highly activated when they are removed from the reactor (because of their exposure to neutron radiation in the reactor core) and are transferred to the spent fuel pool where they are left to radiologically decay.

512 The reactor's planned operation over a period of 60 years may involve construction of an interim storage facility on the reactor site or at another location such as an interim spent fuel store shared between several sites. The site chosen for construction of the UK EPR will have enough space to allow an interim storage facility to be constructed.

513 EDF and AREVA present a 'reference case' solid radioactive waste and spent fuel strategy based on the waste and spent fuel management practices and arrangements of the reference plant for the UK EPR, Flamanville 3. Other possible options to the reference case for spent fuel strategy are presented in the SRWSR.

514 Five interim storage solutions are identified in the SRWSR, including underwater long-term pool storage and four types of dry storage. Wet storage is usual practice in nuclear power plants and is used for initial cooling, and subsequently may be used for

interim storage, before final disposal. Dry interim storage for spent fuel is used in Europe and the USA.

515 Of the five options, one wet pool storage, and two dry storage solutions were identified and assessed in more detail for the UK EPR. EDF and AREVA considered the regulatory requirements for interim storage facilities and in particular Environment Agency requirements in relation to BAT and our radioactive substances environmental principles (REPs).

516 EDF and AREVA considered three spent fuel storage technologies, based on available and proven technologies:

a) wet interim pool storage - fuel assemblies stored in a pool;

b) dry interim cask storage - fuel assemblies stored in metal casks;

c) dry interim storage in purpose designed stores - fuel assemblies stored in vault type storage.

517 The dry interim storage facility uses metallic storage flasks technology; the TN-DUO flask which is designed for both transport and storage. Information is provided on the building layout and safety features in the SRWSR. The storage facility is designed to operate for 100 years. Visual surveillance is carried out as part of a maintenance programme for flasks in the interim storage facility. A permanent check system is implemented which monitors any pressure drop in the interspace between the primary and secondary lid of the TN-DUO flask.

518 The dry storage vault involves placing fuel assemblies into canisters on receipt. The stainless steel canisters contain aluminium partitions to house fuel assemblies and ensure heat dissipation. Details are provided on the building layout and safety features.

519 These designs allow for retrieval and inspection of the fuel, and for refurbishment.

520 PCERsc6.5s4.1 describes the arrangements for interim storage for spent fuel. An interim wet storage facility is described with supporting review information in a report.

521 The interim wet storage pool facility is designed to be in operation to safely and securely store the spent fuel underwater for up to 100 years. A UK EPR will generate approximately 3400 assemblies that will require storage during its 60 year operating life. The lifetime of the store is about 100 years with stated objectives to maintain shielding, preserve the fuel cladding, minimise contamination, cool the fuel, maintain the sub-criticality, and to protect the fuel assemblies from mechanical damage.

522 The review report of interim wet storage (ELI0800224) is based on more than 30 years experience from EDF in underwater storage of spent fuel. The interim wet storage facility will be able to receive and store defective fuel assemblies associated with cladding failures. This damage may have been detected in the reactor pool or it may have occurred during spent fuel transfer or during interim storage. Defective assemblies can be inserted into over packing replacement fuel cylinders and stored in the interim wet store.

523 The design of the wet storage facility for UK EPR spent fuel is based on the last generation of La Hague complex storage pools, and detailed information is presented in the interim wet storage report on the arrangements for receipt of transport containers, handling and loading of fuel assemblies, cooling of the fuel pool, together with details of the building layout, safety and other relevant features.

524 For transportation considerations for the transfer of spent fuel offsite, an IAEA type B transport container is required. EDF and AREVA propose to use the TN-DUO for both storage and transport of UK EPR spent fuel if a dry interim storage option is chosen for spent fuel. The UK EPR adopts a proposed burn up of up to 65,000 MWd tU^{-1} and the TN-DUO is designed to accommodate this.

525 PCERsc5.2 provides information on design aspects in relation to decommissioning; the Environment Agency asks the Requesting Party to consider the whole lifecycle from design to decommissioning in their waste and spent fuel strategy. Improving the strength of fuel cladding materials significantly impacts the classification of waste by limiting the release of alpha and beta emitters. The SRWSR refers to the improvement of fuel cladding integrity to further reduce the likelihood of fuel leakages which EDF and AREVA claim are low.

526 EDF and AREVA have obtained and provided a view from the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of their proposed arisings of spent fuel.

527 RWMD concluded that compared with legacy waste and existing spent fuel, no new issues arise that challenge the fundamental disposability of the waste and spent fuel expected to arise from operation of the UK EPR. (see Annex 5)

528 RWMD indicated that the disposal route for rod cluster control assemblies (RCCAs) will need to be clarified. The RWMD assessment indicates they will not represent a major addition to the overall inventory, and that they could be conditioned separately as ILW or disposed of with the rest of the fuel assembly.

529 The activated core components are considered intermediate level waste (ILW), although they generate heat when they are removed from the reactor. These include RCCAs and the stationary core component assemblies. As they are exposed to radioactivity in the core, the RCCAs are highly activated by the time they are replaced; they are placed in the spent fuel pool to cool, as is the practice in existing PWR plants.

530 EDF and AREVA provided the Regulators with a critique of the RWMD disposability assessment, considering the impact of RWMD disposability assessment on their plans for conditioning, storing and dispatching the waste to a repository (GDF). The critique raised a number of issues. They identified that the principal issues were in relation to fuel burn up, assessment inventories, serious fuel cladding failures, interim storage of spent fuel, the use of supplementary data by RWMD, and the chloride impurity assumption. The Regulators requested further information from EDF and AREVA on how they will address the issues raised in their critique and those issues raised by RWMD in their disposability assessment.

531 The Regulators requested further information from EDF and AREVA on the encapsulation process for disposal for spent fuel since this was not considered in the RWMD assessment. EDF and AREVA provided further information in February 2010, and whilst our views are presented in this consultation document, we note HSE is continuing to review this information in its Step 4 assessment. We will continue to work closely with HSE on this issue, and this work will inform our decision document.

532 The Regulators requested EDF and AREVA to make a case for the disposability of spent fuel and ILW, which demonstrates the following:

a) How the issues identified in their critique of RWMD's Disposability Assessment will be addressed.

b) How the issues in Appendix B of RWMD's Disposability Assessment will be addressed.

c) How they will manage any risks associated with these issues.

533 EDF and AREVA provided information in February and March 2010. We note in particular that EDF and AREVA have consulted with RWMD specifically on the stages in the Letter of Compliance (LoC) process at which they would expect issues to be addressed. We recognise that, in most cases, these issues will need to be addressed by future operators of UK EPRs, rather than by EDF and AREVA, and we understand that EDF and AREVA have also discussed the timing of resolution of these issues with the potential UK EPR operator.

534 In general, we consider the plans proposed by EDF and AREVA to address – or, more commonly, for future licensees to address – outstanding disposability issues to be adequate at this stage. We will expect these plans to be periodically refined and updated in future to reflect developments.

535 We stress, however, that we will expect to see well before any UK EPRs begin operation some further information from EDF and AREVA on the properties of high burn-up spent fuel following long term storage (particularly in relation to the integrity of fuel and Instant Release Fractions (IRFs)). We recognise that detailed and definitive information may not be available until there is direct operational experience (e.g. for the Stage 2 LoC submission, as proposed by EDF and AREVA) , but we will expect much earlier than that to see evidence of sufficient progress to provide reasonable confidence that any issues are likely to be manageable.

536 We note that EDF and AREVA have produced a 'mapping document', intended to indicate where the information that will be needed for future Radioactive Waste management Cases (RWMCs) will come from, and when. This document gives us some assurance at this stage that RWMCs can be compiled at relevant stages in the development of a UK EPR fleet, which is sufficient at this stage of the GDA process. We note, however, that the mapping document in its current form would not yet fully meet our expectations for the format and content of a RWMC.

537 The HSE has commissioned the National Nuclear Laboratory to carry out work to identify mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage. This work will be reviewed in HSE's Step 4 and the findings will be taken into account in our decision document.

538 HSE wrote to us in March 2010 in regard to its step 4 assessment, including those aspects that could affect disposability of spent fuel. Regulatory Observations have been raised by the Regulators on long term storage of waste and disposability of spent fuel as discussed in the preceding paragraphs. The responses to most of the actions associated with these Regulatory Observations were received from EDF and AREVA at the end of February 2010 and in early March 2010. A report from EDF and AREVA on the ability to encapsulate spent fuel for disposal was received at the end of February 2010. HSE through its Step 4 of GDA will continue to work with us to review the information supplied by EDF and AREVA as they finalise the information contained in their submissions on long-term storage and disposability.

12.3 BAT to minimise disposals of spent fuel

539 EDF and AREVA have used a step-by-step approach to apply BAT. The UK EPR reference plant is Flamanville 3, which was designed to take into account experience and feedback from operating PWRs in France and Germany. This allowed improvements to be identified and incorporated as a result of learning from experience. There was an EPR environment design review in 2004, and an action plan and task force was set up. The scope and findings of the design review was discussed at the joint Regulators' inspections in December 2007 and April 2009, and presented in the published joint Regulators' inspection report in 2009.

540 EDF and AREVA claim the improvements in environmental performance of the EPR project with regard to waste and fuel include:

a) a more efficient use of natural uranium resources;

b) a significant reduction in the quantity of long lived radioactive waste resulting from the fuel and its cladding owing to its:

   i) neutronic design (large core, neutron reflector);

   ii) the fuel management performance (high burn up).

541 PCERsc8 describes the use of BAT in the UK EPR design with regard to spent fuel, namely the improved overall use of the fuel material compared with existing plants, as a result of increased operating and safety margins and more efficient use of the neutrons produced. There is less use of nuclear materials to produce the same amount of energy. It is possible to reduce both the consumption of natural uranium and the quantity of waste produced by irradiation, for the same amount of energy produced. Also high burn up of the fuel optimises the use of the fuel and saves approximately 7 per cent of the natural uranium resource required compared with current fuel for a given amount of energy produced.

542 EDF and AREVA claim the UK EPR design has three design features which directly contribute to reducing natural uranium consumption and spent fuel production:

a) the use of a large core with 241 fuel assemblies compared to 205 fuel assemblies for the N4 reactor operating units; the N4 is a predecessor design to the EPR. There is a reduction in neutron leakage due to the larger size of the core. Adopting a larger core with a smaller refuelling fraction enables 7 per cent savings in natural uranium;

b) using a solid steel reflector, the heavy reflector. The reduction in radial neutron leakage leads to savings of 2 - 3 per cent natural uranium;

c) the improvement in overall thermal efficiency and the enhanced turbine efficiency, contributes 5 per cent to the reduction in consumption of natural uranium.

543 EDF and AREVA indicate that the reduction of solid waste arising from fuel and its cladding is linked to the UK EPR's neutronic design, capability for improved burning of the fuel used and the capability of the nuclear power plants in operation to reuse all or part of the spent fuel. EDF and AREVA claim the increased burn up rate leads to a reduction in radiotoxic materials of around 14 per cent and a reduction of high activity long lived waste such as cladding of around 30 per cent.

544 EDF and AREVA note that the improvement in fuel reliability is a major objective for the UK EPR. Information provided indicates that the current EPR fuel design is based on improvements in manufacturing and quality, and research and development. There is a worldwide programme of research and development, including manufacturing and human aspects. Information on fuel failure rate is included earlier in this document; the current EPR fuel AFA 3G assemblies have shown high operational reliability.

545 EDF and AREVA have not provided information on any discharges from spent fuel storage. We would not expect discharges from interim spent fuel storage to be significant, and unless evidence is provided by EDF and AREVA to the contrary, we propose any discharges would be within the limits and levels proposed in Chapters 9 and 10 above.

546 We addressed comments we received on spent fuel from the public involvement process relating to the EPR design by 4 January 2008 in our preliminary assessment report (Environment Agency, 2008a). Public comments on this topic were received during our detailed assessment stage. One comment requested information about the type of spent fuel cask that would be used to transport spent fuel for processing or disposal. EDF and AREVA's response confirmed that TN type transport casks would be used to transport spent fuel in the UK, and provided information about the casks. The TN cask is a dual purpose cask that can be used to store and to transport spent fuel.

547 A comment was received about storage of spent fuel following the closure of reactor operations, and the need for ongoing secure power supplies to service the spent fuel storage pools, water treatment systems, waste treatment systems and storage facilities. The comment also queried whether the design of the dry storage casks would take into account the varying enrichment levels of the fuel elements. EDF and AREVA's response confirmed that the technology for longer term spent fuel management is not chosen, although several options are available such as dry cask or

dry vault storage, or long term pool storage. The response also confirmed the design of the storage facilities will take into account the enrichment and residual heat of the spent fuel elements, whatever technology is chosen. With regard to the ongoing availability of electrical power for services following reactor closure, it was confirmed that it is the aim of the UK national energy policy to ensure security of supply, together with the integrity of back up power supplies to provide power in the event of loss of grid supplies. The latter is considered specifically in GDA.

548 EDF and AREVA's proposals for storage of spent fuel are based on current practice. For interim storage, the RP provided a report (ELI0800224) based on 30 years operating experience worldwide in underwater storage of spent fuel. The Regulators requested further information about the proposed storage facilities to support the safe long-term storage of the spent fuel and to ensure that the fuel does not degrade over the long storage period.

549 **We conclude that in their submission, EDF and AREVA describe how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. EDF and AREVA provided information on the fuel composition and characteristics, and expected fuel burn up, and quantities of spent fuel that will arise. Information is provided in the submission and supporting documents on short and long-term management proposals for spent fuel. EDF and AREVA have obtained a view from the RWMD of the NDA on the disposability of the fuel and have provided their critique to the Regulators.**

550 **EDF and AREVA provided detailed responses in regard to storage and disposability in February and March 2010, and whilst our views are presented in this consultation document, we note HSE is reviewing this information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document. Therefore, our conclusion is subject to the potential GDA Issue:**

a) **Disposability of spent fuel following longer term interim storage pending disposal (UK EPR-I2).**

13 Monitoring of radioactive disposals

551 We did not conclude that the UK EPR utilises the best available techniques to measure and assess radioactive disposals and, therefore, we have identified the following other issue:

a) The monitoring of gaseous, aqueous and solid discharges and disposals of radioactive waste. (UK EPR-OI12)

Question 8: Do you have any views or comments on our preliminary conclusions on monitoring of disposals of radioactive waste?

552 We expect the design to use the best available techniques to measure and assess discharges of radioactive waste to the environment. This will enable any operational UK EPR to:

a) confirm that discharges are as predicted by the designer;

b) assess compliance with limits;

c) provide good quality data for dose assessments.

13.1 Monitoring of gaseous disposals

553 Measures for monitoring discharges are described in chapter 7 of the PCER and in document UKEPR-0007-001 '*Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR'*. BAT is described in chapter 8 of the PCER.

554 Activity concentrations will be determined for tritium, noble gases, iodine and other activation or fission products and carbon-14. Emission rates will be determined using an average flow rate via the stack for the discharge period. EDF and AREVA state that the measuring techniques correspond to BAT with some justification given in PCERsc8.4, including broad consistency to Sizewell B methods. Sampling procedures appear to be reasonable, but the submission is lacking information on sampling locations. EDF and AREVA understand the need for isokinetic sampling and stated arrangements implemented to meet ISO 2889:1975. They are committed to determining detection limits, decision thresholds and expression of results in compliance with EU Commission Recommendation 2004/2/Euratom, however the proposed krypton-85 and carbon-14 limits of detection would not meet required levels (PCERsc8.4 Table 1). The UK EPR gaseous effluent treatment system presents some major differences to that currently in place in existing stations. As such, it is expected that some of the monitoring activities may be different in the UK EPR.

555 The detailed design of the main stack and the associated monitoring arrangements for the reference EPR are not yet finalised. Additionally, EDF and AREVA state that the height of the stack will be site-specific. Further site-specific verification will be needed on the sample probe locations and compliance of the purchase specifications for devices to meet guidance and MCERTs requirements. (PCERsc7.3s1.1.2)

556 EDF and AREVA claim that: (PCERsc7.3s1.1.2)

a) there is redundancy built into the systems which would allow for continuity of monitoring and provision of independent samples;

b) installation of sampling and monitoring equipment would take account of engineering rules, regarding space for monitoring operations and maintenance.

557 We have assessed the information EDF and AREVA provided on the UK EPR design for the determination of gaseous discharges against the requirements of M1 (Environment Agency, 2010a) and M11 (Environment Agency, 1999a) and other best practice for monitoring.

558 **We have concluded that:**

a) **BAT has not been comprehensively demonstrated for the monitoring on the UK EPR gaseous effluent systems.**

b) **We could not make an assessment on the suitability of the sampling lines, EDF and AREVA say that arrangements may be site-specific. We require sample lines to be as short and direct as possible.**

c) **Evidence has not been provided to back up the statements about how representative samples would be achieved, therefore, we could not assess whether monitoring locations being planned are appropriate.**

13.2 Monitoring of aqueous disposals

559 Measures for monitoring discharges are described in chapter 7 of the PCER and in document UKEPR-0007-001 '*Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR*'. BAT is described in chapter 8 of the PCER.

560 Pre-discharge screens are carried out for tritium, to check the absence of gross alpha activity, gross beta, gross gamma and gamma spectrometry. Checks are then carried out on a sample after discharge either taken from the tank before discharge or an aliquot sample representative of all the discharges from the tanks over one period. Activity concentrations will be determined for tritium, iodine radionuclides and other activation or fission products and carbon-14 and activity discharged by multiplying by volume discharged. EDF and AREVA state that their measuring techniques correspond to BAT with some justification given in PCERsc8.4, including broad consistency with Sizewell B. No details have been provided on how the discharge volume is measured and samples taken, but EDF and AREVA demonstrate that they understand the need for homogenous representative samples. They are committed to determining detection limits, decision thresholds and expression of results in compliance with EU Commission Recommendation 2004/2/Euratom, however the proposed tritium limit of detection (LoD) would not meet the required level (PCERsc8.4 Table 2).

561 EDF and AREVA are proposing not to monitor for strontium-90 and they are also not proposing to seek authorisation for alpha emitters (plutonium-239, plutonium-240 and americium-241).

562 EDF and AREVA state that separate flow proportional sampling will be arranged as required by the Regulator. (PCERsc7.3s2.1.3)

563 EDF and AREVA state that they will take into account MCERTS, but they have not given any information as to how and if they have considered whether appropriate instrumentation (for example, flow meters) is available. (PCERsc7.3s2.1.4.1)

564 There are requirements for sampling and monitoring equipment to be protected from the weather and interference by unauthorised personnel and for analysis to achieve ISO17025 and MCERTS accreditation. EDF and AREVA state that sampling is to be carried out in the pumping station which is in a controlled area and that they recognise the need for the laboratory to be accredited. (PCERsc7.3s2.2.3)

565 We have assessed the information provided by EDF and AREVA on the UK EPR design for the determination of aqueous discharges against the requirements of M12 (Environment Agency, 1999b) and other best practice for monitoring.

566 **We have concluded that:**

a) **we were unable to assess whether monitoring locations being planned are appropriate as there was insufficient information in the submission.**

13.3 Monitoring of solid waste disposals

567 EDF and AREVA have not provided any detailed information on monitoring of solid waste disposals.

14 Impact of radioactive discharges

568 We have assessed the information EDF and AREVA provided for the UK EPR relating to the impact on members of the public and non-humans as a result of the disposal of aqueous and gaseous radioactive waste by discharging it to the environment.

569 We conclude that EDF and AREVA's generic site parameters and their values, which define their generic site, are appropriate to use in their assessment of radiological impact at the GDA stage.

570 We conclude that EDF and AREVA have made an adequate assessment of the impact of the discharges, which assumes that the UK EPR 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^{-1} and also below the dose constraint proposed by the Health Protection Agency (HPA, 2009) who recommend 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^{-1}. We also conclude that the discharges would not adversely affect the integrity of any conservation sites.

571 This conclusion depends on a detailed site-specific impact assessment being provided at site-specific permitting. The site-specific assessment will need to be based on the actual environmental characteristics of the proposed site to demonstrate that doses to members of the public from the UK EPR at the proposed site will be as low as reasonably practicable (ALARP) and below relevant dose constraint and dose limits.

572 In their assessment of the impact on members of the public EDF and AREVA 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, their estimate of doses was 26 μSv y^{-1}. This dose was from the operation of a single UK EPR, with discharges at the annual limits specified above. We were able to verify all stages of the assessment produced by EDF and AREVA.

573 Our stage 3 assessment of the doses from the UK EPR was 31 μSv y^{-1}. Our assessment was similar to that of EDF and AREVA but with some different assumptions about food production and human habits.

574 EDF and AREVA made an assessment of radiation dose rates to plants and animals near an operating UK EPR. They predict the highest dose rates to be:

a) 0.003 μGy h^{-1} for a terrestrial organism (a mammal);

b) 0.01 μGy h^{-1} for a marine organism (a polychaete worm).

575 We have also made an assessment of radiation dose rates to plants and animals near an operating UK EPR. We predict the highest dose rates to be:

a) 0.1 μGy h^{-1} for a terrestrial organism (a bird egg);

b) 0.02 μGy h^{-1} for a marine organism (a mammal and reptile).

576 These dose-rates are well below 40 μGy $h^{-1,}$ the value below which we consider that there will be no adverse effect on the integrity of a conservation site (Environment Agency, 2009d).

Question 9: Do you have any views or comments on our preliminary conclusions on the impact of radioactive discharges?

14.1 Verification of assessments of impact

577 EDF and AREVA have made an assessment of the impact of the discharges of radioactivity from the UK EPR to the environment. We have reviewed their assessment in detail. Our review involved two main processes. Our first process was verifying the assessment EDF and AREVA provided. The verification aimed to reproduce the impacts EDF and AREVA assessed, adopting their model and input data. Our second process was to carry out our own assessment of the impacts using best practice and recommended models and assumptions. These are summarised in Table 14.1 below. We also compared the outputs and approach from our own assessment with those of EDF and AREVA. We followed up any significant discrepancies with EDF and AREVA, where appropriate. These processes helped us to be sure that the assessment of impacts on people and the environment were correct and valid.

Table 14.1 summary of assessment outputs from the EDF and AREVA assessment of the UK EPR and our verification for maximum discharges

Assessment	EDF and AREVA calculated dose μSv y^{-1}	Verification of EDF and AREVA assessment	Our calculated dose using our assumptions μSv y^{-1}
Stage 1	138+	V	138+
Stage 2	63+	V	63+
Stage 3	26*	V	31*
Short duration release to atmosphere	1.5**	VC	1.5**

* Dose to the representative person including direct radiation

\+ Sum of doses to the groups most exposed to gaseous and aqueous discharges and direct radiation

** Units are μSv

V – verified – able to reproduce their assessment exactly

VC – validated by comparison between our assessment and EDF and AREVA.

14.2 Generic site concept

578 At present, there are no specific sites for which detailed site-specific assessment can be made. At the generic design assessment stage, ahead of an application to build and operate a UK EPR at a particular site, we have requested an assessment to inform us about the potential impact from an operating UK EPR. This assessment is based on available information on the design. 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 EDF and AREVA to consider a 'generic site'. The characteristics of the generic site should be appropriate to sites in the UK where nuclear power stations might be built and will define the 'envelope' of applicability of any statement of design acceptability that we might issue.

579 We have asked EDF and AREVA to identify the key factors that will affect the doses received and take them into account when establishing the characteristics of the generic site. The key characteristics that are of interest to us include:

a) weather and other parameters affecting gaseous dispersion and deposition;

b) hydrographic and other parameters affecting aqueous dispersion;

c) location of nearest food production, how close people might reasonably live to the site, the location of sensitive habitats and species;

d) food consumption rates and other human habits data.

580 EDF and AREVA have provided information on generic site characteristics. (PCER Chapter 10). They have derived their UK EPR generic site characteristics assuming the UK EPR will be located at a coastal site. They have chosen these characteristics to provide a good geographic representation and represent typical data for sites where potentially a new UK EPR reactor might be located.

14.2.1 EDF and AREVA generic site characteristics and exposed groups

581 EDF and AREVA's UK EPR generic site characteristics include data on:

a) **Human population – Exposed population groups** – for dose assessment purposes, EDF and AREVA have considered two exposure groups:

i) The locally resident farming family selected to represent exposure pathways associated with atmospheric releases from the UK EPR. The local resident family comprises infants, children and adults who live 500 m from the aerial discharge point. They spend most of their time at home, some of which is spent outdoors. They eat food from local sources and milk from local farms, which are 500 m from the aerial discharge point. They eat locally caught fish and shellfish.

ii) The fisherman family selected to represent the exposure pathways associated with discharges from the UK EPR to the coastal environment. The fisherman and his family are assumed to spend time on intertidal sediments in the area and consume high levels of locally caught fish and shellfish as well as smaller amounts of locally produced fruit and vegetables from local sources up to 500 m from the aerial discharge point. This group live far enough from the site not to be exposed to direct radiation from atmospheric releases.

b) **Habits data** - which includes things such as food consumption rates, breathing rates and occupancy rates for three age groups (1 year old infant, 10 year old child and adult). At existing nuclear sites we have collected habits data to use in our impact assessments. However, for the generic sites, where no site-specific data is available, generic habits data can be used. This data is used to define habits for the exposure groups considered in the assessment. Generic habit data derived from UK national surveys is published in recognised sources such as NRPB-W41. (PCERsc11.1 Tables 9 and 12). Generic habits normally lead to greater exposure than site-specific habits, resulting in higher predicted doses than may be expected for a site-specific assessment.

582 **Non-human species** – It is assumed that European and UK protected species may be present including birds, terrestrial mammals, reptiles and amphibians, marine mammals and fish, invertebrates and flora. EDF and AREVA have assumed that all reference organisms specified in the ERICA (see section 14.8 below) integrated approach are present. Using reference organisms with defined anatomical and physiological properties and habits to represent typical organisms in the ecosystem is an accepted practice in assessing the impact on non-human species. (PCERsc10.4 Table 2).

583 **Meteorology** – EDF and AREVA have specified meteorological data for the generic site. They have described as a typical coastal UK location with a uniform windrose and 70 per cent Pasquill category D. Data on atmospheric washout and deposition coefficients have been used which are consistent with data published in recognised sources such as RP72. (PCERsc11.1 Table 7)

584 **Terrestrial environment** – EDF and AREVA have specified the generic terrestrial environment in terms of the parameters that need to be defined for prospective radiological impact assessment purposes. This is a coastal site in a rural agricultural

area. More detailed information on the terrestrial environment will be made available at the site-specific stage. (PCERsc11.1 Table 7)

585 **Coastal environment** – EDF and AREVA have specified the local waters generically by adopting restrictive values for parameters such as volumetric flow rate, depth, coastline length, sediment load, rate and density, bioturbation and diffusion rate for potential sites where the UK EPR might be located. A number of coastal and estuarine sensitive habitats are assumed likely to be present near the generic site. (PCERsc10.4 Table 1 and sc11.1 Table 7)

586 EDF and AREVA use the UK EPR generic site characteristics in their assessment of the potential radiological impact of the UK EPR on members of the public and non-human species.

14.2.2 Our view of the EDF and AREVA generic site characteristics

587 We have reviewed the EDF and AREVA generic site characteristics. We believe that they are justified and reasonable and represent a conservative approach, while also being realistic. We recognise that a detailed site-specific assessment of the radiological impact from the UK EPR will be required for any site where the UK EPR is proposed and, therefore, site-specific data will be required for any site at which a UK EPR reactor may be located.

588 **We conclude that EDF and AREVA's generic site parameters and their values, which define their generic site, are appropriate to use in their assessment of radiological impact at the GDA stage.**

14.3 Our requirements for the assessment of doses to people

589 We have required EDF and AREVA to make an assessment of doses to the representative person. 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 50 years. A reference modelling system is the EC system described in an EC publication number RP-72 and implemented by the HPA in a computer code PC CREAM 98. EDF and AREVA adopted this system for their stage 3 assessment.

590 Doses to members of the public are calculated taking account of the predicted levels of radionuclides in the environment and the habits of members of the public near the site. Those members of the public who are estimated to receive the highest dose overall (from gaseous and aqueous discharges and direct radiation) are described as the 'representative person'. 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 HSE. However, for the purposes of comparing doses to the dose constraints, we have estimated doses from direct radiation based on data for direct radiation doses from Sizewell B in 2007 (Environment Agency et al, 2008). HSE will be making an assessment of direct radiation dose as part of its work in GDA Step 4.

591 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 'representative 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 addition is likely to give rise 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.

592 EDF and AREVA provide information on their assessment of doses to the public in their submission. (PCERsc11.1).

14.3.1 EDF and AREVA assessment approach

593 EDF and AREVA carried out a three-staged approach to their assessment. The first two 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.

a) 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. EDF and AREVA used our published dose per unit release factors given in our initial radiological assessment methodology. For gaseous radioactive waste discharges, EDF and AREVA 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 by volumetric exchange. The volumetric exchange rate used was 100 $m^3 s^{-1}$, which is the conservative value recommended in our initial radiological assessment methodology.

b) Stage 2 is a more refined assessment using more realistic key parameters such as stack height and aqueous dispersion factors. EDF and AREVA 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 EDF and AREVA consider to be more realistic. The UK EPR stack protrudes a few metres above the reactor building, which is likely to be around 60 m high and, taking into account potential entrainment of gaseous radioactive waste in the wake of the reactor building, an effective release height of 20 m was considered to be appropriate. For aqueous discharges, the volumetric exchange rate along the coast was taken to be 130 $m^3 s^{-1}$. This is the lowest exchange rate (worst case) at four locations around England and Wales chosen by EDF and AREVA to represent sites where potentially a new UK EPR reactor might be located.

594 For both stage 1 and 2 our methodology calculates 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 three age groups (infant, child and adult) 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.

595 EDF and AREVA also estimated doses from direct radiation from the UK EPR in order to predict the dose to the representative person.

596 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.

597 EDF and AREVA carried out stage 3 of the assessment using the PC CREAM 98 model assessment system. PC CREAM 98 is an EC system for modelling and assessing the transfer of radionuclides in the environment and making estimates of doses to members of the public. The assessment assumed continuous uniform releases for 50 years at the maximum annual discharge levels for both aqueous and gaseous radioactive waste. The stage 3 assessment takes into account the potential for exposure of members of the public by a combination of internal and external pathways. For example, EDF and AREVA have assumed that members of the local

resident family may also consume seafood at an average rate, and members the fisherman family may consume terrestrial food, 50 per cent of which is locally sourced. This provides a realistic assessment of dose to the representative person for the UK EPR.

598 We consider the approach and assumptions EDF and AREVA made in their dose assessment to be reasonable. For the stage 3 assessment, we note some minor divergences from standard practice. However, we do not consider these will affect the results of EDF and AREVA's dose assessment significantly. The divergences in approach relate to the assumed location of the nearest habitation, inhalation rates for indoors and outdoors and certain marine dispersion parameters. Further detail can be found in our assessment report IMAS/TR/2010/05 (Independent Dose Assessment).

14.3.2 EDF and AREVA's assessment results

599 Table 14.2 shows the doses EDF and AREVA predicted.

Table 14.2: EDF and AREVA predicted doses for the UK EPR design for maximum expected annual discharges.

Pathway	Doses to the public μSv y^{-1}		
	Stage 1	Stage 2	Stage 3
Aqueous discharges	60	46	17
Gaseous discharges	73	11	4
Direct radiation	6	6	5
Total dose	**138**	**63**	**26**
Short duration release to atmosphere+	N/A	N/A	1.5+**

\+ Assuming 1 month's worth of discharge occurs over 24 hours.

** Units are μSv

600 EDF and AREVA's stage 3 assessment resulted in estimated doses to the representative person of the public of 26 μSv y^{-1} to an adult (Table 14.2). Doses to other age groups were 12 μSv y^{-1} to a child and 11 μSv y^{-1} to an infant.

601 The highest contribution to dose was from consuming carbon-14 in fish resulting from aqueous discharges.

602 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. EDF and AREVA have made an assessment of a short duration release – assuming one month's discharge is released over 24 hours. These resulted in estimated doses from a UK EPR to the representative person of the public of 1.5 μSv to an infant. Doses to adults and children are estimated to be 0.9 μSv.

603 **We conclude that all the doses EDF and AREVA assessed are below the dose constraint for members of the public of 300 μSv y^{-1} and the dose constraint recommended by HPA for new build of 150 μSv y^{-1}.**

14.3.3 Our verification of the EDF and AREVA assessment results

604 We were able to repeat all three stages of the EDF and AREVA dose assessment.

605 We have also carried out our own dose assessment, assuming discharges are made at the maximum annual discharges. For this, we used the PC CREAM 98 model and standards practices used by the Environment Agency for regulation under RSA93.

606 Our stage 3 assessment showed the highest estimated doses from an EPR is to an adult representative person of 31 μSv y^{-1}, who is most exposed to aqueous discharges (Table 14.3). We have also proposed some annual limits on discharges for the UK EPR and assessed the potential impact at these limits. The assessed impact is broadly the same as that predicted by EDF and AREVA. Our assessment estimates the dose to be 30 μSv y^{-1} and the slight difference is due to rounding of the numerical results in the calculations.

607 The highest doses are from aqueous discharges and the highest contribution was from carbon-14 in fish.

Table 14.3 Summary of our assessed doses to representative person at stage 3 from the UK EPR design at maximum expected annual discharges and our proposed limits.

Pathway	Doses to the public μSv y^{-1}	
	Maximum expected discharges	Our proposed limits
Aqueous discharges	28	28
Gaseous discharges	3	3
Direct radiation+	0	0
Total dose	**31**	**30***

+The representative person belongs to a group that is most exposed to aqueous discharges and receives no dose from direct radiation

* Rounded figure

14.4 Source dose constraint

608 There is a dose constraint (Defra, 2000) 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^{-1} and it applies to the dose from proposed discharges and direct radiation.

609 As set out above, our assessment shows that, for the UK EPR, the sum of doses to the representative person from the maximum expected discharges and direct radiation is 31 μSv y^{-1} and is below the source dose constraint. At our proposed limits, the sum of doses to the representative person is 30 μSv y^{-1}, which is also below the source dose constraint.

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

14.5 Site dose constraint

611 There is also a dose constraint (Defra, 2000) for the maximum dose to people that may result from discharges from a site as a whole. The constraint is 500 μSv y^{-1} and it

applies to the total dose from the discharges (direct radiation is not included) from all sources at a single location, including discharges from immediately adjacent sites.

612 A number of the sites listed in the Nuclear National Policy Statement (DECC, 2009b) as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA, the specific site at which a UK EPR might be located is not known, but we consider, in the light of our assessment, that the highest total dose is estimated to be 31 μSv y^{-1}. It is very unlikely that doses at the site will exceed the site dose constraint of 500 μSv y^{-1}.

613 **We conclude that site dose should be assessed at site-specific permitting.**

14.6 Dose limit

614 There is also a dose limit (Defra, 2000) for the maximum dose to any member of the public from ionising radiation. The dose limit is 1 mSv y^{-1} (1000 μSv y^{-1}) and it applies to the total dose from all artificial sources including past discharges, but excluding medical and accidental exposure.

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

14.7 Doses to people – collective dose

616 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 measured in man-sieverts (manSv). 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 as part of their criteria for discharges not requiring regulatory control.

617 The UK Health Protection Agency, Radiation Protection Division (HPA-RPD), has 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). HPA-RPD 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 need to look more carefully at the discharge options.

618 EDF and AREVA provide Information on collective dose (PCERs c11.1).

619 EDF and AREVA have estimated collective dose to UK, Europe and world populations truncated at 500 years using PC CREAM 98. Table 14.4 shows the results of EDF and AREVA's collective dose assessment.

Table 14.4 Collective doses estimated by EDF and AREVA from discharges from UK EPR at maximum expected annual discharges

Population	Collective dose manSv y^{-1}	Per person dose nSv y^{-1}
UK	0.11	2.0
Europe	1.26	1.8
World	16.9	1.7

620 EDF and AREVA consider that the collective dose to all populations is dominated by releases of carbon-14 in both aqueous and gaseous radioactive waste.

621 We have also carried out our own calculations of collective dose. We did this for the UK, European and world populations over the next 500 years, assuming discharges are made at the maximum expected discharges of aqueous and gaseous radioactive waste. We used the PC CREAM 98 software to estimate collective dose. Our results are set out in the table 14.5 below.

Table 14.5 Our estimate of collective doses from discharges from UK EPR at maximum expected annual discharges

Population	Collective dose manSv y^{-1}	Per person dose nSv y^{-1}
UK	0.11	2.0
Europe	1.22	1.7
World	16.9	1.7

622 Comparing our assessment of collective dose and the assessment EDF and AREVA carried out shows almost identical results. Our assessment of collective dose similarly showed collective dose to be dominated by contributions from carbon-14 in discharges of both aqueous and gaseous radioactive waste.

623 For comparison, the annual collective dose to the UK population from background radiation has been calculated as 130,000 manSv (HPA, 2005). The collective dose from the UK EPR is above the IAEA level of 1 manSv per year of discharges, indicating that the discharges should be regulated. As the average per person doses are low, we consider that additional measures to minimise discharges are not required to control collective doses.

14.8 Doses to other species

624 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 humans, 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 'guideline values' to assess the level of risk to flora and fauna. As described in our considerations document (Environment Agency, 2009c), we have adopted a value of 40 µGy h^{-1} as the level below which no further regulatory attention is warranted.

625 EDF and AREVA provide information on assessment of doses to non-human species in the PCERsc11.2. Their approach to assessing the impact on non-human species is as follows:

a) EDF and AREVA have predicted the maximum discharges of radionuclides in aqueous and gaseous radioactive waste that are likely to occur from their UK EPR design. They have used this data to assess the potential impact of the discharges to non-human species. (PCERc11)

b) In their assessment, EDF and AREVA used the ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) integrated approach (Beresford, 2007), which is the accepted practice within the European Union. The ERICA integrated 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.

c) To carry out the assessment, EDF and AREVA used the ERICA tool, which is a software programme that calculates the radiation dose rate that a reference organism is 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 (as has been done for human radiation protection). EDF and AREVA have assumed that all reference organisms specified in ERICA are present and have included reference organisms that they consider to be typical or representative of terrestrial, freshwater and marine ecosystems.

626 The ERICA integrated approach has a default screening criterion for all ecosystems or organisms which is an incremental dose rate of 10 µGy h^{-1} below which 95 per cent of all species should be protected from ionising radiation (Andersson, 2009).

627 The ERICA integrated approach takes a tiered approach that allows progressively more detailed assessment depending on the magnitude of the dose rates calculated:

a) 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.

b) Tier 2 is more specific and less conservative – the user defines the radionuclides of interest and edits transfer parameters. Dose rates are calculated for each reference organism individually.

c) 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.

628 EDF and AREVA used the following parameters in their assessment:

a) The maximum predicted activity concentrations of the radionuclides discharged to air and water that were used to derive activity concentrations in sea water, sea bed sediments, air and soil using the PC CREAM 98 model.

b) Default ERICA values for transfer parameters where available, and where not, values from IAEA TRS 422 (IAEA, 2004) or the most conservative parameter for that organism.

629 Results of the assessment carried out by EDF and AREVA:

a) EDF and AREVA carried out their assessment at tier 2 and considered the risk to terrestrial reference organisms from the predicted gaseous discharges and to marine reference organisms from the predicted aqueous discharges.

b) The results of their assessment identified that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than 1 per cent. The highest predicted dose rate for a terrestrial organism was calculated to be 0.003 µGy h^{-1} for a mammal and for a marine organism to be 0.01 µGy h^{-1} for a polychaete worm. (PCERsc11.2s2)

c) The greatest radiological impact to all non-human species from atmospheric discharges is from carbon-14. The radiological impact from marine discharges is generally greatest from carbon-14 and cobalt-60 depending on the species.

630 We carried out two evaluations of the assessment carried out by EDF and AREVA:

a) A validation exercise using the ERICA tool to satisfy ourselves that the results of the EDF and AREVA assessment were reproducible.

b) An independent assessment using the ERICA tool and the R&D128 approach (‘Impact Assessment of Ionising Radiation on Wildlife’, R and D Publication 128, Environment Agency, June 2003) to determine the dose rates using discharge data EDF and AREVA provided and predicted activity concentrations modelled for us by an independent contractor.

631 We were able to reproduce the results of the EDF and AREVA assessment when we used their input parameters. However, we did note that EDF and AREVA had not assessed the impact of noble gases on non-human species, but they state this will be carried out at site-specific permitting using the R&D128 approach. We carried out an assessment for noble gases using the R&D128 approach. For this, we used the EDF and AREVA maximum predicted activity concentrations and conservatively assumed that the reference organism was at the point of release. The maximum predicted dose rate was calculated to be 0.2 µGy h^{-1} for fungi, which does not exceed the screening dose rate of 10 µGy h^{-1}.

632 Our independent assessment identified that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than one per cent. The highest predicted dose rate for a terrestrial organism was calculated to be 0.1 µGy h^{-1} for a bird egg and for a marine organism to be 0.02 µGy h^{-1} for a mammal and reptile. To assess the risks from noble gases, we carried out an assessment following the R&D 128 approach using the predicted activity concentrations, which had been independently modelled for us by an independent contractor. The maximum predicted dose rate was calculated to be 0.00009 µGy h^{-1} for fungi.

633 A summary of the outcomes of a comparison of the EDF and AREVA assessment with our assessments is set out below:

Assessment type	Data source	EDF and AREVA results	Our results
Terrestrial			
ERICA Tier 2	EDF and AREVA	No risk* for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal	No risk* for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal
	Independent	-	No risk* for any individual reference organism. Maximum predicted dose rate is 0.1 µGy h^{-1} for a bird egg
R&D 128	EDF and AREVA	Not assessed	Maximum predicted dose rate is 0.2 µGy h^{-1} for fungi
	Independent	-	Maximum predicted dose rate is 0.00009 µGy h^{-1} for fungi
Marine			
ERICA Tier 2	EDF and AREVA	No risk* for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm	No risk* for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm
	Independent	-	No risk* for any individual reference organism. Maximum predicted dose rate is 0.02 µGy h^{-1} for a mammal and reptile

*No risk means the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than one per cent.

634 There is some variation between the results obtained using the predicted activity concentrations EDF and AREVA provided and those used in our independent

assessment. This results in differences in the maximum predicted dose rates that we calculated compared to those calculated by EDF and AREVA. However, all the results are two or more orders of magnitude lower than the generic screening value and we do not consider that further assessment is justified at the GDA stage.

635 We obtained significantly different results using the R&D128 approach using the EDF and AREVA activity concentrations and those in our assessment. This is because our assessment using the EDF and AREVA activity concentrations had to conservatively assume the organism was living at the point of release. Our assessment using the activity concentrations was more realistic as it used dose rates calculated for an organism living 100 m from the point of releases. However, as the results from the conservative scenario do not exceed the screening dose rate, we do not believe further assessment is justified at the GDA stage.

636 We consider the assessment EDF and AREVA carried out to be conservative and reasonable at the GDA stage, and we consider that EDF and AREVA have used an appropriate approach to assessing the radiological impact of the UK EPR on non-human species.

637 We note, however, that the EDF and AREVA assessment did not consider the impact that discharges of radionuclides might have on freshwater organisms or the impact of discharges of noble gases. We consider that these should be assessed at the site-specific stage as part of the UK EPR site-specific radiological impact assessment for non-human species.

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

15 Other environmental regulations

15.1 Water abstraction

639 We conclude that the EDF and AREVA GDA proposal to abstract cooling water only from the open sea is unlikely to require an abstraction licence from us.

Consultation Question 10: Do you have any views or comments on our preliminary conclusions on the abstraction of water?

640 EDF and AREVA say that the UK EPR will need supplies of freshwater for several purposes (PCERsc3.4s1.1):

a) to supply the demineralisation plant that provides treated water for the primary and secondary circuits;

b) for the industrial water system in the turbine hall;

c) potable water for sanitation needs (showers and lavatories), for the laundry and for firewater and other purposes.

641 The annual requirement for freshwater for a UK EPR is likely to be 331,600 m^3. Providing freshwater will be a site-specific issue, and we have not considered this at GDA. EDF and AREVA mention using a desalination unit or abstraction from surface water sources such as a river or groundwater depending upon site characteristics. If the site needs abstracted surface water, then the operator will need to obtain an abstraction licence from us before any abstraction takes place.

642 EDF and AREVA only consider direct cooling of the steam turbine condensers by seawater in GDA. We accept that direct cooling may be the best option for estuarine and coastal sites, provided that the highest standards of planning, design and mitigation are followed (see Environment Agency, 2010b).

643 EDF and AREVA estimate that, allowing for a temperature increase of 12°C at the discharge point, the flow rate of seawater for cooling will be 67 $m^3\ s^{-1}$. The total annual volume of seawater required will, therefore, be around 2.1 billion m^3.

644 If a desalination unit were used to supply freshwater, see above, an additional annual volume of 680,000 m^3 seawater would be needed.

645 The abstraction of water from the open sea will not normally require an abstraction licence from us, unless the particular location of the abstraction means that it falls within the definition of inland waters. We have assumed for GDA that the cooling water intake will be from the open sea and that the abstraction will not require licensing. We will need to examine carefully the location of abstraction for each specific site to decide whether a licence is needed. Potential operators will need to contact us for advice, giving full details of their proposals.

646 The abstracted seawater will need to be filtered to remove debris, including seaweed before it is used. EDF and AREVA describe using pre-filters followed by drum and chain filters (PCERsc3.4s3.2.1). Handling the removed material will need to be considered for each site, it will be a waste for disposal. In some cases, it can be macerated and returned to the sea. The operator for each specific site will need to discuss with us the need for waste or discharge permits for the option chosen for the site. We have not assessed this issue at GDA.

647 We have concerns on the seawater intake design because of possible damage to fish and invertebrates through entrapment and impingement on filter screens. We

published a report in 2010 '*Cooling Water Options for the New Generation of Nuclear Power Stations in the UK*' (Environment Agency, 2010b) that explains the issues and reviews mitigation measures. We expect operators to contact us at the early stages of site-specific designs so that we can advise on techniques to minimise the impact of cooling water intakes on the marine ecology. We will assess and comment on the proposed intake design in our role as statutory consultee in the planning process. If the abstraction were licensable (under the Water Resources Act 1991), then we would also seek to influence the design through agreed conditions on the abstraction licence, for example, requiring the operator to install mitigation measures and / or carry out monitoring programmes.

648 **We conclude that the EDF and AREVA GDA proposal to abstract cooling water only from the open sea is unlikely to require an abstraction licence from us. The design of the sea water intake to minimise damage to marine life will be a site-specific issue.**

15.2 Discharges to water of non-radioactive substances

649 We conclude that we should be able to permit the discharges of non-radioactive substances to water from a UK EPR under EPR 10. However, this will depend on our determination of site-specific applications, and any application for a permit will need to provide a detailed environmental impact assessment based on dispersion modelling.

Consultation Question 11: Do you have any views or comments on our preliminary conclusions on discharges of non-radioactive substances to water?

650 We have assessed (within the constraints imposed by the generic site) whether discharges to water from the UK EPR could pose an unacceptable risk to the environment.

651 The underlying objective of our detailed assessment is to determine whether we could grant a discharge permit for the UK EPR design, subject to any matters that can only be dealt with at the site-specific stage.

652 The key issues for assessing non-radioactive discharges to water are the discharge of certain dangerous substances and the discharge of thermally adjusted cooling waters. Both these matters would be subject to control by an environmental permit from us (Environmental Permitting Regulations 2010, EPR 10).

653 Dangerous substances (as specified under the Dangerous Substances Directive) are toxic and pose the greatest threat to the environment and human health. The Directive requires that we either eliminate or minimise pollution by these substances. We define pollution by dangerous substances as exceeding environmental quality standards (EQSs) in the water. The EQS defines a concentration in the water below which we are confident that the substance will not have a polluting effect or cause harm to plants and animals.

654 The requirements of the Dangerous Substances Directive are now integrated in the Water Framework Directive, and the Dangerous Substances Directive will be fully repealed in 2013. The Water Framework Directive is designed to improve and integrate the way water bodies are managed throughout Europe. Member states must aim to reach good chemical and ecological status in inland and coastal waters by 2015. This overarching piece of legislation will have wide implications for any new nuclear power station built in Europe, not least of all because EQS compliance serves as a key indicator of both chemical and ecological status.

655 Heat is defined as pollution under the Water Framework Directive. Under the Directive, draft temperature standards have been published based on the requirements for coastal and transitional waters of good ecological status. In common with other directly cooled power stations (both conventional and nuclear), the UK EPR will produce and discharge large volumes of thermally adjusted cooling waters. The main environmental effects of these thermal discharges relate to temperature rise and cooling water system biocide residues.

656 Other important legislation to be considered is the Habitats Directive. The Directive created a network of protected areas around the EU called European sites which form the 'Natura 2000' sites. These sites are found in abundance at various locations around the UK’s coastline and could potentially be affected by new nuclear power station discharges.

657 At GDA it is not possible to assess the UK EPR discharge under the Habitats Directive. To determine whether a discharge is 'relevant' under the legislation, we would need to pinpoint it to a particular location. If the discharge were 'relevant', we

would apply increasingly rigorous assessment stages, ultimately requiring site-specific knowledge about how a discharge plume would behave in the receiving water. Detailed dispersion modelling could be required and this is outside the scope of GDA.

658 EDF and AREVA have carried out an ecological impact assessment based on a representative UK site (PCERsc12.3s3.2). While this is useful as it demonstrates an awareness of the relevant issues, identifying potential impacts and mitigation measures, the results are inconclusive due to the generic nature of the assessment. EDF and AREVA have identified the considerable limitations for this work under GDA and point towards the need for site-specific work to properly assess ecological impacts. This is consistent with our understanding and is consequently why we have not assessed this issue at GDA.

659 EDF and AREVA say that the UK EPR will generate aqueous effluents of two types (PCERsc3.4s5.1):

a) aqueous radioactive effluent associated with the reactor coolant. The radioactivity of this effluent is dealt with in chapter 10, but the effluent will also contain chemicals and metals, for example, corrosion products, that will need to be covered in a discharge permit from us;

b) non-radioactive effluent coming from conventional parts of the UK EPR such as the demineralisation plant, seawater chlorination facility, turbine hall and the site sewage treatment facilities.

660 The main chemicals used in the UK EPR and associated with the aqueous radioactive effluent are (PCERsc3.4s5.3.1):

a) boric acid added to the coolant as a neutron absorber;

b) lithium hydroxide added to the coolant to offset the acidity of the boric acid to prevent equipment corrosion;

c) hydrazine used as an oxygen scavenger in the feedwater;

d) ammonia, morpholine and ethanolamine to adjust pH of secondary circuit water to minimise corrosion;

e) trisodium phosphate used in some auxiliary cooling and heating circuits as a corrosion inhibitor;

f) detergents used in the laundry to clean work clothes.

661 Metals will arise from corrosion and erosion where coolant and other process waters contacts equipment. Metals used in the UK EPR equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), zinc (Zn) and lead (Pb). The UK EPR uses chemical controls to minimise corrosion. Effluents are filtered and, where possible, passed through ion exchange resins. These techniques will minimise the quantities of metals present in discharges.

662 Suspended solids may come from dust in drain effluents or from raw water used in some auxiliary circuits.

663 Chemical oxygen demand (COD) will arise from detergents and other organic chemicals used such as morpholine and ethanolamine.

664 EDF and AREVA predict the annual discharges of chemicals associated with radioactive effluent to be (PCERsc3.4 Table 3):

Chemical	Expected discharge without contingency (kg)	Maximum annual discharge (kg)
Boric acid (boron)	2,000 (350)	7,000 (1,224)
Lithium hydroxide	less than 1	4.4
Hydrazine	7	14
Morpholine	345	840
Ethanolamine	250	460
Nitrogen compounds (as N) excluding hydrazine, morpholine and ethanolamine	2,350	5,060
Phosphate	155	400
Detergents	630	1,600
Metals	16	27.5
Suspended solids	655	1,400
Chemical oxygen demand	1,490	2,525

665 EDF and AREVA have not carried out an impact assessment for those substances used as circuit conditioners (both primary and secondary circuits) that do not have an EQS. These substances require further assessment and may potentially be subject to control in a discharge permit. The operator will need to expand on this topic and provide additional information on the impact of these substances in support of a site-specific application for a discharge permit. Circuit conditioning products should, however, breakdown readily upon dilution with the cooling water return and upon mixing within the marine environment.

666 The distribution of metals is predicted in PCERsc3.4 Table 5:

Al	Cu	Cr	Fe	Mn	Ni	Pb	Zn
8.95%	0.7%	14.1%	59.3%	5.6%	0.75%	0.5%	10.1%

667 In addition to the metals listed above, EDF and AREVA state that traces of mercury, cadmium and arsenic can be present in raw conditioning materials. They also state that silver can arise in trace amounts from corrosion of control rods, although it is not likely to be found as in impurity within bulk raw materials.

668 EDF and AREVA have not provided estimates of discharges of these substances at GDA. However, it is likely that their presence in the discharge will be at low concentrations, possibly trace amounts following filtering and ion exchange treatment. More detailed information will be required for a site-specific application for a discharge permit.

669 We have commissioned a study to help us understand the range and quantity of chemicals discharges: '*Chemical Discharges from Nuclear Power Stations: Historic Releases and Implications for BAT*' (Science Report SC090012/SR). The report should be ready to support our GDA decision in 2011 and our site-specific permitting work.

670 UK EPR aqueous effluents will be collected in tanks – the LRMDS, ExLWDS or CILWDS tanks as already described in section 8.3 above. After sampling and analysis, the contents of the tanks may be authorised for discharge under an internal management procedure. The discharge will be through discharge points W1 and W2 to join the cooling water at the discharge pond. We anticipate that the flow metering and sampling equipment at W1 and W2 specified for radioactivity discharge monitoring will also be used for chemicals and metals monitoring.

671 EDF and AREVA say that demineralised water needed for use in the UK EPR will be produced by a demineralising plant using a fresh water supply or a desalination plant. Both plants would produce effluent and, as an example for GDA, they predict the following annual discharges based on 40 days use of demineralisation and the rest of time by desalination (PCERsc3.4s5.4.1.1):

Substance	Annual discharge (kg)
Suspended solids	1,621
Iron	848
Chlorides	3,616
Sulphates	11,725
Sodium	13,523
Detergents	312

Table from PCERsc3.4s5.4.3.1 (Table 6)

672 EDF and AREVA have not provided information on trace metal contamination of raw materials such as sodium hydroxide and sulphuric acid used in a demineralisation plant. Contamination usually includes cadmium and mercury, which are dangerous substances. However, it is likely that their presence in the discharge will be at low concentrations, possibly trace amounts. More detailed information will be required for a site-specific application for a discharge permit.

673 Seawater cooling circuits need to be protected from biological fouling when the seawater inlet temperature is above 10°C. The UK EPR will use an electrolysis system to produce sodium hypochlorite within the seawater. The system will leave residual oxidants and bromoform in the returning seawater. (PCERsc3.4s5.4.1.3)

674 The electrochlorination process is site-specific and depends on local water quality. However, EDF and AREVA have provided some predictions of discharge concentrations for residual oxidants and bromoform under different treatment scenarios. Increased dosing levels will be necessary where changes in water quality cause excessive biofouling, or where it is necessary to treat those parts of the circuits that are particularly prone to biofouling.

675 EDF and AREVA have provided an estimate of the impact from the electrochlorination process, quantifying the likely concentrations of TRO (Total Residual Oxidant) against its respective EQS. While they conclude that the area of water exposed to TRO concentrations which exceed the EQS would probably be limited to the immediate vicinity of the discharge point, they confirm that this is a highly site-specific assessment area. This is consistent with our understanding and is consequently why we have not assessed this issue at GDA. Future work involving using local water quality information and dispersion modelling would be necessary to support a site-specific application for a discharge permit.

676 The site of a UK EPR will need a sewerage system to collect (and treat where necessary) rainwater, wastewater from lavatories, water drainage that might contain oil and demineralisation plant effluents. The system will be site-specific and, therefore, has not been assessed under GDA. We note that EDF and AREVA have identified that oil traps and a retention area (to collect fire water or accidentally polluted water)

will be needed in such a system and we confirm that we will require these techniques. The operator will need to provide details and justification of the site-specific design in an application for a discharge permit. (PCERsc3.4s5.4.1.4/5)

677 The discharge arrangements for the demineralisation plant and sewage system are not defined at GDA. The operator for a specific site will need to define all points of discharge, detail flows and composition of effluent at each point and provide appropriate MCERTS flow metering and sampling equipment.

678 EDF and AREVA have provided an impact assessment for some of the substances discharged to sea from a UK EPR. This follows the principles of the Environment Agency's H1 guidance (modified slightly to better reflect the discharge of substantial plumes to the marine environment)(Environment Agency, 2010e). H1 is used for assessing the risks to the environment and human health from facilities that are applying for a permit under the Environmental Permitting Regulations 2010. Insignificant risks are screened out and more detailed assessment is only needed where the risks justify it.

679 EDF and AREVA have assessed those substances that currently have an EQS. They include:

a) metals contained in the radioactive aqueous effluent and non-radioactive demineralisation plant effluent;

b) other circuit conditioning chemicals (PCERsc12.2s2.5).

680 The assessment of metals takes into account the corrosion (and erosion) products arising in both the primary and secondary circuits and which are collected in the LRMDS and CILWDS tanks. From PCERsc12.2 Table 5:

Substance	Annual discharge (kg)	Discharge concentration ($\mu g\ l^{-1}$)(DC)	Environmental quality standard ($\mu g\ l^{-1}$)(EQS)	DC/EQS (%)
Ammonia unionised (as N)	167	0.08	21 (our proposed EAL)	0.4
Boron	1224	0.58	7,000	0.008
Iron	864	0.41	1,000	0.04
Copper	0.19	0.0001	5	0.002
Nickel	0.21	0.0001	30	0.0003
Chromium	3.88	0.002	15	0.0122
Zinc	2.78	0.0013	40	0.0033
Lead	0.14	0.00007	25	0.0003

681 The discharge concentration (DC) is that at the final discharge point to the sea after the effluent has been diluted with 67 m^3/s of returning cooling seawater. The discharge concentrations of all metals assessed are well below one per cent of their EQS.

682 Our procedures for permitting dangerous substances to coastal waters are based on the relationship between the discharge concentration and the EQS. We again apply a staged approach, which involves more rigorous assessment as each stage is passed. The rigour of each stage is reflected in the need for increasing levels of site-specific information and possibly dispersion modelling studies.

683 If the discharge concentration of a substance is much less than the EQS then it is considered insignificant. At the other end of the scale, we may have to define what is an acceptable '*mixing zone'* for a particular substance, taking account of local constraints such as sensitive ecological areas and specify appropriate limits for that substance on a discharge permit.

684 The discharge concentrations for dangerous substances estimated by EDF and AREVA suggest that in terms of our dangerous substances assessment, these concentrations are not significant. More detailed information would be required in support of a site-specific permit application, in particular information on those metals not considered so far, for example, aluminium and manganese and more harmful substances, such as cadmium and mercury.

685 EDF and AREVA say that the thermal impact of the returning cooling seawater (67 $m^3 s^{-1}$ at 12°C above the inlet water temperature) can only be modelled on a site- specific basis. This is consistent with our understanding and, therefore, we have not assessed potential thermal impact under GDA. Due to the highly localised data requirements of dispersion modelling, a detailed study will be required for a site- specific application for a discharge permit.

686 We have identified above a number of issues to be resolved at the site-specific permitting stage. This is because in order to fully assess the environmental impact of the UK EPR discharge we require an accurate representation of the behaviour of the receiving waters and of their interaction with the various substances to be discharged. This can only be achieved by computational dispersion modelling, using localised monitoring data - this is outside the scope of GDA. Nevertheless, based on our assessment of the information submitted by EDF and AREVA, we believe, in principle and without prejudice to our formal determination of an application in due course, that we should be able to grant a permit to discharge liquid effluents from the UK EPR to the sea.

687 **We conclude that:**

a) **the predicted discharges of non-radioactive substances from a UK EPR are less than one per cent of any environmental quality standards at the point of disposal to the sea and therefore should be compatible with the Water Framework Directive aim of achieving good ecological and chemical status in the receiving water; and**

b) **we should be able to permit the discharges of non-radioactive substances to water from a UK EPR under EPR 10. However, this will depend on our determination of site-specific applications and any application for a permit will need to provide a detailed environmental impact assessment based on dispersion modelling.**

15.3 Pollution prevention for non-radioactive substances

688 We conclude that:

a) the site of a UK EPR should not need to be permitted by us for a discharge to groundwater;

b) pollution prevention techniques used in the UK EPR are adequate to prevent any leaks or spills entering groundwater.

Consultation Question 12: Do you agree with our preliminary conclusions on pollution prevention for non-radioactive substances?

689 Under the Environmental Permitting Regulations 2010 (EPR 10), a permit is required for the discharge of certain substances, to groundwater, with the aim of preventing or limiting pollution of groundwater.

690 EDF and AREVA claim that there is no likelihood of direct or indirect discharges of relevant substances to groundwater from the UK EPR. In that case, a UK EPR should not need to be permitted by us for a discharge to groundwater under EPR 10.

691 EDF and AREVA list the following substances relevant to groundwater pollution as liable to be on a UK EPR site (PCERsc12.2s2.2):

a) hazardous substances: hydrazine hydrate, bromoform, hydrocarbons and radioactive substances;

b) non-hazardous pollutants: metals, phosphates, ammonia and nitrates.

692 Diesel fuel (a hydrocarbon) used by the UK EPR stand-by generators will present a potential risk to groundwater. However, its use will be within a permit from us, see section 15.4 below, and we will ensure through that permit that BAT are used to prevent any discharge to groundwater.

693 EDF and AREVA claim that any other '*storage tanks, chemical stores, refuelling areas and other activities that have the potential to pollute the environment will be placed on hard surfaces or bunded to contain spills*'. We will inspect facilities on specific sites during construction to confirm that appropriate prevention measures are in place before operations commence. (PCERsc12.2s2.2)

694 EDF and AREVA identify that the operator of a UK EPR site will need to have emergency procedures to be implemented in the case of any accidental spillage. The procedures should ensure that sources of contamination are found quickly and that the sources and any contaminated soil are treated to protect groundwater from pollution. We confirm that we expect operators to have such procedures in place before operations commence.

695 The borehole network mentioned in section 8.3 above should also be used to monitor for non-radioactive contaminants.

696 **We conclude that:**

a) **the site of a UK EPR should not need to be permitted by us for a discharge to groundwater under the Environmental Permitting Regulations 2010;**

b) **pollution prevention techniques used in the UK EPR are adequate to prevent any leaks or spills entering groundwater.**

15.4 Environmental Permitting Regulations 2010 (EPR 10) Installations

697 We conclude that the emergency diesel generators should be acceptable for permitting as a Part A (1) installation under EPR 10. However, this will depend on our determination of site-specific applications and any application for a permit will need:

a) a BAT assessment for the chosen diesel engine;

b) site-specific modelling to demonstrate compliance with air quality objectives.

Consultation Question 13: Do you agree with our preliminary conclusions on EPR 10 Schedule 1 activities?

698 The Environmental Permitting Regulations 2010 (before 1 April 2008 this was PPC (Pollution Prevention and Control Regulations 2000)) require operators of installations containing certain activities to apply for and obtain a permit from us before commencing operations. In relation to the UK EPR, combustion activities, where fuel is burned in two or more appliances with an aggregated rated thermal input of 50 MW or more, are relevant.

699 The UK EPR will include four main emergency backup electricity generators (emergency diesel generator – EDG). Each will have a thermal input of 17.6 MW to generate 7.5 MW of electricity. There will also be two ultimate emergency backup generators (station black out – SBO), each of 6 MW input to generate 2.5 MWe. The total thermal input for the six diesels (compression ignition engines) will be 82.4 MW, therefore any operator of a UK EPR will need to obtain a combustion activities permit from us. (PCERsc3.3s4.2.1.1)

700 The emergency generators are all nuclear safety equipment to provide backup power supplies in the unlikely event of loss of off-site supply or if UK EPR load operation fails. They will not normally operate except for periodic testing. EDF and AREVA claim that the estimated annual running time of each diesel should be less than 20 hours.

701 EDF and AREVA say that the choice of diesel generator suppliers will only be made at later stages of construction. Therefore, precise details of diesel performance and discharges can only be provided at the site-specific permitting stage. They have provided '*Generic information for UK EPR diesel generators*' in the supporting document UKEPR-0004-001. We have reviewed the document and have the following comments:

a) Site Report – this is a site-specific issue and cannot be assessed at GDA.

b) A technical description is provided: essentially there are two buildings each with two EDGs and one SBO, each EDG having a fuel oil storage tank of 180 m^3 capacity and each SBO having a fuel oil storage tank of 25 m^3 capacity. The operator will need to demonstrate that BAT are used for the design of the buildings and facility to prevent any leaks of oil reaching land or groundwater.

c) The main aerial emissions of concern are sulphur dioxide (SO_2) and oxides of nitrogen (NOx) in the waste combustion gases:

i) minimisation of emissions of SO_2 will be by using low sulphur content fuel oil (current UK regulations limit sulphur content to 0.1 per cent by weight), we accept this as BAT;

ii) minimisation of emissions of NOx will rely on engine design and will not be confirmed until a late stage of site-specific permitting. EDF and AREVA have quoted a typical discharge concentration of 2,542 mg m^{-3} NOx (as nitrogen dioxide, NO_2 at 5 per cent oxygen). The operator will need to provide a detailed BAT options appraisal with the permit application to show that the engine chosen minimises discharges of NOx. We believe that the concentration quoted as typical is high and that engines are currently available with much lower discharge concentrations of NOx. This is a technology area where improvements are taking place and we expect the operator to review latest available equipment to identify BAT.

iii) EDF and AREVA review abatement techniques for NOx (for example, selective catalytic reduction). It is likely that none will be BAT when the intermittent basis of operation (20 hours y^{-1}) is considered. EDF and AREVA defer any decision on abatement until the site-specific stage, the operator will need to provide evidence that abatement options have been considered in the application BAT assessment.

d) The operator will need to show that there will be appropriate management systems in place for the installation. This is an operator and site-specific issue and is not assessed at GDA. EDF and AREVA suggest an environmental management system such as ISO 14001:2004 would be appropriate and we agree with this suggestion.

e) Apart from fuel oil there will be few raw materials used – some lubricating oil and antifreeze – and little waste generated.

f) Cooling water for the engines will be in a sealed system, so there should be no liquid effluents to be disposed of to the sea.

g) The generators are essential for safety of the nuclear plant and, therefore, energy efficiency concerns are not appropriate. EDF and AREVA state that any electricity generated during tests would be exported to the grid together with the electricity generated by the UK EPR itself.

h) Noise from the operation of diesel generators can be an issue. EDF and AREVA say that as operation of the generators is intermittent so noise generated will also be intermittent. However, we believe intermittent noise can have its own issues and an operator will need to show procedures to minimise any impact. The operator will need to show that the design of the generator buildings and engine exhaust silencers are BAT to minimise impact of noise.

i) We are unlikely to require any continuous monitoring of emissions from the diesel engines or any environmental monitoring. Occasional testing of emissions by MCERTS portable equipment should be enough.

j) Diesel generators and their associated facilities should not be a significant issue at site closure.

k) EDF and AREVA expect the annual fuel usage to be 31 te for each EDG and 10.5 te for each SBO, a total of 145 te. On this fuel usage the annual emission of sulphur dioxide (at 0.1 per cent sulphur content) would be 290 kg. The annual NOx emissions are quoted as 1.7 te for each EDG and 0.6 te for each SBO, an annual total of 8 te (as NO_2). These emissions are not significant on a national basis, the national atmospheric emissions inventory 2006 gives SO_2 as 676,000 te and NO_2 as 1,595,000 te.

l) For local impact, SO_2 and NO_2 are subject to the Air Quality Regulations and the operator will need to demonstrate that emissions from the diesel installation will not compromise environmental quality standards. EDF and AREVA used our H1 methodology (Environment Agency, 2010e) to generate some impact values, PCERsc12.1s2.1.1.3:

i) The long-term impacts (assessed as an annual average) of both SO_2 and NO_2 are at low levels compared to the AQ standards and we do not consider this to be an issue.

ii) The short-term impacts are more difficult to assess. The AQ standards relate to exceedences in a year, and H1 is only appropriate to give a rough indication of issues. Further, H1 is very pessimistic for emissions from a combustion plant. The PCER shows NO_2 as particularly significant.

702 We used our internal screening model to give a more accurate assessment of AQ impacts. We used inputs of 1.91 g s^{-1} for SO_2 and 33.81 g s^{-1} for NO_2 (the emission rates for one EDG) and assumed 88 hours of operation in a year for the annual average. The maximum concentrations were found at a distance of about 400 m:

a) annual average SO_2 = 0.01 µg m^{-3} – not significant against our environmental assessment level of 50 µg m^{-3};

b) annual average NO_2 = 0.16 µg m^{-3} – not significant against the environmental quality standard of 40 µg m^{-3};

c) 99.9^{th} percentile 15 minute mean SO_2 = 15.9 µg m^{-3} – not significant against the environmental quality standard of 266 µg m^{-3} not to be exceeded more than 35 times a year;

d) 99.97^{th} percentile 1 hour mean NO_2 = 101.4 µg m^{-3} – significant against the environmental quality standard of 200 µg m^{-3} not to be exceeded more than 18 times a year but possibly tolerable depending on background levels of NO_2 at a specific site and allowing for infrequent operation.

703 The operator will need to provide site-specific modelling to demonstrate compliance with AQ standards at sensitive locations as part of the permit application. The modelling will need to include any effects on dispersion from the large nuclear power plant buildings near by.

704 EDF and AREVA show an understanding of the requirements of the Environmental Permitting Regulations. There are issues for an operator to resolve at the site-specific stage, such as BAT for the diesel engines and a demonstration that the short- term impact of the emissions of NO_2 does not compromise AQ standards. Nevertheless, in principle and without prejudice to our formal determination of an application in due course, we believe we can issue a permit for the operation of the stand-by diesel generators.

705 The operator will need to identify any Natura 2000 sites near a specific site. We will then determine whether the Habitats Regulations are relevant to the specific site and need to be considered in our determination of a permit. We have not assessed this matter at GDA.

706 **We conclude that:**

a) **the UK EPR's emergency diesel generators (EDG) will be a Part A(1) installation as described in section 1.1 of chapter 1 in Part 2 of Schedule 1 of EPR 10. The operation of the EDG will require an environmental permit from the Environment Agency;**

b) **we should be able to issue a permit under EPR 10 for the operation of the EDG, but any application for a permit will need:**

i) a BAT assessment for the chosen diesel engine;

ii) site-specific modelling to demonstrate compliance with air quality objectives.

15.5 Management of non-radioactive waste

707 We conclude that EDF and AREVA's strategy for non-radioactive waste from the UK EPR is consistent with the waste hierarchy and the objective that waste is recovered or disposed of without endangering human health and without using processes or methods that could harm the environment.

Consultation Question 14: Do you have any views or comments on our preliminary conclusions on non-radioactive waste?

708 All non-radioactive waste management is subject to the requirements of the Environmental Permitting Regulations and / or certain sections of the Environmental Protection Act 1990 and, where relevant, the Hazardous Waste Regulations 2005. We, therefore, expect EDF and AREVA's strategy and proposals for non-radioactive waste management to be consistent with:

a) the waste hierarchy (EC, 2006);

b) the objective that waste is recovered or disposed of without endangering human health and without using processes or methods that could harm the environment (EC, 2006);

c) the requirement that waste shall not be treated, kept or disposed of in a manner likely to cause environmental pollution or harm to human health (HMSO, 1990);

d) the duty to take reasonable measures to prevent waste from escaping (HMSO, 1990).

709 EDF and AREVA's integrated waste strategy (IWS) outlines their current strategy for managing radioactive and non-radioactive waste produced from the construction, operation and decommissioning of the UK EPR.

710 EDF and AREVA state in their IWS that the production of waste on a UK EPR will be an inevitable consequence of the construction of a power station and operation and management of the site. However, the design will help reduce arisings at the point of origin, including the careful choice of raw materials. This is discussed for the operational phase of a UK EPR in PCERsc3.3 and for the construction phase in PCERsc4.3.

711 EDF and AREVA state in their IWS that during construction a wide range of solid waste will be produced as well as excavation spoil. This includes:

a) packaging;

b) chemicals (material coating, surface treatment) and chemical containers;

c) off spec raw material (wood, plastics, metals).

712 They also state that excavation of the site, including rock crushing and concrete manufacturing, will produce dust and other particulates, and that demolition of existing buildings (if any) will also produce dust.

713 EDF and AREVA state in their IWS that non-radioactive solid waste is produced during the operation and maintenance of the process plant (for example, the maintenance of pipes and equipment), and also as a result of a number of routine activities (for example, removing algae from the water abstraction structure, maintaining control rooms equipment, activities in the workshops, waste from office work, packaging and from the canteen). The range of waste is very large.

714 Non-radioactive waste consists of ‘industrial waste’ (chemical and material additives, effluents, materials), ‘inert waste' (rubble) and ‘commercial waste’ (canteen, office waste). Several of these types of waste will be classed as hazardous under the Hazardous Waste (England and Wales) Regulations 2005 (as amended) and require special storage and treatment arrangements in accordance with the relevant legislation in order to minimise their impact. Hazardous waste includes solids (batteries, aerosol spray cans, electrical equipment), liquids (solvents, oils) and sludge (paint residues, decontamination products). A more detailed identification of the waste with reference to the European Waste Catalogue and the types of waste found on other nuclear power stations is given in PCERsc3.3.

715 EDF and AREVA claim in their IWS that the non-radioactive solid waste management strategy is designed to comply with the requirements of the Waste Framework Directive as implemented in the UK by the Environmental Permitting Regulations and the Environmental Protection (Duty of Care) Regulations 1991. They state that they will ensure compliance with these regulations by minimising waste production and storing and transferring waste responsibly. They claim that comprehensive waste management procedures will be implemented for all waste streams through the site environmental management system (EMS).

716 EDF and AREVA state in their IWS that the way that daily operation and maintenance activities are organised on the power station is important in minimising the amount of non-radioactive waste produced. They claim that waste production will be minimised through effectively implementing the waste hierarchy. Where possible, they will re-use potential waste on site. Where it is technically and economically feasible, potential waste will be recycled. Waste may be sent for energy recovery; it will only be disposed of to landfill or to incinerator as a final option, where no other reasonably practicable option exists. Information on the volumes of waste that are disposed, recycled or recovered at other stations is provided in PCERsc3.3. Waste that is recycled or recovered includes batteries, packaging and mixed metals. EDF and AREVA claim that waste produced from the UK EPR will be recycled where appropriate routes are available in the UK. They note that arisings of non-radioactive waste are largely determined by operational procedures and practices, and are not solely dependent on the design.

717 The following table (Table 5 in the IWS) gives an estimate of the annual arisings of the main different types of non-radioactive solid waste.

Waste type	Annual quantity (tonnes)
Inert waste and commercial waste	470
Hazardous (non-radioactive) waste	100
Total arisings (annual)	570

718 **We conclude that EDF and AREVA’s strategy and proposals for the management of non-radioactive waste are consistent with:**

a) **the waste hierarchy;**

b) **the Waste Framework Directive objective that waste is recovered or disposed of without endangering human health and without using processes or methods that could harm the environment;**

c) **the requirement of *The Environmental Protection Act 1990* (EPA 90) that waste shall not be treated, kept or disposed of in a manner likely to cause environmental pollution or harm to human health;**

d) **the duty under EPA 90 to take reasonable measures to prevent waste from escaping.**

15.6 Control of Major Accident Hazards Regulations (COMAH)

719 We conclude that a UK EPR will be COMAH lower tier installation.

Question 15: Do you have any views or comments on our preliminary conclusions on COMAH substances?

720 EDF and AREVA estimated the quantities of chemicals potentially to be stored on the site of a UK EPR and compared to the qualifying quantities of named dangerous substances to which COMAH applies (COMAH (Amendment) Regulations 2005). The most significant chemicals are shown below (PCERsc3.3s7.3):

Chemical	Stored quantity (te)	Lower tier threshold (te)	Upper tier threshold (te)
Hydrazine hydrate	1.5	0.5	2
Hydrogen	0.38	5	50
Petroleum spirits (diesel for back-up generators)	770	2,500	25,000

721 EDF and AREVA, therefore, state that the site of a UK EPR will become a COMAH lower tier installation because of the expected storage quantity of more than 0.5 tonne of hydrazine hydrate.

722 The operator of a lower tier installation needs to notify the Competent Authority (CA) (ourselves and HSE) and prepare a major accident prevention policy (MAPP) before starting operations. The operator also needs to be able to demonstrate to the CA that he has taken all measures necessary to prevent major accidents and limit their consequences to people and the environment. The notification, MAPP and demonstration will be site-specific issues for the operator and we have not considered at GDA – our main purpose at GDA was to find out if COMAH would apply.

723 EDF and AREVA also considered the storage quantities of generic categories such as toxic and flammable substances. These are presented in the PCERsc3.3 Table 8. Aggregation of these categories does not exceed any COMAH threshold, so does not affect the lower tier status determined above.

724 Hydrazine hydrate is used in small quantities as an additive to water in the secondary circuit to consume residual oxygen. It is usually delivered to site as a solution in drums or intermediate bulk containers (IBCs) and transferred, as required, to buffer storage tanks in the injection system. Hydrazine is a named carcinogen in the COMAH Regulations – hence the low threshold values – and its main risk is to the workforce.

725 Hydrazine hydrate is a liquid and could have a pathway to the sea in an accident through the site drains. It is classified as dangerous to the environment and is toxic to aquatic organisms. However, its toxicity diminishes with concentration, it is not very bio-cumulable and tends to decompose in the aquatic environment.

726 EDF and AREVA claim that the UK EPR will contain preventative measures to avoid accidental pollution of the aquatic environment:

a) all containers or tanks will be bunded;

b) any failure of a bund or spillage outside a bund would be collected by the CILWDS drain system and held in a discharge storage tank (an ex tank) pending a decision on disposal;

c) hydrazine systems have automatic shut-offs in event of failure.

727 EDF and AREVA claim that the risk of any hydrazine reaching the sea is very low due to the preventative measures. Also, the low quantity of hydrazine stored and its immediate dilution by the cooling water flow mean that consequences would be very limited. They conclude that a major accident to the environment (MATTE) is highly unlikely from any accident involving hydrazine. We agree with this qualitative risk assessment at this time for GDA, but we will need to assess this in more detail at the site-specific stage.

728 **We conclude that:**

a) **the UK EPR will store hydrazine (a dangerous substance as defined in the COMAH regulations) in quantities exceeding the lower tier COMAH threshold and will, therefore, be a COMAH lower tier installation;**

b) **the EDF and AREVA qualitative assessment that a major accident to the environment involving hydrazine is highly unlikely is reasonable. The operator will need to provide a more detailed risk assessment before any hydrazine is first stored;**

c) **the operator should be able to demonstrate that all measures necessary to prevent major accidents and limit their consequences to people and the environment have been taken for a UK EPR installation.**

729 The above conclusion relates only to the consequences of major accidents to the environment from hydrazine storage. Our partner in the Competent Authority for COMAH regulation, HSE, is responsible for assessing matters relating to impacts on people.

15.7 EU Emissions Trading Scheme

730 This scheme is one of the policies introduced across the European Union (EU) to help it meet its greenhouse gas emissions reduction target under the Kyoto protocol.

731 A UK EPR will have 82.4 MW (thermal) of combustion plant (see above) and will be an installation required to hold a greenhouse gas emissions permit. An operator of a specific site will need to obtain such a permit from us before any combustion plant operates.

16 Conclusion

732 At this stage, we propose that we could issue an interim statement of design acceptability for the UK EPR. This would be subject to the GDA Issues and other issues identified throughout this document and in Annex 1 and Annex 2. In particular, it would be valid only for a site meeting the identified generic site characteristics (see section 14.2 above).

733 A draft interim statement of design acceptability is included at Annex 1 to help inform this consultation. But we will not make a final decision on whether to issue a statement of design acceptability until we have considered all relevant responses to this consultation.

Consultation Question 16: Do you have any views or comments on our overall preliminary conclusion on acceptability of the design?

Consultation Question 17: Do you have any overall comments to make on our assessment, not covered by previous questions?

References

(Anderson, 2009) Andersson, P., Beaugelin-Seiller, K., Beresford, N. A., Copplestone, D., Della Vedova, C, Garnier-Laplace, J., Howard, B. J., Howe, P., Oughton, D.H., Wells, C., and Whitehouse, P., Numerical Ranges for Protecting Species from Radiation in the Environment: Proposed Levels, Underlying Reasoning and Recommendations (2009).
http://www.ceh.ac.uk/protect/outputs/documents/PROTECT_D5_final.pdf

(Beresford, 2007) Beresford, N., Brown, J., Copplestone, D., Garnier-Laplace, J., Howard, B., Larsson, C., Oughton, D., Prohl, G. and Zinger, I., An Integrated Approach to the Assessment and Management of Environmental Risks from Ionising Radiation (2007).
https://wiki.ceh.ac.uk/download/attachments/115017395/D-Erica.pdf?version=1

(BERR, 2008a) *Meeting the Energy Challenge. A White Paper on Nuclear Power,* BERR, January 2008.
http://www.berr.gov.uk/files/file43006.pdf

(BERR 2008b) Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Stations
http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/new/waste_costs/waste_costs.aspx

(BSi, 2005) BS EN ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories

(DTI, 2004) The Decommissioning of the UK Nuclear Industry's Facilities, Department of Trade and Industry, Sept 2004.
http://www.berr.gov.uk/files/file30124.pdf

(DECC 2009a) Statutory Guidance to the Environment Agency concerning the regulation of radioactive discharges into the environment, Department of Energy and Climate Change and Welsh Assembly Government, 2009.
http://www.decc.gov.uk/media/viewfile.ashx?filepath=what%20we%20do/uk%20energy%20supply/energy%20mix/nuclear/radioactivity/dischargesofradioactivity/1_20091202160019_e_@@_guidanceearadioactivedischarges.pdf&filetype=4

(DECC 2009b) Draft Nuclear National Policy Statement
https://www.energynpsconsultation.decc.gov.uk/nuclear/

(DECC 2009c) Consultation on proposed Regulatory Justification decisions on new nuclear power stations (AP1000 and EPR)
http://www.decc.gov.uk/en/content/cms/consultations/reg_just_cons/reg_just_cons.aspx

(Defra et al, 2008) Managing Radioactive Waste Safely. A Framework for Implementing Geological Disposal, (Cm 7386), Defra, BERR and the devolved administrations for Wales and Northern Ireland, June 2008.
http://www.official-documents.gov.uk/document/cm73/7386/7386.pdf

(Defra, 2000) The Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000, Defra, May 2000.

(Defra, 2010)	Environmental Permitting Guidance, Radioactive Substances Regulation For the Environmental Permitting (England and Wales) Regulations 2010, March 2010, Version 1.1 http://www.defra.gov.uk/environment/policy/permits/documents/ep2010radioactive.pdf
(EC, 2006)	Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste. Official Journal L114, 27/04/2006, p. 9-21. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0009:0021:EN:PDF
(Environment Agency, 1999a)	Monitoring of Radioactive Releases to Atmosphere from Nuclear Facilities. Technical Guidance Note (Monitoring). M11 1999 ISBN 0 11 310133 3.
(Environment Agency, 1999b)	Monitoring of Radioactive Releases to Water from Nuclear Facilities. Technical Guidance Note (Monitoring). M12 1999 ISBN 0 11 310135 X.
(Environment Agency, 2005)	Development of Guidance on Setting Limits on Radioactive Discharges to the Environment from Nuclear Sites, (Science Report: SC010034/SR, Environment Agency, December 05) http://publications.environment-agency.gov.uk/pdf/SCHO1205BIVK-e-e.pdf
(Environment Agency, 2006)	Environment Agency, Initial Radiological Assessment Methodology (Parts 1 and 2), Science Report SC030162/SR1 (2006) http://publications.environment-agency.gov.uk/pdf/SCHO0106BKDT-e-e.pdf
(Environment Agency, 2007)	Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, Jan 2007. http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf
(Environment Agency, 2008a)	Environment Agency Generic design assessment of new nuclear power plant designs, Statement of findings following preliminary assessment of the submission by EDF and AREVA for their UK EPR design, March 2008. http://www.hse.gov.uk/newreactors/reports/epr.pdf
(Environment Agency, et al 2008b)	*Radioactivity in Food and the Environment, 2007* (RIFE – 13), Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, 2008.
(Environment Agency, et al 2009a)	*Radioactivity in Food and the Environment, 2008* (RIFE – 14), Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, 2009.
(Environment Agency, 2009b)	Creating a better place 2010–2015: Our Corporate Strategy, Environment Agency 2009 http://publications.environment-agency.gov.uk/pdf/GEHO1109BQXE-e-e.pdf
(Environment Agency, 2009c)	Considerations for Radioactive Substances Regulation under the Radioactive Substances Act at Nuclear Sites in England and Wales, Environment Agency, Jan 2009 (version 2). http://publications.environment-agency.gov.uk/pdf/PMHO0106BKDG-e-e.pdf

(Environment Agency, 2009d)	Environment Agency, Habitats Assessments for Radioactive Substances (2009) http://publications.environment-agency.gov.uk/pdf/SCHO0309BPML-e-e.pdf
(Environment Agency, 2010a)	Sampling requirements for stack emission monitoring Technical Guidance Note (Monitoring). M1 v6 2010 http://publications.environment-agency.gov.uk/pdf/GEHO0110BRRO-E-E.pdf
(Environment Agency, 2010b)	Cooling Water Options for the New Generation of Nuclear Power Stations in the UK (Science Report: SC070015/SR3, Environment Agency 2010)
(Environment Agency, 2010c)	Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation - Environmental Principles (REPs), 2010 http://publications.environment-agency.gov.uk/pdf/GEHO0709BQSB-e-e.pdf
(Environment Agency, 2010d)	Regulatory Guidance Series, No RSR 2: The regulation of radioactive substance activities on nuclear licensed sites, 2010 http://www.environment-agency.gov.uk/static/documents/Business/GEHO0310BSGF-E-E.pdf
(Environment Agency, 2010e)	Horizontal Guidance Note H1 – Environmental risk assessment for permits http://publications.environment-agency.gov.uk/pdf/GEHO0410BSHR-e-e.pdf
(HMSO, 1990)	Environmental Protection Act 1990, HMSO. http://www.opsi.gov.uk/acts/acts1990/ukpga_19900043_en_1
(HPA, 2005)	Ionising Radiation Exposure of the UK Population - 2005 Review (HPA-RPD-001), Health Protection Agency, May 2005. http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947389360
(HPA, 2009)	Application of the 2007 ICRP Recommendations to the UK – Advice from the Health Protection Agency, RCE-12, July 2009 http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1246519364845
(HSE, 2008)	Nuclear Power Station Generic Design Assessment – Guidance to Requesting Parties, HSE, Aug 2008 (version 3). http://www.hse.gov.uk/newreactors/ngn03.pdf
(HSE, 2009b)	Public Report on the Generic Design Assessment of New Nuclear Reactor Designs. Update on the Public Involvement Process for GDA Step 3 of the Generic Design Assessment Process, HSE GDA-007 November 2009 www.hse.gov.uk/newreactors
(IAEA, 2004)	International Atomic Energy Agency Technical Report Series 422 – Sediment Distribution Co-efficients and Concentration Factors for Species in the Marine Environment (2004). http://www-pub.iaea.org/MTCD/publications/PDF/TRS422_web.pdf
(Isukul, 2009)	Isukul, A., Assessing Types and Quantities of Solid Radioactive Waste Arising from Operational Discharge Abatement Plants of Pressurized Water Reactors, September 2009 (MSc sponsored by the Environment Agency as part of the EMPOWER project)
(Joint Regulators, 2010)	Management of GDA Outcomes (including GDA scope, HSE DAC, our SODA and GDA Issues). HSE and Environment Agency, 2010 www.hse.gov.uk/newreactors

(OCNS, 2007) Guidance Document for Generic Design Activities, Office for Civil Nuclear Security, Jan 2007.
http://www.hse.gov.uk/nuclear/ocns/ocnsdesign.pdf

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 which consist of two neutrons and two protons.

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:

a. comparable processes, facilities or methods of operation which have recently been successfully tried out;
b. technological advances and changes in scientific knowledge and understanding;
c. the economic feasibility of such techniques;
d. time limits for installation in both new and existing plants;
e. 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.

Critical group: a group of members of the public whose radiation exposure is reasonably similar and is typical of people receiving the highest dose from a given source.

Decommissioning: the process whereby a facility, at the end of its life, is taken permanently out of service and its site is made available for other purposes.

Direct radiation: radiation received directly from a source such as a nuclear power station, instead of indirectly as a result of radioactive discharges.

Discharge: the release of aerial 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 man 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^{-1}.

Final SODA: The statement of Design Acceptability provided when all GDA Issues have been addressed to the satisfaction of the Environment Agency.

Fission: splitting of atomic nuclei.

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 issue considered by regulators to be particularly significant, but still resolvable. Where there are GDA Issues, the Statement of Design Acceptability or Design Acceptance Confirmation would be labelled as 'Interim', and the regulators will expect the RPs to produce a Resolution Plan that identifies how the Issue would be addressed. Example GDA Issue: Additional fault transient analysis needs to be completed for large loss of coolant accidents and the results accepted by HSE.

GDA Submissions: These include 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: This is a 'live' document that documents precisely what GDA submissions have been made, at any one point in time.

Generic Site Envelope: The Requesting Party specified generic siting characteristics for a range of UK sites against which the regulators assess the acceptability of the design safety case. These characteristics, such as seismic hazard, extreme weather events, environmental receptors, etc., 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 while there are remaining GDA Issues

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. There are existing MCERTS standards on liquid effluent flow and automatic sampling of liquid effluents which are relevant to nuclear sites and we are developing a new MCERTS standard on radioanalysis of waters.

Man-sievert (manSv): a measure of collective dose.

Nuclear safety related construction: This 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: in the judgement of the Regulators, a finding or concern for which, for the design submitted and the mode of operation proposed, the requesting party has not demonstrated (or may not be able to demonstrate) that risks will be reduced as low as reasonably practicable (ALARP), or that regulatory requirements are met, or that the best available techniques (BAT) will be used to minimise the arisings and impact of conventional and radioactive waste, and which is important enough that it would prevent successfully completing GDA or lead to a Statement of Design Acceptability Issue.

Regulatory Observation (RO): an assessment finding that requires further justification by and / or discussion with the requesting party and further assessment by the Regulators in the expectation that it can be resolved to the satisfaction of the Regulators. A Regulatory Observation that has not been satisfactorily resolved may, at the discretion of a Regulator, be converted to a Regulatory Issue (RI).

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.

Stellite: a hard, wear- and corrosion-resistant family of nonferrous alloys of cobalt (20-65%), chromium (11-32%), and tungsten (2-5%); resistance to softening is exceptionally high at high temperature.

Technical Query (TQ): A request for clarification or further information resulting from the inspection / assessment process. A Technical Query is not a Regulatory Observation or a Regulatory Issue, but may result in an Observation or Issue being raised by the Regulators to the Requesting Party where the query cannot be satisfactorily resolved.

Substances and measurements

MW	megawatt
MWe	megawatt electric
GBq y^{-1}	gigabecquerels per year
MBq y^{-1}	megabecquerels per year
µSv y^{-1}	microSievert per year
te	tonne

Abbreviations

AGR	Advanced gas-cooled reactor
BAT	Best available techniques
BWR	Boiling Water Reactor
C&I	Control and Instrumentation
CILWDS	Conventional island liquid waste discharge system
COMAH 99	Control of Major Accident Hazards Regulations 1999 (amended 2005)
CSTS	Coolant Storage and Treatment System
CVCS	Chemical and Volume Control System
EA 95	Environment Act 1995
EAL	Environmental Assessment Level
EDG	Emergency diesel generator
EPA 90	Environmental Protection Act 1990
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EPRB	GDA UK EPR – BAT demonstration, document UKEPR-0011-001
EPRB 3.5s1.2	EPRB form 3.3 section 1.2 (example reference)
EPRI	Electrical Power Research Institute – an independent USA organisation
EQS	Environmental Quality Standard
ETB	Effluent Treatment Building
ExLWDS	Additional liquid waste discharge system
FAPs	Fission and Activation Products
GDA	Generic design assessment
GWPS	Gaseous Waste Processing System
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
ILW	Intermediate level waste
INSA	Independent Nuclear Safety Assessment
IWS	GDA UK EPR – Integrated Waste Strategy Document UKEPR-0010-001 Issue 00
JPO	Joint Programme Office
LLW	Low level waste
LLWR	Low level waste repository
LRMDS	Liquid radwaste monitoring and discharge system
LWPS	Liquid Waste Processing System

NDA	Nuclear Decommissioning Authority
NVDS	Nuclear Vent and Drain System
OCNS	Office for Civil Nuclear Security
P&ID	Process and information document
PCER	Pre-Construction Environmental Report
PCERsc3.3s4.1	PCER sub-chapter 3.3 section 4.1 (example reference)
PCSR	Pre-Construction Safety Report
PPC	Pollution Prevention and Control
PQAB	Project Quality Assurance Plan
PWR	Pressurised water reactor
QNL	Quarterly Notification Level
RBWMS	Reactor Boron and Water Make-up System
RCCA	Rod Cluster Control Assemblies
RCS	Reactor Coolant System
REPs	Radioactive substances environmental principles
RSA 93	Radioactive Substances Act 1993
RWMD	Radioactive Waste Management Directorate (of NDA)
SBO	Station Black Out
SG	Steam Generator
SODA	Statement of Design Acceptability
US NRC	United States Nuclear Regulatory Commission
VCT	Volume Control Tank
WRA 91	Water Resources Act 1991

Annex 1 – Draft interim statement of design acceptability

Generic assessment of candidate nuclear power plant designs

Interim statement of design acceptability for the UK EPR design submitted by Electricité de France SA and AREVA NP SAS

(EDF and AREVA)

The Environment Agency has undertaken a Generic Design Assessment of the EDF and AREVA UK EPR design, during the period July 2007 to June 2011, 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 EDF and AREVA's UK EPR[2].

The Environment Agency is satisfied that EDF and AREVA has demonstrated the acceptability for environmental permitting of the UK EPR, as defined in Schedule 1, subject to the GDA Issues identified in Schedule 2.

This statement is provided as advice to EDF and AREVA, under section 37 of the Environment Act 1995. It does not guarantee that any site-specific applications for environmental permits for the UK EPR will be successful.

Name	Date
[name of authorised person]	

Authorised on behalf of the Environment Agency

References

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, January 2007.

   http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf

2. Decision Document for the Generic Design Assessment of EDF and AREVA's UK EPR, Environment Agency, June 2011.

Schedule 1 – Scope of the GDA

This statement of design acceptability refers to the UK EPR as described in the design reference documentation:

Document reference	Title	Version number
UKEPR-0003-011	PCER-Sub-chapter 1.1 - Introduction	03
UKEPR-0003-012	PCER – Sub-chapter 1.2 – General description of the unit	01
UKEPR-0003-013	PCER – Sub-chapter 1.3 – Comparison with reactors of similar design	02
UKEPR-0003-014	PCER – Sub-chapter 1.4 – Compliance with regulations	01
UKEPR-0003-015	PCER – Sub-chapter 1.5 – Safety assessment and international practice	01
UKEPR-0003-020	PCER – Chapter 2 – Quality and Project Management	02
UKEPR-0003-030	PCER – Chapter 3 – Aspects having a bearing on the environment during operation phase	02
UKEPR-0003-040	PCER – Chapter 4 – Aspects having a bearing on the environment during construction phase	00
UKEPR-0003-050	PCER – Chapter 5 – Design principles related to decommissioning	03
UKEPR-0003-060	PCER – Sub-chapter 6.0 – Safety requirements	01
UKEPR-0003-061	PCER – Sub-chapter 6.1 – Sources of radioactive materials	03
UKEPR-0003-062	PCER – Sub-chapter 6.2 – Details of the effluent management process	03
UKEPR-0003-063	PCER – Sub-chapter 6.3 – Outputs for the Operating Installation	03
UKEPR-0003-064	PCER – Sub-chapter 6.4 - Effluent and waste treatment systems design architecture	03
UKEPR-0003-065	PCER – Sub-chapter 6.5 – Interim storage facilities and disposability for UK EPR	02
UKEPR-0003-070	PCER – Chapter 7 – Measures for monitoring discharges	01
UKEPR-0003-080	PCER – Chapter 8 – Best Available Techniques	01
UKEPR-0003-090	PCER – Chapter 9 – Principles and methods used for environmental approach at the design stage	02
UKEPR-0003-100	PCER – Chapter 10 – Site environmental characteristics	03
UKEPR-0003-110	PCER – Chapter 11 – Radiological impact assessment	02

Document reference	Title	Version number
UKEPR-0003-120	PCER – Chapter 12 – Non radiological impact assessment	02
UKEPR-0011-001	GDA UK EPR-BAT Demonstration	03
NXA/10488242	GDA: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR	Oct 09
NXA/10747397	GDA: Disposability Assessment of Wastes and Spent Fuel Arising from the Operation of the EPR Part 1 Main Report	Jan 10
NXA/10777960	Generic Design Assessment: Disposability Assessment of Wastes and Spent Fuel Arising from the Operation of the EPR Part 2 Data Sheets and Inventory Tables	Jan 10
REG EPR00182N (Appendix)	Critique of the NDA RWMD Disposability Assessment	25/09/09
ELI0800226	Dry Interim Storage facility for ILW	A
LLWR EPR0001	UK EPR LLWR Disposability Assessment – Preliminary D1 Form Information	23/10/08
LLWR 320.L.027	Form D1 Application: UK EPR Project	03/12/08
ELIDC0801302	EPR UK – Decommissioning waste inventory	A
UKEPR-0010-001	GDA UK EPR – Integrated Waste Strategy Document	02
ELI0800224	Interim storage facility for spent fuel assemblies coming from an EPR plant	A
UKEPR-0007-001	Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR	01
UKEPR-0004-001	PPC Application – diesel generators	00
NESH-G/2008/en/0123	Solid Radioactive Waste Strategy Report (SRWSR)	A
UKEPR-0008-001	Longer Term ILW Interim Storage Facility	01
UKEPR-0009-001	Longer Term Spent Fuel Interim Storage Facility	01
UKEPR-0012-001	Radioactive Waste Management Case	01
UKEPR-I-002	UK EPR Reference Design Configuration	05

As requested by EDF and AREVA, the following matters are out of scope for this GDA: None

Schedule 2 – GDA Issues

Reference	GDA Issue	Resolution plan
UK EPR-I1	Decommissioning of the UK EPR	A resolution plan will need to be developed for each GDA Issue by EDF and AREVA and submitted to the Environment Agency for agreement
UK EPR-I2	Disposability of spent fuel following longer term interim storage pending disposal	

Schedule 3 – Assessment Reports

Document reference	**Generic design assessment** **UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA** **Assessment Report -**
EAGDAR UK EPR-01	Management Systems
EAGDAR UK EPR-02	Integrated Waste Strategy
EAGDAR UK EPR-03	Best Available Techniques to prevent or minimise the creation of radioactive wastes
EAGDAR UK EPR-04	Gaseous radioactive waste disposal and limits
EAGDAR UK EPR-05	Aqueous radioactive waste disposal and limits
EAGDAR UK EPR-06	Solid radioactive waste (LLW and ILW)
EAGDAR UK EPR-07	Spent Fuel
EAGDAR UK EPR-08	Disposability of ILW and Spent Fuel
EAGDAR UK EPR-09	Monitoring of radioactive disposals
EAGDAR UK EPR-10	Generic site
EAGDAR UK EPR-11	Radiological impact on members of public
EAGDAR UK EPR-12	Radiological impact on non-human species
EAGDAR UK EPR-13	Other Environmental Regulations
IMAS/TR/2010/05 EAGDAR UK EPR-14	Independent dose assessment

Annex 2 – Compilation of other issues

These following other issues will have to be met for every UK EPR that is constructed in England and Wales.

Reference	Description
UK EPR-OI01	The changes to the 'reference case' for the site-specific strategy and evidence that the site-specific strategy achieves the same objectives shall be provided at site-specific permitting.
UK EPR-OI02	Zinc injection as an option for the UK EPR to aid corrosion control
UK EPR-OI03	Assessment of the removal of secondary neutron sources (to further minimise creation of tritium) when EPR operational information becomes available.
UK EPR-OI04	Review of the BAT assessment on the minimisation of the production of activated corrosion products for the following matters where possible improvements were identified in the PCER: i) corrosion resistance of steam generator tubes; ii) electro-polishing of steam generator channel heads; iii) specification of lower cobalt content reactor system construction materials; iv) further reducing use of stellites in reactor components, in particular the coolant pump; and incorporation of the improvements into the design where appropriate.
UK EPR-OI05	Providing the design of the discharge tanks (LRMDS, ExLWDS and CILWDS tanks) with associated demonstration of BAT for size and leak-tight construction.
UK EPR-OI06	Providing a BAT assessment to demonstrate that controls on the fuel pool minimise the discharge of tritium to air.
UK EPR-OI07	The sizing of filters and the demineralisation system in the liquid waste processing system.
UK EPR-OI08	Disposability of Intermediate Level Waste following longer term interim storage pending disposal.
UK EPR-OI09	If smelting of any Low Level Waste is pursued at site-specific permitting, demonstrate that the conditions of acceptance of any available smelting facilities can be met.
UK EPR-OI10	If incineration is pursued at site-specific permitting for SGBS ion-exchange resins (without regeneration), evaporator concentrates, pre-compacted operational waste and operational waste, demonstrate that the conditions of acceptance of any available incineration facilities can be met.
UK EPR-OI11	Provide evidence at site-specific permitting that the specific arrangements for minimising the disposals of Low Level Waste and Intermediate Level Waste for each site represents BAT.
UK EPR-OI12	The monitoring of gaseous, aqueous and solid discharges and disposals of radioactive waste.

Annex 3 – Range of discharges from operating PWRs

A3.1 Introduction

734 The White Paper on Nuclear Power (paragraph 2.87) states that 'The Environment Agencies will ensure that radiation exposure of members of the public from disposals of radioactive waste, including discharges, are as low as reasonably achievable (ALARA) by requiring new nuclear installations to use the best available techniques (BAT) to meet high environmental standards. This will help ensure that radioactive wastes created and discharges from any new UK nuclear power stations are minimised and do not exceed those of comparable power stations across the world.'

735 Industrial processes produce waste and power generation is no exception. Although nuclear power stations produce far less gaseous waste than conventional power stations, they produce radioactive waste not only in gaseous waste but in aqueous and solid waste as well.

736 By gaseous waste we mean contaminated air, particulate, gases and vapours released from the reactor or areas where contaminated materials or waste are handled. Aqueous radioactive waste may be reactor coolant or other effluent, for example, from workshops handling contaminated plant and equipment or change areas. Solid waste may be contaminated having been in contact with reactor plant and equipment.

737 This annex covers only low level radioactive waste, it does not cover higher activity waste or irradiated nuclear fuel.

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

739 These measurements and assessments are particularly valuable in determining what the impact on our environment is and whether there is any impact on the food chain.

740 Knowing what radioactive waste was discharged from operational stations also allows us to consider whether technology can be used to minimise the amount of waste from new stations.

741 Radioactivity in waste is not just affected by technology used to minimise it. Improvements in reactor design lead to more efficient burn-up of the nuclear fuel, so less radioactive waste is produced for each unit of electricity generated. Other aspects of reactor design can lead to less radioactivity in waste, for example selecting materials, coolant flow rates and operating conditions.

742 This annex is in two parts: firstly a section covering the discharges from operating reactors that are immediate predecessors to the EPR to compare the discharges per unit of electricity with those claimed for the EPR; secondly a wider view of a larger number of operating PWRs that compares the long-term average discharges normalised to installed electrical capacity. Some of the average data in the second section includes contributions from reactors in the first section.

743 Radioactive waste from nuclear power stations contains a wide range of radionuclides. We talk about harm from radioactivity in terms of radiation dose. Some radionuclides are more important than others as they may lead to higher radiation dose. We consider the half life of a radionuclide, its chemical and physical form, its behaviour in the environment and other properties when assessing radiation dose.

A3.2 Radionuclides produced in low level radioactive waste from nuclear power stations

744 The major radionuclides or groups of radionuclides produced are:

a) tritium – a low energy beta emitting radionuclide with a half-life of 12.3 years. It absorbs through pores in the skin as tritiated water;

b) carbon-14 - a low energy beta emitter with a very long half-life. It can be taken up by crops and marine life;

c) noble gases – xenon and krypton radionuclides formed by fission (and less importantly argon-41). The highest contributor to the group is xenon-133 with a half-life of 5.25 days. Noble gases are beta and gamma emitters. They neither impact on the food chain nor are absorbed by lungs. The exposure route to members of the public is directly by radiation from the plume. This is a trivial route of exposure for discharges from water cooled reactors;

d) iodines – several radionuclides of iodine are formed during nuclear fission. The most important of these is iodine-131, with a relatively short half-life of 8 days, it is both a beta and gamma emitter. The main pathway for dose to the public is by being deposited on crops and then eaten, for example deposited on grass, grazing by cows, then consumption of contaminated milk;

e) other radionuclides – we have grouped other radionuclides produced together as they tend to be minimised by the same techniques (for example filtration or ion exchange) and are usually measured as a group using a gross activity method. The most important of these are:

   i) cobalt-60 and cobalt-58, these are activated corrosion products with half-lives of 5.3 years and 71 days respectively. They are both beta and gamma emitters.

   ii) caesium-137 and caesium-134, these are fission products with half-lives of 30 and two years respectively. They are both beta and gamma emitters.

f) cobalt-60 is the most significant of these radionuclides in terms of radiation dose to the public from aqueous discharges from water cooled reactors. Cobalt-60 has a medium length half-life. It can accumulate in marine sediments on which, fish and shellfish live and pass to humans who consume seafood;

g) a number of other activated corrosion products can also be produced in less significant amounts. These radionuclides include iron-55 and nickel-63.

A3.3 Section One - Discharges from operating predecessor reactors

745 We commissioned Areva Risk Management Consulting Ltd to research records of radioactive waste disposal from comparable operating nuclear power stations worldwide. The results of this work are contained in science reports SC070015/SR1 and 2.

A3.3.1 What the science report covered

746 The science report researched information on four types of candidate reactor:

- AP1000 submitted by Westinghouse;
- Evolutionary pressurised reactor, EPR submitted by EDF and AREVA;
- Economic simplified boiling water reactor, ESBWR submitted by GE-Hitachi;
- ACR-1000, submitted by AECL.

747 This annex covers the EPR only.

748 It provides discharge information from seven stations that are predecessors to the EPR design.

749 Where discharge information was not provided directly by operators of those nuclear-power stations, it was obtained indirectly from the nuclear Regulators in the country where they were operating or from reports from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The report presents the discharges having normalised them to gigabecquerels per gigawatt-hour (GBq/GWeh).

A3.3.2 Discharges from the operational nuclear power stations

750 The discharge data for the predecessor nuclear power stations allows us to compare and extrapolate so we can predict discharges from candidate nuclear power stations. It is important not to draw comparisons too closely as there are many uncertainties in the datasets. The largest uncertainty is probably differences in sampling and measurement techniques that the predecessor stations evolved and use – these are general improvements in sampling equipment and instrument sensitivity leading to more accurate measurements being carried out.

A3.3.2.1 Gaseous discharges

Table 1: Releases of gaseous waste from operating station

		Gaseous discharge				
	Years	Tritium (MBq/GWeh)	Carbon-14 (MBq/GWeh)	Noble Gases (MBq/GWeh)	Iodines (kBq/GWeh)	Fission and activation products (kBq/GWeh)
Predecessor actual – **EPR**	'90-'06	10 - 200	5 – 50	9 - 300	0.006 - 9	0.0003 - 800
Comments		V. low consequences				

A3.3.2.2 Aqueous discharges

Table 2: Releases of aqueous waste from operating stations

	Aqueous release	
	Tritium (GBq/GWeh)	Other Radionuclides (kBq/GWeh)
Predecessor actual – **EPR**	0.8 – 4	0.009 - 9000

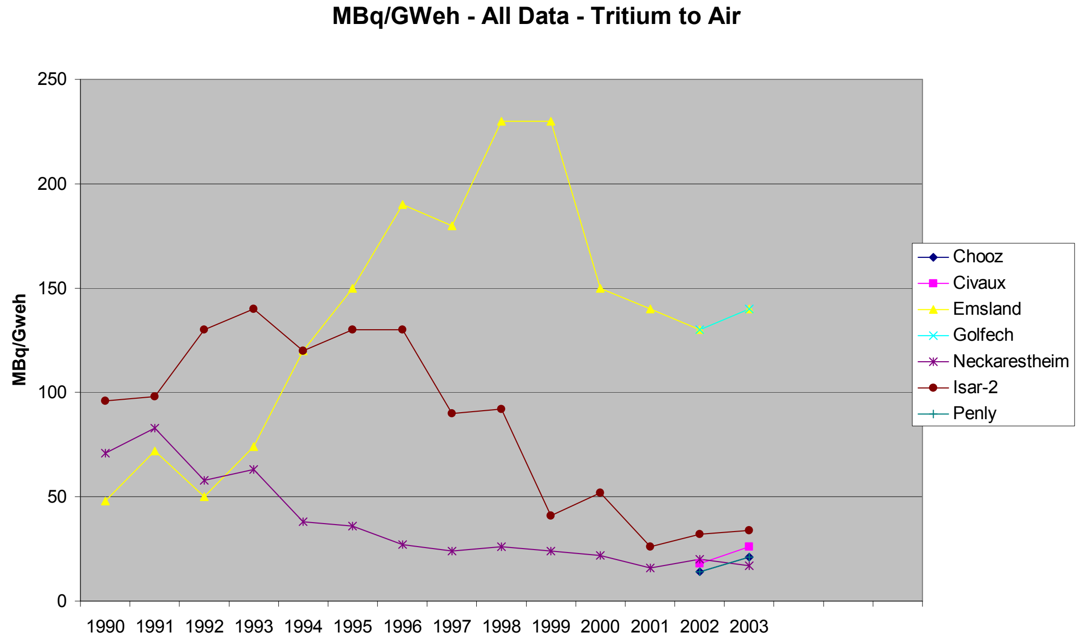
Notes:

1) The ranges presented in tables 1 and 2 represent the range of activity in discharges over the seventeen-year reporting period.
2) The science report breaks down discharges of aqueous waste into two categories – tritium and other.
3) Figures have been rounded to one significant figure.

A3.3.3 EPR PREDECESSOR STATIONS

Gaseous tritium

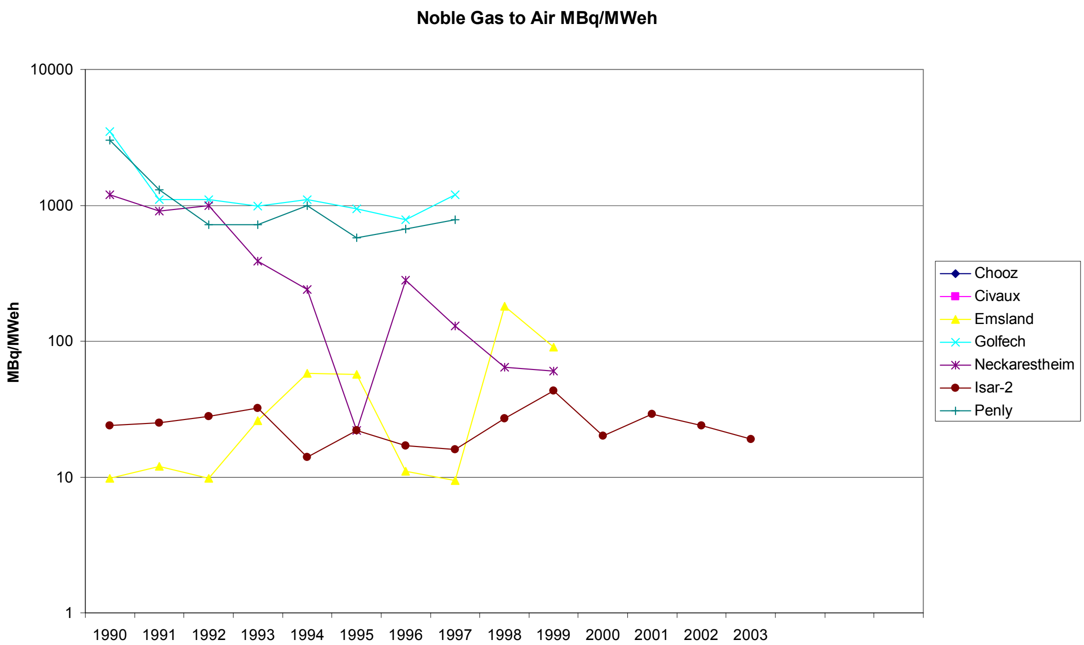
751 Below is a graph of all of the gaseous tritium discharges for predecessor PWRs to the EPR:



752 This indicates that 75 per cent of the discharges are within the range 20 -130 MBq/GWeh.

Noble gases

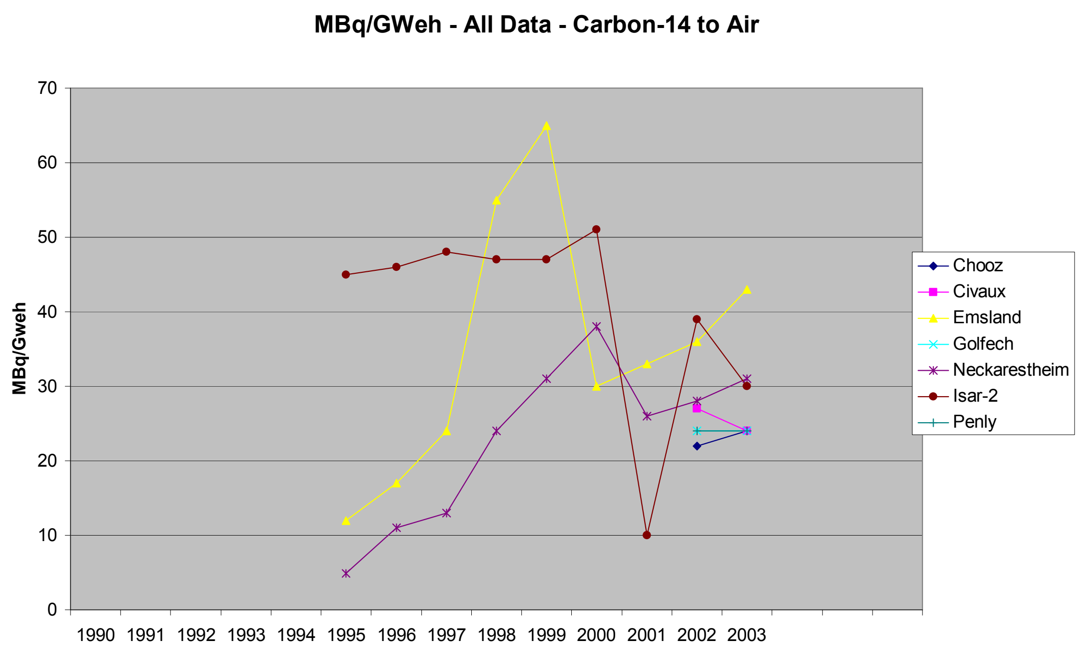
753 Below is a graph of all of the airborne noble gas discharges for predecessor PWRs to the EPR:



754 This indicates that 75 per cent of the discharges are within the range 10 -1000 MBq/GWeh.

Carbon-14

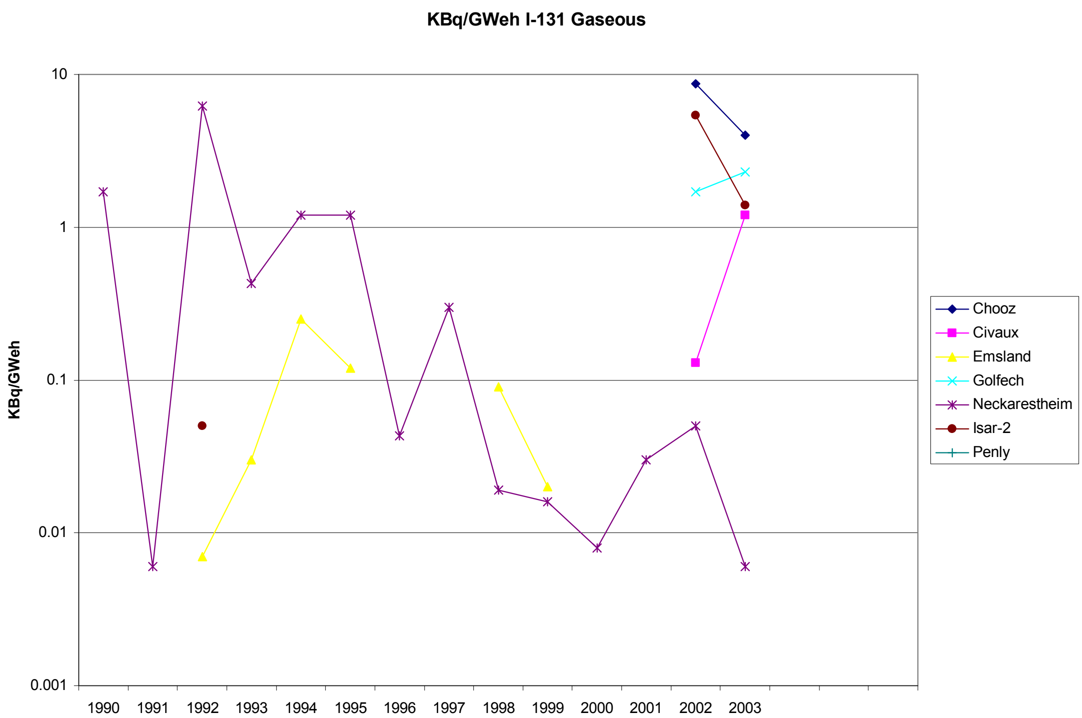
755 Below is a graph of all of the airborne carbon-14 discharges for predecessor PWRs to the EPR:



756 This indicates that 75 per cent of the discharges are within the range 14 -48 MBq/GWeh.

Iodine -131

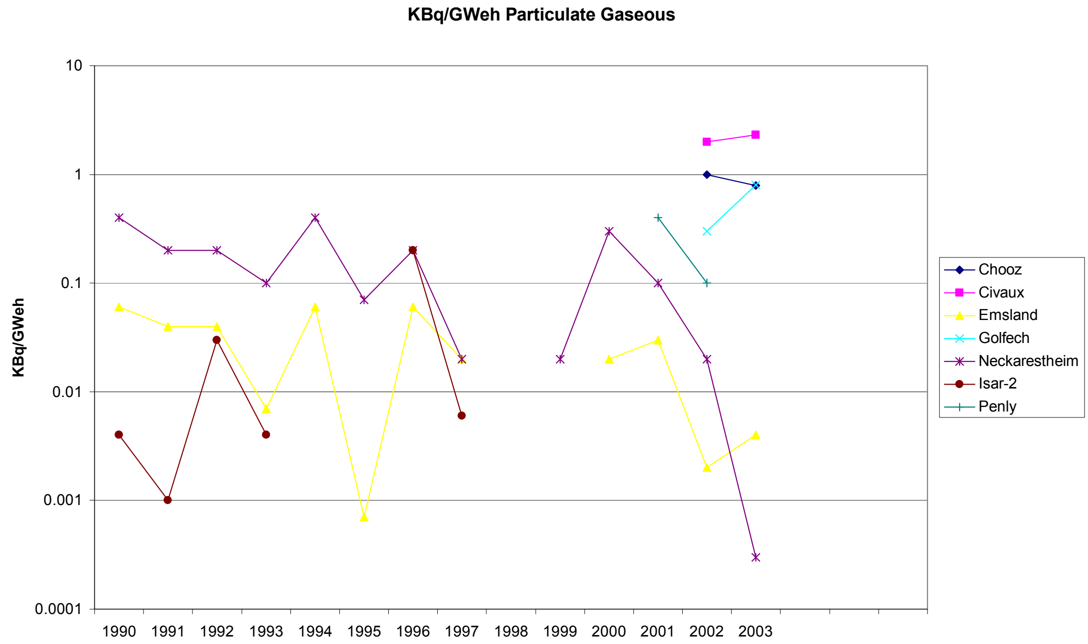
757 Below is a graph of all of the iodine-131 gaseous discharges for predecessor PWRs to the EPR:



758 The data set is comparatively small and indicates that 75 per cent of the discharges are within the range 0.07 -20 kBq/GWeh.

Gaseous particulate

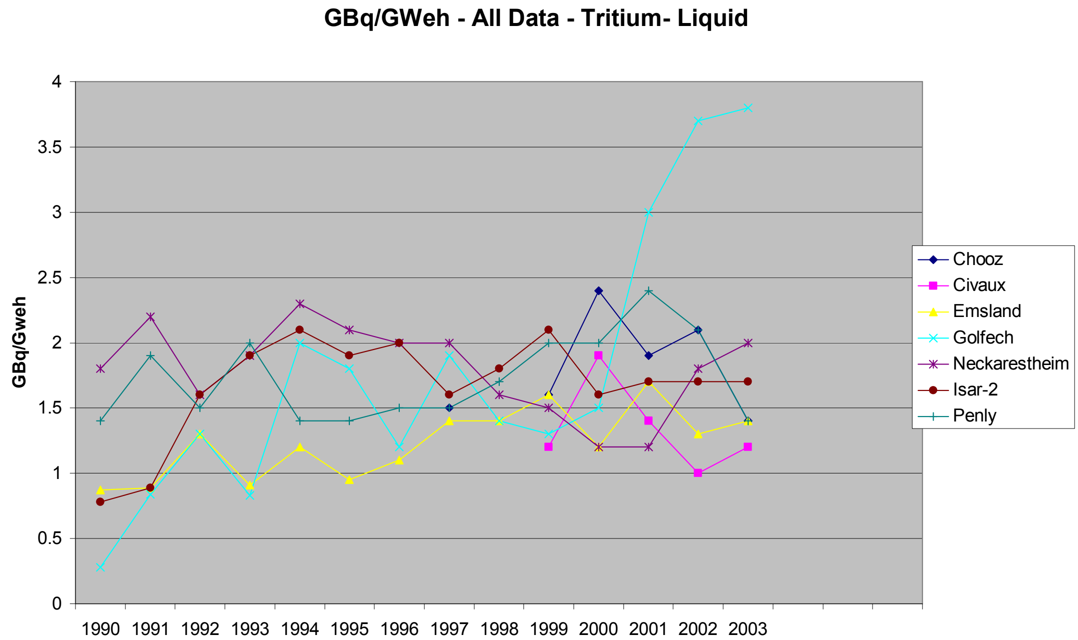
759 Below is a graph of all of the gaseous particulate discharges for predecessor PWRs to the EPR:



760 This indicates that 75 per cent of the discharges are within the range 0.01 - 0.3 MBq/GWeh.

Aqueous tritium

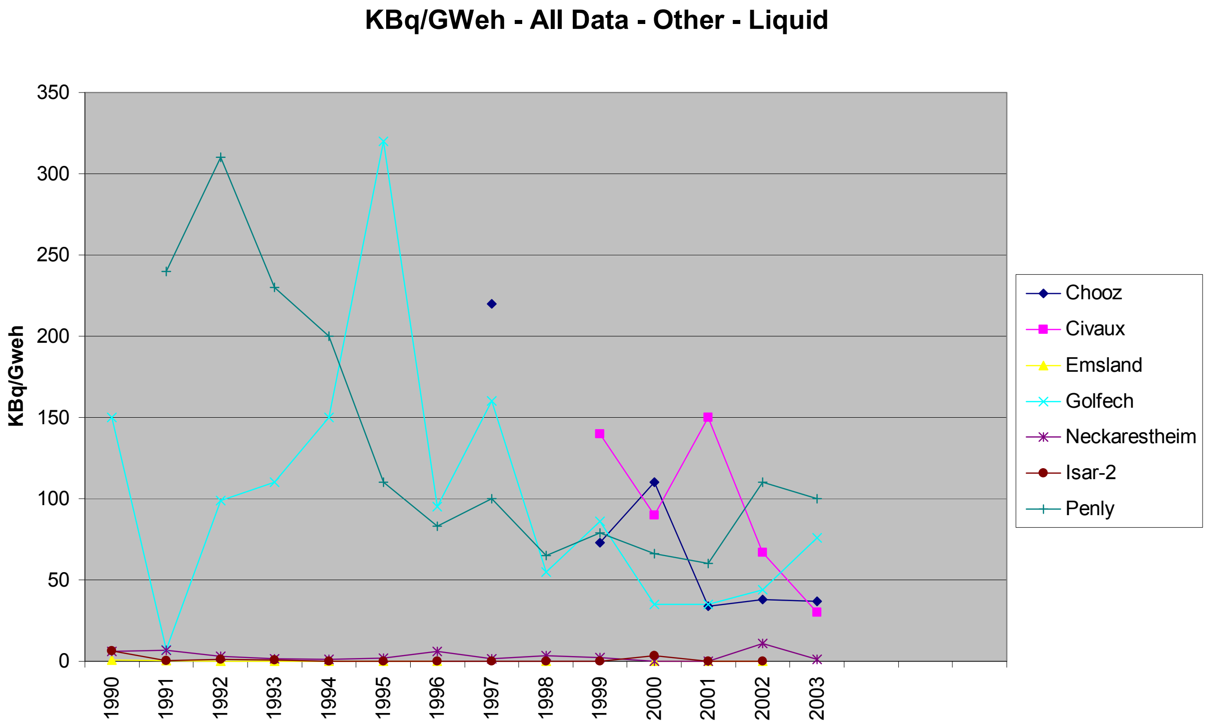
761 Below is a graph of all of the aqueous tritium discharges for predecessor PWRs to the EPR:



762 This indicates that 75 per cent of the discharges are within the range 1.2 - 2 GBq/GWeh, which is a relatively narrow range.

Aqueous other radionuclides

763 Below is a graph of all of the aqueous other radionuclide discharges for predecessor PWRs to the EPR:-



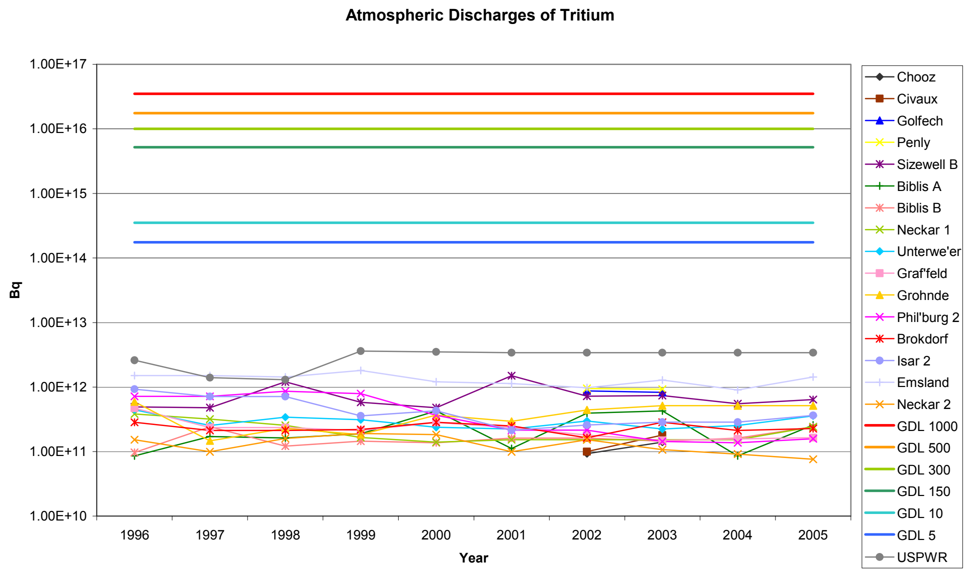
764 This indicates that 75 per cent of the discharges are within the range 0 – 70 kBq/GWeh, which is a relatively narrow range. This is one of the most diverse ranges of the datasets. Some stations reported discharges at extremely low levels, which indicate that they operate with a much better abatement plant than other stations.

A3.4 Section Two - Average discharges from the wider PWR sector

A3.4.1 Atmospheric discharges

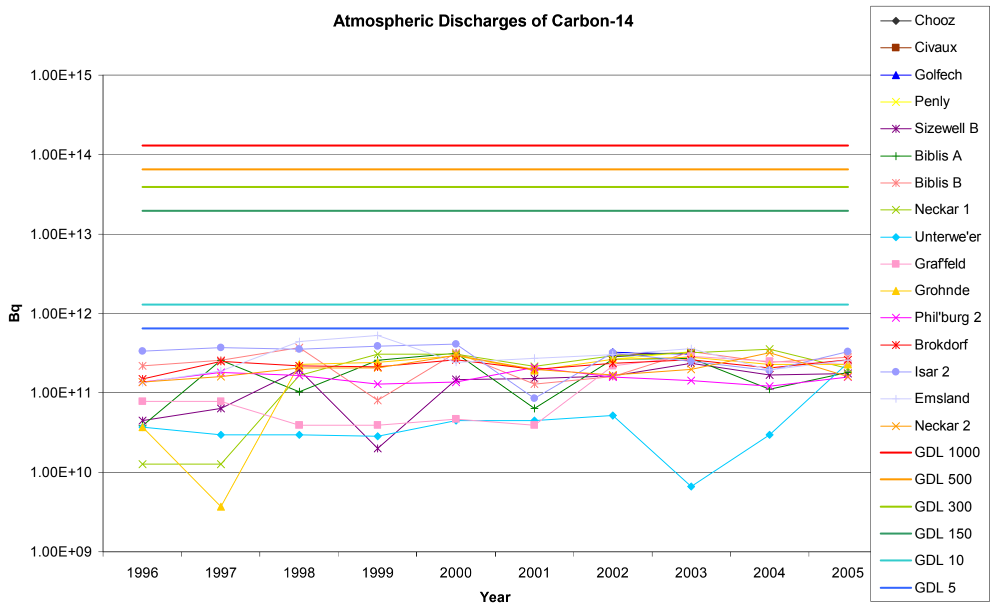
Tritium - Atmospheric discharge

765 From our examination of historic discharges from European PWRs (References 1 and 3) and US PWRs (Reference 2) operating over the last 10 to 15 years, we conclude that there is a normal operating range of 100 to 3600 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.2 μSv. The generalised derived limits (GDL) used in the graph represent the values of discharge leading to doses to the most exposed individual of 1000, 500, 300, 150, 10 and 5 μSv.



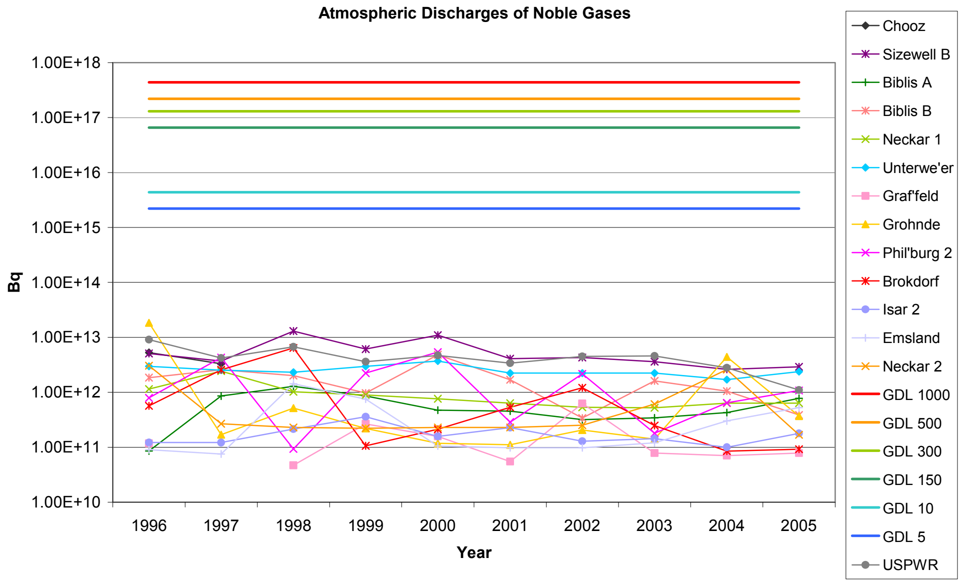
Carbon-14 - Atmospheric discharge

766 From our examination of historic discharges from European PWRs operating over the last 10 to 15 years (see the graph below), we conclude that there is a normal operating range of 40 to 530 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 3 μSv.



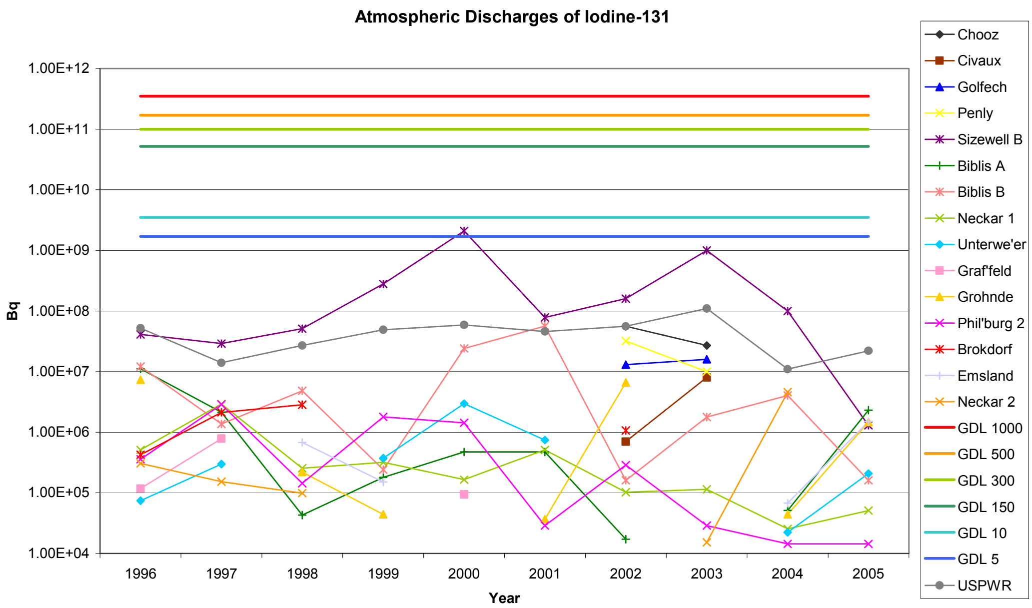
Noble gases - Atmospheric discharge

767 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years (see graph below), we conclude that there is a normal operating range of 100 to 10 000 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.05 μSv (assuming all discharges comprise the most restrictive species krypton-85 - used for the GDL values in the graph).



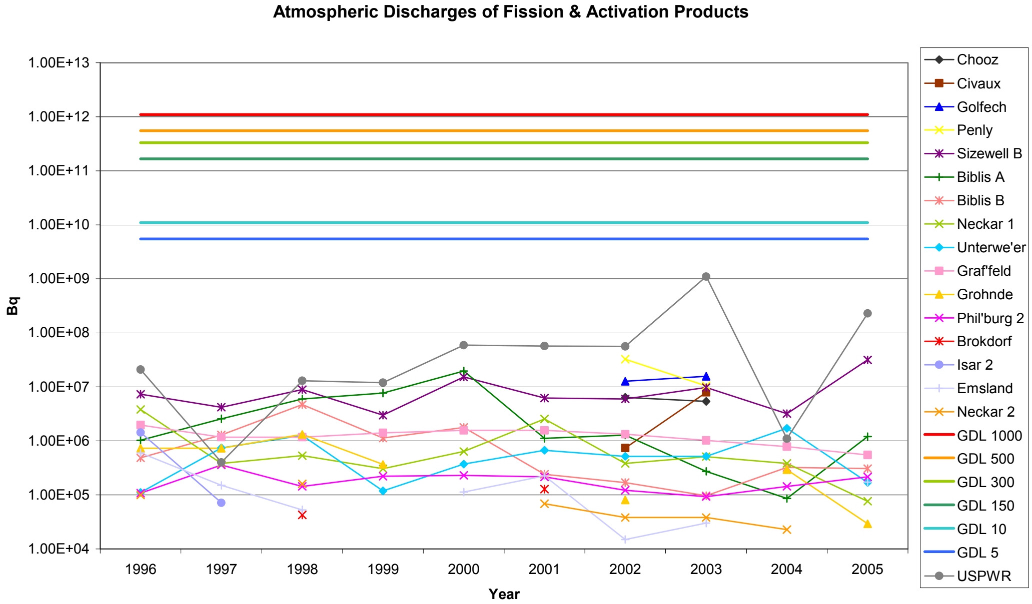
Iodine - Atmospheric discharge

768 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to atmosphere of iodine-131 there is a normal operating range of from less than 1 to 2000 MBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.5 μSv (assuming all discharge to iodine-131).



Fission and activation products - Atmospheric discharge

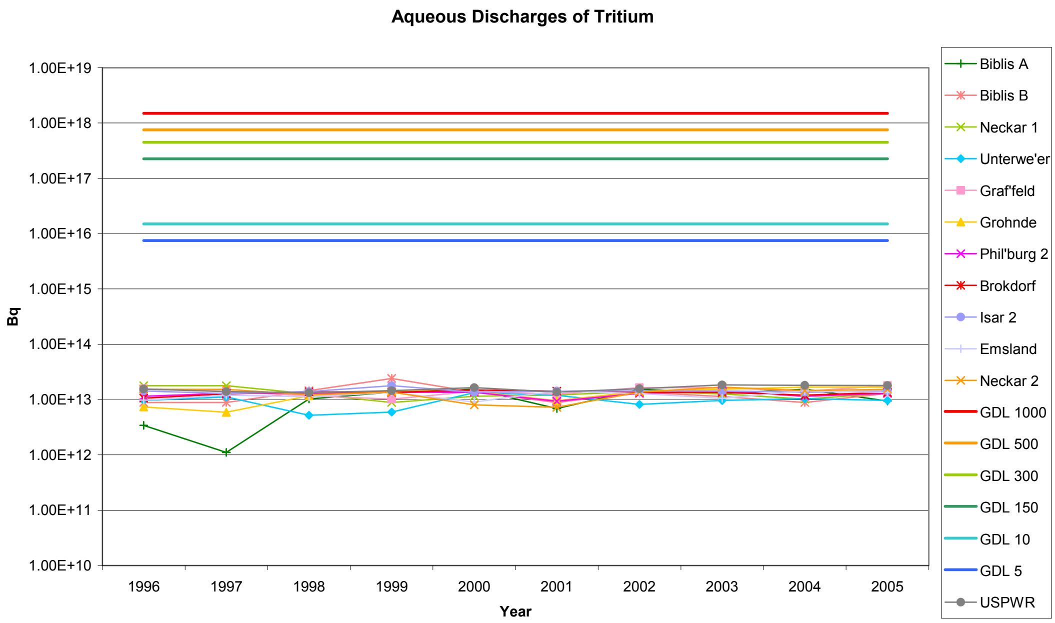
769 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to atmosphere of fission and activation products there is a normal operating range of from less than 1 to 1000 MBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 5 μSv (assuming all discharge comprises caesium-137).



A3.4.2 Aqueous discharges

Tritium - Aqueous discharge

770 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of tritium there is a normal operating range of 2000 to 30 000 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.05 μSv .



Carbon-14 - Aqueous discharge

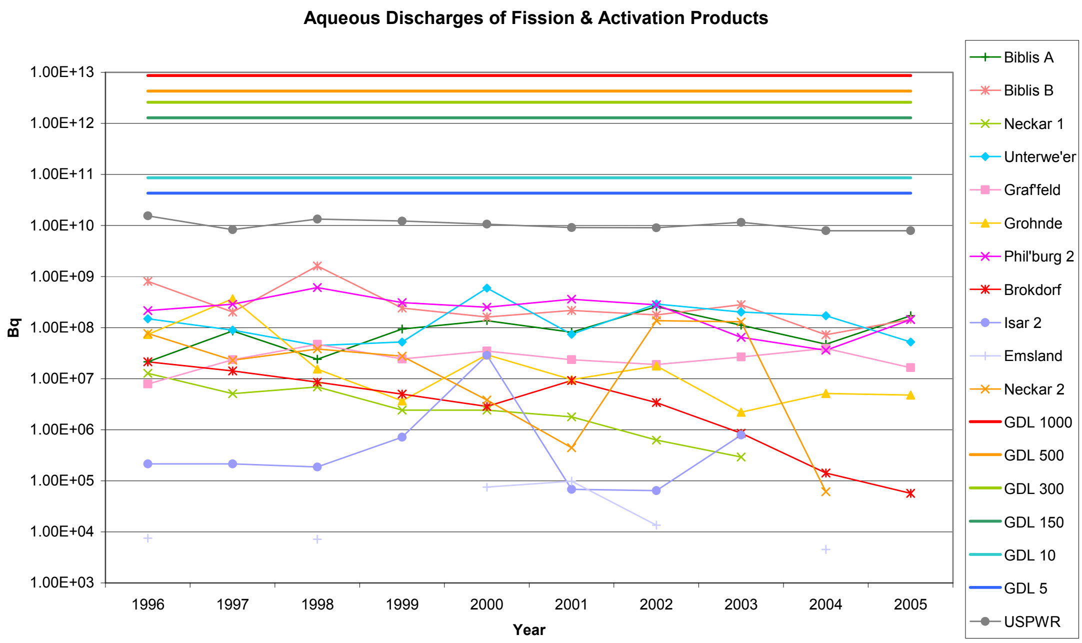
771 From our limited information about PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of carbon-14 there is a normal operating range of 3 to 45 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 20 µSv.

Iodine - Aqueous discharge

772 From our limited information about PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of iodines there is a normal operating range of 0.01 to 0.03 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 0.00006 µSv. Assuming all the iodine is iodine-131.

Fission and activation products - Aqueous discharge

773 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years, we conclude that in terms of discharge to water of fission and activation products there is a normal operating range of from less than 1 to 15 GBq per annum for a 1000 MWe power station. At the maximum of this range, the dose to the most exposed individual under conservative generic conditions would be less than 1 µSv. Assuming all of the discharge is due to caesium-137.



A3.5 Data analysis of normalised discharges from PWR sites

Atmospheric discharges of tritium

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	592 GBq
Median discharge from all sites from 1996-2005	270 GBq
Standard deviation from all sites from 1996-2005	781 GBq
Standard error of the mean from all sites from 1996-2005	67 GBq
Maximum discharge within one year from a single site (USPWR, 1999[3])	3600 GBq
Minimum discharge within one year from a single site (Neckar 2, 2005)	76 GBq

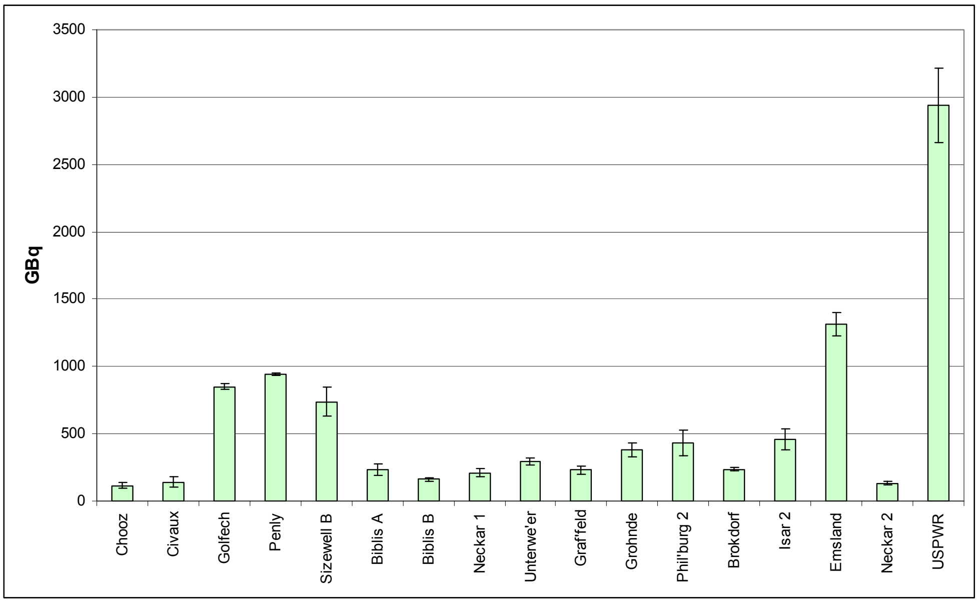


Figure 1: Mean atmospheric discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

774 The data for atmospheric discharges[4] of tritium are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that reported discharges lie within a substantial range over several orders of magnitude. US PWRs report substantially greater discharges than the German and French reactors, as well as Sizewell B.

[3] USPWR data (United States Pressurised Water Reactor) within this report are the average discharges for that year from the USPWR fleet, and not the discharge of a single site.

[4] Where this section makes reference to 'discharges', this refers to reported discharges which have been normalised to a 1000 MWe reactor, and not actual reported discharges.

Atmospheric discharges of carbon-14

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	202.61 GBq
Median discharge from all sites from 1996-2005	207.22 GBq
Standard deviation from all sites from 1996-2005	108.14 GBq
Standard error of the mean from all sites from 1996-2005	9.56 GBq
Maximum discharge within one year from a single site (Emsland, 1999)	526.71 GBq
Minimum discharge within one year from a single site (Grohnde, 1997)	3.68 GBq

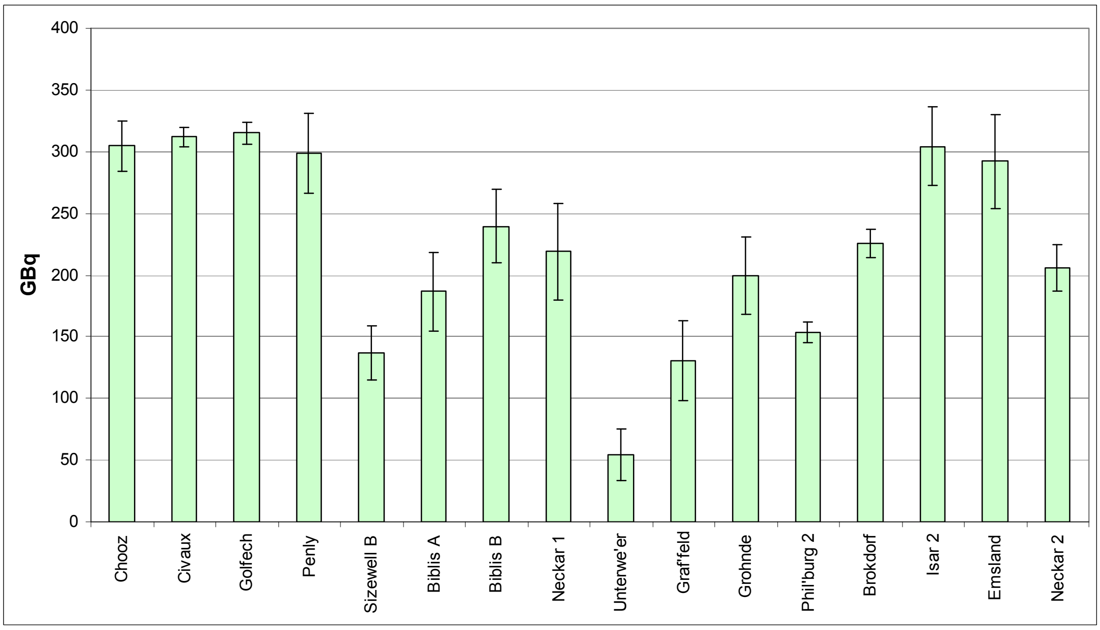


Figure 2: Mean atmospheric discharge of carbon-14 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

775 The data for atmospheric discharges of carbon-14 are slightly positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The chart and table above show that reported discharges lie within a substantial range over several orders of magnitude. French reactors report greater discharges than the German reactors on average, whilst Sizewell B discharges are on average below mean and median discharges from all sites.

Atmospheric discharges of noble gases

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	1801 GBq
Median discharge from all sites from 1996-2005	637 GBq
Standard deviation from all sites from 1996-2005	2635 GBq
Standard error of the mean from all sites from 1996-2005	230 GBq
Maximum discharge within one year from a single site (Grohnde, 1996)	18382 GBq
Minimum discharge within one year from a single site (Graf'feld, 1998)	47 GBq

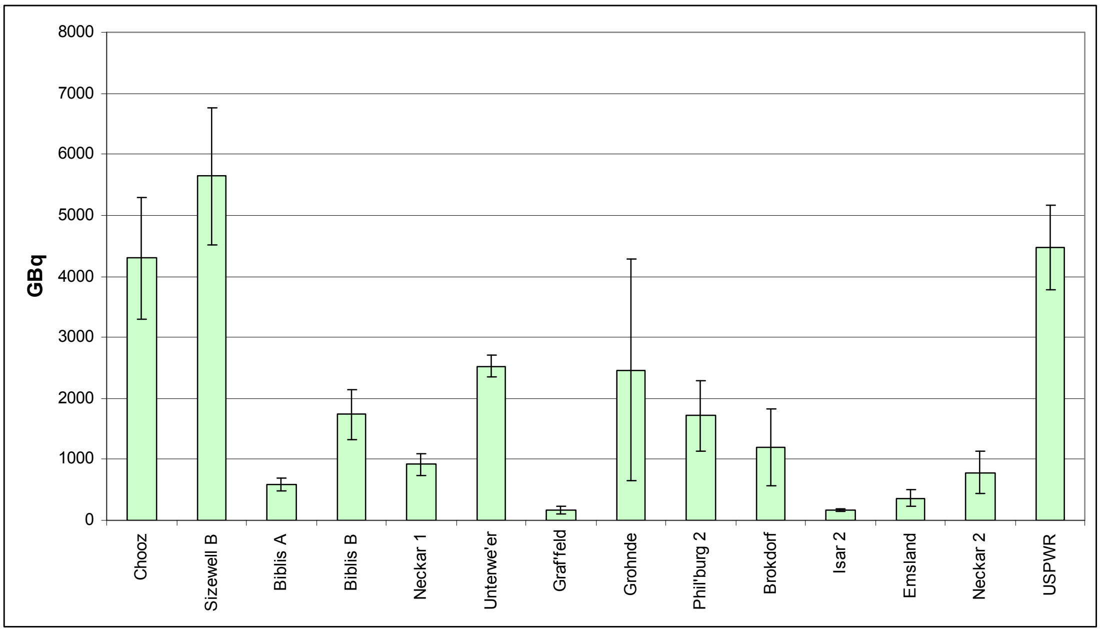


Figure 3: Mean atmospheric discharge of noble gases between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

776 The data for atmospheric discharges of noble gases are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that discharges lie within a broad range. The USPWR, Sizewell B and Chooz sites generally report greater average discharges than the German reactors.

Atmospheric discharges of iodine-131

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	0.05 GBq
Median discharge from all sites from 1996-2005	0.0013 GBq
Standard deviation from all sites from 1996-2005	0.24 GBq
Standard error of the mean from all sites from 1996-2005	0.024 GBq
Maximum discharge within one year from a single site (Sizewell B, 2000)	2.10 GBq
Minimum discharge within one year from a single site (Phil'burg, 2005)	0.000014 GBq

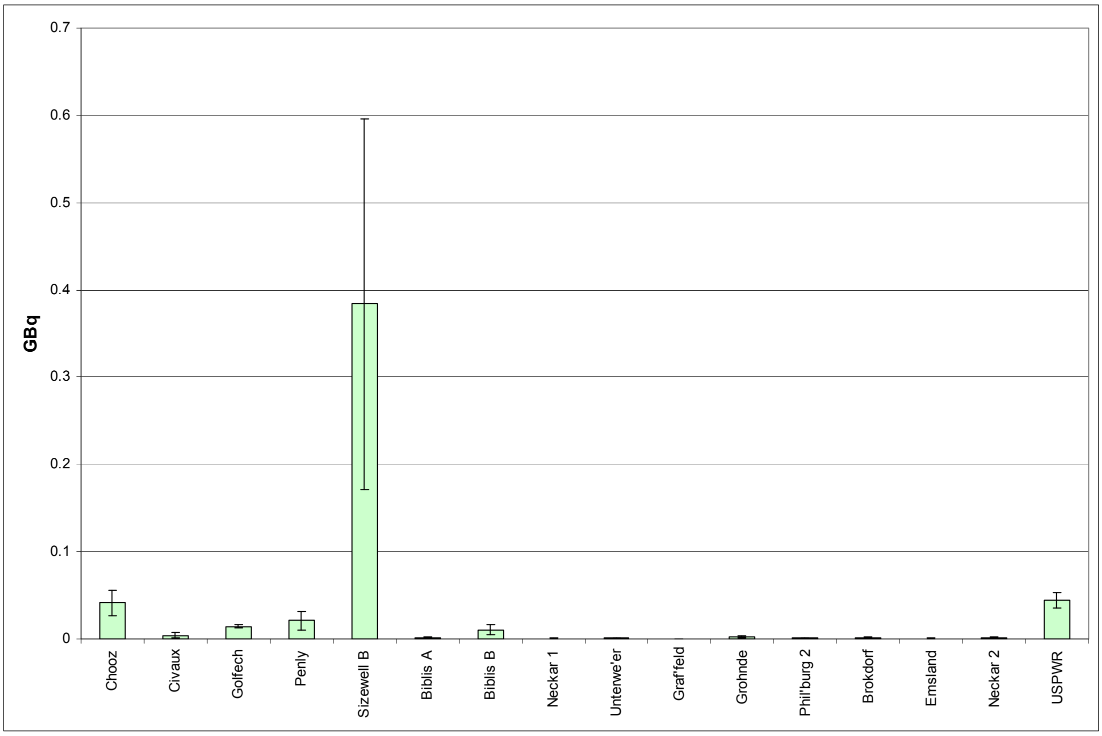


Figure 4: Mean atmospheric discharge of iodine-131 between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

777 The data for atmospheric discharges of Iodine-131 are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph shows that average reported discharges from most sites lie well below 0.1 GBq. Average discharges from Sizewell B are substantially greater than the others, which can partially be attributed to two relatively high reported discharges in 2000 and 2003, although discharges from Sizewell B are also generally higher than the other sites. The German reactors typically report lower discharges than the USPWR and French reactor sites.

Atmospheric discharges of fission and activation products

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	0.016 GBq
Median discharge from all sites from 1996-2005	0.00074 GBq
Standard deviation from all sites from 1996-2005	0.11 GBq
Standard error of the mean from all sites from 1996-2005	0.010 GBq
Maximum discharge within one year from a single site (USPWR, 2003)	1.10 GBq
Minimum discharge within one year from a single site (Emsland, 2002)	0.000015 GBq

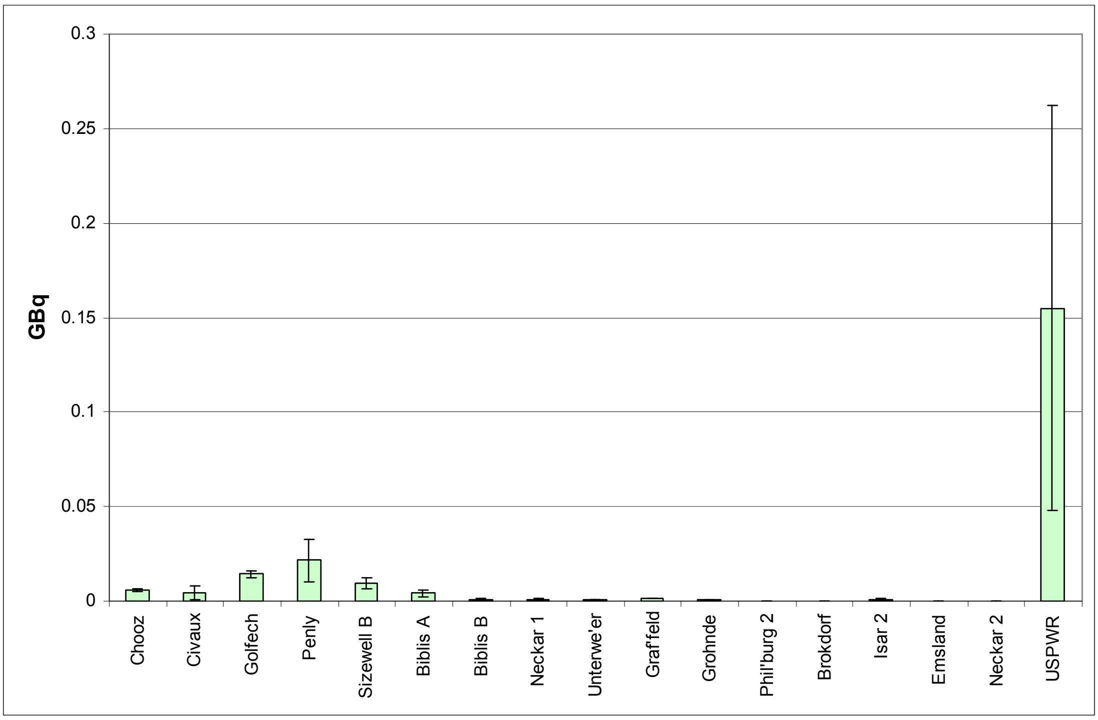


Figure 5: Mean atmospheric discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

778 The data for atmospheric discharges of fission and activation products are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph and table above show that reported discharges lie within a substantial range over several orders of magnitude. The USPWR sites on average report substantially greater discharges than all other sites. The German reactors generally perform better than the French reactors and Sizewell B, in terms of discharges of fission and activation products to the atmosphere.

Aqueous discharges of tritium

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	12817 GBq
Standard deviation from all sites from 1996-2005	3274 GBq
Standard error of the mean from all sites from 1996-2005	299 GBq
Maximum discharge within one year from a single site (Biblis B, 1999)	24194 GBq
Minimum discharge within one year from a single site (Biblis A, 1997)	1114 GBq

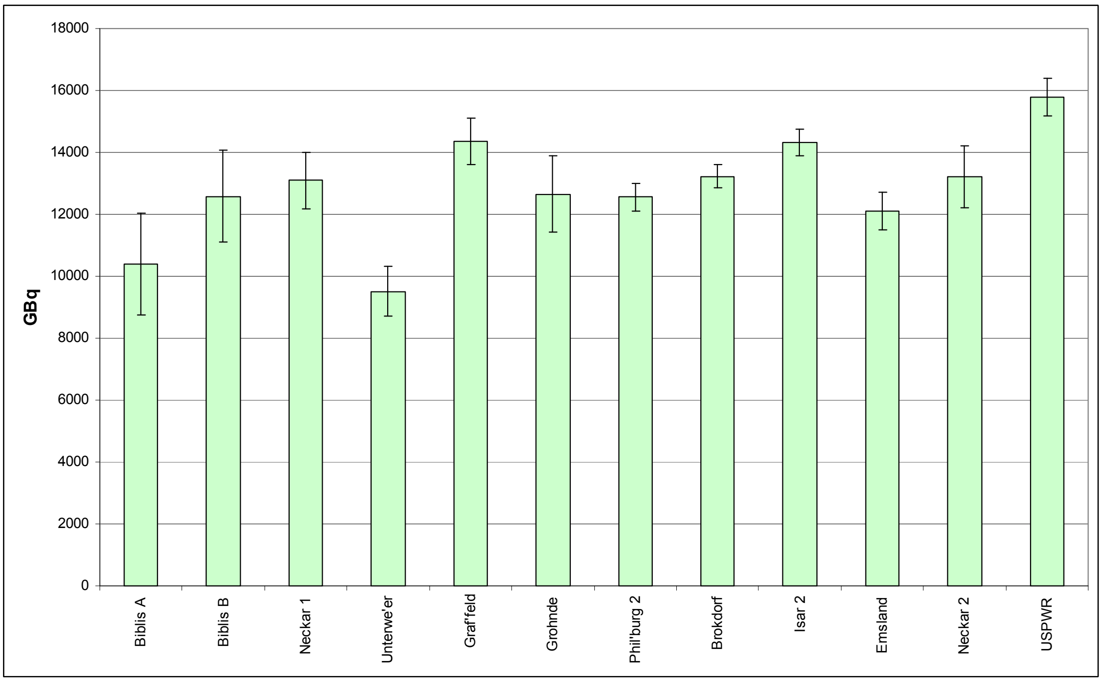


Figure 6: Mean aqueous discharge of tritium between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

779 The data for aqueous discharges of tritium are normally distributed, and, therefore, the mean value may be a useful indicator of future discharges. The graph shows that reported discharges are relatively stable across all sites, with a relatively small range of discharges and a small margin of error. The USPWR sites on average report slightly greater discharges than the German reactor sites.

Aqueous discharges of fission and activation products

Statistic	Normalised to 1000 MWe reactor
Mean discharge from all sites from 1996-2005	1.05 GBq
Median discharge from all sites from 1996-2005	0.04 GBq
Standard deviation from all sites from 1996-2005	3.10 GBq
Standard error of the mean from all sites from 1996-2005	0.29 GBq
Maximum discharge within one year from a single site (USPWR, 1996)	15.50 GBq
Minimum discharge within one year from a single site (Emsland, 2004)	0.0000045 GBq

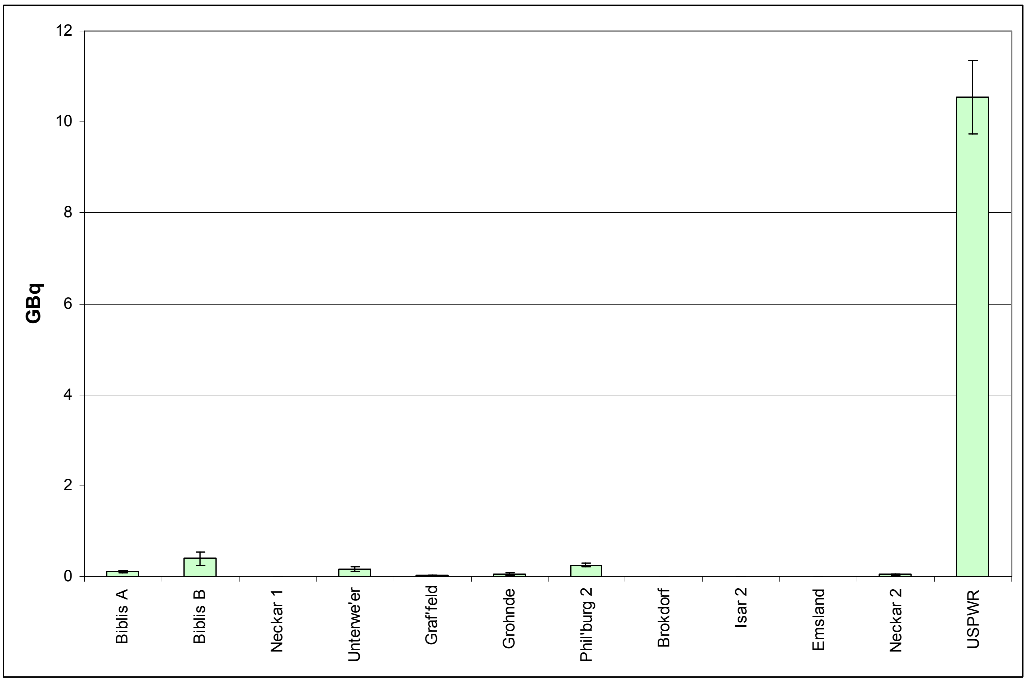


Figure 7: Mean aqueous discharge of fission and activation products between 1996-2005, for PWR sites, using site-specific data normalised to a 1000 MWe output.

780 The data for aqueous discharges of fission and activation products are positively skewed, and, therefore, the median value may be a more accurate parameter than the mean, in terms of indicating future discharges. The graph and table above show that reported discharges lie within a substantial range over several orders of magnitude. The USPWR sites consistently report substantially greater discharges than the German sites, with a mean discharge of over 10 GBq.

References:

1. Berichte der Strahlenschutzkommission (SSK) des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit – Heft 58 (2009) Bewertung der epidemiologischen Studie zu Kinderkrebs in der Umgebung von
2. Radiological Effluents Released by US Commercial Nuclear Power Plants from 1995-2005. Health Physics December 2008, Volume 95, Number 6
3. Environment Agency Science Reports SC070015/SR1 and 2.

Annex 4 - Sources and types of radioactivity in pressurised water reactors

Introduction

781 At the start of its life a pressurised water reactor (PWR) has only a fairly small amount of radioactivity inside it, due to its core of uranium oxide fuel. The quantity depends on two factors:

a) the total quantity of uranium fuel in the core - typically 100 tonnes;

b) the level of enrichment of the uranium in the isotope uranium-235 - typically around two to three per cent, but up to a maximum of five per cent.

782 Once it starts operation the nuclear reactions going on in the uranium in the fuel produce heat and increased radioactivity in the form of fission products - two or more 'new' chemical elements from each uranium atom that has split - and 'new' chemical elements that are heavier than uranium - transuranic or actinide elements - that are formed by uranium atoms (strictly the centre part of the atom or 'nucleus') absorbing one or more neutrons without splitting. Fission products and transuranic elements are produced and retained within the uranium oxide fuel. Neutrons that escape from the fuel without causing fission or creating transuranic elements can react with other atoms in the reactor core - or passing through it - to form 'new' elements. These are called activation products.

783 This annex describes the types of new radioactive species and the way that they are formed and covers:

a) fission products;

b) transuranic elements;

c) activation products.

784 Some radioactive elements can be formed by more than one of these mechanisms.

Fission products

785 The fission process can be explained using the 'liquid drop' model of an atom's core: the nucleus. In normal circumstances, the nucleus is nearly spherical in shape like a water droplet. After the absorption of a neutron, the nucleus will be in an excited state and start to oscillate and become distorted. If the oscillations cause the nucleus to become shaped like a dumbbell, the repelling electrostatic forces (or charges) will overcome the shorter-range nuclear forces and the nucleus will split. The heaviest nuclei are easily fissionable because they require only a small distortion from the spherical shape to allow the electric forces to overcome the nuclear force to break the nucleus.

786 Each fission produces two or more smaller nuclei - fission products - and neutrons, gamma rays and beta particles. All of these have considerable energy for their size, which is given up as heat when they strike nearby atoms in the uranium oxide fuel. Heat from fission is measured in the unit electron-volt (eV) or megaelectron-volt (MeV) - one million electron-volts.

787 In a single fission of a uranium nucleus approximately 200 MeV of useful energy is produced as heat. It would take nearly 3000 million million - 3×10^{15} - fissions to produce enough heat to boil enough water for a mug of tea at the same time converting about 1 millionth of a gram (1 microgram - μg) of uranium into fission products.

788 Many fission products are themselves radioactive and have some general features in common:

a) they undergo radioactive decay by emitting a beta particle;

b) the most common atomic mass numbers are grouped near 95 and 140.

789 The amount of each fission product arising in a reactor is called the 'yield' and is expressed as a percentage. For example, strontium-90 and caesium-137 each have a yield of about 6 per cent, that is they are created in about 6 per cent of total fissions.

790 The vast majority of radioactive fission products have half-lives that are much shorter than the uranium in the fuel (that is they undergo more radioactive decays per second than the same mass of uranium would have done). This means that most fission products are much more radioactive than the original uranium.

791 A typical modern nuclear reactor generates 1250 megawatts of electricity (MWe) and operates at a thermal efficiency of 33 per cent (that is 33 per cent of the energy from fission is converted to electricity). The total energy required to operate at full power for a year would need the heat raised by 3.7 x 10^{27} (3700 million million million million) fissions. This would consume nearly 1.5 tonnes of uranium. The fission yield for caesium-137 is about 6 per cent so about 50 kilograms (kg) would be produced from the fissioning of the uranium. The radioactivity of the original uranium was about 40 gigabecquerels (GBq). The radioactivity of 50 kg of caesium-137 is about 160,000 terabecquerels (TBq) - or about four million times as great. Caesium-137 has a half-life of about 30 years, so it will take some 660 years for it to fall below that of the original uranium in the fuel.

792 The more important fission products are listed in Table 1 with their yields, and half-lives.

Table 1. Fission products

Fission product nuclide	**Symbol**	**Yield % (Total U-235)**	**Half-life**
Tritium	H-3	0.01	12.3 y
Krypton-85	Kr-85	0.286	10.7 y
Krypton-85m	Kr-85m	1.303	4.5 h
Strontium-90	Sr-90	5.73	28.8 y
Zirconium-95	Zr-95	6.5	64 d
Niobium-95	Nb-95	6.5	35 d
Molybdenum-99	Mo-99	6.1	2.7 d
Technetium-99	Tc-99	6.1	210 000 y
Ruthenium-103	Ru-103	3.1	39 d
Tellurium-132	Te-132	4.3	3.2 d
Iodine-129	I-129	0.7	15 000 000 y
Iodine-131	I-131	2.9	8 d
Iodine-133	I-133	6.6	6.6 h
Iodine-135	I-135	6.4	9.1 h
Xenon-133	Xe-133	6.6	5.2 d
Xenon-135	Xe-135	6.6	9 h
Caesium-134	Cs-134	<0.001	2.1 y
Caesium-137	Cs-137	6.2	30 y

Fission product nuclide	Symbol	Yield % (Total U-235)	Half-life
Barium-140	Ba-140	6.3	12.8 d
Lanthanum-140	La-140	6.3	1.7 d
Cerium-141	Ce-141	5.9	32 d
Praesodymium-144	Pr-144	5.5	17 m
Neodymium-144	Nd-144	5.5	2.4 y
Neodymium-147	Nd-147	2.2	10.98 d
Promethium-149	Pm-149	1.05	2.2 d
Promethium-151	Pm-151	0.42	1.18 d

Actinides / Transuranics

793 Where the absorption of a neutron in a uranium atom is achieved without the energy to distort the nucleus enough to cause it to fission, a new, heavier nucleus is formed. These are called actinides or transuranic elements. The most common of these are the isotopes of plutonium, americium and curium. Of course, the absorption of further neutrons will lead to either fission or the creation of heavier-still nuclei and so on. In summary, the heat that is ultimately used to raise steam to drive the turbine to make electricity comes from fission; fission occurs in uranium and other heavy atoms created in the fuel; other heavy atoms that will not fission remain in the fuel as actinides/transuranics. It is not possible to use every fissionable atom within the current types of commercial reactor for reasons connected to nuclear physics, and the original fuel must be replaced by fresh uranium when the former has undergone as many fissions as practicable; the old fuel is described as 'spent'. The amount of heat energy extracted from the fuel is described as 'burn-up' and is measured in the percentage of heavy atoms that have fissioned or, more commonly in commercial reactors, in a unit of megawatt-days per tonne of uranium (MWd tU^{-1}) or gigawatt-days per tonne of uranium (GWd tU^{-1}). A reactor generating 1250 MW of electricity; at 33 per cent efficiency; with a core containing 100 tonnes of uranium will require to replace about 30 tonnes of uranium per year. This represents a burn-up of about five percent heavy atoms or 45,000 MWd tU^{-1}.

794 When fresh fuel starts its life in the reactor 100 per cent of the fissions occur in uranium-235 nuclei; the uranium oxide fuel has been enriched in the U-235 isotope in varying quantities - typically 1 to 2 per cent but up to 5 per cent (compared with the natural U-235 content of 0.715 per cent). The enrichment varies across the reactor core, again, for reasons of reactor physics. As the fuel becomes older, other heavy nuclei - uranium-238 and plutonium isotopes created by neutron absorption - make an increasing contribution to the fission process. For example, when fuel enriched to a U-235 content of 2.5 per cent reaches a burn-up of 15,000 MWd tU^{-1}, the U-235 is responsible for half the total fissions. The other major contributors are plutonium-239 - Pu-239 - (37.5 per cent of fissions) and U-238 and Pu-241.

795 Table 2 below contains a list of the important transuranic elements created in a PWR.

Table 2. Transuranic elements

Nuclide	Symbol	Half-life	Decay mode
Neptunium-237	Np-237	2140000 y	α γ
Plutonium-236	Pu-236	2.9 y	α γ
Plutonium-238	Pu-238	87.7 y	α γ
Plutonium-239	Pu-239	24100 y	α γ
Plutonium-240	Pu-240	6560 y	α γ
Plutonium-241	Pu-241	14.4 y	β γ
Plutonium-242	Pu-242	374000 y	α γ
Americium-241	Am-241	433 y	α γ
Americium-242m	Am-242m	141 y	IT γ
Americium-243	Am-243	7360 y	α γ
Curium-242	Cm-242	163 d	α γ
Curium-243	Cm-243	30 y	α γ
Curium-244	Cm-244	18.1 y	α γ
Curium-245	Cm-245	8500 y	α γ
Curium-246	Cm-246	4730 y	α γ
Curium-248	Cm-248	340000 y	α γ
Californium-249	Cf-249	351 y	α γ
Californium-250	Cf-250	131 y	α γ
Californium-251	Cf-251	898 y	α γ
Californium-252	Cf-252	2.65 y	α γ

Activation

796 Some of the neutrons responsible for keeping the fission process going will react with other chemical elements in or passing through the reactor core including:

a) the metal cladding surrounding the uranium oxide fuel;

b) the structural supporting metal of the core itself;

c) the steel pressure vessel;

d) the reactor coolant - mostly water but also carrying a variety of chemicals designed to control the fission process by absorbing neutrons; preventing corrosion of fuel cladding and other reactor components; and small quantities of substances arising from the natural erosion and corrosion processes taking place as a result of high pressure hot fluids moving around the circuits.

797 The new substances formed in these reactions are called activation products.

798 Water and any impurities in it are activated only as they pass through the reactor core when there are enough neutrons to cause the reactions. The water only spends a few seconds in the core, but as the circuits are closed the same water passes through the

core over and over again. The rate at which activation products are made depends on a number of things including:

a) how many atoms of water or impurity are present - sometimes called the parent target atom;

b) how long the parent atoms spend in the core – flowrate;

c) how many spare neutrons are present - the neutron flux: neutrons per second passing through one square centimetre. The neutron flux rises as the reactor power increases;

d) how fast the neutrons are moving - measured as their energy of movement in a quantity called the electron-volt. There is a wide range of neutron speeds but the two important ones for activation products are: fast (F) neutrons with an energy of 1 megaelectron-volt - MeV - (1 MeV is one million electron-volts) - these travel at about 14 000 km/s; and thermal (T) neutrons with energy of 0.025 eV and a speed of 2200 km/s;

e) the probability that a neutron hitting an atom will cause the reaction of interest. This is a feature of the parent atom and is really a measure of how much of a target area it presents to the neutron so it has a unit related to area - the 'barn' or a fraction of a barn the 'millibarn' - one thousandth of a barn. A barn is equal to 1 x 10^{-24} of a square centimetre. An atom presenting an area or cross-section of 50 barns is 10 times more likely to be activated than an atom of 5 barns when faced with a neutron of the same energy.

799 Note that other types of radiation can cause activation - for example, protons, gamma rays etc. - and the rate of production will depend on similar factors to the five above.

800 Activation products have three main points of interest:

a) their half-life - how long will it take for half of the atoms to decay;

b) the type of radiation - and its energy - they emit when they decay;

c) their chemical properties, that is will they react chemically and stick to other atoms either in the core, adjoining circuits or coolant clean-up and treatment plant?

801 The process of activation can be complex but may be simplified and written down in shorthand. The key pieces of information are:

a) what is the target?

b) how much of the target is there?

c) what types of radiation are involved? Normally one type - a neutron, say - penetrates the target atom and another type - a gamma ray - escapes.

d) what is the probability of reaction or cross-section of the target and is this for fast or thermal neutrons?

e) what new radionuclide is formed?

f) what is its half-life?

g) what type of radiation does it emit when it decays?

802 Using the activation of the stable atom carbon-13 to produce radioactive carbon-14 as an example the shorthand is as follows:

C-13(n, γ)C-14 - 1.11% - 0.9 mb(T) - 5730 years - β

In words: the target is carbon-13; it makes up 1.11% of all carbon in the natural world; it is struck by a neutron and gives off a gamma ray; the probability of the reaction is 0.9 millibarns with a thermal neutron; the activation product is carbon-14 with a half-life of 5730 years emitting only beta radiation as it decays.

803 Some of the important activation product data is given in more logical order in Table 3 below.

Table 3. Activation products

Nuclide	Half-life	Emission	Reaction	Parent %	Cross-section
Tritium	12.3 y	β	H-2(n,α)H-3	0.015	0.53 mb(T)
			Li-6(n,α)H-3	7.5	942 b(F)
			B-10(n,2α)H-3		5.6 mb(F)
Carbon-14	5730 y	β	C-13(n,γ)C-14	1.11	0.9 mb(T)
			N-14(n,p)C-14	99.63	1.8 b(F)
			O-17(n,α)C-14	0.038	240 mb(F)
Carbon-15	2.45 s	β/γ	O-18(n,α)C-15	0.204	1.5 mb(F)
Nitrogen-13	9.97 m	β+	O-16(p,α)N-13	99.76	50 mb(P)
Nitrogen-16	7.13 s	β/γ	O-16(n,p)N-16	99.76	19 mb(F)
Oxygen-19	26.9 s	β/γ	O-18(n,γ)O-19	0.204	160 mb(T)
Fluorine-18	1.83 h	β+	O-18(p,n)F-18	0.204	300 mb(P)
Sodium-24	14.96 h	β/γ	Na-23(n,γ)Na-24	100	528 mb(T)
Phosphorus-32	14.28 d	β	P-31(n,γ)P-32	100	190 mb(T)
			S-32(n,p)P-32	95	69 mb(F)
Chlorine-38	37.2 m	β/γ	Cl-37(n,γ)Cl-38	24.2	430 mb(T)
Argon-41	1.83 h	β/γ	Ar-40(n,γ)Ar-41		
Calcium-45	162.7 d	β			
Chromium-51	27.7 d	EC/γ	Cr-50(n,γ)Cr-51		
			Cr-52(n,2n)Cr-51		
			Fe-54(n,α)Cr-51		

Nuclide	Half-life	Emission	Reaction	Parent %	Cross-section
Manganese-54	312 d	EC/γ	Mn-54(n,2n)Mn-54		
			Fe-54(n,p)Mn-54		
			Fe-56(n,t)Mn-54		
Iron-59	44.5 d	β/γ	Fe-58(n,γ)Fe-59		
			Co-59(n,p)Fe-59		
			Ni-62(n,α)Fe-59		
Cobalt-58	70.8 d	EC/β/γ	Co-59(n,2n)Co-58		
			Ni-58(n,p)Co-58		
Cobalt-60	5.27 y	β/γ	Co-59(n,γ)Co-60		
			Ni-60(n,p)Co-60		
			Cu-63(n,α)Co-60		
Nickel-63	100 y	β	Ni-62(n,γ)Ni-63		
Zinc-65	244 d	β	Zn-64(n,γ)Zn-65		T
			Zn-66(n,2n)Zn-65		F
			Zn-67(n,3n)Zn-65		F
Silver-110m	250 d	β/γ			
Antimony-122	2.72 d	β/γ	Sb-121(n,γ)Sb-122		

The main radionuclides

804 **Tritium.** Symbol H-3, an isotope of hydrogen with one proton and two neutrons in its nucleus. Formed naturally in the upper atmosphere when neutrons arising from cosmic radiation interact with atoms of, for example, lithium. The total quantity of tritium in the biosphere that has been produced naturally is about seven kilograms or 2.5 million TBq. Tritium is also produced in nuclear reactors by fission and activation; it is present in discharges to air and water from nuclear facilities. Tritium is present in water - liquid and vapour - because it readily replaces the non-radioactive hydrogen - H-1 - atoms in a water molecule. Tritium poses a health hazard only if it is taken into the body; it decays with the emission of a very weak beta particle that cannot penetrate the skin.

805 **Carbon-14.** Symbol C-14, an isotope of carbon with six protons and eight neutrons in its nucleus. Formed naturally in the upper atmosphere when neutrons interact with atoms of nitrogen and, to a lesser extent, carbon (-13) and oxygen. Every year about 1400 TBq of carbon-14 is formed in the atmosphere. The total quantity of carbon-14 in the biosphere that has been produced naturally is about 6000 kg or 1 million TBq, most of which is in the oceans. Carbon-14 is also produced in nuclear reactors by neutron activation of nitrogen, carbon and oxygen; it is present in discharges to air and water from nuclear facilities and in solid radioactive waste. Carbon-14 behaves in the same way as stable carbon isotopes, so it is present in all organic material in the natural carbon cycle in the biosphere. The average person contains between 3000 and 4000 becquerels of carbon-14, which will cause 250 million to 350 million beta particle missions every day. Carbon-14 decays with the emission of a weak beta particle, and its main hazard arises from taking it into the body in food, water or breathing air.

806 **Noble gases.** The noble gases comprise helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn). Only radon has significant radioactive isotopes that occur in nature. Argon-40 makes up over 99 per cent of the stable argon present naturally in air, but if it is exposed to neutrons will form the activation product argon-41. Radioactive isotopes of krypton and xenon are formed as fission products in a nuclear reactor and their appearance outside of the reactor core indicates failure of the fuel pin containment, more commonly called the cladding. Noble gases do not become incorporated in food and the main hazard from their radioactive species is due to direct beta and gamma radiation as a plume of gas disperses.

807 **Iodine.** Iodine is a very volatile element in that it changes from a solid to a gas at room temperature. It is formed in a reactor as the fission products I-129, I-131, I-133 and I-135. Iodine's appearance outside of the reactor core indicates a failure in the fuel cladding. A small quantity of I-129 forms naturally in the upper atmosphere by the interaction of high energy particles from cosmic rays with xenon. Iodine can be taken into the body in food, water and by breathing.

808 **Particulate matter.** A number of metallic radionuclides are generated in the reactor as activation products. These are tiny quantities - in mass terms - of corrosion/erosion species that come from structural components of the reactor. These species have been exposed to neutrons and the most important radionuclides are manganese-54, cobalt-58, iron-59, cobalt-60, chromium-51, nickel-63, silver-110m, antimony-122, -124 and -125. These radionuclides can remain in the reactor coolant water in suspension or solution or become entrained in ventilation air. Both waterborne and airborne radionuclides of this type can be removed before discharge but in practice very small quantities will reach the environment. Their hazard arises from being breathed in or swallowed in food and water.

Annex 5 – Documents forming EDF and AREVA's submission for GDA

Document reference	Title	Version number
UKEPR-0003-011	PCER-Sub-chapter 1.1 - Introduction	03
UKEPR-0003-012	PCER – Sub-chapter 1.2 – General description of the unit	01
UKEPR-0003-013	PCER – Sub-chapter 1.3 – Comparison with reactors of similar design	02
UKEPR-0003-014	PCER – Sub-chapter 1.4 – Compliance with regulations	01
UKEPR-0003-015	PCER – Sub-chapter 1.5 – Safety assessment and international practice	01
UKEPR-0003-020	PCER – Chapter 2 – Quality and Project Management	02
UKEPR-0003-030	PCER – Chapter 3 – Aspects having a bearing on the environment during operation phase	02
UKEPR-0003-040	PCER – Chapter 4 – Aspects having a bearing on the environment during construction phase	00
UKEPR-0003-050	PCER – Chapter 5 – Design principles related to decommissioning	03
UKEPR-0003-060	PCER – Sub-chapter 6.0 – Safety requirements	01
UKEPR-0003-061	PCER – Sub-chapter 6.1 – Sources of radioactive materials	03
UKEPR-0003-062	PCER – Sub-chapter 6.2 – Details of the effluent management process	03
UKEPR-0003-063	PCER – Sub-chapter 6.3 – Outputs for the Operating Installation	03
UKEPR-0003-064	PCER – Sub-chapter 6.4 - Effluent and waste treatment systems design architecture	03
UKEPR-0003-065	PCER – Sub-chapter 6.5 – Interim storage facilities and disposability for UK EPR	02
UKEPR-0003-070	PCER – Chapter 7 – Measures for monitoring discharges	01
UKEPR-0003-080	PCER – Chapter 8 – Best Available Techniques	01
UKEPR-0003-090	PCER – Chapter 9 – Principles and methods used for environmental approach at the design stage	02
UKEPR-0003-100	PCER – Chapter 10 – Site environmental characteristics	03
UKEPR-0003-110	PCER – Chapter 11 – Radiological impact	02

Document reference	Title	Version number
	assessment	
UKEPR-0003-120	PCER – Chapter 12 – Non radiological impact assessment	02
UKEPR-0011-001	GDA UK EPR-BAT Demonstration	03
NXA/10488242	GDA: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR	Oct 09
NXA/10747397	GDA: Disposability Assessment of Wastes and Spent Fuel Arising from the Operation of the EPR Part 1 Main Report	Jan 10
NXA/10777960	Generic Design Assessment: Disposability Assessment of Wastes and Spent Fuel Arising from the Operation of the EPR Part 2 Data Sheets and Inventory Tables	Jan 10
REG EPR00182N (Appendix)	Critique of the NDA RWMD Disposability Assessment	25/09/09
ELI0800226	Dry Interim Storage facility for ILW	A
LLWR EPR0001	UK EPR LLWR Disposability Assessment – Preliminary D1 Form Information	23/10/08
LLWR 320.L.027	Form D1 Application: UK EPR Project	03/12/08
ELIDC0801302	EPR UK – Decommissioning waste inventory	A
UKEPR-0010-001	GDA UK EPR – Integrated Waste Strategy Document	02
ELI0800224	Interim storage facility for spent fuel assemblies coming from an EPR plant	A
UKEPR-0007-001	Monitoring of liquid and gaseous discharges: Prospective arrangements for the UK EPR	01
UKEPR-0004-001	PPC Application – diesel generators	00
NESH-G/2008/en/0123	Solid Radioactive Waste Strategy Report (SRWSR)	A
UKEPR-0008-001	Longer Term ILW Interim Storage Facility	01
UKEPR-0009-001	Longer Term Spent Fuel Interim Storage Facility	01
UKEPR-0012-001	Radioactive Waste Management Case	01

All of the above documents can be accessed at:

www.epr-reactor.co.uk

In addition to the documents above we also considered the following documents to inform our assessment

Document reference	Title	Version number
UK EPR-I-002	UK EPR Reference Design Configuration	05
REG EPR00101N	UK Disposability Assessments	09/04/09
TQ-EPR-124	Changes to waste characteristics over the life of the EPR	17/06/09
TQ-EPR-159	Solid Radioactive Waste Estimates	17/06/09
TQ-EPR-469	Solid Radioactive Waste Data	05/00/09
TQ-EPR-341	Disposability of EPR Waste Oils	16/11/09
TQ-EPR-222	EPR Intermediate Level Waste	27/11/09

Annex 6 - Criteria for consultation

809 This consultation follows the Government's Code of Practice. In particular, we aim to:

a) formally consult at a stage where there is scope to influence the outcome;

b) consult for at least 12 weeks with consideration given to longer timescales where feasible and sensible;

c) be clear about the consultation process in the consultation documents, what is being proposed, the scope to influence and the expected costs and benefits of the proposals;

d) ensure the consultation exercise is designed to be accessible to, and clearly targeted at, those people it is intended to reach;

e) keep the burden of consultation to a minimum to ensure consultations are effective and to obtain consultees' 'buy-in' to the process;

f) analyse responses carefully and give clear feedback to participants following the consultation;

g) ensure officials running consultations are guided in how to run an effective consultation exercise and share what they learn from the experience.

Annex 7 – Places where consultation documents are advertised or can be viewed and list of consultees

Libraries

810 A poster advertising the consultation has been sent to 1798 local authority run libraries in England and Wales.

811 A poster advertising the consultation has been sent to 743 public sector management libraries in England and Wales.

Print media

812 An advert has been placed in one daily local newspaper in each of the areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

813 An advert has been placed in one weekly local newspaper in each of the areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

814 Where possible and when available an advert has been placed in local authority magazines which cover areas around potential new build sites listed in DECC's draft Nuclear National Policy Statement consultation.

Environment Agency Offices where the documents can be viewed

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

Environment Agency
Coverdale House
Aviator Court
Amy Johnson Way
Clifton Moor
York
YO30 4GZ

Environment Agency
Trentside Office
Scarrington Road
West Bridgeford
Nottingham
NG2 5FA

Environment Agency,
Buckley Office
Chester Road
Buckley
CH7 3AJ

Environment Agency
Rivers House
East Quay
Bridgewater
Somerset
TA6 4YS SW

Environment Agency,
Orchard House
Endeavour Park
London Road
Addington,
West Malling
Kent
ME19 5SH

Environment Agency
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough
PE2 5ZR

List of consultees

815 We have written to a wide range of organisations that we believe might be interested in this consultation. A list of these is available upon request.

816 We have also written to MPs, MEPs and Welsh AMs and will be providing information to those who have requested it.

817 Our regional teams have developed local engagement plans which we've published on our joint website (www.hse.gov.uk/newreactors/publicinvolvement.htm).

Annex 8 - Response form

How to respond

Visit our website at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda. The online consultation has been designed to make it easy to submit responses to the questions. We would like you to register so you can respond online. This will help us to gather and summarise responses quickly and accurately. To do this you must first log in or register if you have not yet done so already.

If that is not possible, you can submit your response by email, letter or fax. Please use this form when responding. It can be downloaded at: https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda

If you use any additional sheets, please make sure that each page is clearly labelled and numbered.

This 16 week consultation began on 28 June 2010 and will close on 18 October 2010. Please send your response to arrive by 18 October 2010.

If you have any problems with sending your response, please contact us on:

gda@environment-agency.gov.uk and phone 08708 506 506* (Mon – Fri 8-6)*.

Please read the notices below before sending your response to:

Email: gda@environment-agency.gov.uk

Post: Sue Riley
Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria CA11 9BP

Fax: 01768 865606

* Approximate call costs: 8p plus 6p per minute (standard landline). Please note charges will vary across telephone providers

Data Protection Notice

How we will use your information

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

We may refer to any comments / issues raised by you in our Decision Document and in other Environment Agency documents related to GDA for the UK EPR, unless you have specifically requested that we keep your response confidential. We may also publish all responses after the consultation has closed. 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.

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

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). If you want us to treat the information that you provide as confidential, please be aware that, under the FOIA, 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.

About you

Name	
Organisation (if relevant)	
Job title (if relevant)	
Address (inc 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 the radioactive waste and spent fuel strategy? If so, please use the box below to provide any details.

Q3: Do you have any views or comments on our preliminary conclusions on best available techniques to minimise the production of radioactive waste? If so, please use the box below to provide any details.

Q4: Do you have any views or comments on our preliminary conclusions on:

a) best available techniques to minimise the gaseous discharge of radioactive waste

b) our proposed gaseous annual disposal limits

c) our proposed gaseous quarterly notification levels?

If so, please use the box below to provide any details.

Q5: Do you have any views or comments on our preliminary conclusions on:

a) best available techniques to minimise the aqueous discharge of radioactive waste

b) our proposed aqueous annual disposal limits

c) our proposed aqueous quarterly notification 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 solid radioactive waste? If so, please use the box below to provide any details.

Q7: Do you have any views or comments on our preliminary conclusions on 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 monitoring of 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 the abstraction of water? If so, please use the box below to provide any details.

Q11: Do you have any views or comments on our preliminary conclusions on discharges of non-radioactive substances to water? If so, please use the box below to provide any details.

Q12: Do you have any views or comments on our preliminary conclusions on pollution prevention for non-radioactive substances? If so, please use the box below to provide any details.

Q13: Do you have any views or comments on our preliminary conclusions on EPR 10 Schedule 1 activities? If so, please use the box below to provide any details.

Q14: Do you have any views or comments on our preliminary conclusions on non-radioactive waste? If so, please use the box below to provide any details.

Q15: Do you have any views or comments on our preliminary conclusions on COMAH substances? If so, please use the box below to provide any details.

Q16: Do you have any views or comments on our overall preliminary conclusion on acceptability of the design? If so, please use the box below to provide any details.

Q17: Do you have any overall views or comments to make 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	

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