DEPARTMENT OF ENERGY & CLIMATE CHANGE

The arrangements for the management and disposal of waste from new nuclear power stations: a summary of evidence

November 2009

Introduction

1. In the draft Nuclear National Policy Statement (NPS), the Government sets out its preliminary view that it is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations. The basis on which this conclusion has been reached is set out in Annex G of the "Consultation on draft National Policy Statements for Energy Infrastructure".

2. Before reaching its conclusion, the Government has reviewed a range of evidence on the arrangements for the management and disposal of the waste from new nuclear power stations. This evidence is summarised in this paper, which is being published as additional background information.

The structure of this paper

3. In order to ensure that the review of evidence on the arrangements for managing and disposing of wastes from new nuclear power stations was thorough and systematic, a structured approach was adopted and this paper follows that approach. This has provided a set of evidence that the Government was able to draw upon when making its assessment.

4. This paper covers solid radioactive waste, non-radioactive hazardous waste, and liquid and gaseous radioactive discharges. On the presumption of a once-through fuel cycle for new nuclear power stations, as set out in the Nuclear White Paper[1] (and therefore assuming no reprocessing of fuel), the solid radioactive waste from new nuclear power stations falls into three defined categories: low level waste (LLW), intermediate level waste (ILW) and spent fuel[2].

5. This paper considers each waste category in turn. In addition, the sections on spent fuel, ILW and LLW have been further broken down so that interim storage, transport and disposal are considered separately for each waste category. Operational and decommissioning wastes have not been considered separately, but have instead been considered under their respective waste category (for example the ILW section covers both operational ILW and decommissioning ILW).

[1] Nuclear White Paper page 116.
http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/white_paper_08/white_paper_08.aspx

[2] Each of these waste categories is defined in the relevant section of this paper.

6. This paper describes the framework for the management and disposal of wastes through their lifecycle. For each section, firstly we have considered the legal and policy framework in place, in particular:
   - the Government policy framework;
   - the Government's strategy to implement its policy;
   - the legal frameworks that give effect to the policy;
   - the regulatory frameworks in place to enforce and monitor the policy.

7. Secondly we have considered the technological and physical capability to manage and dispose of wastes from new nuclear power stations. In particular we have considered:
   - Do acceptable technologies exist, or are they likely to exist within an appropriate timeframe, for managing and disposing of the waste (given its expected characteristics and quantities)?
   - Does capacity exist, or is it likely to exist within an appropriate timeframe, to manage and dispose of the waste in a manner which is safe, secure and which ensures environmental and sustainability impacts are manageable?

8. As set out in the draft Nuclear NPS, an Appraisal of Sustainability (AoS) has been carried out. The purpose of this appraisal was to ensure that the Government's consideration of the arrangements for managing and disposing of waste takes account of the environmental and sustainability impacts of those arrangements. This paper does not deal directly with environmental impacts as they are dealt with in the AoS.

9. This paper has been produced with extensive input from the Nuclear Decommissioning Authority (NDA) on the technological issues relating to managing and disposing of radioactive materials produced by new nuclear power stations, as the NDA has strategic responsibility for managing much of the UK's radioactive waste and will implement geological disposal. It has also drawn on input from the nuclear regulators[3], and from nuclear waste producers and prospective operators in the UK. The independent Committee on Radioactive Waste Management (CoRWM) has commented on a draft of this paper from the point of view of factual accuracy and clarity of expression.

[3] The nuclear regulators and their responsibilities are set out in Section A1.4 below.

Devolved Administration positions

10. The UK Government's policy for the management of higher activity radioactive wastes is set out in the Managing Radioactive Waste Safely (MRWS) White Paper (2008)[4].

11. The Department of the Environment in Northern Ireland (DoENI) supports the MRWS programme, in recognition that it is in the best interests of Northern Ireland that the UK's higher activity radioactive waste is managed in the safest and most appropriate manner.

12. The Welsh Assembly Government will continue to play a full part in the MRWS programme in order to secure the long-term safety of radioactive wastes, to ensure the implementation of a framework appropriate to the needs of Wales and to ensure that the interests of Wales are taken into account in the development of policies in this area. The Assembly Government has, however, reserved its position on the proposals for taking forward geological disposal of higher level radioactive wastes.

13. The Scottish Executive does not support the MRWS policy framework for geological disposal. The Scottish Executive's policy is to support long-term near-surface, near-site storage.

14. The UK policy for the long term management of the UK's solid low level radioactive waste (LLW), as set out in the 2007 "Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom" 2007[5], is supported by all Devolved Administrations.

[4] MRWS White Paper, available at http://mrws.decc.gov.uk/.
[5] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom. http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/waste/low/low.aspx

Detailed sections

A Spent Fuel	
A1	**Interim storage**
A2	**Transport**
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B Intermediate level waste (ILW)	
B1	**Interim storage**
B2	**Transport**
B3	**Disposal**
C Low level waste (LLW)	
C1	**Interim storage**
C2	**Transport**
C3	**Disposal**
D Non-radioactive hazardous waste	
D	**Non-radioactive hazardous waste**
E Radioactive discharges	
E1	**Liquid radioactive discharges**
E2	**Gaseous radioactive discharges**

A Spent fuel

15. Spent fuel is defined[6] as "nuclear fuel that has been irradiated in and permanently removed from a reactor core". Spent fuel from currently operating nuclear power stations is not categorised as waste, because it still contains uranium and plutonium which could potentially be separated out through reprocessing and used to make new fuel. Much of the UK's spent fuel from civil reactors has been reprocessed in this way, producing separated plutonium and uranium and high level waste (HLW), ILW and LLW as waste by-products. Spent fuel from modern reactors need not be reprocessed, however, and could instead be packaged and disposed of directly in a geological disposal facility (GDF), as is planned in Canada, Finland and Sweden[7].

16. The Nuclear White Paper explained that in the absence of any proposals from industry, the Government has concluded that any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should also proceed on this basis[8]. The Government's assessment has therefore been carried out on this basis.

17. There is uncertainty around the quantity of spent fuel that might be produced by a new nuclear programme. The volume of spent fuel produced by a single new nuclear power station depends on a number of factors, including the capacity of the plant, its operational lifetime and various other operational considerations (including burn-up[9]).

18. The Consultation on the Future of Nuclear Power contained some figures on the impact of a new build programme on the "footprint" of geological disposal facilities. In relation to spent fuel, it was estimated that a new build programme equivalent to 10 AP-1000s would increase the footprint of a dedicated HLW/spent fuel GDF by around 90%[10].

19. More recent work by NDA means it is now possible to update this estimate. NDA has, in their disposability assessments carried out for the "Requesting Parties"[11] under the Generic Design Assessment (GDA) process[12], produced estimates for the lifetime spent fuel arisings for the new nuclear power station designs being scrutinised by the regulators in GDA. NDA has considered the potential impact on the size of a GDF of the disposal of

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[6] Definition taken from IAEA glossary. http://www.iaea.org/ns/tutorials/regcontrol/intro/glossarys.htm
[7] Storage and Disposal of Spent Fuel and High Level Radioactive Waste. IAEA. Additional paper to the IAEA's Nuclear Technology Review 2006.
http://www.iaea.org/About/Policy/GC/GC50/GC50InfDocuments/English/gc50inf-3-att5_en.pdf
[8] Nuclear White Paper page 116.
[9] Burn-up is a measure of the amount of energy extracted for a given mass of uranium. Units are GWd/tU (gigawatt days per tonne uranium). Burn-up is discussed in Section 1.5.
[10] The Future of Nuclear Power: Consultation document 2007 page 135. http://www.berr.gov.uk/files/file39197.pdf
[11] The term "requesting party" is used in relation to the GDA process to identify the organisation requesting assessment for a design through GDA. This request will normally originate from a reactor vendor, however this may also be done as a vendor/operator partnership. Consequently, the term `requesting party' is used to identify the organisation seeking the design acceptance and to distinguish it from a nuclear site licence applicant.
[12] Through the GDA process the nuclear regulators are assessing the safety, security and environmental impact of power station designs, including the quantities and types of waste that are likely to arise, their suitability for storage, transport and their disposability. More information about GDA is available at the HSE's new nuclear power stations website. http://www.hse.gov.uk/newreactors/index.htm

spent fuel from a single new nuclear reactor and from a 10GW new nuclear programme. 10GW equates to 9 AP-1000 reactors or 6 EPR reactors[13].

20. NDA has estimated that an AP-1000 operating for 60 years would give rise to an estimated 640 disposal canisters[14], requiring an area of approximately 0.11 km^2 for the associated disposal tunnels. A fleet of nine such reactors would require an area of approximately 1 km^2, excluding associated service facilities. This represents approximately 6% of the area required for legacy HLW and spent fuel per reactor, and approximately 55% for the illustrative fleet of nine AP-1000 reactors[15].

21. NDA has estimated that an EPR operating for 60 years would give rise to an estimated 900 disposal canisters, requiring an area of approximately 0.15 km^2 for the associated disposal tunnels. A fleet of six such reactors would require an area of approximately 0.9 km^2, excluding associated service facilities. This represents approximately 8% of the area required for legacy HLW and spent fuel per reactor, and approximately 50% for the illustrative fleet of six EPR reactors[16].

22. A further reason for uncertainty as to the quantity of spent fuel that will be produced by a new nuclear programme is that it will be for investors to make proposals to build new nuclear power stations. This is a particular consideration when considering arrangements for the disposal of spent fuel, where a new build programme is likely to substantially increase the total volume of spent fuel to be disposed of in a GDF. This is discussed further in Section A3.1 below.

A1 Spent fuel – interim storage

A1.1 Policy framework

23. The Nuclear White Paper explained the Government's policy on waste and decommissioning, including the Government's view on interim storage of higher activity wastes[17]. This is that the Government considers that spent fuel from new nuclear power stations can and should be stored in safe and secure interim storage facilities until a geological facility is available.

24. The Government's policy is that progress towards geological disposal should be coupled with a robust programme of safe and secure interim storage[18]. The Nuclear White Paper said that, given the ability of interim stores to be maintained in order to hold waste safely and securely if necessary for very long periods, or if necessary refurbished or replaced, the

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[13] The Summary Disposability Assessment for the AP-1000. http://www.nda.gov.uk/documents/upload/TN-17548-Generic-Design-Assessment-Summary-of-DA-for-Wastes-and-SF-arising-from-Operation-of-APPWR-October-2009.pdf. Summary Disposability Assessment for the EPR. http://www.nda.gov.uk/documents/upload/TN-17548-Generic-Design-Assessment-Summary-of-Disposability-Assessment-for-Wastes-and-Spent-Fuel-arising-from-Operation-of-the-EPWR.pdf

[14] The reference design currently being used by NDA for the purposes of estimating the costs of a GDF envisages spent fuel being packaged in copper canisters prior to disposal. The capacity of a copper canister is four PWR spent fuel assemblies. See page 71 of the MRWS White Paper for more on this.

[15] Summary Disposability Assessment for the AP-1000 page 6.

[16] Summary Disposability Assessment for the EPR page 7.

[17] Nuclear White Paper pages 83-99.

[18] Government Statement on the MRWS process and geological disposal, October 2006. (See also Box 1 in the Nuclear White Paper.) *Response to the Report and Recommendations from the Committee on Radioactive Waste Management (CoRWM).* http://mrws.decc.gov.uk/en/mrws/cms/Home/What_is_the_Go/What_is_the_Go.aspx

Government was satisfied that it was reasonable to proceed with allowing operators to build new nuclear power stations in advance of a GDF being available[19].

25. More detail on the requirement for a robust programme of safe and secure interim storage was provided in the MRWS White Paper, which said that existing interim stores will have their service lives extended as required in order to provide sufficient safe and secure interim storage through the GDF development programme[20]. Extension would be subject to regulatory approval addressing store safety, security, environmental impact and any impact on waste characteristics. Storage facilities that met the regulators' conditions would need to be constructed for new nuclear power stations.

26. The Nuclear White Paper also set out the Government's policy that the owners and operators of new nuclear power stations must set aside funds over the operating life of the power station to cover the full costs of decommissioning and their full share of waste management and disposal costs[21]. This includes the costs of providing safe, secure, environmentally acceptable interim storage for spent fuel until a GDF is ready to accept this material.

27. Owners and operators of new nuclear power stations will be required to have a Funded Decommissioning Programme (FDP), approved by the Secretary of State, in place before construction of a new nuclear power station begins and to comply with this programme thereafter. This ensures they set aside funds over the operating life of the power station to cover the full costs of decommissioning and their full share of waste management and disposal costs. A legal framework that implements this policy has now been set through the Energy Act 2008 and the Government also published a consultation on draft FDP guidance in February 2008[22], providing further detail on what an FDP should contain.

A1.2 Strategic framework

28. The GDA and site licensing and permitting processes are intended to ensure that operators provide safe, secure and environmentally acceptable interim storage for spent fuel. Licensing consent for a new nuclear power station will not be granted unless the regulators are satisfied with the operator's proposal for interim storage of the spent fuel produced by the proposed new nuclear power station.

29. GDA is intended to ensure that the technical aspects of designs for nuclear power stations are considered ahead of site-specific licence applications[23]. As part of this process, the Requesting Parties are required to identify the management arrangements they propose for the spent fuel and radioactive waste arising from operation of the reactors for their projected life. These proposed arrangements are then scrutinised by the nuclear regulators as part of the GDA process. These generic arrangements will then be subject to further scrutiny and approval as part of the site specific licensing process.

30. To implement the Government's policy that operators must make adequate provision for the costs of decommissioning and waste management, new legal duties on operators have been created through the Energy Act 2008[24].

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[19] Nuclear White Paper page 91.
[20] MRWS White Paper page 25.
[21] Nuclear White Paper page 147.
[22] Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Stations. http://www.berr.gov.uk/files/file44486.pdf
[23] Generic Design Assessment Guidance to Requesting Parties. http://www.hse.gov.uk/newreactors/ngn03.pdf
[24] Energy Act 2008. http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080032_en.pdf

31. To enable the Government to estimate the potential costs of waste management, disposal and decommissioning and to ensure that operators make adequate provision for their funding, the draft FDP guidance set out a means by which waste can be managed and disposed of and decommissioning carried out. This was termed the “Base Case”[25]. It built on existing policy and regulations for waste management and decommissioning and also made additional assumptions to ensure that it represented a realistic and prudent way to estimate the costs of and carry out these activities.

A1.3 Legal framework

32. There is a range of relevant UK and international legislation and conventions. These include:

- All relevant Euratom Treaty requirements as transposed into UK law, including Council Directive 96/29/Euratom laying down basic safety standards for the protection of the health of workers and the general public against the dangers of ionising radiation (the Basic Safety Standards Directive).
- All relevant legislation, including the Radioactive Substances Act 1993 (RSA93), Ionising Radiations Regulations 1999, the Health and Safety at Work etc. Act 1974 (HSWA74), the Nuclear Installations Act 1965 (NIA65), the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG09) and the Nuclear Industries Security Regulations 2003.
- The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and the Convention on Physical Protection of Nuclear Material.
- The principles of radiological protection established by the International Commission on Radiological Protection (ICRP) as reflected in European Union and UK legislation and standards, the latter based on independent advice from bodies such as the Health Protection Agency (HPA) and the Committee on Medical Aspects of Radiation in the Environment (COMARE).

33. With regard to funding arrangements, the legal framework for the Government’s policy on waste and decommissioning funding arrangements for new nuclear power stations was put in place in the Energy Act 2008. Clauses in the Energy Act require operators of any new nuclear power stations to submit an FDP for approval to the Secretary of State[26].

[25] FDP Guidance Consultation Section 4.
[26] Section 3 of the FDP Guidance Consultation had a description of the main provisions of the Energy Act in relation to waste and decommissioning funding arrangements.

A1.4 Regulatory framework

34. Individual aspects of regulation will be carried out in accordance with the statutory responsibilities of each regulatory body and will be clearly delineated. The regulatory bodies involved and their responsibilities are:

- **Health and Safety Executive (HSE).** The statutory body responsible for the enforcement of health and safety law on nuclear sites in Great Britain. HSE is the licensing authority for nuclear installations in Great Britain and, through its Nuclear Installations Inspectorate (NII), regulates the nuclear and radiological safety of nuclear installations.

- **Environment agencies.** The Environment Agency is responsible in England and Wales for the enforcement of environmental protection legislation in the context of sustainable development. It authorises and regulates radioactive and non-radioactive discharges and disposals to air, water (both surface water and groundwater) and land. The equivalent body in Scotland is the Scottish Environment Protection Agency (SEPA) and in Northern Ireland this function is carried out by the Northern Ireland Environment Agency.

- **Office for Civil Nuclear Security (OCNS).** This Division within HSE's Nuclear Directorate regulates security arrangements in the civil nuclear industry, including security of nuclear material in transit, exercising statutory powers on behalf of the Secretary of State for Energy and Climate Change.

- **Department for Transport (DfT).** Regulation of the safety of radioactive material transport by road, rail and sea in Great Britain is carried out by DfT, HSE, the Office of Rail Regulation (ORR) and the Maritime and Coastguard Agency (MCA). The DfT exercises its statutory powers of enforcement on behalf of the Secretary of State for Transport.

- **UK Safeguards Office** is part of the Nuclear Directorate of the HSE and oversees the application of nuclear safeguards in the UK to ensure that the UK complies with its international safeguards obligations.

35. A joint DECC/DWP consultation, which ran from 30 June to 22 September 2009, detailed proposals to re-structure HSE's Nuclear Directorate, and include some regulatory functions currently within DfT, as an independent, sector specific issue regulator within the auspices of HSE[27]. Secondary legislation would be used to create the new body as a Statutory Corporation. The proposals only address the governance and organisational aspects of nuclear regulation, and do not amend the requirements and standards with which duty holders must comply.

36. The Energy Act 2008 also gives the Secretary of State a range of powers in relation to enforcing the provisions of the Act relating to waste and decommissioning financing[28].

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[27] The consultation can be found at http://decc.gov.uk/en/content/cms/consultations/hse_restruct/hse_restruct.aspx.

[28] FDP Guidance Consultation, Section 3.

A1.5 Technology

37. The Nuclear White Paper set out that the Government is satisfied that interim storage will provide an extendable, safe and secure means of containing waste for as long as it takes to site and construct a GDF[29]. This is based on experience in the UK and overseas of the interim storage of higher activity wastes and spent fuel in line with requirements for safety, security and environmental protection.

38. The UK has extensive experience of managing higher activity wastes. For example high level wastes (HLW) have been safely managed and stored at Sellafield for a number of years. HLW occurs as a liquor following the reprocessing of spent fuel from the UK's older Magnox and Advanced Gas-cooled Reactor (AGR) nuclear power stations. The liquor is vitrified and made into a passively safe form for interim storage.

39. The UK already manages spent fuel from the nuclear power stations currently operating[30]. Spent fuel from Magnox nuclear power stations is stored in either water filled ponds or, at Wylfa power station, in dry stores, prior to being sent to Sellafield for reprocessing. Spent fuel from AGR nuclear power stations is held under water in containers prior to being sent to Sellafield for reprocessing. Spent fuel from the UK's only Pressurised Water Reactor (PWR), Sizewell B, is currently being stored under water. Spent light water reactor (LWR)[31] fuel from Europe and Japan has been transported from power station ponds to Sellafield for reprocessing.

40. With regard to experience overseas, a report from the OECD Nuclear Energy Agency (NEA)[32] found that spent fuel has been safely and securely stored in OECD member countries for several decades and such storage could continue for many more decades, given proper controls and supervision as well as repackaging of some wastes and periodic refurbishment of stores. The NEA also noted that stores of modern design have typically been licensed for periods of decades, in one case (the HABOG in the Netherlands) for a century[33]. HABOG became operational in 2003 and will store HLW and spent fuel until 2130[34].

41. In the USA spent fuel has been safely and securely managed on arising sites for decades[35] and the US Nuclear Regulatory Commission (NRC) has formally expressed its confidence that spent fuel can be safely and securely stored on-site, without significant environmental impact, for at least 100 years[36].

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[29] Nuclear White Paper page 96.
[30] The United Kingdom's Third National Report on compliance with the obligations of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. http://www.hse.gov.uk/nuclear/meetings/spentfuel09/report.pdf
[31] LWR is the generic name given to nuclear reactors cooled and usually moderated by ordinary water. The PWR is the most common type of LWR, using water at very high pressure in a primary circuit and forming steam in a secondary circuit, which is subsequently used to drive a turbine-generator.
[32] "The roles of storage in the Management of Long-lived Radioactive Waste". http://www.nea.fr/html/rwm/reports/2006/nea6043-storage.pdf
[33] The Roles of Storage in the Management of Radioactive Waste. NEA 2006. http://www.oecdnea.org/html/rwm/reports/2006/nea6043-storage.pdf
[34] The IAEA Radioactive Waste Management Database – Netherlands Report. http://newmdb.iaea.org/reportindex.aspx?ByCountry=NL&ByYear=7&RPart=11
[35] http://www.nrc.gov/reading-rm/doc-collections/commission/speeches/2008/s-08-023.html
[36] http://www.nrc.gov/reading-rm/doc-collections/commission/speeches/2009/s-09-012.html

42. Modern nuclear power stations that are developed internationally include robust spent fuel storage arrangements[37]. Following discharge from the reactor the fuel is required to be cooled, initially in a water-filled pool, as is the case currently at Sizewell B and internationally. The minimum period for storing spent fuel under water is 9-12 months, after which dry storage can be considered[38] and internationally the storage of spent fuel in dry casks has become increasingly popular[39 40]. Common practice for modern PWR designs is for fuel to reside in pool storage only for the period when it is hottest and then for it to be transferred to a dry cask storage system for the remainder of the time required to be stored on-site[41].

43. Although there are currently no dry fuel stores for PWR spent fuel in the UK, there is considerable international experience (see below) which gives confidence that similar stores can be constructed and licensed for operation in the UK. Indeed, British Energy has examined spent fuel management options at Sizewell B[42], which include the option of dry storage. British Energy has subsequently submitted a request for a scoping opinion[43] to the Secretary of State for Energy and Climate Change. A response from the Department will be issued shortly.

44. Dry storage may provide an advantage over wet storage of being easier and less expensive to monitor and maintain, and dry fuel surface storage is adopted in USA, Germany, Switzerland, and other countries[44]. It is noted also that the Wylfa Magnox power station already has a dry store for spent Magnox fuel. There are several examples of existing dry storage systems including those that could be utilised for spent fuel from UK new nuclear power stations (see below)[45].

45. The decision whether to adopt dry or prolonged pool storage will rest with the operator and will require the approval of the regulators, but both represent technologies that are already being successfully deployed to store LWR spent fuel. The operator of the new nuclear power station would be responsible for developing the safety and environmental cases for dry storage of spent fuel in the UK.

46. New nuclear power reactor designs are of increased efficiency as compared to previous PWR designs (e.g. Sizewell B) and are designed to extract more energy from the fuel by leaving it in the reactor longer for increased irradiation, otherwise known as "burn-up". The higher burn-up of the fuel will mean that comparatively fewer spent fuel assemblies will require to be managed, but higher burn-up means that an individual fuel assembly will have

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[37] Fukuda, et al. IAEA Overview of global spent fuel storage. IAEA-CN-102/60 2003. www.iaea.org/NewsCenter/Features/UndergroundLabs/Grimsel/storageoverview.pdf

[38] Storage and Disposal of Spent Fuel and High Level Radioactive Waste, IAEA. http://www.iaea.org/About/Policy/GC/GC50/GC50InfDocuments/English/gc50inf-3-att5_en.pdf

[39] www.nrc.gov/reading-rm/doc-collections/fact-sheets/dry-cask-storage.html

[40] National Waste Management Organisation Canada, 2008 Annual Report. www.nwmo.ca/annual_reports

[41] The Long Term Storage of Radioactive Waste. http://www-pub.iaea.org/MTCD/publications/PDF/LTS-RW_web.pdf

[42] www.british-energy.com/documents/Spent_Fuel_brochure.pdf

[43] http://www.british-energy.com/documents/Sizewell_B_Dry_Fuel_Store_Env_Scoping_Report.pdf

[44] Operation and Maintenance of Spent Fuel Storage and Transportation Casks/Containers. IAEA-TECDOC-1532 January 2007. http://www-pub.iaea.org/MTCD/publications/PDF/te_1532_web.pdf

[45] Further information is available on international dry storage technologies. See for example:
- Nexia Solutions report for NDA 'International Spent Fuel management Study (Report No (06)7748 Issue 1, 27 October 2006). Presentation available at www.nda.gov.uk;
- JAI Corporation, Shipping and Storage Cask Data – for commercial spent nuclear fuel, JAI Corporation, Fairfax, Virginia. http://www.jaicorp.com/JAI%20publications.htm

a higher heat output and external radiation compared with a fuel assembly discharged from an existing LWR.

47. One of the characteristics of increased burn-up fuel is that the inventory of long-lived radionuclides[46] in the fuel increases. These long-lived radionuclides will decay causing the spent fuel to emit gamma and neutron ionising radiation and, as a consequence, to be thermally hot. Therefore higher burn-up spent fuel will in general require longer periods of cooling in interim storage – this is discussed further below.

48. With regard to external radiation, immediately on discharge from the reactor the heat output and radioactivity of spent fuel is dominated by the presence of short-lived radionuclides. The amounts of short-lived radionuclides produced are independent of fuel burn-up. Therefore in the short-term (up to about one month) there will be no significant difference in heat output and overall radioactivity between fuels discharged from a currently operating LWR (e.g. Sizewell B) and any future new-build LWR.

49. However, in the longer term (beyond one month) as the short-lived radioactivity decays, heat output and radioactivity becomes dominated by decay of longer-lived radionuclides. The concentration of longer-lived radionuclides in general increases with burn-up, the result of which will be increasing heat output, gamma and neutron dose rates. It is calculated that at equivalent cooling times, the neutron dose rate from a fuel assembly irradiated to higher burn-ups will be greater (how much greater is dependent on the level of burn-up) than for a fuel assembly irradiated to burn-ups typical for a currently operating LWR. However, this is not significant for the management of the spent fuel since the total external dose rate from the spent fuel is dominated by the gamma radiation dose and not the neutron dose, which would contribute, at most (e.g. for a burn-up of 60GWd/tU), only 6% to the total external dose rate with the remainder being gamma.

50. As discussed above, as part of the GDA process the disposability of the wastes that are proposed to be produced by new nuclear power stations has been assessed by the NDA. Regulators will scrutinise these assessments. The NDA has reported its findings to the Requesting Parties and has concluded that compared with legacy wastes and existing spent fuel, no new issues arise that challenge the fundamental disposability of the spent fuel expected to arise from operation of the EPR and AP-1000 reactors. This conclusion is supported by the similarity of the wastes to those expected to arise from the existing PWR at Sizewell B. Given a disposal site with suitable characteristics, the spent fuel from the EPR and AP-1000 are expected to be disposable[47].

51. The time that will be required for the safe and secure on-site interim storage of spent fuel prior to disposal is contingent on a number of factors.

52. NDA's disposability assessments also include the finding that if spent fuel is produced at the highest burn-up considered (which is 65 GWd/tU), spent fuel cooling (the combined time in wet and/or dry stores) might be required for a period of up to 100 years before disposal[48].

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[46] A radionuclide is an unstable species of atom that emits ionising radiation when it decays. The rate that a radionuclide decays is inversely related to its half-life, the latter being the time taken for the radionuclide to lose half of its activity by decay.

[47] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.

[48] Summary Disposability Assessment for the AP-1000 page 5. Summary Disposability Assessment for the EPR page 6.

Therefore it is possible that a new nuclear power station's interim storage systems might be needed for 100 years after end of generation, to enable an adequate cooling period for fuel discharged following the end of its operation. This is in addition to the power station's requirements for interim storage of spent fuel and ILW during its operational lifetime. The Requesting Parties' submissions to the regulators as part of the GDA process assume a reactor life of 60 years.

53. Therefore it is possible to envisage a scenario in which on-site interim storage might be required for around 160 years from the start of the power station's operation. However this is based on some conservative assumptions and there are a number of factors that could reduce, or potentially increase (in the event that the power station operates for more than 60 years), the total duration of on-site spent fuel storage.

54. The NDA's finding that up to 100 years' cooling might be required is based on a set of conservative assumptions and these are discussed in the Summary Disposability Assessments. There are a number of factors that may shorten the actual storage period that is likely to be required for spent fuel from new nuclear power stations.

55. Firstly, the storage periods prior to disposal estimated by NDA are not firm requirements. They will depend crucially on the actual level of burn-up achieved. In their calculation, NDA had conservatively assumed that all fuel assemblies had achieved maximum burn-up. In reality fuel assemblies will experience a range of burn-ups with an average considerably lower than the maximum, and lower burn-up fuel will require shorter periods of cooling before reaching a suitable state ready for disposal. For example, NDA's disposability assessment has considered the case where average burn-up is 50 GWd/tU. In this case the estimated cooling period required is 75 years.

56. The actual cooling time required will also depend in practice upon the designs of the disposal package, the final disposal concept and design and its geological setting, which will all offer scope for optimisation and which could shorten the required storage time. As set out in the MRWS White Paper, the NDA will undertake further research during the GDF design process. This will include optimising facility design and delivery[49].

57. Also, the storage period may also be shortened by mitigating actions which could reduce the heat load on each disposal canister. These include putting fewer fuel bundles, or a combination of lower and higher burn-up fuel bundles, in each canister. NDA's disposability assessment has estimated that in the case where three, rather than four, spent fuel bundles of average 50GWd/tU are placed in each disposal canister, the required period of cooling in interim storage is further reduced, to 50 years.

58. Moreover it is not necessarily the case that the whole interim storage period for the spent fuel produced by a new nuclear power station will be on-site. The "Base Case" described in Section 1.2 assumes that spent fuel will be stored on the site of the new nuclear power station until it is disposed of in a GDF[50]. In the absence of any proposals for alternative storage arrangements, the Government is still of the view that interim storage on each site should remain the assumption in the Base Case. However the Government has stated that it does not wish to preclude alternative arrangements, for example an operator with more than one new nuclear power station may prefer to construct a central store for the waste

[49] MRWS White Paper page 30.
[50] FDP Guidance Consultation page 46.

from their fleet, if they can make the case to the regulators that it is safe, secure and environmentally sound[51].

A1.6 Capacity

59. As stated above, PWR spent fuel interim dry storage is an established technology overseas, where cask storage systems have been licensed for the storage of spent fuels from other modern PWRs and boiling water reactors (BWRs).

60. The CASTOR[52] cask system manufactured by GNS is an example which illustrates current capabilities. The CASTOR V/19 cask[53] is licensed to the IAEA Type B (U) standard, meaning that the licence is recognised in all IAEA member states including the UK (for transport). It is licensed to carry 19 fuel assemblies of which four can be in the burn-up range 55-65 GWd/tU. The licence permits storage and transport (see discussion below on transport). A modified design that can carry all assemblies at 65 GWd/tU is currently going through the licensing process[54]. As of April 2009 there are 164 casks being used to store spent fuel in Germany[55].

61. Similar capabilities exist in the US with the HI-STORM 100 system which is licensed for storage of fuel with maximum 68 GWd/tU burn-up[56]. The Magnastor[57] system developed by NAC International is on the US Nuclear Regulatory Commission's list of approved spent fuel storage casks[58]. The Magnastor concept has an expanded fuel parameter coverage, including burn-ups to 70 GWd/tU[59].

62. The US Nuclear Regulatory Commission reported in 2002 that around 160,000 spent fuel assemblies, containing 45,000 tonnes of spent fuel from nuclear power stations, were in storage in the USA. The vast majority of these assemblies were stored in water pools, with around 5% stored in dry casks[60]. For new build waste in the UK the provision of stores would be the responsibility of the operator of the nuclear power station.

A2 Spent fuel – transport

A2.1 Policy framework

63. The Nuclear White Paper set out the Government's view, which is that the risks of transporting nuclear materials are very small and there is an effective regulatory framework in place that ensures that these risks are minimised and sensibly managed by industry[61].

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[51] Government Response to the consultation on draft FDP guidance, paragraph 2.13. http://www.berr.gov.uk/files/file47629.pdf

[52] CASTOR V19 and V52 developed by GNS Gesellshaft für Nuklear-Service mbH. www.siempelkamp.de/CASTOR-R-Cask-Bodies.804.0.html

[53] GNS Castor V/19 information leaflet No. 3/09.

[54] GNS Information Leaflet BTE1/VH/090555 20/04/2009.

[55] www.bmu.de/files/pdfs/allgemein/application/pdf/3nationaler_bericht_atomenergie_en.pdf

[56] US NRC. Approved Contents and Design Features for the HI-STORM 100 Cask System, Appendix B to COC. www.regulations.gov/fdmspublic/component/main?main=DocumentDetail&o=09000064803d6a2d

[57] www.nacintl.com/Default.aspx?pgid=magnastor

[58] http://www.regulations.gov/search/Regs/home.html#documentDetail?R=0900006480845c61

[59] https://external.nacintl.com/nacintl/newsroom.nsf/7d072075e628a5e185256a6b006cbb48/e08c3e108b7e403885256f030048d064?OpenDocument

[60] www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0216

[61] Nuclear White Paper page 82.

64. The policy for the transportation of radioactive wastes is that the wastes will be transported in accordance with the GB[62] transport legislation for such material, which is based upon international (IAEA) regulations and European Agreements and Directives. The packaging requirements for material containing radionuclides are dependent upon the radionuclide specific activity of the material, its form (solid, liquid or gas) and the total quantity of activity in the consignment.

65. The funding arrangements for the transport of spent fuel produced by new nuclear power stations are covered by the FDP framework described above.

A2.2 Strategic framework

66. It is the Government's strategy to ensure the safe transportation of spent fuel through the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG 2009)[63]. CDG 2009 implements the European Agreements concerning the International Carriage of Dangerous Goods by Road (ADR)[64] and the International Carriage of Dangerous Goods by Rail (RID). As a signatory to the European agreements concerning the ADR and RID, and as a member state of the EU, the UK is committed to harmonisation of national and international regulations as far as possible.

67. CDG 2009 covers all road and rail carriage of dangerous goods, and now includes radioactive substances (Class 7). CDG 2009 cross-refers to ADR to a large extent, and it is ADR that contains the detailed requirements.

68. The GDA disposability assessments referred to earlier have also addressed transport of spent fuel to a future GDF. NDA has concluded that spent fuel from EPR and AP-1000 reactors should in principle be compatible with plans for transport and geological disposal of existing spent fuel[65].

69. Experience in the UK and overseas shows that spent fuel can be, and is currently, transported safely and securely. Within the UK, spent fuel has been safely transported to Sellafield for reprocessing for a number of decades now.

A2.3 Legal framework

70. The requirements for the safe transport of radioactive material by road, rail and sea stem from international agreements and European Directives. These requirements have been implemented in UK legislation setting out what types of transport package are allowed, how much radioactivity they are allowed to contain, and how they should perform against specified tests.

71. There are a large number of national and international requirements to ensure the safe transport of radioactive wastes. The MRWS White Paper[66] highlighted some key relevant UK and international legislation and conventions. These include:

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[62] Legislation in Northern Ireland falls under The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment (Amendment) Regulations (Northern Ireland) 2006. www.opsi.gov.uk/sr/sr2006/20060525.htm.

[63] Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009, radioactive material is Class 7. http://www.opsi.gov.uk/si/si2009/uksi_20091348_en_1. More information can be found in the Carriage of Dangerous Goods Manual at http://www.hse.gov.uk/cdg/manual/index.htm.

[64] The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR). http://www.unece.org/trans/danger/publi/adr/adr2009/09ContentsE.html

[65] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.

[66] MRWS White Paper reference 36 page 83.

- International Atomic Energy Agency (IAEA) TS-R-1 Regulations for the Safe Transport of Radioactive Materials 1996 Edition (Revised) or 1996 Edition (As Amended 2005).

- International Maritime Organisation (IMO) International Maritime Dangerous Goods (IMDG) Code (Amdt 32-04).

- United Nations Economic Commission for Europe (UNECE) European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) 2007 Edition.

- Intergovernmental Organisation for International Carriage by Rail (OTIF) Convention concerning International Carriage by Rail (COTIF) Appendix B. Uniform Rules concerning the Contract for International Carriage of Goods by Rail (CIM) Annex 1 Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) 2007 Edition.

- Council Directive 94/55/EC of 21 November 1994 on the Approximation of the Laws of Member States with regard to the Transport of Dangerous Goods by Road.

- Council Directive 96/49/EC of 23 July 1996 on the Approximation of the Laws of Member States with regard to the Transport of Dangerous Goods by Rail.

- The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG09), SI 2009 No. 1348.

- For British registered ships and all other ships whilst in UK territorial waters, The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997, SI 1997 No 2367; Merchant Shipping Notice No MSN 1791(M), The Carriage of Dangerous Goods and Marine Pollutants in Packaged Form – Amendment 32-04 to the International Maritime Dangerous Goods (IMDG) Code.

72. The above legislation and conventions are subjected to a process of periodic review and revision.

73. Transporters of nuclear material outside of civil licensed nuclear sites also have to be approved by OCNS and transport security plans are required to be in place before the transport of certain nuclear materials can take place. The OCNS is the security regulator for the UK's civil nuclear industry. OCNS conducts its regulatory activities under the authority of the Nuclear Industries Security Regulations 2003 (NISR 2003)[67].

A2.4 Regulatory framework

74. Regulation of the safety of radioactive material transport by road, rail and sea in Great Britain is carried out by DfT, HSE, the Office of Rail Regulation (ORR) and the Maritime and Coastguard Agency (MCA). The DfT exercises its statutory powers of enforcement on behalf of the Secretary of State for Transport.

75. The proposals to re-structure HSE's Nuclear Directorate, described in section A1.4 above, include a proposal to transfer certain regulatory functions in relation to the transport of radioactive material from DfT to an independent, sector-specific regulator under the auspices of HSE[68]. The regulatory functions affected would be those in relation to the

[67] The Nuclear Industries Security Regulations 2003. http://www.opsi.gov.uk/si/si2003/20030403.htm#16
[68] http://decc.gov.uk/en/content/cms/consultations/hse_restruct/hse_restruct.aspx

safety of the transport of radioactive material (including nuclear material), and in relation to the security of the transport of non-nuclear[69] radioactive material, in each case by road and rail. The proposals only address the governance and organisational aspects of nuclear regulation, and do not amend the requirements and standards with which duty holders must comply.

A2.5 Technology

76. Spent fuel from new nuclear power stations will be transported in a shielded transport flask designed to reduce external dose rates to low levels[70] and to provide containment of radioactivity both during normal transport conditions and conditions representing transport accidents involving fire and impact. This is the case with spent fuel from existing nuclear power stations.

77. The UK has decades of experience of transporting spent fuel in a safe and secure fashion. There has never been an incident involving radiological release from a UK transport of spent fuel[71].

78. Flasks used to transport spent fuel are required to be designed to meet the stringent standards defined by the IAEA Transport Regulations[72] and as set out in UK transport legislation[73]. Several flasks suitable for transport of spent fuel are in existence (see Section A2.6).

79. Before spent fuel can be accepted for disposal at a GDF it will need to be loaded and sealed inside a purpose-designed and robust disposal container (see later discussion on disposal at Section A3.5). There are two basic options for this packaging operation (sometimes for spent fuel referred to as "encapsulation"):

- packaging into disposal containers at the nuclear power station site;
- packaging into disposal containers at a central location, such as at the GDF.

80. There are therefore two options for transport to be considered:

(i) Transport of spent fuel packaged in disposal containers.
In this option the packaging process occurs at the nuclear power station site and the transport flask has to accommodate the fuel packaged in the sealed disposal container. The current reference disposal concept (see discussion on disposal in Section 3.5) envisages that the disposal container will be sized to accommodate four fuel assemblies and be manufactured from iron, steel, copper or other durable material. The concept design of a flask for this option has been developed by NDA Radioactive Waste Management Directorate (RWMD). This is discussed further in Section A2.6.

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[69] Regulation of the security of sensitive nuclear materials in transit by road and rail throughout the UK (and worldwide when carried on UK-flagged vessels) is carried out by OCNS, which is already part of the Nuclear Directorate.
[70] Dose rate limits are prescribed in the transport regulations. See International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standard TS-R-1. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1225_web.pdf
[71] HPA-RPD-056 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK 2008 Review. http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1248766807377
[72] International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standard TS-R-1. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1225_web.pdf
[73] Department for Transport www.dft.gov.uk/pgr/freight/dgt1/ A bibliography covering the Transport of Radioactive Materials can be found at the Society for Radiological Protection website www.srp-uk.org/biblio9.html

(ii) Transport of spent fuel not packaged for disposal.
In this option the packaging process occurs on receipt at a central location and the transport flask has to accommodate fuel in the non-packaged form, similar to current UK and overseas practice. In this case there already exist transport flasks that would meet this need, although there may be benefit in developing new purpose designed flasks that can be accommodated with more flexibility within the existing UK transport infrastructure. This is discussed further in Section A2.6.

A2.6 Capacity

81. Various designs of transport flask already exist that can meet the needs of Option (ii). For instance CASTOR V/19[74] can carry 19 fuel assemblies in total, of which four are permitted in the range 55-65 GWd/tU. The flask design can accommodate a total heat load of 39kW. This flask design is currently being updated so that it can carry all fuel at a maximum of 65 GWd/tU. Other licensed designs include TN24E and Excellox6[75]. The capability and technology to transport the spent fuel, and the capacity to further develop this capability, already exist.

82. Depending upon the eventual location of a GDF, there may be benefits in purpose-designed transport flasks that are lighter and which have the flexibility to be shipped within the constraints of the UK “standard” transport infrastructure. NDA RWMD has developed concept designs for such flasks to provide a planning basis in the event that this approach is seen to be advantageous[76].

83. In the case of Option (i), a flask capable of carrying a spent fuel disposal package does not yet exist as there has been no need to construct one to date. However NDA RWMD has developed a design concept that could meet this need[77]. The Disposal Canister Transport Container would be similar to one of the already licensed flasks described but designed to accommodate a disposal container containing four fuel assemblies. Shielding to reduce gamma and neutron dose would be provided, and the flasks would be designed to meet safety criteria defined in international regulations.

84. In respect of external dose rate, the encapsulation, transport and emplacement of high burn-up spent fuel is feasible using existing technology. The relevant IAEA dose rate limits for transport can be met after a period of interim storage by providing a combination of a 14 cm thick stainless steel gamma shield surrounded by a 5 cm thick neutron shield. Shield configurations based on these principles will be deployed in returning vitrified HLW from the UK to overseas fuel reprocessing customers. This HLW already has a much higher neutron dose rate than that calculated for any proposed new build spent fuel.

85. Prior to the use of any new flask design, the transportation operator will need to formally submit transport flask design safety cases to demonstrate to the regulator (currently DfT) that the flask will meet the transport regulatory safety requirements and obtain a certificate of approval from the regulator before the spent fuel is transported off the nuclear licensed site where it is stored.

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[74] CASTOR V19 and V52 developed by GNS Gesellshaft für Nuklear-Service mbH. www.siempelkamp.de/CASTOR-R-Cask-Bodies.804.0.html
[75] Operation and Maintenance of Spent Fuel Storage and Transportation Casks/Containers. IAEA-TECDOC-1532. http://www-pub.iaea.org/MTCD/publications/PDF/te_1532_web.pdf
[76] Nirex, Outline Design of a Transport System for High Level Waste and Spent Fuel, Technical Note No. 482783, August 2007.
[77] RMC Areva, Study of the Transport of UK High Level Waste and Spent Fuel, Report for NDA, Report No. R08-099 Issue A, August 2008.

A3 Spent fuel – disposal

A3.1 Policy framework

86. In October 2006, following recommendations made by CoRWM, the UK Government and the Devolved Administrations published a response[78] accepting CoRWM's recommendations that geological disposal, preceded by safe and secure interim storage, was the best available approach for the long-term management of existing and committed higher activity radioactive wastes. The response made a commitment to consult on a framework for implementing geological disposal as the next stage of the MRWS programme. The consultation was carried out in 2007. The MRWS White Paper, published in June 2008, then set out the Government's framework for implementing this policy.

87. With regard to waste from new nuclear power stations, the 2008 Nuclear White Paper set out the Government's view that "it is technically possible to dispose of new higher-activity radioactive waste in a GDF and that this would be a viable solution and the right approach for managing waste from any new nuclear power stations. The Government considers that it would be technically possible and desirable to dispose of both new and legacy waste in the same geological disposal facilities and that this should be explored through the MRWS Programme"[79].

88. The disposability assessments undertaken by NDA to inform the Requesting Parties' GDA submissions support that conclusion and have concluded that compared with legacy wastes and existing spent fuel, no new issues arise that challenge the fundamental disposability of the spent fuel expected to arise from operation of the EPR and AP-1000 reactors. This conclusion is supported by the similarity of the wastes to those expected to arise from the existing PWR at Sizewell B. Given a disposal site with suitable characteristics, the spent fuel from the EPR and AP-1000 is expected to be disposable[80].

89. The Nuclear White Paper also concluded[81] that any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should proceed on that basis. This means that the spent fuel from new nuclear power stations would be treated as waste and disposed of in a GDF.

90. The MRWS White Paper said that it would be possible to build more than one GDF and this could be necessary if the geology at potential sites was not suitable for a "co-located" GDF (i.e. a GDF containing all higher activity wastes). However, the MRWS White Paper also stated that in principle the UK Government sees no case for having separate facilities if one facility can be developed to provide suitable safe containment for the Baseline Inventory[82]. This will be explored through the MRWS process of site selection, through detailed site investigations and through ongoing research and development into disposal concepts.

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[78] UK Government and the devolved administrations, "Response to the Report and Recommendations from the Committee on Radioactive Waste Management (CoRWM)" (PB 12303) October 2006. http://mrws.decc.gov.uk/en/mrws/cms/Home/What_is_the_Go/What_is_the_Go.aspx

[79] Nuclear White Paper page 99.

[80] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.

[81] Nuclear White Paper page 116.

[82] MRWS White Paper page 29.

91. With regard to the disposal of new build wastes, the Nuclear White Paper said that the size of any programme of new nuclear power stations will have an impact on whether all of the new waste could be disposed of in the same GDF as legacy waste[83]. The Consultation on the Future of Nuclear Power contained some figures on the impact of a new build programme on the "footprint" of geological disposal facilities. In relation to spent fuel, it was estimated that a new build programme equivalent to 10 AP-1000s could increase the footprint of a dedicated HLW/spent fuel GDF by about 90%[84]. The latest estimates of the quantities of spent fuel produced by new nuclear power stations, as set out above, are that the spent fuel expected to be generated by a 10GW programme is estimated to increase the total area required for the disposal of HLW/spent fuel by around 50-55%.

92. Further, the MRWS White Paper noted[85] that whilst Government policy is to pursue the geological disposal of higher activity radioactive waste, Government recognises the need to take account of developments in storage and disposal options, as well as possible new technologies and solutions. Further research and development may identify new options for dealing with some wastes, which under application of the waste hierarchy[86] could reduce the amounts of waste requiring disposal.

93. The funding arrangements for disposal of spent fuel are covered by the FDP framework described above and operators will be required to make provision for the costs of waste disposal as part of their FDP. The FDP consultation set out the Government's policy to set a fixed unit price for operators of new nuclear power stations for disposal of ILW and spent fuel and a schedule for the Government to take title to, and liability for, these materials[87].

94. In the Nuclear White Paper, Government said that potential investors in new nuclear power stations need clarity on the maximum amount that they would be expected to pay for the Government to take responsibility for their future waste in a GDF[88]. This cost certainty would enable them to take investment decisions and seek financing. Energy companies have indicated that they would be prepared to pay a significant risk premium over and above the expected costs of disposing of ILW and spent fuel, in return for having the certainty of a fixed upper price.

95. The Government expects to set a fixed price per unit of ILW or spent fuel for disposal, to ensure that the total amount that operators pay is relative to the amount of ILW or spent fuel they produce. This price will be set at a level over and above expected costs and will include a significant risk premium. This risk premium should help to ensure that the operator bears the risks around uncertainty in waste costs and will provide the taxpayer with material protection against the eventuality that the actual costs of geological disposal exceed the projected costs. Should the actual costs of providing the waste disposal service prove to be lower than expected, these lower costs will not be passed on to nuclear operators, who would have gained from certainty of a fixed price and would not have been exposed to the risk of price escalation.

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[83] Nuclear White Paper page 93.
[84] The Future of Nuclear Power page 135. http://www.berr.gov.uk/files/file39197.pdf
[85] MRWS White Paper page 31.
[86] This is the use of a hierarchical approach to minimise the amounts of waste requiring disposal. The hierarchy consists of: non-creation where practicable; minimisation of arisings where the creation of waste in unavoidable; recycling and reuse; and, only then, disposal.
[87] FDP Guidance Consultation, Section 2.
[88] Nuclear White Paper page 152.

96. The implications of the size of the new build programme on the costs of geological disposal, and hence the level of the fixed unit price that the Government will provide operators of new nuclear power stations for the disposal of their ILW and spent fuel, has been considered in a series of pre-consultation discussion papers that DECC has published on a methodology to set a fixed unit price for the disposal of ILW and spent fuel[89].

A3.2 Strategic framework

97. As set out in the MRWS White Paper, the Government's response to CoRWM in October 2006 gave responsibility for planning and implementing geological disposal to the NDA, so as to enable the NDA to take an integrated view across the waste management chain, with both long and short term issues addressed in planning and strategy development[90]. Since then NDA RWMD has been established, incorporating resources from the former United Kingdom Nirex Ltd, which will develop into an effective delivery organisation to implement geological disposal.

98. It is envisaged that RWMD will evolve under the NDA into the 'NDA's delivery organisation' for the GDF. This organisation will be responsible for the delivery of a GDF and in due course its management can be opened up to competition in line with other NDA sites.

99. The MRWS White Paper also said that implementation of geological disposal will be undertaken on a staged basis, with clear decision points allowing progress to be reviewed, including assessment of safety, environmental and sustainability impacts, costs, affordability and value for money[91]. In this way Government will ensure that delivery is achieved in a robust fashion with proper processes being adhered to.

100. Operators will be required by the regulators to confirm that the specific wastes identified to be produced could be placed in a GDF in line with requirements for safety, security and environmental protection. The operators' submissions will be underpinned by advice from NDA based on their assessment of the disposability of the wastes that are proposed to be produced. NDA has carried out initial assessments on behalf of Requesting Parties that will be considered as part of the GDA process. In the future when reactor site-specific consideration is given to waste management, a Radioactive Waste Management Case[92] will be required and detailed consideration of waste disposability will be addressed by NDA through the established Letter of Compliance assessment process[93]. In cases where NDA has concluded that the proposed waste package is compliant with geological disposal and underpinning assessments, NDA will confirm this by the issue of a Letter of Compliance. The independent regulators will scrutinise the operators' and NDA's assessments.

101. The NDA has reported the findings of its disposability assessments to the Requesting Parties. As set out above NDA has concluded that compared with legacy wastes and existing spent fuel, no new issues arise that challenge the fundamental disposability of the spent fuel expected to arise from operation of the EPR and AP-1000 reactors. This

[89] See in particular pages 14-16 in Discussion Paper 2. The three Discussion Papers are available at http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/new/waste_costs/waste_costs.aspx
[90] MRWS White Paper page 34.
[91] MRWS White Paper page 10.
[92] HSE, Environment Agency, SEPA, The management of higher activity radioactive waste on nuclear licensed sites. Part 1. The regulatory process, December 2007.
[93] The Letter of Compliance assessment process was established in the late 1980s to give confidence to site operators, regulators and stakeholders, that wastes being conditioned into passively safe forms would also be compatible with plans for the development of a GDF. www.nda.gov.uk/documents/upload/WNM-PP-011-Letters-of-Compliance-LoC-Assessment-Process-1-January-2008.pdf.

conclusion is supported by the similarity of the wastes to those expected to arise from the existing PWR at Sizewell B. Given a disposal site with suitable characteristics, the spent fuel from both the EPR and AP-1000 is expected to be disposable[94].

102. The MRWS White Paper confirms Government's commitment to a staged decision-making process for the implementation of geological disposal. Site selection is to be taken forward through voluntarism and partnership with potential host communities to share knowledge and address any local concerns openly and transparently. The MRWS White Paper sets out the Government's framework to take this forward in practice.

103. The site selection process described in the MRWS White Paper will take a number of years to complete, due to the need for extensive technical investigations at any prospective site and the need to move at a pace consistent with maintaining public confidence. However, the voluntarism process being applied draws on the most advanced programmes overseas, for example Finland, Sweden and France, which are all moving towards construction of a disposal facility through undertaking underground work now. The process being followed under the MRWS programme draws lessons from these overseas successes and also from less successful processes at home and abroad, such as earlier efforts to identify a UK site for geological disposal, which did not engender public trust, and efforts to site a US facility at Yucca Mountain. The process seeks to emulate international best practice by having a partnership approach based on working together with interested communities through open discussion and shared understanding of the issues.

104. The 2008 MRWS White Paper sets out the details of the voluntarist process that was developed following CoRWM's original work and further public consultation by Government. In the year following publication of the White Paper a number of local authorities have taken the first steps in the process (known as "Expressions of Interest") and the Government has started working with them. At the time of writing two Borough Councils, Copeland and Allerdale in West Cumbria, have made "Expressions of Interest" in the MRWS site selection process. In addition Cumbria County Council has made an expression of interest covering the areas of Copeland and Allerdale, which lie within Cumbria County. These three Councils are now working together in partnership to take forward this process.

105. Government continues to discuss the possibilities of involvement in the MRWS programme with local authorities in England and Wales and remains open to further expressions of interest. It is an early stage in this process but orderly progress is being made. The timescales for implementing geological disposal are long and the process set out in the MRWS White Paper is designed to be flexible enough to accommodate local needs and future developments over many years.

106. The Government is committed to making the voluntarist and partnership approach to site selection work through the MRWS process. However, in the MRWS White Paper the Government also stated that "in the event that at some point in the future, voluntarism and partnership does not look likely to work, Government reserves the right to explore other approaches"[95]. The Government recognises it has a responsibility to deal with long-term higher activity waste management and is committed to geological disposal as the technical solution; such that it will seek to develop alternative ways to implement that solution if the

[94] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.

[95] MRWS White Paper page 47.

current framework, as set out in the MRWS White Paper, ultimately proves to be unsuccessful in the UK.

107. In taking forward the implementation of geological disposal the NDA is continuing to update its programme and develop the necessary technological and stakeholder engagement base that underpins it. RWMD's research and development strategy[96] and NDA's public and stakeholder engagement and communications framework for geological disposal[97] were both completed in 2008. In the period 2009/2010 RWMD is planning to publish further materials on a wide range of key topics such as its plans for implementing geological disposal, the updated research and development strategy, the approach to environmental and sustainability appraisal as well as the first version of a safety case for the overall geological disposal concept.

108. CoRWM has a continuing role to provide independent scrutiny and advice on the long-term management, including storage and disposal, of radioactive waste. CoRWM's primary task is to provide independent scrutiny on the Government's and NDA's proposals, plans and programmes to deliver geological disposal, together with robust interim storage, as the long term management option for the UK's higher activity wastes. CoRWM was reconstituted following the publication of their original 2006 report with new Terms of Reference[98] and new membership recruited to give them the skills, experience and expertise necessary to provide this effective scrutiny.

109. The restructuring of CoRWM was completed in May 2008. The Committee has already submitted its first substantive report to Government, on Interim Storage[99], and Government has responded[100]. CoRWM has also submitted its reports on geological disposal[101] and on research and development[102].

A3.3 Legal framework

110. The MRWS White Paper addressed the legal framework for geological disposal[103]. It described the relevant UK and international legislation and conventions and stated that the Government does not consider that bespoke legislation is required for implementation of geological disposal but it will keep this under review.

111. The MRWS White Paper also said that the NDA's delivery organisation for a GDF will meet all relevant regulatory requirements[104]. It will be the responsibility of the delivery organisation to ensure that its programme is appropriately coordinated as part of a staged application and approval process to ensure that permissions are obtained in the right order. A GDF will comply fully with the requirements of the independent regulators, who will work closely together.

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[96] http://www.nda.gov.uk/documents/upload/Draft-NDA-RWMD-Proposed-Research-and-Development-Strategy-May-2008.pdf

[97] http://www.nda.gov.uk/documents/upload/NDA-Consultation-on-a-Public-and-Stakeholder-Engagement-and-Communications-Framework-for-Geological-Disposal-August-2008.pdf

[98] CoRWM's terms of reference: http://www.corwm.org.uk/Pages/Lnk_pages/about_us.aspx

[99] http://www.corwm.org.uk/Pages/Involving%20People/Forms/DispForm.aspx?ID=16

[100] http://www.corwm.org.uk/Pages/Plenary%20Meetings/2632%20-%20Governments%20Response%20to%20CoRWM's%20Interim%20Storage%20Report%20-%20FINALpdf.pdf

[101] http://www.corwm.org.uk/Pages/Current%20Publications/2550%20CoRWM%20Report%20on%20Geological%20Disposal%20Final%2031%20July%2009.pdf

[102] http://www.corwm.org.uk/Pages/Current%20Publications/2543%20CoRWM%20Report%20on%20RD%20Final%2030%20October%202009.pdf

[103] MRWS White Paper page 38.

[104] MRWS White Paper page 38.

A3.4 Regulatory framework

112. The MRWS White Paper sets out the Government's commitment to strong and effective control and regulation of the GDF development process and described how it will be enforced[105]. The NDA and its delivery organisation will be subject to the appropriate regulatory and planning processes. Government will look to early and continued involvement of the regulators, who will make clear their regulatory requirements to the NDA's delivery organisation at an early stage. Regulatory processes for granting any necessary licences or authorisations will provide opportunity for input and assessment of public and stakeholder views.

113. The MRWS White Paper stated that the development of a GDF will be subject to staged authorisation by the environmental regulator[106]. The existing provisions in section 13 of the Radioactive Substances Act 1993[107] do not expressly deal with staged permitting, therefore the Government intends, through the second phase of the Environmental Permitting Programme (EPP2), to introduce legislation that provides for a staged regulation process.

114. Through the proposals set out in the EPP2 Consultation[108] the Government proposed that permitting for the disposal of solid radioactive waste under the Environmental Permitting (EP) Regulations makes clear that early environmental regulatory control is required for relevant stages of the development of a GDF. This would be achieved by providing for permitting of the activities that precede disposal as well as regulating that disposal. The responses to the consultation presented no new arguments against staged regulation for deep geological disposal, and the Government has consulted on its implementation of the proposed new guidance to support Regulations[109]. Following this consultation, EPP2 Regulations would come into force at the earliest on the common commencement date in April 2010.

115. The MRWS White Paper[110] also stated that a GDF will require a licence under the Nuclear Installations Act 1965, and recognises that this may require legislative change. Other facilities specifically for disposal are also in prospect. Action is required to take forward legislative change to implement the Government's expectation of licensing for a GDF and to clarify the position for any other planned disposal facilities. Work is in hand to develop the required legislation in the form of a modification to the Nuclear Installations Regulations 1971.

116. NDA has an agreement with regulators for RWMD to move to "Prospective Site Licence Company (SLC)" status by the end of 2009. The Prospective SLC will embody the culture, and demonstrate the competences, of a company that is intended at some point in the future to hold an environmental permit/authorisation and a nuclear site licence including having an independent assurance function. Early establishment of these features will give the regulators confidence in RWMD's ability to apply for and receive regulatory consents and also give confidence in the underpinning technical work.

117. The MRWS White Paper also said that the environment agencies will be providing updated guidance on the requirements for authorisation of geological disposal facilities, and in

[105] MRWS White Paper page 36.
[106] MRWS White Paper page 39.
[107] Radioactive Substances Act 1993. www.opsi.gov.uk/acts/acts1993/ukpga_19930012_en_1
[108] The Second Phase Environmental Permitting Programme Consultation ran for 12 weeks and closed on 11 May 2009. http://www.defra.gov.uk/corporate/consult/env-permitting/index.htm
[109] http://www.defra.gov.uk/environment/policy/permits/index.htm
[110] MRWS White Paper, paragraphs 5.10 – 5.12.

February 2009 the Environment Agency and the Northern Ireland Environment Agency published detailed guidance, "Geological Disposal Facilities on Land for Solid Radioactive Wastes. Guidance on Requirements for Authorisation"[111].

118. Civil nuclear installations must have a site-specific security plan approved by the OCNS, and any proposed changes to security plans must also be approved in advance by OCNS. Nuclear safeguards are international measures that assure individual states comply with their international obligations not to use civil nuclear materials (plutonium, uranium and thorium) for nuclear explosives purposes. Information on the basic design and operation of a new GDF must be provided to the Safeguards Inspectorate of the European Commission. This information provides a basis for agreement with the Safeguards Inspectorate on safeguard arrangements to be applied to the facility.

119. Once a GDF has been filled with waste, a process which could take many decades, the shafts and tunnels can be backfilled and sealed and the surface facilities dismantled or used for something else. There will then follow a period of post-closure institutional control and monitoring in accordance with regulatory requirements.

A3.5 Technology

120. A number of geological disposal concepts, based on the use of multiple containment barriers, have been shown to be capable of meeting high standards of safety and security, as required in the UK[112]. Although no spent fuel GDF is in operation currently, programmes in Finland[113] and Sweden[114] are well advanced, aiming for each of these countries to have such a facility operational by about 2020, following underground research that is already being undertaken. Sweden has now identified a site at Forsmark, following extensive research in the Äspö underground rock laboratory and a lengthy site selection process, and will be submitting applications for permits, including an environmental impact assessment and safety analysis, in 2010. The facility is planned to be ready for operations by 2023[115].

121. STUK, the Finnish Radiation and Nuclear Safety Authority, presented their preliminary safety assessment for the expansion of the Finnish disposal facility to accept spent fuel from a new nuclear power station in June 2009[116]. STUK did not identify any reason why the project couldn't move forward. The application process for the decision-in-principle will proceed for the Finnish Government to make its decision and then for Parliament to ratify it. This follows an earlier Preliminary Safety Assessment[117] carried out by STUK in 2001 for new nuclear power in Finland. That Safety Assessment found that "In principle, the intended final disposal repository can be extended to hold also the spent nuclear fuel from the new nuclear power plant, but in this case it has to be ensured that the extension is

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[111] http://publications.environment-agency.gov.uk/pdf/GEHO0209BPJM-e-e.pdf

[112] The OECD Nuclear Energy Agency, taking inputs from policy-makers, regulators and waste management organisations, has published a statement that geological disposal provides an acceptable and technologically feasible method for the long-term management of long-lived high-activity wastes such as spent fuel. www.nea.fr/html/rwm/reports/2008/nea6433-statement.pdf

[113] www.nea.fr/html/rwm/profiles/Finland.pdf

[114] www.nea.fr/html/rwm/profiles/Sweden_profile_web.pdf

[115] http://www.skb.se/default____24417.aspx

[116] Application for the Decision-in-Principle on the Final Disposal of the Spent Nuclear Fuel from Olkiluoto 4. Posiva Oy. June 2009. http://www.posiva.fi/en/nuclear_waste_management/required_permissions_and_procedures/decision-in-principle/application_for_the_decision-in-principle_on_the_final_disposal_of_the_spent_nuclear_fuel_from_olkiluoto_4

[117] Preliminary safety assessment of the new nuclear power plant project. STUK, February 2001. http://www.stuk.fi/ydinturvallisuus/ydinvoimalaitokset/ydinvoimalaitosluvat/viides/en_GB/safety_judgement/_files/12222632510025726/default/alustava_turvallisuusarvio_0702en.pdf

carried out inside a geologically intact rock area. STUK has assessed the extended final underground repository facility in the preliminary safety assessment given by it, and has not identified any matters which would prevent the extension".

122. In planning the implementation of the national policy of geological disposal, the NDA has assessed that a UK facility could be operational for the disposal of legacy ILW by about 2040, with legacy HLW/spent fuel emplacement beginning around 2075, consistent with the principles laid down in the Government's MRWS programme[118]. Disposal of legacy waste is estimated to be completed by about 2130 and it is currently anticipated that disposal of new build wastes would begin once disposal of legacy wastes is completed (though it might be possible to dispose of new build ILW somewhat earlier). These proposals would be scrutinised by the regulators who would seek that the programme for disposals is optimised overall.

123. The technology identified in disposal concepts that would be suitable for spent fuel from new nuclear power stations is already available in terms of engineered barrier designs and materials[119]. Therefore the technology is expected to be available in an appropriate timeframe to be applied at a suitable site that becomes available through the site selection process described above and in the MRWS White Paper.

124. The UK does not present special geological difficulties that would make successful implementation unlikely on a technological basis. The British Geological Survey (BGS) undertook a review[120] in support of the activities of the original CoRWM that concluded that at least 30% of the UK land mass has suitable geology for siting a deep geological disposal facility"[121]. Similar support to CoRWM was provided by the Geological Society[122] [123]. Furthermore CoRWM found that "there is high confidence in the scientific community that there are areas of the UK where the geology and hydrogeology at 200 metres or more below ground will be stable for a million years and more into the future"[124]. A 2008 report on geological disposal[125] carried out for the NDA found that there is a wide range of geological environments that could be suitable for hosting a GDF for higher activity waste in the UK; and that a wide range of engineering solutions is available.

125. Spent fuel from new nuclear power stations will contain a similar range of radionuclides to that found in the spent fuel of current designs of LWRs and, when compared on the basis of equivalent power production, will also contain similar levels of inventory. This is particularly

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[118] "GDF PIP presentation to CoRWM 17_9_08 issue 1", available at http://www.corwm.org.uk/Pages/Plenary%20Meetings/Forms/Meetings.aspx

[119] Posiva Oy (Finland) Environmental Impact Assessment Report: Expansion of the Repository for Spent Fuel, 2008. www.posiva.fi/en/nuclear_waste_management/required_permissions_and_procedures/environmental_impact_assessment_procedure

[120] BGS and Nirex, A note by the British Geological Survey and Nirex on the Suitability of UK Geology for Siting a Repository for Radioactive Waste, CoRWM document 1797, March 2006.

[121] UK Nirex Ltd and British Geological Survey, "A note by the British Geological Survey and Nirex on the Suitability of UK Geology for Siting a Repository for Radioactive Waste", document 1797, March 2006.

[122] Geological Society, Geoscience Verdict on Radioactive Waste Disposal, News release PR26/99, 1999 (CoRWM document 2026)

[123] Geological Society, Confidence in the Safe Geological Disposal of Radioactive Waste, 2006, (CoRWM Document 2027).. http://www.geolsoc.org.uk/gsl/site/GSL/lang/en/rwd

[124] CoRWM Report: Recommendations to Government. Page 106, paragraph 28. http://www.corwm.org.uk/Pages/Current%20Publications/700%20-%20CoRWM%20July%202006%20Recommendations%20to%20Government.pdf

[125] www.nda.gov.uk/documents/upload/Geological-Disposal-Options-for-High-Level-Waste-and-Spent-Fuel-January-2008.pdf

the case for the longer-lived radionuclides that are most significant for the long-term safety of disposal and whose behaviour has been extensively researched over the past three decades[126]. The higher burn-up of the fuel from new nuclear power stations compared to those in operation in the UK today will mean that there will be comparatively fewer spent fuel assemblies to be managed but the heat output and external radiation dose rate will decay more slowly due to the influence of longer-lived radionuclides compared with fuel assemblies discharged from existing LWRs.

126. In respect of external dose rate, the encapsulation, transport and emplacement of high burn-up spent fuel can be shown to be feasible using existing technology. In particular, the relevant IAEA dose rate limits for transport can be met after interim storage by providing a combination of a 14 cm thick stainless steel gamma shield surrounded by a 5 cm thick neutron shield. Shield configurations based on these principles will be deployed in returning vitrified HLW from the UK to overseas fuel reprocessing customers. This HLW already has a much higher neutron dose rate than that calculated for any proposed new build spent fuel. Well-established methods exist for developing potential disposal facility designs to take account of heat generated by such wastes and the external radiation dose rate is less than that from materials such as vitrified HLW which are already managed safely under existing arrangements through storage awaiting final disposal at a GDF.

127. It also follows that there will be higher concentrations of radionuclides in an individual fuel assembly than was the case in the previously studied LWR systems. Observations on changes in the physical structure of spent uranium oxide fuels as a function of burn-up also lead to the conclusion that the releasability of some mobile radionuclides (e.g. iodine-129) is likely to increase as a function of burn-up and should be taken into account when developing a disposal facility safety case[127].

128. The specific technological challenges presented by spent fuel from new nuclear power stations have been examined by Posiva in Finland in the context of an Environmental Impact Assessment for the extension of its spent fuel GDF to accept fuel discharged from the EPR-type reactor under construction and planned at Olkiluoto[128]. The assessments carried out show that the technology is available to provide suitable shielding to enable safe handling of high burn-up spent fuel. They also show that existing engineered barrier technologies, as envisaged for the spent fuel from currently operating nuclear power stations, can be applied to the safe disposal of high burn-up fuel. In particular they show that, under the conditions relevant to the Finnish GDF, the long-term safety of the facility is robust to an extreme scenario of simultaneous failure of all disposal containers and instantaneous release of all the readily releasable radionuclides in the spent fuel.

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[126] SAM Ltd, The International RD&D Basis for Geological Repositories, SAM report to Nirex, J112-R1, 2006.

[127] Nagra (Switzerland), Spent Fuel Evolution under Disposal Conditions – Synthesis of Results from EU Spent Fuel Stability (SFS) Project, A Report of the Spent Fuel Stability Project of the Euratom 5th Framework Programme, Report No. NTB 04-09, 2005.

[128] Posiva Oy (Finland) Environmental Impact Assessment Report: Expansion of the Repository for Spent Fuel, 2008.
www.posiva.fi/en/nuclear_waste_management/required_permissions_and_procedures/environmental_impact_assessment_procedure

129. The OECD Nuclear Energy Agency (NEA) published a statement in 2008[129]: "The overwhelming scientific consensus worldwide is that geological disposal is technically feasible". The NEA further noted that "Releases from engineered barriers would occur over thousands of years after disposal and would be very small. Additionally these releases are diluted and slowed by the geological formation surrounding the repository and are further reduced by radioactive decay. The resulting potential radiological exposure in the biosphere would not represent, at any time, a significant increment above the natural background".

A3.6 Capacity

130. **Disposal containers:** A range of disposal container designs and materials are envisaged in the disposal concepts that have been developed and assessed internationally. In all cases a metallic container is envisaged, but there is a sub-division into concepts that rely on a highly corrosion-resistant metal (e.g. copper) or alloy (e.g. nickel-based Alloy-22) or a thick-walled, "sacrificial" container that will take a long time to corrode through, typically carbon steel[130]. The ability to fabricate these containers to the required quality standards has been demonstrated by a number of programmes and in many cases uses technological capacity provided by UK suppliers (e.g. The Welding Institute developed "friction stir welding", the Swedish preferred method to seal copper containers for spent fuel) or that is available in the UK (e.g. metallurgical drawing of copper containers)[131]. The materials used in the manufacture of the various proposed container designs are routinely used in other industrial applications in the UK. Assessment of continuity of supply is a well-established practice when selecting materials for a major project such as a GDF.

131. **Geotechnical engineered barriers:** Buffer material to surround each disposal container, backfill to fill access tunnels and shafts, and high integrity engineered seals to seal off key compartments of a disposal facility are variously envisaged to involve the use of swelling clay (typically bentonite) and concretes (as well as other components such as rock spoil in the case of tunnel backfill). The ability to utilise these various barriers has been demonstrated in various underground research facilities and the engineering methods used are documented[132] [133]. The materials required are readily available[134] [135]. There are known large reserves of bentonite clay in other countries, and internationally research and development has been carried out to show that, in some cases, indigenous clays can satisfy the functional requirements to be met by the bentonite.

132. **Retrievability:** In the MRWS White Paper Government acknowledged that there is a divergence of views on the issue of waste retrievability but on balance considered that CoRWM's conclusion was correct, i.e. that leaving a facility open, for centuries after waste

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[129] OECD Nuclear Energy Agency (NEA), Moving Forward with Geological Disposal of Radioactive Waste, A Collective Statement by the NEA Radioactive Waste Management Committee (RWMC), NEA No. 6433, 2008 http://www.nea.fr/html/rwm/reports/2008/nea6433-statement.pdf

[130] Baldwin, Chapman and Neall, Geological Disposal Options for High Level Waste and Spent Fuel, Report for NDA, January 2008.

[131] SKB (Sweden) Programme for research, development and demonstration. http://www.skb.se/upload/publications/pdf/R&D2007_webb.pdf

[132] SKB (Sweden) Backfilling of KBS-3V Deposition Tunnels – possibilities and limitations. www.skb.se/upload/publications/pdf/R-08-59webb.pdf

[133] SKB (Sweden) Äspö Hard Rock laboratory: Annual report 2007. www.skb.se/upload/publications/pdf/TR-08-10webb.pdf

[134] www.bgs.ac.uk/downloads/start.cfm?id=1408

[135] http://minerals.usgs.gov/minerals/pubs/commodity/clays/190303.pdf

has been deposited, increases the risks disproportionately to any gains[136]. Closure at the earliest opportunity once facility waste operations cease provides greater safety, greater security from terrorist attack, and minimises the burdens of cost, effort and worker radiation dose transferred to future generations. However, there are varying degrees of retrievability, involving different degrees of access to the containers or leaving only particular areas of a facility open, for example. The MRWS White Paper also set out the Government's view, which is that the decision about whether or not to keep a GDF (or vaults within it) open once facility waste operations cease can be made at a later date in discussion with the independent regulators and local communities. In the meantime the planning, design and construction can be carried out in such a way that the option of retrievability is not excluded. Any implications for the packaging of wastes will be kept under review.

133. **Underground construction:** The excavation of access shafts, inclined drifts and tunnels and of disposal tunnels and vaults, as variously envisaged in disposal concepts for a range of potentially suitable geological settings, is within the scope of existing mining and geotechnical engineering activities[137]. Furthermore the capability to excavate openings to the exacting specifications for disposal has been demonstrated in underground research facilities in strong rocks such as granite (e.g. at the Swedish Äspö Hard Rock Laboratory)[138] and weaker sedimentary rocks (e.g. at the French Bure Underground Facility located in mudstones)[139] and in operating geological disposal facilities in salt formations (e.g. the WIPP facility in New Mexico, USA[140]). In particular research and development has been carried out to develop methods of controlled excavation that limit the hydraulic and mechanical disturbance of the surrounding rock and to optimise the method of rock support required to maintain stable openings according to the rock quality and geological conditions.

134. Although all the required technological capabilities are currently available, there has been a marked decline in the number of competent shaft-sinking contractors both in the UK and Europe, matching a decline in mining activity. The developing programme for radioactive waste disposal in Europe and mining activities will help sustain an international skills-base in mining and shaft-sinking. Maintaining close international cooperation with overseas' waste management agencies and with new mining activities, will help the skills-base deliver these activities when required.

135. The MRWS White Paper sets out the Government's preference for a co-located spent fuel/HLW and ILW GDF, should an available site prove suitable for this[141]. This concept would be designed to allow for the appropriate disposal facilities to be provided underground separately for spent fuel/HLW and ILW (and other materials that may eventually be declared as higher activity waste) but for essential infrastructure and services to be shared. For this approach to be confirmed, the following must be achieved:

- The site selection process must deliver a site with suitable characteristics and volumetric capacity sufficient to accommodate the aggregated wastes.

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[136] MRWS White Paper page 28.
[137] Nirex, Large Underground Caverns, Precedent Experience Study: Global Survey. Summary Index of Key Findings, Nirex Report No. 802, 1995.
[138] SKB (Sweden), Choice of Rock Excavation Methods for the Swedish Deep Repository for Spent Nuclear Fuel, Report No R-04-62, 2004. www.skb.se/upload/publications/pdf/R-04-62webb.pdf
[139] Andra (France) Clay in Natural and Engineered Barriers for Radioactive Waste Confinement, Sciences and Technology Series, No.334, The Meuse/Haut Marne Underground research Laboratory: Seven years of Scientific Investigation, J Delay, P L Forbes and J Roman, pp7-21, December 2008.
[140] http://www.wipp.energy.gov/
[141] MRWS White Paper page 29.

- A satisfactory safety case must be developed for the co-located facility. This would need to consider potential interactions between the spent fuel/HLW and ILW facilities. As an example, an ILW disposal concept utilising a high pH “chemical” barrier to promote conditions of low solubility would need to be arranged so that the high alkaline conditions do not adversely interact so as to disrupt the spent fuel/HLW disposal concept which may be designed to rely on a bentonite buffer to protect the disposal packages, as bentonite can be adversely affected by high pH solutions.

136. As the MRWS White Paper states, there is no reason why co-location should not be technically possible. It notes however that research will be required to support the detailed design and safety case and that the final decision would be made in the light of the latest technical and scientific information, international best practice and site specific environmental, safety and security assessments. The MRWS White Paper also states that it would be possible to build more than one GDF, for example one for ILW/LLW and one for HLW/spent fuel (or indeed two facilities that each took some of each waste type). This could be necessary if the geology at potential sites was not suitable for a ‘co-located’ GDF[142].

137. In the MRWS White Paper the Government also recognised the need to take account of developments in storage and disposal options, as well as possible new technologies and solutions. Further research and development (R&D) may identify new options for dealing with some wastes, which under application of the waste hierarchy could reduce the amounts of waste requiring geological disposal. The NDA will also keep options, such as borehole disposal of certain types of waste, under review. As recommended by CoRWM, the MRWS White Paper commits that there will be ongoing research and development to support optimised delivery of the geological disposal programme, and the safe and secure storage of radioactive waste in the interim, and this is being taken forward by NDA through the development of an R&D strategy[143] [144]. CoRWM’s recent R&D Report[145] provided a summary of the many organisations in the UK that are involved in funding and carrying out R&D relevant to the management of higher activity wastes. These include the NDA and its Site Licensed Companies, other nuclear industry organisations (civil and defence), the National Nuclear Laboratory, regulators, Research Councils, universities, and consultants and contractors.

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[142] MRWS White Paper page 29.
[143] www.nda.gov.uk/documents/upload/Draft-NDA-RWMD-Proposed-Research-and-Development-Strategy-May-2008.pdf
[144] www.nda.gov.uk/documents/upload/Research-and-Development-Strategy-to-Underpin-Geological-Disposal-of-the-UK-Higher-Activity-Radioactive-Wastes-March-2009.pdf
[145] CoRWM. Report on National Research and Development for Interim Storage and Geological Disposal of Higher Activity Radioactive Waste, and Management of Nuclear Materials. http://www.corwm.org.uk/default.aspx

B Intermediate Level Waste (ILW)

138. ILW is defined in the UK as waste "with radioactivity levels exceeding the upper boundaries for low-level wastes, but which do not require heating to be taken into account in the design of storage or disposal facilities"[146]. ILW arises mainly from the reprocessing of spent fuel, from general operations and maintenance at nuclear sites and from decommissioning. ILW can include metal items such as fuel cladding and reactor components, and sludges, filters and resins from the treatment of radioactive liquid effluents.

139. ILW needs to be managed and converted into a passively safe form as soon as reasonably practicable and placed into interim storage. Typically in the UK, ILW is packaged for disposal by encapsulation in cement in highly-engineered 500 litre stainless steel drums or in higher capacity steel or concrete boxes.

140. As with spent fuel, there is uncertainty over the quantity of ILW that is expected to be produced by a new nuclear programme. The total quantity of ILW produced by a new nuclear programme will depend on the size of the programme, but is expected to be small in comparison with the volumes of legacy ILW. The 2007 consultation on the Future of Nuclear Power contained estimates that a new build programme equivalent to 10 AP-1000s would increase the quantity of ILW by around 3%[147].

141. More recent work by NDA means it is now possible to update this estimate. NDA has, as part of their disposability assessments to inform the GDA process, which reported its findings to the Requesting Parties, produced estimates for the lifetime ILW arisings for the new nuclear power station designs being assessed in GDA.

142. The volume of packaged ILW (both operational and decommissioning) produced by an EPR operating for 60 years is estimated to be in the range 2097-3651m^3 dependent upon the packaging system used[148]. For an AP-1000 operating for 60 years, the volume of packaged ILW produced is estimated[149] to be around 3450m^3.

143. NDA has considered the potential impact on the size of a GDF of the disposal of ILW from a single new nuclear reactor and from a 10GW new nuclear programme. 10GW equates to 9 AP-1000 reactors or 6 EPR reactors. The volume of ILW for disposal is subject to some variation depending on assumptions regarding packaging and conditioning technologies that might be adopted by future operators, but NDA has concluded that in all cases the necessary increase in the GDF "footprint area" is small.

144. For the AP-1000 the necessary increase in the GDF "footprint area" corresponds to approximately 65m of disposal vault length for each AP-1000. This represents approximately 1% of the area required for the legacy ILW per reactor, and less than 10% for the illustrative fleet of 9 AP-1000 reactors.

145. The findings are similar for the EPR, where NDA has calculated that each EPR would require an additional 60m of disposal vault length, representing approximately 1% of the

[146] MRWS White Paper page 16.
[147] The Future of Nuclear Power page 135.
[148] Summary of Disposability Assessment for the EPR pages 21-22.
[149] Summary of Disposability Assessment for the AP-1000 page 17.

area required for the legacy ILW per reactor, and less than 10% for the illustrative fleet of six EPR reactors.

146. Much of the analysis set out above in relation to the interim storage, transport and disposal of spent fuel applies equally to ILW from new nuclear power stations and for brevity is not repeated in this section, which addresses primarily additional considerations specific to ILW.

B1 ILW interim storage

B1.1 Policy framework

147. The description of the policy framework with regard to the interim storage of spent fuel described in Section A1.1 above applies equally to ILW from new nuclear power stations. Similarly, an operator's FDP must include provision for the costs of providing safe, secure, interim storage for ILW until a GDF is ready to accept their waste.

B1.2 Strategic framework

148. The strategic framework described in Section A1.2 above applies equally to ILW from new nuclear power stations. The GDA and site licensing processes are intended to ensure that operators provide safe, secure interim storage for ILW and therefore licensing consent for a new nuclear power station will not be granted unless the regulators are satisfied with the operator's proposal for interim storage of the ILW that will be produced.

149. The disposability assessments referenced earlier, which have been carried out by NDA to inform the Requesting Parties' GDA submissions, also considered ILW from new nuclear power stations.

150. The NDA's strategy, published in March 2006, made a clear commitment to hazard and environmental risk reduction by ensuring that radioactive waste (whether HLW, ILW or LLW) is managed and converted into a passively safe form as soon as reasonably practicable and placed into interim storage[150]. This will continue to be the preferred strategy for handling ILW that arises in future from new nuclear power stations in line with regulatory requirements.

151. Within its strategy, NDA made a commitment to review interim storage opportunities within the UK. This review has now been completed and incorporated into a wider review of UK radioactive waste storage that was prompted by the original CoRWM report and Government's response to it. The UK Radioactive Higher Activity Waste Storage Review was published in March 2009[151]. It included an assessment of storage regimes for solid ILW (raw and immobilised) across the UK on both NDA and non-NDA sites. It produced a number of findings and potential topics for NDA's future work programme.

152. In March 2009 the reconstituted CoRWM published the first of its formal reports to Government: "Interim Storage of Higher Activity Wastes and the Management of Spent

[150] NDA Strategy 2006. http://www.nda.gov.uk/documents/upload/NDA_Final_Strategy_published_7_April_2006.pdf
[151] UK Radioactive Higher Activity Waste Storage Review. http://www.nda.gov.uk/documents/upload/UK-Radioactive-Higher-Activity-Waste-Storage-Review-March-2009.pdf

Fuels, Plutonium and Uranium"[152] . The Government welcomed the Committee's report and responded on 10 July 2009[153].

B1.3 Legal framework

153. The legal framework described in Section A1.3 above applies equally to ILW from new nuclear power stations.

B1.4 Regulatory framework

154. The regulatory framework described in Section A1.4 above applies equally to ILW from new nuclear power stations. In the specific case of ILW arising from future new nuclear power stations, the regulators' GDA process has been initiated to give confidence that new build reactor designs will be compatible with UK licensing and other requirements. The GDA process is also considering the wastes that will be generated and is addressing whether these will be compatible with existing plans for waste management in the UK, including interim storage, transport to a GDF and ultimate disposal.

B1.5 Technology

155. The philosophy being adopted by the Requesting Parties in the GDA process is that new power station developments will include provision for safe and secure on-site interim storage of "operational" ILW[154 155]. Operational ILW is the term given to those wastes that will arise during the everyday operation of the facility and which fall into the ILW category. Other operational wastes will be categorised as LLW and non-radioactive – these are discussed later. ILW that arises as a result of decommissioning and dismantling of the reactor might not require on-site storage as it could be conditioned and packaged for disposal as it arises.

156. The technology for storing ILW already exists and ILW conditioning and packaging is already being implemented in the UK. As of end-March 2009, some 45,000 ILW waste packages had been manufactured and were in safe and secure interim storage awaiting provision of a GDF[156]. These packages have been assessed through the Letter of Compliance process described above, to give confidence that they not only meet requirements for interim storage but also will be compliant with the needs of transport and disposal. As set out above, NDA has conducted a detailed review of the status of existing storage capacity in the UK for higher activity radioactive waste[157].

157. The ILW that has been packaged in the UK does not yet include ILW from the PWR at Sizewell B. However conditioning and packaging technologies for ILW from PWRs are currently utilised in other countries including USA[158], Finland[159] and Switzerland[160].

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[152] http://www.corwm.org.uk/Pages/Involving%20People/Forms/DispForm.aspx?ID=16
[153] http://www.corwm.org.uk/Pages/Plenary%20Meetings/2632%20-%20Governments%20Response%20to%20CoRWM's%20Interim%20Storage%20Report%20-%20FINALpdf.pdf
[154] http://www.epr-Reactor.co.uk/scripts/ssmod/publigen/content/templates/show.asp?P=139&L=EN
[155] https://www.ukap1000application.com/Reactor.aspx
[156] NDA interactions with Waste Producers on plans for packaging radioactive wastes April 2008 to March 2009, Report no. NDA/RWMD/012, 2009.
[157] NDA, UK Radioactive Higher Activity Waste Storage Review, Issue 1, March 2009. http://www.nda.gov.uk/documents/upload/UK-Radioactive-Higher-Activity-Waste-Storage-Review-March-2009.pdf
[158] www.em.doe.gov/pdfs/3rd%20US%20Rpt%20on%20SNF%20JC--%20COMPLETE%20REPORT%20-%2010%2013%2008.pdf
[159] www.stuk.fi/julkaisut/stuk-b/stuk-b96.pdf
[160] www.nagra.ch/g3.cms/s_page/83280/s_name/wastemanagementtoday

B1.6 Capacity

158. Various treatment technologies that could be used for new build operational ILW are available and already in use[161]. For example:

- Ion exchange resins – drying and loading into disposal container, cementation, thermal destruction and loading residue into disposal container.
- Cartridge filters – cementation and packaging.
- Sludges – drying and loading into disposal container, cementation, thermal destruction and loading residue into disposal container.

159. Decommissioning ILW, which is generally activated steel (for example reactor pressure vessel components), will be size-reduced and loaded into disposal containers. The technology for achieving this is not new and capacity to provide the necessary facilities will be provided with the new nuclear power station. The complete decommissioning of nuclear power stations has already taken place in the USA[162]. In the case of decommissioning wastes there may exist the option to transport the waste off-site to a GDF immediately without the need for on-site interim storage.

B2 ILW transport

B2.1 Policy framework

160. The description of the policy framework with regard to the transport of spent fuel described in Section A2.1 above applies equally to ILW from new nuclear power stations. The funding arrangements for transport of ILW are covered by the FDP framework described above.

B2.2 Strategic framework

161. Similarly, the strategic framework described in Section A2.2 above applies equally to the transport of ILW from new nuclear power stations.

B2.3 Legal framework

162. The legal framework described in Section A2.3 above applies equally to the transport of ILW from new nuclear power stations.

B2.4 Regulatory framework

163. The regulatory framework described in Section A2.4 above applies equally to the transport of ILW from new nuclear power stations.

B2.5 Technology

164. ILW packaging arrangements are already being implemented in the UK for legacy wastes. NDA RWMD is developing a family of transport containers that will meet transport regulatory requirements in order to give confidence that these wastes can ultimately be transported to a GDF. Similar arrangements would also be applicable to ILW generated from the operation and decommissioning of new nuclear power stations..

[161] Wisbey, Guppy and Vines, the Benefits of Cementitious Encapsulation Matrices for the Conditioning of Intermediate Level Wastes, Proceedings of ICEM Conference, Oxford 2003.
[162] www.connyankee.com/html/decommissioning.html

165. The Standard Waste Transport Container (SWTC) is a transport container concept being developed to transport packaged ILW to a GDF. The SWTC will provide up to 285mm of steel shielding and will reduce external dose rates to levels defined within IAEA Transport Regulations[163]. If wastes are loaded into disposal containers which are certified as transport containers in their own right, then they will themselves provide sufficient shielding to achieve the regulatory requirements[164].

B2.6 Capacity

166. Waste packaging already exists for some of the ILW that will be transported within the UK[165]. Internationally ILW has been regularly transported. Since 1999, shipments of trans-uranic waste (similar to long-lived ILW) have been taking place from across the USA to the WIPP facility in New Mexico. There have been almost 6,000 shipments to August 2007 in compliance with transport regulations.

167. In France concrete containers (C1 and C4) and in Germany cast iron containers (Type II), which meet the needs for disposal and transport have been licensed[166].

168. The development of the SWTC in the UK is being coordinated by NDA RWMD. It has been developed to concept stage. Whilst the SWTC does not as yet exist, it is designed using principles and technology that are already in use and licensed in the UK. Similar transport containers are routinely used in the UK for the transportation of spent fuel from AGR and Magnox nuclear power stations to reprocessing facilities at Sellafield.

169. The concept of a disposal package that is certified as a transport package in its own right is well established. Half-height ISO containers (albeit for LLW) have been in routine use in the UK for the past 15 years or more[167], and NDA RWMD has defined 4 metre and 2 metre boxes as “standard” containers particularly suited for decommissioning wastes[168].

170. In the disposability assessments undertaken as part of the GDA process, NDA RWMD has undertaken assessments of ILW that is likely to be produced from EPR and AP-1000 type reactors, which are being considered by utilities if new nuclear power stations are deployed in the UK. NDA RWMD has concluded that the ILW that will be produced should be compatible with plans for transport and geological disposal[169].

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[163] International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standard TS-R-1, 2005 Edition. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1225_web.pdf
[164] Generic Waste Package Specification, Nirex report N/104 Issue 2, March 2007.
[165] http://mrws.decc.gov.uk/en/mrws/cms/Waste/Packaging_of_r/Packaging_of_r.aspx
[166] NDA, UK Radioactive Higher Activity Waste Storage review, Issue 1, March 2009. http://www.nda.gov.uk/documents/upload/UK-Radioactive-Higher-Activity-Waste-Storage-Review-March-2009.pdf
[167] http://www.ukaea.org.uk/downloads/dounreay/dounreay_llw.pdf
[168] Generic Waste Package Specification, Nirex report N/104 Issue 2, March 2007.
[169] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.

B3 ILW disposal

B3.1 Policy framework

171. The description of the policy framework with regard to the disposal of spent fuel described in Section A3.1 above applies equally to ILW from new nuclear power stations. The funding arrangements for the disposal of ILW are covered by the FDP framework described above, and the Government will provide operators with a fixed unit price for the disposal of their ILW in a GDF.

B3.2 Strategic framework

172. Similarly, the strategic framework described in Section A3.2 above applies equally to the disposal of ILW from new nuclear power stations, which is that NDA is responsible for planning and implementing geological disposal. The disposability assessments carried out by NDA's RWMD to inform the GDA process also considered ILW from new nuclear power stations.

B3.3 Legal framework

173. The legal framework described in Section A3.3 above applies equally to ILW from new nuclear power stations, and the implementation of a GDF programme by NDA will comply fully with relevant UK and international legislation and conventions.

B3.4 Regulatory framework

174. The regulatory framework for geological disposal described in Section A3.4 above applies equally to ILW from new nuclear power stations.

B3.5 Technology

175. As set out above, the assessments carried out by NDA to inform the GDA process have concluded that given a disposal site with suitable characteristics, the ILW from the AP-1000 and EPR reactors is expected to be disposable[170]. The operational and decommissioning ILW that would be produced from new nuclear power stations would be very similar to that which is currently produced, or will be produced in the future, from Sizewell B and from LWRs operated in other countries, the safe and secure disposal of which has been extensively researched and, in the case of operational wastes, implemented in a number of countries (e.g. Sweden[171], Finland[172] and France[173]).

176. In European countries where disposal of operational ILW is already taking place the disposal facility is near-surface, i.e. less than 100 metres below ground surface. WIPP in the USA is a deep GDF for "trans-uranic" wastes, broadly equivalent to our long-lived ILW category, operating at 650m depth in salt formations under New Mexico. UK policy categorises operational and decommissioning ILW as higher activity waste requiring geological disposal, although recognising that the need to take account of developments in storage and disposal options, as well as possible new technologies and solutions that could reduce the amounts of waste requiring geological disposal.

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[170] Summary Disposability Assessment for the AP-1000 page 7. Summary Disposability Assessment for the EPR page 8.
[171] http://www.sweden.gov.se/content/1/c6/05/40/89/fc570cf2.pdf
[172] http://www.stuk.fi/julkaisut/stuk-b/stuk-b96.pdf
[173] http://www.asn.fr/sites/default/files/files/Third_national_report.pdf?nocache=1228143993.68

177. The technology identified in disposal concepts that would be suitable for ILW from new nuclear power stations is already available in terms of engineered barrier designs and materials[174]. Given the similarity between new build and legacy wastes the same disposal technologies would be expected to apply. In terms of immobilisation and packaging, it is expected that the ILW waste packages currently in use would be acceptable for disposal in all potentially suitable UK geological settings.

178. Decommissioning wastes can be a significant source of long-lived radionuclides produced through neutron activation of materials used in the construction of the reactor. The understanding of activation processes and underlying research on their impact on safety cases can be used to guide material specifications that will reduce long-lived radionuclide production and hence significance on the long-term disposal safety case.

B3.6 Capacity

179. **Disposal containers[175]:** In line with international practice, the UK has developed standardised disposal containers and through the GDA process is working with the Requesting Parties to define package requirements for new build wastes. Containers chosen for new build ILW are likely to be fabricated from steel or concrete, using current UK or internationally approved designs. Large numbers of some types of these standard containers are routinely manufactured and used in the UK to package legacy ILW under regulatory control. The materials used in the manufacture of the various containers are routinely available in the UK for use in other industrial applications. Assessment of continuity of supply is a well-established practice when selecting materials for a major project such as a GDF.

180. **Geotechnical engineered barriers:** Backfill material to surround each ILW disposal container after emplacement in a GDF, mass-backfill to fill access tunnels and shafts, and high integrity engineered seals to close-off key compartments of a GDF are variously envisaged to involve the use of cement-based grouts, crushed minerals and swelling clay, as well as other components such as rock spoil in the case of tunnel backfill. The ability to emplace these various barriers has been demonstrated in operating disposal facilities overseas and various test facilities (including underground research facilities) and the engineering methods used are well-documented. The materials required are readily available. Continuity of supply of the concrete[176] systems envisaged in some of the various barrier applications are likely to remain available in the UK over the period of many decades that are of interest for geological disposal.

181. The discussion on underground construction in Section A3.6 is also applicable to the geological disposal of ILW, whether in a dedicated or co-located facility.

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[174] Galson Sciences, Concepts for the Geological Disposal of Intermediate Level Radioactive Waste, Report for NDA, Report 0736-1, April 2008. http://www.nda.gov.uk/documents/upload/Concepts-for-the-Geological-Disposal-of-Intermediate-level-Radioactive-Waste-2008.pdf

[175] Galson Sciences, Concepts for the Geological Disposal of Intermediate Level Radioactive Waste, Report for NDA, Report 0736-1, April 2008. www.nda.gov.uk/documents/upload/Concepts-for-the-Geological-Disposal-of-Intermediate-Level-Radioactive-Waste-April-2008.pdf

[176] www.bgs.ac.uk/downloads/start.cfm?id=1408

C Low level waste (LLW)

182. LLW is the lowest activity category of radioactive waste, and was defined in the "Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom"[177] as: "Radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq/te) of alpha or 12 GBq/te of beta/ gamma activity".

183. Very low level waste (VLLW) is a subset of the LLW category of radioactive waste, covering miscellaneous waste arising with very low concentrations of radioactivity. VLLW is divided into two types: low volume VLLW and high volume VLLW. Low volume VLLW is defined as "radioactive waste that may be disposed of to an unspecified destination, with each $0.1m^3$ having less than 400 kBq total activity or single items with less than 40 kBq of total activity". High volume VLLW is defined as "having a maximum concentration of 4 MBq/tonne of total activity which may be disposed of to specified landfill sites".

184. LLW/VLLW waste producers must hold authorisations under the Radioactive Substances Act 1993 (RSA93). Depending on its physical form, low volume VLLW is incinerated or disposed of to landfill, and neither type of facility has to hold an authorisation under RSA93. However, high volume VLLW can only go to landfills that do hold authorisations under RSA93.

185. LLW currently being generated consists largely of plastics and scrap metal items that have been used in hospitals, research establishments and the nuclear industry.

186. Although LLW makes up more than 90% of the UK's radioactive waste legacy by volume, it contains less than 0.1% of the total radioactivity[178]. Most operational LLW is currently super-compacted to reduce its volume and sent for disposal at the LLW repository (LLWR) in West Cumbria, where it is packaged and encapsulated in cement and large steel containers. These are then placed in an engineered vault a few metres below the surface. A small fraction of the total volume of LLW cannot be disposed of in this way, due principally to the concentration of specific radionuclides (e.g. those with very long half-lives) and so will need to be disposed of in a GDF.

187. As with other waste categories in this paper, there is uncertainty over the quantity of LLW that is expected to be produced by a new nuclear programme. The inventory of LLW produced by new nuclear power stations is likely to be small when compared to volumes of legacy LLW.

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[177] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the UK page 5. http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/waste/low/low.aspx

[178] MRWS White Paper page 17.

C1 LLW – storage

C1.1 Policy framework

188. In March 2007 the Government published its "Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom"[179]. The policy outlines the priorities for managing LLW responsibly and safely, by:

- allowing greater flexibility in managing the wide range of LLW that already exists and will arise in the future;
- maintaining a focus on safety, with arrangements supported by the independent regulators, including the HSE and the environment agencies;
- seeking to first minimise the amount of low level waste created before looking at disposal options, through avoiding generation, minimising the amount of radioactive substances used, recycling and reuse;
- creating a UK-wide strategy for managing low level waste from the nuclear industry;
- initiating a UK-wide strategy for the management of non-nuclear industry LLW;
- emphasising the need to involve communities and the wider public in developing and delivering LLW management plans.

189. Among other things the policy set out that plans for the management of all radioactive waste, including LLW, must be developed by waste managers. These plans must be prepared in a form, and to a level of detail, suitable for consideration by the relevant regulatory bodies.

190. LLW storage is not a major feature of power station operations. Regulators discourage accumulation of waste at sites of origin if a disposal route is available. The "Base Case" in the FDP consultation[180] included a number of assumptions in relation to LLW, including that LLW will be disposed of promptly after it has been generated in a suitable disposal facility.

191. The FDP framework described above will also cover the costs of managing and disposing of LLW from new nuclear power stations. The costs of managing and disposal of operational LLW will be met from operational expenditure. The costs of managing and disposing of decommissioning LLW will be met from the operator's independent Fund.

C1.2 Strategic framework

192. In line with a Government commitment given in the 2007 LLW Policy Statement, the NDA is currently developing a UK Nuclear Industry LLW Strategy and this was published for consultation in June 2009[181]. The consultation document sets out various ways of putting the principles set out in the LLW Policy Statement into practice, whilst extending the lifetime of the LLWR and emphasises the need for optimised management of LLW. The draft strategy reflects the LLW Policy Statement in advocating application of the waste hierarchy

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[179] http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/waste/low/low.aspx
[180] Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Stations section 4.
[181] UK Nuclear Industry LLW Strategy. www.nda.gov.uk/loader.cfm?csModule=security/getfile&pageid=29908

and pursuit of alternative disposal routes where the necessary safety assessments can be carried out to the satisfaction of the environmental regulators.

193. All nuclear licensed sites have a plan for the management of their LLW holdings and predicted future arisings that is part of a wider integrated waste management strategy, and is compatible with proposed end states. LLW management plans must take into account all current and anticipated future arisings of LLW, and their radiological and non-radiological properties. This may necessitate additional characterisation work. Such plans must be developed with appropriate regulatory and stakeholder involvement and should take into account current best practice. As a general principle, such plans should be developed and agreed with the regulatory bodies in advance of the production of any new LLW streams[182].

C1.3 Legal framework

194. The legal framework described in Section A1.3 above applies equally to the management and disposal of LLW from new nuclear power stations.

C1.4 Regulatory framework

195. The regulatory framework described in Section A1.4 above applies equally to the management and disposal of LLW from new nuclear power stations.

C1.5 Technology

196. LLW storage and disposal technology is well-established[183]. It is expected that LLW from new nuclear power stations will be handled in a manner similar to current practice and in line with Government policy on LLW. The LLW originating from new build power plants will not vary greatly from that of existing plants. LLW includes for example contaminated equipment and protective clothing from facilities that handle nuclear material and this type of waste will be produced by any new nuclear power stations built in the UK.

197. As stated above, LLW storage is not a major feature of power station operations. Therefore power station sites during operation place LLW in containers such as half-height isofreight (ISO) containers and send these for disposal when full. However storage does take place in particular circumstances, for example at Dounreay where LLW is being stored in anticipation of a planned local disposal facility becoming available. Here LLW is packaged in half-height ISOs and stored in a specially constructed temporary storage facility above ground.

198. Current practice is, following application of appropriate volume reduction methods, to send waste containers to LLWR for disposal where it is packaged and encapsulated in cement prior to emplacement.

199. LLW generated during dismantling and decommissioning of nuclear power stations is likely to consist predominantly of structural materials such as steel and concrete. These can be treated and disposed of in the same way as described above for operational LLW, however NDA is currently consulting on a LLW Strategy[184] which encourages consideration to be given to alternative technologies which could be implemented in line with the 2007 LLW Policy Statement for long-term management of solid LLW. New technologies, which may include techniques such as melting, recycling or on-site disposal, may well be established

[182] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the UK page 7
[183] http://www.llwrsite.com/llw-repository-operations
[184] http://www.nda.gov.uk/consultations/details.cfm?customel_datapageid_28748=28818

within the UK context by the time new nuclear power stations are due to be decommissioned.

C1.6 Capacity

200. As stated above, storage of LLW on-site is currently being carried out in some cases and could be carried out in the same way in future but regulators discourage accumulation of waste at sites of origin if a disposal route is available.

C2. LLW – transport

C2.1 Policy framework

201. The description of the policy framework with regard to the transport of radioactive waste described in Section A2.1 above applies equally to LLW from new nuclear power stations.

202. The 2007 LLW Policy Statement set out that when options' assessments are carried out to support the development of LLW management plans, "transport" should be explicitly considered, taking into account the volumes and activity of the waste as well as the distance over which it will need to be transported for each option.

203. The funding arrangements for transport of LLW from new nuclear power stations are covered by the FDP framework described above.

C2.2 Strategic framework

204. Similarly, the strategic framework described in Section A2.2 above applies equally to the transport of LLW from new nuclear power stations.

205. The UK Nuclear Industry LLW Strategy published for consultation by the NDA in June 2009 recognises that, although the desire to avoid excessive transportation of materials is an important consideration, it must be balanced with all the other relevant factors on a case-by-case basis. The Strategy sets out that the NDA will want to work with their contractors and non-NDA waste producers to minimise the impact of transport as far as can be achieved.

C2.3 Legal framework

206. The legal framework described in Section A2.3 above applies equally to the transport of LLW from new nuclear power stations.

C2.4 Regulatory framework

207. The regulatory framework described in Section A1.4 above applies equally to the transport of LLW from new nuclear power stations.

C2.5 Technology

208. LLW transport[185] methods are well-established (by both road and rail). LLW is routinely transported in Industrial Packages or Type A packages that are designed, certified and transported by industry as permitted in the transport legislation. DfT has regulatory oversight and verifies the system operated by industry, backed by enforcement powers, to

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185 http://www.llwrsite.com/UserFiles/File/OperationalStrategy/InitialOperationalStrategy-January2009.pdf (Section 5.3 Transportation).

ensure that LLW transport packages meet the prescribed requirements of the transport regulations. As set out in Section A1.4, a consultation which ran from 30 June to 22 September 2009 set out proposals for changes to regulatory oversight[186].

C2.6 Capacity

209. The UK has an established road and rail infrastructure with annual road freight totalling 173 billion tonne kilometres and rail freight totalling 21 billion tonne kilometres[187]. Half a million packages of radioactive materials are shipped within the UK each year[188]. Transport of radioactive materials is associated with a number of activities and industries, for example electricity generation, healthcare, university research and education, with the nuclear industry making up only a small proportion of these movements.

210. The LLWR receives between 500 and 700 half height ISO containers per year in addition to occasional large items for disposal. Most of this waste (75-80%) is delivered to the LLWR by rail from Sellafield. This waste is typically generated at Sellafield or received at Sellafield from other sites by road for super compaction prior to consignment to the LLWR. Virtually all waste arriving directly to the LLWR from other consignors is transported by road.

C3. LLW – disposal

C3.1 Policy framework

211. The Government's view, as set out in the 2007 LLW Policy Statement, is that disposal to an appropriately engineered facility, either below or above ground, with no intent to retrieve should be the end point for LLW that remains following the application of the waste hierarchy[189]. The LLW Policy Statement also stated that this position is held on the basis that new disposal facilities will be of sufficiently robust design such that risks to the public in the future will be within the post-closure risk target, and therefore that postponing final disposal to future generations is unjustified[190].

212. The funding arrangements for the disposal of LLW are covered by the FDP framework as described above.

C3.2 Strategic framework

213. As set out in section C1.2, NDA published a UK Nuclear Industry LLW Strategy for consultation in June 2009.

C3.3 Legal framework

214. The legal framework described in Section A1.3 above applies equally to the management and disposal of LLW from new nuclear power stations.

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[186] The consultation can be found at http://decc.gov.uk/en/content/cms/consultations/hse_restruct/hse_restruct.aspx
[187] www.dft.gov.uk/adobepdf/162469/221412/190425/220778/trends2008.pdf
[188] www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947392224
[189] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the UK page 6.
[190] The Policy for the Long Term Management of Solid Low Level Radioactive Waste in the UK page 8.

C3.4 Regulatory framework

215. The regulatory framework described in Section A1.4 above broadly applies to the management and disposal of LLW from new nuclear power stations.

C3.5 Technology

216. Current practice is to send LLW to the LLWR in large metal containers, after appropriate volume reduction techniques have been applied. Where possible waste is compacted prior to transfer to LLWR. All waste is grouted in place within containers before being disposed of in concrete lined vaults[191].

217. LLWR or an alternative disposal route[192] will be available for new build operational LLW. The amount of operational and decommissioning LLW from new nuclear power stations is expected to be relatively small in comparison to the overall UK demand. Technologies for VLLW treatment and disposal will be developed in line with Government policy and NDA strategy.

C3.6 Capacity

218. NDA has strategic responsibility to maintain the LLW disposal route for nuclear industry LLW under the 2007 LLW Policy Statement. This extends to pursuing capacity beyond the existing LLWR if it proves to be necessary in future decades. NDA is working with the site to maximise its operational life, making best use of this national asset and developing a UK nuclear industry LLW strategy to support application of the waste hierarchy and flexibility in managing LLW through alternative, fit for purpose disposal routes.

219. Vault 8 of the LLWR is currently near capacity. The next vault (Vault 9) is being constructed ready for receiving waste when Vault 8 is full. Vault 9 is currently only consented for the storage of LLW. Its suitability for permanent disposal of LLW will be contingent on the operator providing an acceptable updated safety case to the Environment Agency in 2011. The NDA's LLW Strategy consultation sets out various ways of extending the lifetime of the LLWR.

220. There are various options available (as stated in the 2007 LLW Policy Statement[193]) that may be considered for the disposal of the wide spectrum of waste types and activity concentrations within LLW in the UK. These are:

- disposal to facilities that have yet to be constructed to take ILW;
- disposal to near-surface facilities of the kind employed at the LLWR near Drigg, where disposal is by way of compaction, grouting and placement in a concrete vault;
- disposal to specific areas of, or adjacent to, nuclear licensed sites (e.g. the current landfill-type disposal at Sellafield) or to disposal facilities that might, in future, be constructed at, or adjacent to, nuclear sites;
- in-situ disposal; that is, burial at the point of arising;

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[191] UK Nuclear Industry LLW Strategy page 33.

[192] The 2007 LLW Policy Statement (page 11) gives reassurance that Government wishes to ensure that there are disposal routes available for the long term management of LLW arisings.

[193] Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom. 26 March 2007 page 24.

- disposal at specified landfill sites for LLW and high volume VLLW, including the practice of “controlled burial”, providing that this meets specified regulatory requirements;
- general disposal of low volume VLLW to an unspecified destination, together with municipal, commercial or industry wastes;
- incineration and subsequent disposal of radioactive residues.

221. LLW produced from eventual power station decommissioning is a different issue from the management of operational waste. Larger volumes of waste will be produced, some of which will be VLLW in the form of lightly contaminated steel or concrete. In line with the 2007 LLW Policy Statement, NDA strategy is to minimise VLLW being consigned to highly engineered LLW disposal facilities where this is not necessary for such low activity material. Thus during decommissioning the VLLW that arises might be consigned to landfills or other fit for purpose disposal arrangements at existing or new locations, in line with the LLW Policy Statement. The management of LLW radioactive waste should be in accordance with the waste hierarchy principles set out in 2007 LLW Policy Statement.

D. Handling and disposal of non-radioactive hazardous wastes

222. Non-radioactive wastes are produced from operating and maintaining both the "conventional" side of the new nuclear power station and the "nuclear island", and this includes some non-radioactive hazardous wastes, such as waste pond water, laboratory chemicals, and lubricating and fuel oils, which need safe management and disposal.

223. Hazardous waste is waste with one or more properties that are hazardous to health or to the environment[194]. Categories or generic types of hazardous wastes as well as the properties of hazardous waste are listed in the European Commission's Hazardous Waste Directive[195]. Controls are implemented by the Hazardous Waste Regulations[196].

224. The volume of non-radioactive hazardous wastes produced by new nuclear power stations is expected to be small in relation to the total volume of such wastes produced in the UK. The 2007 Nuclear Sector Plan Environmental Performance Report[197] notes that the existing nuclear sector produced around 27,000 tonnes of this waste, of which around half was asbestos, which is not expected to be generated in new nuclear power stations. This is very small in relation to current UK hazardous waste arisings from all sectors of around 6.4 million tonnes.

D1 Government policy

225. While waste management policy is a devolved matter and therefore both waste policy and waste legislation varies across the UK there remains substantial consistency in waste management. Non-radioactive hazardous wastes will be managed according to regulatory requirements and current practices and will be disposed of promptly using established disposal routes.

226. The FDP framework described above will also cover the costs of managing and disposing of non-radioactive hazardous waste from new nuclear power stations. The costs of managing and disposing of such wastes from operations will be met from operational expenditure. The costs of managing and disposing of such wastes from decommissioning will be met from the operator's independent Fund.

[194] http://www.environment-agency.gov.uk/business/topics/waste/32200.aspx
[195] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991L0689:EN:HTML
[196] http://www.opsi.gov.uk/si/si2005/20050894.htm
[197] http://publications.environment-agency.gov.uk/pdf/GEHO1208BPDD-e-e.pdf

D2 Strategic framework

227. England[198], Wales[199], Scotland[200] and Northern Ireland[201] each have waste strategies. These broadly seek to encourage:

- decoupling waste growth from economic growth by avoiding or reducing the generation of waste;
- adopting and implementing a sustainable, integrated approach to waste production, management and regulation;
- securing the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste;
- getting the most environmental benefit from investment through increased recycling of resources and recovery of energy;
- meeting and exceeding the Landfill Directive waste diversion targets.

D3 Legal framework

228. There is a wide body of legislation on waste in the form of both primary legislation and regulation. This largely addresses the implementation of a number of European Directives and Regulations established under the waste Framework Directive[202] as well as addressing the priorities set out in the strategies outlined above.

229. In particular any organisation generating waste has a 'duty of care' across the UK to ensure that the waste for which it is responsible is stored and transported safely, is only transferred to parties authorised to receive it and that it is treated and disposed of in facilities permitted for this purpose.

D4 Regulatory framework

230. The treatment and disposal of waste is regulated by the UK environment agencies in order to ensure the protection of the environment and human health[203].

D5 Technology

231. Amounts of non-radioactive hazardous waste arising from reactor construction and decommissioning are expected to be broadly equivalent to those arising from any major infrastructure or power construction or demolition project and amenable to the normal waste minimisation techniques. The construction of a new nuclear power station is likely to require a specific Site Waste Management Plan as with any other large construction site.

232. The most notable hazardous waste arising from the decommissioning of Magnox reactors (following disposal of surplus water treatment chemicals, lubricating and transformer oil) is

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198 England Waste Strategy 2007 (Defra, May 2007). http://www.defra.gov.uk/environment/waste/strategy/strategy07/documents/waste07-strategy.pdf

199 Waste Strategy 2009 – 2050: Towards Zero Waste http://new.wales.gov.uk/consultations/environmentandcountryside/wastestrategy/?lang=en

200 National Waste Management Plan for Scotland (Scottish Executive and Scottish Environment Protection Agency 2003). www.sepa.org.uk/waste/moving_towards_zero_waste/national_waste_plan.aspx

201 Towards Resource Management: The Northern Ireland Waste Management Strategy 2006 - 2020 (Department for Environment Northern Ireland, 2006). www.ni-environment.gov.uk/waste-home/strategyni.htm

202 http://www.defra.gov.uk/environment/waste/strategy/legislation/wasteframework/index.htm

203 http://www.environment-agency.gov.uk/business/topics/waste/32180.aspx

asbestos insulating material, but this would be replaced by manmade mineral fibres in any new nuclear power stations.

233. Waste not disposed of on-site would be transported to an appropriate facility through existing disposal routes.

234. More information on waste arising and recycling rates within the nuclear industry is contained in the Nuclear Sector Plan performance reports produced by the Environment Agency[204]. This information is an indicator of the types of waste arising and recycling rates that might reasonably expect to occur and be achieved in respect of any new nuclear power stations that could be built in this country.

235. Information on current UK waste arisings and landfill capacity is available in the Defra e-digest of environmental statistics[205].

236. The England Waste Strategy (and the Welsh, Scottish and Northern Irish equivalents) explore wider issues with non-radioactive waste management and are available from the appropriate authorities.

237. Current waste management legislation (Environmental Permitting Regulations 2008[206]) dictates that hazardous wastes can only be stored on the site where they were produced for a maximum of 6 months.

D6 Capacity

238. Hazardous waste arising during operation is expected to be dominated by waste pond water, laboratory chemicals and used transformer and lubricating oil, together with sump and bund cleaning wastes.

239. No substantial on-site treatment is expected to be required for the management of non-radioactive hazardous wastes other than segregation of wastes dependent upon disposal route and safe storage pending commercial disposal. Based on existing nuclear power station sites, wastes would be disposed to commercial recycling and disposal routes at the nearest practicable facility in the same way as wastes from any other site.

240. Based on this information above new nuclear power stations would not be expected to contribute significantly to the amount of hazardous non-radioactive wastes or requirements for future disposal capacity.

[204] http://www.environment-agency.gov.uk/business/sectors/39789.aspx
[205] http://www.defra.gov.uk/evidence/statistics/environment/index.htm
[206] http://www.environment-agency.gov.uk/business/topics/permitting/default.aspx

E Radioactive discharges

241. This section covers planned releases of radioactive materials into the environment, either in liquid form into the sea or in gaseous form into the air. The liquid and gaseous radioactive discharges from new nuclear power stations will, in general, be lower than those of existing nuclear power stations in the UK.

242. The Nuclear White Paper said that "in the absence of any proposals from industry, the Government has concluded that any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed"[207]. The absence of future reprocessing would reduce the radioactive discharges that are currently produced through reprocessing of spent fuel.

243. There are many technical developments in plant design, including those designs likely to be built in the UK, and operational practices that have reduced the amount of radioactive wastes produced; for example through the selection of materials, the segregation and recycling of effluent streams to enable more effective treatment and abatement, fuel design and improvements of the management of coolant chemistry. The technologies used in the UK for existing plant and those proposed for new build are consistent with international best practice and have been, or will need to be, demonstrated to the relevant regulators as representing BAT (Best Available Techniques). As a contracting party to the Oslo/Paris (OSPAR) Convention the UK is also committed to the reduction of radioactive discharges into the North East Atlantic. This commitment, and the proposed plan in meeting it, is set out in the UK's Radioactive Discharges Strategy[208].

E1 Liquid radioactive discharges

E1.1 Policy framework

244. Government policy recognises that the unnecessary introduction of radioactivity into the environment is undesirable, even at levels where doses to humans and other species are low and, on the basis of current knowledge, are unlikely to cause harm.

245. The revised UK strategy for radioactive discharges, published in July 2009, sets out the principles underpinning the strategy, and states the Government's view that the application of these principles through the regulatory framework will continue to drive the delivery of progressive reductions in discharges, where practicable, in order to meet the OSPAR intermediate objective for 2020.

[207] Nuclear White Paper page 116.
[208] UK Strategy for Radioactive Discharges July 2009.
http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/government/discharges/strategy/strategy.aspx

E1.2 Strategic framework

246. The first UK strategy for radioactive discharges 2001-2020 was published in July 2002[209]. The 2002 UK strategy has now been updated following a public consultation exercise in 2008 and the UK's revised Strategy for Radioactive Discharges[210] was published in July 2009.

247. The UK Strategy for radioactive discharges aims, in part, to deliver the UK's obligations under the OSPAR Radioactive Substances Strategy, in respect of progressive and substantial reductions in radioactive discharges. The objective of the OSPAR strategy is to prevent pollution of the maritime area covered by the OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) from ionising radiation.

248. In particular, the OSPAR objective for 2020 is to reduce discharges to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, are close to zero.

249. The UK is obliged to produce a national report for the next OSPAR Ministerial meeting in 2010 and the revised strategy will provide this. It is also an assessment of the position reached since 2002 and of future projections, to inform UK Ministers, regulators and industry.

250. The revised strategy reaffirms the UK Government's commitment to the progressive reduction of: radioactive discharges and discharge limits; human exposure to ionising radiation arising from radioactive discharges; and concentrations of radionuclides in the marine environment resulting from radioactive discharges.

E1.3 Legal framework

251. All radioactive discharges in the UK are regulated under the Radioactive Substances Act 1993 to ensure that radioactivity discharged remains well within internationally agreed levels which are designed to protect both human health and the environment.

252. There are a number of EU legislative measures, international conventions and advisory bodies, all of which feed into and play an important part in the development of UK policy and legislation on radioactive discharges. More information on EU legislative measures, international conventions and advisory bodies is set out in the UK strategy for radioactive discharges. In summary these are:

- Euratom Treaty.
- Basic Safety Standards Directive (BSSD).
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
- OSPAR Convention.
- London Convention.
- United Nations Convention on the Law of the Sea.

[209] The 2002 Strategy is available at http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/government/discharges/discharges.aspx

[210] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/radioactivity/government/discharges/strategy/strategy.aspx

- International Commission on Radiological Protection.
- United Nations Scientific Committee on the Effects of Atomic Radiation.

E1.4 Regulatory framework

253. Operators of licensed nuclear sites in England and Wales must have an authorisation from the Environment Agency to cover liquid discharges. These authorisations set out limits and conditions on minimising radioactive waste creation and on the amount and way they dispose of their waste. Statutory guidance on the regulation of radioactive discharges into the environment from nuclear licensed sites is a vehicle through which the Environment Agency implements the UK strategy for radioactive discharges in England and Wales, which in turn implements the UK's obligations in respect of the OSPAR strategy.

254. The Environment Agency is responsible for ensuring that new nuclear power stations can meet high environmental standards and use BAT to achieve this, as required by the OSPAR Convention. As stated above the regulators for England and Wales (HSE and the Environment Agency) are currently carrying out a Generic Design Assessment of proposed designs for new nuclear power stations. Through this assessment, the Environment Agency is working to ensure that the need to meet high environmental standards is considered at an early stage and that the most modern techniques to minimise radioactive waste – including discharges to the environment – can be incorporated into the designs of modern nuclear power stations. The application of BAT in England and Wales will ensure that discharges from new nuclear power stations constructed in the UK will not exceed those from comparable nuclear power stations across the world.

E1.5 Technology

255. Technology exists and is applied in the UK and internationally to reduce the radioactive discharges from operational and decommissioning nuclear power stations effectively and within regulatory limits. Current use of abatement technology is described in the revised UK Discharge Strategy published in July 2009. Government has no reason to believe that new nuclear power stations will be so different as to necessitate new technology. The specific abatement technologies will depend on the reactor design but are likely to include the use of ion exchange resins and filtration to abate liquid discharges. The independent regulators will be scrutinising proposals.

256. Ion exchange and filtration technologies reduce the amount of soluble and insoluble radionuclides in discharges. These techniques are consistent with best practice internationally and for existing sites are regarded as BAT in the UK.

E2 Gaseous radioactive discharges

E2.1 Policy framework

257. The policy framework for liquid discharges described in Section E1.1 above applies equally to gaseous discharges, such that Government policy recognises that the unnecessary introduction of radioactivity into the environment is undesirable, even at levels where doses to humans and other species are low and, on the basis of current knowledge, are unlikely to cause harm.

E2.2 Strategic framework

258. The first UK strategy for radioactive discharges 2001-2020 was published in July 2002. The 2002 UK strategy has now been updated following a public consultation exercise in 2008 and the UK's revised Strategy for Radioactive Discharges was published in July 2009. The revised strategy builds on and extends the scope of the 2002 Strategy to include gaseous as well as liquid discharges from decommissioning as well as operational activities and from the non-nuclear as well as the nuclear industry sectors.

E2.3 Legal framework

259. The legal framework for liquid discharged wastes described in Section E1.3 above applies equally to gaseous discharged wastes, which is that all radioactive discharges in the UK are regulated under the Radioactive Substances Act 1993 to ensure that radioactivity discharges remains well within internationally agreed levels, which are designed to protect both human health and the environment.

E2.4 Regulatory framework

260. The regulatory framework for liquid discharged wastes described in Section E1.4 above applies equally to gaseous discharged wastes. Operators of licensed nuclear sites must have an authorisation from the Environment Agency to cover gaseous discharges. These authorisations set out limits and conditions on minimising radioactive waste creation and on the amount and way they dispose of their waste.

E2.5 Technology

261. Technology exists and is applied in the UK and internationally to effectively reduce the radioactive discharges from operational and decommissioning nuclear power stations[211]. The specific abatement technologies will depend on the reactor design and the specific application at the power station, but are likely to include the use of high efficiency particulate (HEPA) filters and activated carbon beds to abate gaseous discharges. The independent regulators will be scrutinising proposals.

262. Ventilation air from radiologically controlled areas is HEPA filtered. Delay tanks or carbon bed delay systems treat reactor off-gas, which reduces the activity discharged by allowing for the radioactive decay of short half life nuclides, such as iodine and noble gases.

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[211] Current use of abatement technology is described Current use of abatement technology is described in the revised UK Discharge Strategy published in July 2009.

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