

**C O N T R A C T O R S   R E P O R T   T O   N D A**

# 2010 UK RADIOACTIVE WASTE & MATERIALS INVENTORY: SCENARIO FOR FUTURE RADIOACTIVE WASTE & MATERIAL PRODUCTION

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## **PREFACE**

The 2010 United Kingdom Radioactive Waste & Materials Inventory (hereafter referred to as the 2010 Inventory) will provide comprehensive and up-to-date information on radioactive waste and materials as at 1 April 2010. It is part of an ongoing programme of research jointly conducted by the Department of Energy and Climate Change (DECC) and the Nuclear Decommissioning Authority (NDA).

DECC and NDA have commissioned the 2010 Inventory to provide information on the status of radioactive waste stocks (at 1 April 2010) and forecasts of future arisings in the United Kingdom. Additional information on radioactive materials which may become wastes is collated. Its aim is to provide data in an open and transparent manner for those interested in radioactive waste and material issues.

This report presents the scenario on which estimates of future radioactive waste and material arisings for the 2010 Inventory are based

The document has been prepared on the basis of information supplied to Pöyry Energy, the contractor to support NDA in preparing the 2010 Inventory. This information was verified in accordance with arrangements established by Pöyry Energy.

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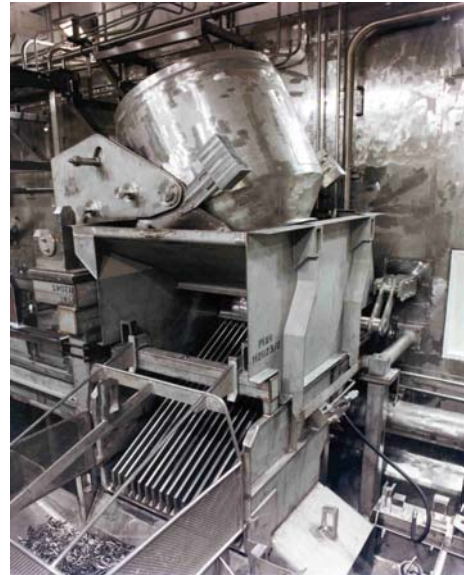
## **Feedback**

You are invited to provide feedback to the NDA on the content, clarity and presentation of this report and the UK Radioactive Waste Inventory (i.e. the Inventory). Please do not hesitate to contact the NDA if you have any queries on the Inventory and radioactive waste issues. Such feedback and queries should be addressed to:

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2010 UK Radioactive Waste & Materials Inventory:  
Scenario for Future Radioactive Waste & Material Production

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## **1 INTRODUCTION**

This report presents the scenario for future arisings that underpins estimates of radioactive waste and material quantities in the 2010 UK Radioactive Waste & Materials Inventory (hereafter referred to as the 2010 Inventory). The report has been compiled from information in the published 2007 UK Radioactive Waste Inventory updated with more recent information by the organisations with responsibilities for operating sites that produce radioactive wastes and for managing these wastes. The report excludes information that might be inappropriate for release into the public domain because of security or commercial sensitivities.

Chapter 2 gives an outline of the processes that give rise to radioactive wastes in the UK. Chapter 3 presents the scenario for radioactive waste arisings in the 2010 Inventory. Chapter 4 gives information on the types of radioactive material in the UK. Chapter 5 presents the scenario for radioactive material arisings in the 2010 Inventory. Chapter 6 summarises the principal changes in the 2010 Inventory scenarios from the scenarios adopted for the 2007 Inventory. Chapter 7 comprises a list of references.

Chapter 3 of this report forms the text included in the 2010 Inventory Main report (Chapter 3), and Chapters 4 and 5 form the text included in the 2010 Inventory Materials report (Chapter 2 and Annex 1).

## **2 SUMMARY OF PROCESSES THAT GIVE RISE TO RADIOACTIVE WASTE**

This chapter provides an outline of the processes that currently give rise to radioactive wastes in the UK and are envisaged to give rise to wastes in the future.

### **2.1 Fuel Fabrication and Uranium Enrichment**

#### **2.1.1 Springfields**

The Springfields site manufactures nuclear fuel products for the UK's nuclear power stations and for international customers. Operations at Springfields comprise the fabrication of oxide fuels for Advanced Gas-cooled Reactors (AGRs) and Light Water Reactor (LWRs) and intermediate fuel products such as powders, granules and pellets. The production of uranium metal fuel for the Magnox reactors has reached completion, and the site continues to supply natural uranium hexafluoride manufactured from uranium trioxide supplied by Cameco.

The site is also currently focussed on recovering historic legacy stocks of uranium residues.

Oxide fuel is manufactured in the Oxide Fuel Complex, which has been operational since 1995. Enriched uranium hexafluoride is returned to the Springfields site for conversion into uranium dioxide, which is used in the fabrication of AGR fuel, intermediates and potentially LWR fuels.

Fuel fabrication and uranic residues recovery operations involve bulk chemical and metallurgical processing that produce a number of low level radioactive waste streams, these include soft and hard trash. Process residues are also produced which are recycled via residues recovery processes to extract uranium. The net material from these processes is in the form of waste cake which is disposed of as radioactive waste.

Natural uranium hexafluoride is produced at Springfields and transferred to Urenco Capenhurst and other enrichment sites worldwide for U-235 enrichment. At the Urenco facilities, enrichment is carried out in gas centrifuge plants.

#### **2.1.2 Capenhurst**

Urenco's Capenhurst facility receives natural uranium hexafluoride from Springfields for U-235 enrichment. Enrichment is carried out in gas centrifuge plants. The uranium enrichment process produces two streams – one stream enriched in U-235 to the required level, which then passes to the next stage of the fuel manufacturing process, and a by-product stream depleted in U-235. A small quantity of U-235 (usually less than 0.25%) remains in the depleted stream.

Uranium enrichment involves bulk chemical processing that produces a number of low level radioactive waste streams. These include filters, process residues, and soft and hard trash.

#### **2.1.3 Sellafield**

Mixed oxide (MOX) fuel is manufactured at Sellafield in the Sellafield MOX Plant (SMP). Full commercial operation started in 2002.

### **2.2 Nuclear Power Stations**

Eleven Magnox power stations were built in the UK. Two twin-reactor stations at Oldbury and Wylfa are still generating electricity. The other nine stations are shut down and being decommissioned: the twin-reactor stations Berkeley, Bradwell, Dungeness A, Hinkley Point A,

Sizewell A, Trawsfynydd and Hunterston A, and the four-reactor stations Calder Hall and Chapelcross.

There are seven operating twin-reactor AGR stations in the UK: Dungeness B, Hartlepool, Heysham 1 & 2, Hinkley Point B, Hunterston B and Torness.

There is a single Pressurised Water Reactor (PWR) station: Sizewell B.

Whilst operators are developing plans to construct new nuclear power stations in the UK, the first regulatory consent is not anticipated before 2011.

Intermediate Level Waste (ILW) arisings from commercial nuclear power stations include: ion exchange material from the treatment of cooling pond water, pressure vessel cooling system water and liquid effluents; sludges and concentrates from the filtration of liquid effluents and cooling pond water; reactor components; filters from the processing of liquids; desiccants and catalysts from the drying and recombination of carbon dioxide reactor coolant; and general hard trash. Low Level Waste (LLW) arisings comprise general hard and soft trash.

## **2.3 Spent Fuel Reprocessing**

### **2.3.1 Sellafield**

Sellafield is a large, complex nuclear chemical facility, which has supported the civil nuclear power programme since the 1940s. The first reprocessing plant operated at Sellafield from 1952 to 1964. This reprocessed defence fuel from the Windscale Piles and fuel from the first Magnox reactors. Part of this plant was modified as a 'Head End' to demonstrate and gain experience in oxide fuel reprocessing. It operated from 1969 to 1973, processing Windscale Advanced Gas-cooled Reactor (WAGR), Steam Generating Heavy Water Reactor (SGHWR) and foreign water-cooled reactor fuel.

There are now two reprocessing plants operating at Sellafield. One treats fuel from Magnox reactors, the other (Thorp) treats oxide fuels from UK AGRs and water-cooled reactors - principally overseas PWRs and Boiling Water Reactors (BWRs).

High Level Waste (HLW), ILW and LLW all arise as a result of reprocessing and support operations. HLW is mainly the concentrated liquid residue produced during the primary stage of reprocessing, which is being progressively solidified into a passively safe form, and also includes some scrap items from the HLW vitrification plant. ILW includes Plutonium Contaminated Material (PCM) arising from the final stages of reprocessing; fuel element cladding; sludges and flocs from the treatment of liquid effluents; sludges from the corrosion of Magnox fuel element cladding in ponds and silos; ion exchange resins from the treatment of liquid effluents; and general hard trash. LLW includes general hard and soft trash arising from routine operations and maintenance.

### **2.3.2 Dounreay**

The reprocessing of spent fuel from research reactors has been carried out at Dounreay, although the reprocessing facilities are now shutdown. The volumes of wastes produced were very much less than at Sellafield.

## **2.4 Nuclear Research and Development**

The UK has undertaken research and development in support of nuclear fuel cycle operations for over fifty years at a number of sites: Dounreay, Harwell, Windscale, Winfrith and Culham. Most of the plants at these sites have now been closed down, and have either already been decommissioned or are currently being decommissioned.

Wastes produced from research and development activities at other sites (other than at Berkeley Centre) are not separately identified, and are included in the appropriate activity area as a very small component of overall waste arisings. Research and development in support of Magnox reactors and AGRs was conducted at Berkeley Centre, but this work has now come to an end, and facilities are being decommissioned.

Waste arisings from research and development activities generally have a form and composition similar to those arising from commercial fuel cycle operations. Exceptions include certain arisings from fusion and fast reactor research, such as tritiated wastes. ILW arisings include PCM, which has been produced by both reprocessing and fast reactor fuel fabrication activities; fuel element debris; reactor components; ion exchange resins from the treatment of liquid effluents; and general hard and soft trash. LLW includes general hard and soft trash from operations and maintenance.

#### **2.4.1 Dounreay**

Dounreay was the UK centre for fast reactor research. Three reactors were built on site: the Dounreay Fast Reactor (DFR), the Prototype Fast Reactor (PFR) and the Dounreay Materials Test Reactor (MTR). These reactors are now closed. The site also includes facilities for reprocessing spent PFR fuel, Post Irradiation Examination (PIE) of fuels and the manufacture and reprocessing of MTR fuels. In addition the Marshall Laboratory was used in the development of reprocessing technology for plutonium fuels. All of these facilities are no longer operational. The core programme of work at Dounreay is now focussed on the decommissioning of the reactors and other facilities including the ILW Shaft and Wet Silo.

#### **2.4.2 Harwell**

Harwell has been a site for basic research into a variety of nuclear related topics for over 50 years. A range of reactors and other research facilities (including accelerators, radioactive handling facilities and laboratories) operated until the 1990s. The three remaining reactors, BPEO (British Experimental Pile O) and two Material Research Reactors have been put into care and maintenance pending decommissioning. The Active Handling Facility and Radiochemical Building will finish operations shortly and be prepared for a period of care and maintenance pending decommissioning. Waste processing will continue in the Solid Waste Complex.

#### **2.4.3 Windscale**

The Windscale site was originally established to produce plutonium for the UK weapons programme and to develop nuclear fuel reprocessing techniques. Later, research into gas-cooled reactors and properties of irradiated fuel and materials was carried out. The site includes the Windscale Piles, WAGR and extensive PIE facilities. Both Windscale Piles were shut down following the fire in Pile 1 in 1957. WAGR was shut down in 1981 and is the UK's demonstration project for the complete decommissioning of power reactors.

#### **2.4.4 Winfrith**

The Winfrith site carried out research and development work into different reactor types. A total of nine reactors were constructed and operated at Winfrith, of which only two remain. SGHWR used heavy water as a moderator and light water for cooling. It featured vertical pressure tubes rather than a pressure vessel. The Dragon reactor was an experimental high temperature gas-cooled reactor featuring a single pressure vessel utilising small fuel pellets housed in a helium-cooled graphite

matrix. The reactors are being prepared for a period of care and maintenance pending decommissioning.

#### **2.4.5 Culham**

Culham is the UK centre for fusion research. In 1978 the site became the host to the European 'flagship' fusion project The Joint European Torus (JET). The JET fusion experiment facilities are currently operated by United Kingdom Atomic Energy Authority under contract to Euratom, which acts on behalf of the parties to the European Fusion Development Agreement. Continuing operation will depend on the availability of EU funds. Other facilities at Culham include the Compass and Mast fusion research machines.

### **2.5 Defence Activities**

The Ministry of Defence (MoD) produces radioactive wastes primarily as a result of the nuclear weapons and nuclear propulsion plant programmes, research and development activities and through the redundancy of assorted equipments that contain radioactive substances. In addition, volumes of waste are produced as a result of the remediation of radioactively contaminated land on both nuclear and non-nuclear defence sites.

ILW arisings from MoD activities include PCM, sludges and flocs from the treatment of liquid effluents, ion exchange resins from decontamination processes, and tritium-contaminated materials that include luminised equipment. LLW comprises mixed trash.

#### **2.5.1 Nuclear Weapons Programme**

The Atomic Weapons Establishment (AWE) sites at Aldermaston and Burghfield in Berkshire undertake the design, manufacture and servicing of Trident nuclear warheads, conduct research and development into warhead technology and carry out decommissioning of associated process plants.

#### **2.5.2 Naval Nuclear Propulsion Programme**

The Royal Navy submarine flotilla is now made up exclusively of vessels powered by nuclear reactors. These vessels include the UK's nuclear deterrent capability deployed in ballistic missile-firing boats, as well as fleet submarines armed with conventional torpedoes and cruise missiles. In addition to the operations of these present generation vessels, MoD also has responsibility for dealing with the decommissioning and eventual disposal of earlier generations of nuclear-powered submarines.

The two main sites that support the operation, refuelling and refitting of the nuclear submarine flotilla are Her Majesty's Naval Base (HMNB) at Devonport and the Clyde submarine base (Faslane). However, Faslane does not have the facilities to carry out the much more complicated operations associated with submarine refit and refuelling. Nuclear submarine refuelling and refitting work at HMNB Rosyth came to an end in 2003, and progressive site decommissioning has started.

A number of nuclear-powered submarines have been taken out of service and decommissioned. These are held at Devonport and Rosyth.

The Naval Reactor Test Establishment (NRTE) Vulcan is located at Dounreay and operated by the MoD. The site develops the Royal Navy's nuclear propulsion plant and acts as the test bed for prototype nuclear reactors.

Reactor cores, fuel and associated equipment for the nuclear submarine fleet are manufactured by Rolls-Royce Marine Power Operations Ltd (RRMPOL) in Derby. RRMPOL also operates a low energy reactor (Neptune), which is used in the development of submarine reactor designs.

At Barrow-in-Furness, BAE Systems Marine Ltd (BAESM) builds, tests and commissions nuclear submarines in support of the MoD nuclear submarine programme.

### **2.5.3 Other Defence Activities**

HMNB Portsmouth is the principal receiving and disposal authority for radioactive wastes arising from the decommissioning and disposal of naval vessels taken in hand at Portsmouth together with the associated naval stores equipment and instrumentation involving a range of radioactive substances.

The site at Eskmeals generates low level radioactive waste from testing of depleted uranium projectiles. The firing range at Eskmeals has not been used since 1995. The MoD has stated that Eskmeals will be maintained for the foreseeable future, but that no decision has been made about the long-term future of the battery.

The Defence Storage and Distribution Agency (DSDA) service depot at Donnington acts as a collection centre for radioactive materials arising at various sites, principally redundant depleted uranium balance weights and tritium contaminated equipment and instrumentation.

### **2.6 Medical and Industrial Activities**

This category consists of GE Healthcare and minor waste producers who generate radioactive wastes at a number of UK sites as a result of their medical, industrial and research activities.

GE Healthcare is a supplier of radioisotopes for medical, research and industrial uses.

Waste arisings from medical and industrial activities are generally low level and in the form of soft trash. Some hard trash also arises. ILW arises mainly in the form of radioactive sources.

### **3 2010 INVENTORY SCENARIO FOR ARISING OF RADIOACTIVE WASTES**

#### **3.1 Introduction**

The figures given in the 2010 Inventory for future waste arisings are projections made by the organisations that operate sites where radioactive waste is generated on the basis of their assumptions as to the nature, scale and timing of future operations and activities. These projections represent their planning positions at 1 April 2010, which have been constructed for the purpose of preparing data for the 2010 Inventory. Projections may need to be amended as plans and arrangements are developed or are changed for commercial, policy or funding reasons, or if improved data become available.

Since the 1 April 2010 there have been developments in the forward plans at a number of sites. This means that certain assumptions used in preparing data for the 2010 Inventory have already been revised or are being reviewed, and there will be or are likely to be some changes to waste estimates. Revisions can affect either or both the quantity and timing of future arisings.

Section 3.9 describes how certain changes in the assumptions used to prepare 2010 Inventory data could affect projections of future waste arisings.

#### **3.2 Nuclear Decommissioning Authority Sites**

##### **3.2.1 Sellafield**

Sellafield is a large, complex nuclear chemical facility, which has supported the civil nuclear power programme since the 1940s. Operations at Sellafield include spent fuel reprocessing, mixed oxide (MOX) fuel fabrication; and the storage of nuclear materials and radioactive wastes.

The scenario assumptions described below were constructed for the 2010 Inventory. Actual quantities of fuel to be reprocessed and/or stored are subject to contractual arrangements to be agreed between NDA and its customers.

The Magnox reprocessing plant at Sellafield reprocesses spent fuel from the UK's Magnox stations. At 1 April 2010, the total quantity of fuel reprocessed was approximately 51,000tU. This includes spent fuel from the overseas Magnox reactors at Latina in Italy and Tokai Mura in Japan, which the authors estimate, from publicly available sources, to total about 3,000tU. It is anticipated that all spent fuel from the continuing operation of Magnox stations in the UK will be reprocessed, and that the reprocessing plant will continue to operate until 2016. The lifetime throughput of the plant is expected to be approximately 55,000tU.

The Thermal Oxide Reprocessing Plant (Thorp) reprocesses spent fuel from the UK's Advanced Gas-cooled Reactor (AGR) power stations, as well as spent fuel from overseas Light Water Reactor (LWR) power stations. In addition, Thorp will reprocess the smaller quantities of spent fuel from the Windscale AGR (WAGR) and the Winfrith Steam Generating Heavy Water Reactor (SGHWR). At 1 April 2010, the total quantity of fuel reprocessed was about 6,000tU. Thorp has an order book that currently extends to around 2021, and the lifetime throughput of the plant is expected to be approximately 9,900tU.

The estimate of lifetime waste arisings from Thorp has assumed the reprocessing of approximately 5,500tU AGR fuel. All other spent fuel generated during the lifetimes of the UK's seven AGR power stations will be held in long-term storage at Sellafield. Measures including the reuse of pond furniture and continuing improvements in pond management practices will result in only small volumes of wastes being generated during fuel storage. Estimated arisings of such wastes are

included in the Inventory. It is anticipated that spent fuel would be stored on site until about 2085, pending disposal in a purpose built repository.

Waste arisings from overseas LWR spent fuel reprocessing in Thorp are based on a total throughput of approximately 4,400tU. Spent fuel from the Pressurised Water Reactor (PWR) station at Sizewell is not included (see Section 3.3).

Waste arisings from Thorp also include those from reprocessing 28tU of WAGR fuel, 120tU of SGHWR fuel and 44tU DFR breeder material, plus a small amount of other Post Irradiation Examination (PIE) type materials.

MOX fuel fabrication in the Sellafield MOX Plant (SMP) started in 2002. The facility uses plutonium separated from reprocessing, and blends it with uranium to make MOX fuel. Waste arisings are based on fuel fabrication continuing until 2036.

In addition to the wastes from the reprocessing plants and SMP, there are routine waste arisings on the Sellafield site from waste packaging plants, effluent treatment plants, plutonium and fuel handling plants, other facilities and site construction activities.

Decommissioning activities for nuclear chemical plants at Sellafield are broken down into the following phases:

- **Initial Decommissioning** which seeks to remove or fix further loose radioactive material with the intention of enabling useful manual access for the interim decommissioning phase. It typically involves decontamination activities to reduce dose rates and removal of ancillary equipment and may include installation of systems to support the surveillance and maintenance phase (if required).
- **Surveillance and Maintenance (S&M)** describes the period of supervision of a plant or facility that may occur between the end of Post Operational Clean Out (POCO) and prior to the start of the Interim Decommissioning phase. It would typically include operation and maintenance of radiological monitoring and ventilation systems in addition to the more general maintenance of the fabric of the building. This phase only occurs in the event of a requirement to delay decommissioning.
- **Interim Decommissioning** involves the removal of the active plant, equipment and associated systems. In general, the end-point of this phase is a building shell that contains only traces of activity, which are assumed to be localised LLW. It is anticipated that decontamination may not be entirely effective, so it is expected that more remote decommissioning activities may be required.
- **Care and Maintenance** describes the period of supervision of a building shell, at minimal cost. This would normally entail minimum maintenance of the fabric of the building with the objective of ensuring that it presents no physical hazard to individuals or adjacent plants, while preventing any significant deterioration of the building. As with the S&M phase, plants and facilities only undergo this phase when there is a requirement to delay the final decommissioning phase.
- **Final Decommissioning** is the final activity associated with bringing a plant or facility to its agreed or assumed end-point (but excluding any contaminated ground or groundwater remediation). This is assumed to be the demolition/deconstruction to base slab or ground level depending on the principles of ALARP (As Low As Reasonably Practicable). It is assumed that this will be carried out using predominantly conventional techniques.

- **Groundwater Remediation** covers the activities necessary to remediate any contaminated groundwater.
- **Contaminated Land Remediation** covers activities necessary to remediate any contaminated ground.

There is a wide range of facilities on the Sellafield site, and the development of a decommissioning strategy takes into account both plant specific and site wide considerations. The decommissioning plan for each facility is considered individually, but basic strategies can be summarised as follows:

- **Reprocessing and Associated Plant** which contain radionuclides that emit significant gamma radiation, some of which have comparatively short half-lives. Deferring decommissioning for some of these plants can therefore offer safety and cost benefits.
- **Plutonium plants** present less of a radiation hazard however over time it has the potential to increase due to decay of specific radioactive isotopes. Deferring decommissioning presents no advantage and so equipment removal from these plants on an early timescale is preferred in order to remove any hazard and to restrict the additional radiological constraints that are posed by the 'in-growth' of, for example, americium.

Decommissioning scheduling is subject to overall site priorities and is driven primarily by hazard and risk management with due consideration of environmental and security requirements.

### Key Dates

- All reprocessing activities, including POCO (except for the already contracted storage of fuel and POCO of associated plants), will cease by about 2030; decommissioning of the majority of associated facilities will commence shortly thereafter. Note some commercial activities continue on the site to at least 2085.
- Prior to 2045, contaminated ground and groundwater activities are assumed to be based around monitoring and characterisation.
- Significant contaminated ground and groundwater activities will commence at 2050.
- Decommissioning activities will be largely complete (waste stored on site) by 2070.
- All buildings/waste stores (except product stores and supporting ancillary buildings) will be demolished by 2120.
- It is assumed that institutional control will be maintained after 2120.
- WAMAC will cease operation in 2020<sup>1</sup>.

### 3.2.2 Windscale

There are three shutdown reactors on the Windscale site: the Windscale Advanced Gas-cooled Reactor (WAGR), Pile 1 and Pile 2. WAGR, which was operated until 1981, is currently undergoing interim decommissioning, scheduled to be complete by 2014. Final decommissioning (Stage 3) of WAGR will be complete by 2030.

The two pile reactors were operated until 1957 when a fire damaged the Pile 1 core. Stage 2 decommissioning has been completed for Pile 2 and will be complete for Pile 1 in 2021. Following a

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<sup>1</sup> Due to the planned closure of WAMAC, Sellafield has reported raw waste volumes for LLW arisings post-2020. For the purpose of the 2010 Inventory, these raw volumes have been converted to packaged volumes based on the same assumptions relating to treatment and packaging practices applied to pre-2020 arisings.

period of care and maintenance, Stage 3 decommissioning (removal of core and bioshield) will be complete by 2036 for Pile 1 and by 2044 for Pile 2.

LLW will be consigned for disposal as it arises, although decay storage to allow disposal as Exempt waste is also an option. ILW will be repackaged appropriately and stored on site until a national long-term management solution is available.

The timetable for the operation and decommissioning of remaining major facilities on the Windscale site is shown in Table 3.1 below.

**Table 3.1: Proposed decommissioning timetable for major Windscale facilities**

Facility	Operation	Decommissioning		
		Stage 1	Stage 2	Stage 3
Pile 1	1950 – 1957	Ends 2021		2026 – 2036
Pile 2	1950 – 1957	Complete		2035 – 2044
WAGR	1962 – 1981	Complete	Ends 2014	Ends 2030

Notes: For an explanation of the three stages of decommissioning see Section 3.2.7.

### 3.2.3 Capenhurst

The Capenhurst Uranium Gaseous Diffusion Plant operated from 1961 to 1982. The site is the UK's primary uranic storage facility, holding uranium tails from the enrichment operations and other uranium stocks. The site has almost completed its main plant decommissioning programme and is close to concluding its waste disposal operations for materials arising from that programme. This includes the processing and packaging of legacy low-level wastes, and consignment to the Low Level Waste Repository (LLWR) and the Clifton Marsh landfill site; the investigation and implementation of a management strategy for any contaminated ground; and preparing the site and buildings for remaining storage operations.

The current plan for the site is to reduce progressively and remove historical hazards from the site, and undertake the necessary arrangements to hold a UK strategic stock of uranium to 2120 and beyond. During the storage period, the uranium tails will be converted from uranium hexafluoride to oxide form, starting no later than 2020. Longer term, any remaining ground contamination under the storage buildings will be investigated and removed when the stores are replaced in 2050.

### 3.2.4 Magnox Stations

Eleven Magnox power stations came into operation over the period 1956 to 1971. At 1 April 2010 two stations were still operating: Oldbury and Wylfa. Nine stations are shut down: Berkeley, Bradwell, Calder Hall, Chapelcross, Dungeness A, Hinkley Point A, Hunterston A, Sizewell A and Trawsfynydd.

A timetable for the operation and decommissioning of all Magnox stations is given in Table 3.2.

**Table 3.2: Proposed timetable for Magnox stations<sup>(1)</sup>**

Station	Operation	Defuelling & Care and Maintenance Preparations	Care and Maintenance	Final Site Clearance
Calder Hall	1956 – 2003	2003 – 2032	2033 – 2104	2105 – 2114
Chapelcross	1959 – 2004	2005 – 2022	2022 – 2089	2089 – 2095
Berkeley <sup>(2)</sup>	1962 – 1989	1989 – 2026	2026 – 2074	2070 – 2080
Bradwell <sup>(3)</sup>	1962 – 2002	2002 – 2027	2027 – 2087	2083 – 2093
Hunterston A	1964 – 1990	1990 – 2020	2020 – 2072	2072 – 2080
Trawsfynydd	1965 – 1993	1993 – 2021	2022 – 2074	2074 – 2083
Hinkley Point A	1965 – 2000	2000 – 2031	2031 – 2085	2081 – 2091
Dungeness A	1965 – 2006	2007 – 2034	2034 – 2092	2088 – 2098
Sizewell A	1966 – 2006	2007 – 2034	2034 – 2092	2088 – 2098
Oldbury <sup>(4)</sup>	1967 – 2011	2011 – 2027	2027 – 2095	2096 – 2101
Wylfa <sup>(5)</sup>	1971 – 2011	2011 – 2025	2025 – 2096	2096 – 2101

1. The dates in the table refer to financial years not calendar years. All future dates for operation, defuelling and care and maintenance preparations are under review and could change. Dates given are those used in preparing waste volumes data for inclusion in the Inventory.

2. Berkeley Site comprises the Magnox station site and that part of what was Berkeley Centre containing the R&D active handling facilities.

3. In October 2010, a business case was submitted to the NDA to accelerate decommissioning activities at Bradwell to place it in early Care and Maintenance by 2015. This will be subject to business case approval and funding availability.

4. Since the 2010 Inventory data were compiled, NDA has announced it is engaging with nuclear regulators and Government to secure a short-term life extension for Oldbury, subject to business case approval and funding availability.

5. In October 2010, it was announced that Wylfa Power Station will continue operating for up to two additional years beyond December 2010. Extended generation will be subject to safety case approval.

The decommissioning strategy for the Magnox reactor sites is “Deferred Site Clearance”:

**Defuelling & Care and Maintenance Preparations:** Removing the fuel from the reactor; removing most plants and structures other than the reactor buildings. This is planned to take between 14 and 37 years.

**Care and Maintenance:** A period of deferment, planned to extend to between about 50 and 70 years.

**Final Site Clearance:** Dismantling of all remaining structures, clearing and restoring the site. This is assumed to take between 5 and 10 years.

After defuelling, exterior cladding on the reactor containment building would be replaced as necessary with high-integrity materials and un-needed openings would be in-filled to create a low-maintenance structure.

Wastes that arise during the defuelling of Magnox reactors are the same as those that arise during operation. For this reason they are included with operational wastes.

The active handling facilities at Berkeley Site (previously part of Berkeley Centre) used to provide research and development facilities including a post-irradiation examination service. Operations ended in 2005, and the facilities are undergoing decommissioning.

### 3.2.5 LLWR

The Low Level Waste Repository (LLWR) near the village of Drigg is the national disposal site for low level wastes. It has operated since 1959, and accepts LLW from a wide variety of sources

throughout the UK including nuclear licensed sites, hospitals, research establishments and industrial concerns.

Operations at the site are forecast to continue beyond 2080, and will generate small quantities of LLW.

The site has also been used for storing plutonium contaminated materials (PCM), initially in former munitions storage magazines, subsequently in a custom built drum store. During 2007 all remaining PCM was retrieved and removed from the site for long-term storage at nearby Sellafield. Current plans include the redundant magazines and drum store being decommissioned and demolished by 2010.

### 3.2.6 Dounreay

The three reactors on the Dounreay site are shut down. The Prototype Fast Reactor (PFR) and Dounreay Fast Reactor (DFR) are undergoing decommissioning. The Dounreay Materials Test Reactor (DMTR) is currently under a Care and Maintenance regime, Stage 1 decommissioning having been completed.

Both fuel reprocessing plants are shut down. There will be no further arisings of MTR raffinate, DFR raffinate or PFR raffinate. It is intended that existing stocks will be conditioned in the Dounreay Cementation Plant or the planned Remote Handled Intermediate Level Waste (RHILW) Encapsulation, Immobilisation and Storage Facility.

The Dounreay Historic High Beta Gamma Storage Facility will be emptied of waste. Some decontamination of the rock may be undertaken, at least to LLW levels. The Silo will be emptied and decontaminated, and the structure will be removed. The Historic High Beta Gamma Storage Facility and Silo waste will be conditioned in the planned Waste Treatment Plant. Solid ILW currently in store and other decommissioning ILW will be conditioned in the RHILW Encapsulation, Immobilisation and Storage Facility.

The site plan is that all redundant facilities will be decommissioned by 2025<sup>2</sup>. The timetable for the operation and decommissioning of the major facilities on the Dounreay site is shown in Table 3.3 below.

**Table 3.3: Proposed decommissioning timetable for major Dounreay facilities**

Facility	Operation	Decommissioning – Key Dates		
		Stage 1	Stage 2	Stage 3
PFR	1974 – 1994	PFR decommissioning complete by 2025		
DFR	1959 – 1977	DFR decommissioning complete by 2025		
DMTR	1958 – 1969	DMTR decommissioning complete by 2023		
PFR reprocessing plant	1980 – 2001	2007 – 2018	2018 – 2019	2019 – 2021
MTR reprocessing plant	1959 – 1998	Complete	To be completed by 2014	
Development laboratory	1985 – 2022	2022 – 2023	2023 – 2024	2024
Shaft	1959 – 1971	Retrieval and packaging 2017 – 2021 Shaft decommissioning 2023 – 2024		
Silo	1971 – 1998	Retrieval and packaging 2017 – 2023 Silo decommissioning 2023 – 2024		

Note: The dates in the table refer to calendar years.

<sup>2</sup> This was the position at 1.4.2010. The NDA draft strategy published September 2010 states that the date is now 2039.

### 3.2.7 Harwell

Three redundant reactors remain on the Harwell site since GLEEP decommissioning was completed in 2005. The BEPO reactor and the materials test reactors DIDO and PLUTO were decommissioned to Stage 2 several years ago, and all are currently under a minimum Care and Maintenance regime.

The reference strategy at 1 April 2010 is to decommission and remediate the site so that by 2031 the only licensed facilities remaining would be stores for packaged operational and decommissioning ILW. Final decommissioning of the reactors is scheduled to start in 2015 for BEPO and 2021 for the MTRs.

The radiochemical facility ceased operations in 2004, although parts of the building are now being used to treat certain historic wastes and for the interim storage of contact-handled ILW in drums. Stage 1 decommissioning of certain laboratories was undertaken before full shutdown, and under the reference plan, the whole of the building should be decommissioned by 2023.

The timetable for the operation and decommissioning of the remaining major facilities on the Harwell site is shown in Table 3.4 below.

**Table 3.4: Proposed decommissioning timetable for major Harwell facilities**

Facility	Operation	Decommissioning		
		Stage 1	Stage 2	Stage 3
BEPO	1948 – 1968	Complete	Complete	2015 – 2023
DIDO	1956 – 1990	Complete	Complete	2021 – 2031
PLUTO	1957 – 1990	Complete	Complete	2021 – 2031
Radiochemical building	1947 – 2004	Complete 2012	2016 – 2023	

Decommissioning is divided into three stages:

**Stage 1:** For reactors: remove fuel, coolant and non-fixed items of plant such as process materials and rigs. For other facilities: remove all radioactive sources and readily removable equipment. Prepare facility for a period of Care and Maintenance if required.

**Stage 2:** Dismantle and remove most of the remaining fixed radioactive material. Prepare facility for a further period of Care and Maintenance if required.

**Stage 3:** Return facility to a condition where no significant hazard remains.

### 3.2.8 Winfrith

There are two remaining shutdown reactors on the Winfrith site: the SGHWR and the Dragon high temperature gas-cooled reactor. Most of the secondary facilities associated with these buildings have been decommissioned, and the reactors will continue in care and maintenance until final decommissioning starts in 2023.

The timetable for the operation and decommissioning of remaining major facilities on the Winfrith site is shown in Table 3.5 below.

**Table 3.5: Proposed decommissioning timetable for major Winfrith facilities**

Facility	Operation	Decommissioning		
		Stage 1	Stage 2	Stage 3
SGHWR	1968 – 1990	Complete	2023 – 2038	
Dragon	1964 – 1975	Complete	2023 – 2032	

Notes: For an explanation of the three stages of decommissioning see Section 3.2.7.

Legacy wastes at Winfrith, largely comprising the SGHWR sludges, will be immobilised by 2010. The external active sludge tanks (EAST) and Winfrith EAST treatment plant (WETP) will be decommissioned by 2012.

### 3.2.9 Springfields

Operations at Springfields comprise the fabrication of oxide fuels for AGRs and LWRs, intermediate fuel products such as powders, granules and pellets, the production and delivery of natural uranium hexafluoride and the delivery of Magnox fuel stocks. In addition, redundant plants and buildings are being demolished, and there is an ongoing programme to recover the site's historic legacy of uranic residues via residues recovery facilities.

Estimates of future arisings at the site are based on a number of projections. Magnox fuel deliveries will continue to supply the remaining two operational Magnox power stations until they cease operations. The final recovery of legacy natural and enriched uranium residues is due for completion by approximately 2017/18. Uranium hexafluoride (Hex) production will continue until 2016 at about 5,000tU per year.

Oxide manufacturing will continue until 2023 supplying AGR fuel in line with the current planned closure dates of the AGR power stations, and uranium dioxide products for UK and overseas customers. The annual capacity for AGR fuel manufacture is approximately 260tU, with current demand at 215tU. Intermediate oxide product annual demand is between 200 and 400tU.

The decommissioning of the Magnox and Residue Recovery plant has been delayed due to the need to utilise these facilities for residues storage and processing. Decommissioning of residues facilities is now expected to be completed by 2017, and the Hex Plant and Oxide Fuels Complex have a provisional date of 2045. Final site clean-up and remediation now has a provisional date of ~2100.

### 3.3 EDF Energy Sites

EDF Energy through its licence holder company British Energy Generation Ltd operates seven AGR power stations and one PWR power station.

The AGR stations came into operation in the UK over the period 1976 to 1988, and the PWR station in early 1995. All eight stations are still operating. Predicted waste arisings from AGR stations assume an operational lifetime of 31, 35 or 40 years, depending on the station. The PWR station is assumed to operate for 40 years.

A timetable for the operation and decommissioning of stations is given in Table 3.6.<sup>3</sup>

<sup>3</sup> Since 2010 Inventory data were compiled, EDF Energy has announced operational life extensions for Heysham 1 and Hartlepool of 5 years to 2019. Moreover, the company announced that full deployment of its Plant Lifetime Extension programme could enable extended lifetimes for all AGR stations by an average of 5 years and for Sizewell B by 20 years.

**Table 3.6: Proposed timetable for EDF Energy power stations**

Station	Operation	Defuelling & Care and Maintenance Preparations	Care and Maintenance	Final Site Clearance
<b>AGR</b>				
Hinkley Pt B	1976 – 2016	2016 – 2024	2024 – 2101	2101 – 2109
Hunterston B	1976 – 2016	2016 – 2024	2024 – 2101	2101 – 2109
Dungeness B	1983 – 2018	2018 – 2026	2026 – 2103	2103 – 2111
Heysham 1	1983 – 2014	2014 – 2022	2022 – 2099	2099 – 2107
Hartlepool	1983 – 2014	2014 – 2022	2022 – 2099	2099 – 2107
Heysham 2	1988 – 2023	2023 – 2031	2031 – 2108	2108 – 2116
Torness	1988 – 2023	2023 – 2031	2031 – 2108	2108 – 2116
<b>PWR</b>				
Sizewell B	1995 – 2035	2035 – 2045	Not applicable	2045 – 2055

Note: The dates in the table refer to calendar years and not to financial years.

EDF Energy has proposed an “Early Safestore” strategy for AGR decommissioning, with the start of final reactor dismantling deferred for a period of at least 85 years after the end of generation for AGRs. The decommissioning strategy is divided into three stages as follows:

**Defuelling & Care and Maintenance Preparations:**

The reactor is defuelled and the fuel transferred for reprocessing or storage. Non-radioactive buildings and plant external to the reactor area are dismantled. Accumulated operational waste is retrieved and packaged. A Safestore is constructed to retain all of the active plant and materials on the site in a safe and secure state. These activities are assumed to take about 8 years.

Significant plant decommissioning activities that were planned to take place coincident with reactor dismantling (about 85 years after end of generation) are now to be carried out in the first few years following reactor shutdown.

**Care and Maintenance:**

There is a period of care and maintenance with inspection and repair as necessary. The duration is assumed to be at least 77 years for the AGRs.

**Final Site Clearance:**

Safestore dismantling and final site clearance is envisaged to start about 85 years after reactor shutdown. All activities are assumed to take about 8 years.

For the Sizewell B PWR the strategy is Early Site Clearance, with reactor dismantling deferred for a period of 10 years after station shutdown. All decommissioning work on the site is planned to be completed 20 years after station shutdown. This strategy has been adopted following a review of international best practice for PWR decommissioning.

Wastes arising during the defuelling of the reactors are the same as those which arise during operation. For this reason they are included with the operational wastes.

EDF Energy has contracts that cover the management of spent fuel generated during the lifetimes of the AGR power stations. The contracts provide for a mixture of long-term storage and reprocessing at Sellafield, and the radioactive wastes generated are included in wastes reported for Sellafield site.

For the Sizewell B PWR, the strategy is to store spent fuel until a disposal route is available, although this does not foreclose potential alternative options.

### **3.4 Ministry of Defence Sites**

The MoD produces radioactive wastes primarily as a result of the nuclear weapons and nuclear propulsion plant programmes, research and development activities and through the redundancy of assorted equipments that contain radioactive substances. In addition, volumes of waste are produced as a result of the remediation of radioactively contaminated ground on both nuclear and non-nuclear defence sites.

The figures for future waste arisings are projections made by MoD and/or its site operators on the basis of assumptions as to the nature and scale of future operations and activities, and reflect the most likely national defence strategy.

Many of MoD's sites are operated on its behalf by contractor organisations. For some sites ownership has also been transferred. However the ownership of radioactive wastes at all sites rests with the MoD, which also bears the cost of waste management and decommissioning.

#### **3.4.1 Atomic Weapons Establishment**

UK Government policy is to sustain a credible deterrent capability through to the 2020s and beyond. The existing nuclear warhead design will last into the 2020s. The MoD does not yet have sufficient information to know whether it can, with some refurbishment, be extended beyond that point or whether it will need to develop a replacement warhead: a decision is likely to be necessary in the next Parliament.

The Atomic Weapons Establishment (AWE) sites at Aldermaston and Burghfield undertake research and development, design, manufacturing, servicing and decommissioning of nuclear warheads. The AWE sites are operated under a Government Owned Contractor Operated (GOCO) arrangement. AWE plc operates the sites on behalf of MoD which owns the sites and assets. Wastes from Burghfield are included with those from Aldermaston, from where radioactive waste storage and disposal is co-ordinated.

Legacy sea disposal packages suitable for disposal at the LLWR will be overpacked and consigned. Many older facilities have come to the end of their operational lives, and are either under Care and Maintenance pending decommissioning or are actually being decommissioned.

#### **3.4.2 Her Majesty's Naval Base Devonport**

The Devonport site comprises the Naval Base (owned and operated by the MoD) and its co-located Dockyard (owned and operated by Babcock International Group plc).

Devonport provides maintenance and support services for the operational UK nuclear submarine squadrons. It has the facilities to carry out operations associated with submarine refitting and defuelling. Since 2004 all UK nuclear submarine refitting work has been carried out at Devonport.

Operational waste arisings from Devonport have been derived by extrapolation of historical data and are forecasted up to 2100.

#### **3.4.3 Rosyth Royal Dockyard**

Submarine refitting and refuelling activities at Rosyth ceased in 2003. Progressive site decommissioning has started, and is forecast to continue until 2013/14.

#### **3.4.4 HMNB Clyde**

HMNB Clyde (Faslane) provides maintenance and support services for the operational UK nuclear submarine squadrons. It deals with radioactive wastes arising from the operation at sea and the maintenance ashore of submarine nuclear propulsion systems.

Operational wastes are at a significantly lower level than those resulting from refitting work at Devonport. The predicted arisings are based on the number of submarines maintained and future development work, and are thus subject to change.

#### **3.4.5 Decommissioned Nuclear Powered Submarines**

When nuclear powered submarines leave Naval service the nuclear fuel is removed, equipment taken off and the vessel prepared for storage afloat. This process is called decommissioning, but in the Naval sense, and is distinct from the decommissioning of nuclear power stations. After Naval decommissioning, radioactivity remains contained within the reactor compartment structures.

To date 16 nuclear-powered submarines have left naval service, and 11 have been defuelled. They are being stored afloat at Rosyth and Devonport dockyards.

Future arisings of submarine decommissioning wastes assume a continuing naval nuclear propulsion programme with a fleet of up to 8 SSNs (nuclear powered, conventionally armed submarines) and 4 SSBNs (nuclear powered submarines with ballistic nuclear weapons). Submarines are assumed to have a hull life of between 25 and 30 years and to be stored afloat for 30 years before being cut up and the waste processed. Future arisings of submarine decommissioning wastes are forecast up to 2100.

MoD's Project SDP (Submarine Dismantling Project) formerly known as ISOLUS (Interim Storage Of Laid Up Submarines) is reviewing options for interim storage of decommissioned nuclear submarines pending the implementation of a UK strategy for the long-term management of ILW. The chosen interim storage route may affect the current 30-year afloat storage policy, which may in turn affect the rate at which the waste is processed.

#### **3.4.6 HMNB Portsmouth**

HMNB Portsmouth is involved in managing naval stores and de-equipping redundant naval surface vessels that can contain equipment and instrumentation incorporating radioactive materials. The base produces small quantities of radioactive waste from these activities.

#### **3.4.7 Dounreay (Vulcan)**

The Naval Reactor Test Establishment (NRTE) Vulcan at Dounreay is involved in development work, acting as the test bed for prototype submarine nuclear reactors. Operations are forecast to continue to the end of core life in 2014.

This will be followed by a post-operational phase that is estimated to continue until 2020. Decommissioning is assumed to take place during the period 2020 until 2050.

#### **3.4.8 Rolls Royce Marine Power Operations Ltd Derby**

Rolls Royce Marine Power Operations Ltd (RRMPOL) operates two nuclear licensed sites at Raynesway in Derby, where work is carried out in support of the MoD's nuclear submarine programme. RRMPOL manufactures the reactors for the Navy's nuclear powered submarines, and operates the low energy Neptune reactor used to develop submarine reactor designs.

The future of the sites is inextricably linked to the future operational requirements of the submarine fleet. It is envisaged that both of the nuclear licensed sites will operate at the current levels of activity for at least the next six years.

### **3.4.9 BAE Systems Marine Ltd Barrow-in-Furness**

BAE Systems Marine (BAESM) Ltd builds, tests and commissions nuclear submarines in support of the MoD nuclear submarine programme. The site generates only small quantities of radioactive waste associated with the commissioning of submarine nuclear reactors.

### **3.4.10 Eskmeals**

The Eskmeals site, operated by QinetiQ on behalf of MoD, has been used for proof firing of a wide range of different calibre weapons by the UK's armed services. This included test firing of projectiles made up in part of depleted uranium, and the use of 'hard targets' for testing the effectiveness of armour plating containing depleted uranium.

The firing programme using depleted uranium projectiles is currently suspended, but there are no plans to close the site.

QinetiQ are in the closing stages of the first phase of decommissioning for the MOD, but do not yet have full figures of how much LLW and VLLW this has produced.

### **3.4.11 Defence Storage and Distribution Agency Donnington**

The Defence Storage and Distribution Agency (DSDA)<sup>4</sup> at Donnington holds redundant equipment containing radioactive materials pending a decision on their future use, and when declared as waste are disposed of as soon as possible in accord with current legislation.

The future needs of MoD will govern waste arisings. It is assumed that waste will continue to arise at current levels.

### **3.4.12 Defence Estates**

Defence Estates is responsible for managing the MoD estate.

As part of their work Defence Estates manages a major Land Quality Assessment (LQA) programme to identify and manage land contamination, including radioactive land contamination across the MoD Estate. This has the potential to create volumes of low level waste comprising predominantly soil, ash and rubble from the remediation of radioactively contaminated ground. The principal source of the contamination is expected to be radium associated with the historic maintenance and disposal of luminised equipment.

## **3.5 United Kingdom Atomic Energy Authority Site**

Small quantities of ILW and LLW will continue to be produced from the operational phase of the JET fusion experiment located at Culham. The reference decommissioning strategy at 1 April 2010 assumes that operations continue to 2013, and the facility then moves immediately into decommissioning.

However, the length of future operations is uncertain. United Kingdom Atomic Energy Authority's contract to operate JET is dependent on the experimental requirements, the performance of the JET

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<sup>4</sup> DSDA was renamed Joint Supply Chain Services (JSCS) with effect from 1 August 2010.

machine and on EU funding, and operations are expected to continue for some time in support of ITER. There is some uncertainty over what further experiments will take place, and therefore what will be the final inventory of the plant and of the resultant decommissioning waste quantities. There is, however, an agreed limit on the maximum neutron production from deuterium-tritium operations, and this has been used to define a bounding inventory for the wastes.

United Kingdom Atomic Energy Authority has been investigating possible treatment and packaging options for JET ILW streams including options for reduction of the tritium inventory to enable its return to source. On the basis of a start date of January 2014 for the decommissioning, removal of the torus facility is programmed for completion in 2020. The Active Gas Handling System needs to remain operational during the dismantling of the JET machine, but should then be fully decommissioned by 2022, and the JET site completely cleared by the end of 2023.

### **3.6 GE Healthcare Sites**

Expansion of GE Healthcare Ltd's activities is expected to be mainly in non-radioactive products. Future radioactive waste arisings are estimated up to 2040. Volumes are based on a continuation of the current rate of arising. Market forces will govern future business and manufacturing activities, so the medium and longer-term estimates of waste volumes and type can only be approximate.

Predictions for decommissioning waste arisings are included in operational wastes, since facilities do not have a fixed operating lifetime but are refurbished as necessary. The rate of arising of refurbishment wastes reflects expected facilities development plans for commercial activities.

### **3.7 Urenco Site**

Future arisings at Urenco's Capenhurst site will be dependent on the commercial contracts won by the group and the installation of new enrichment capacity. The use of either natural uranium or recycled uranium from reprocessing as the enrichment feedstock will be a commercial and regulatory decision. Waste volumes are estimated up to 2030. Uranium recovery routes are in place for some waste materials, and it is assumed that these will remain open in the short term. In the long term it is envisaged that uranium recovery will be undertaken at Capenhurst.

### **3.8 Minor Waste Producers**

The rates of arisings from the numerous minor waste producers are difficult to predict. In recent years annual arisings of ILW have fallen, and are now at very low levels. Future arisings are expected to be minimal. Most LLW is consigned to the LLWR near Drigg. The rate of future LLW arisings is assumed to be the same as current arisings, and is estimated up to 2050.

### **3.9 Discussion of Scenario**

#### **3.9.1 Fuel Manufacturing and Uranium Enrichment**

Springfields manufactures oxide fuels for AGRs and LWRs, and intermediates for export. Uranium hexafluoride continues to be manufactured and exported. Future operations at Springfields will depend on commercial strategies and the outlook for the worldwide nuclear power industry. The 2010 Inventory scenario assumes that oxide fuel and product manufacture and uranium enrichment operations do not continue beyond 2030.

Urenco's business at Capenhurst supplies enriched uranium for oxide fuel manufacture. Future operations at Capenhurst will depend on the outlook for the worldwide nuclear power industry. The 2010 Inventory scenario assumes that uranium enrichment operations do not continue beyond 2030.

Fabrication of MOX fuel in the SMP at Sellafield will also depend on the future level of business. Further to the 2010 contract with overseas utilities for its continued use, NDA will continue to evaluate the performance of the SMP, which has not met original expectations, together with commercial opportunities associated with its role in repatriating foreign owned plutonium. However, at the time the 2010 Inventory data were collated the SMP was scheduled to operate up to 2036 and the waste forecasts in the 2010 Inventory are consistent with this date.

Assumptions could be revised to accommodate an extension of AGR lifetimes or a renaissance of nuclear energy generation in the UK and overseas.

### **3.9.2 Nuclear Power Station Operation**

Power station operating lifetimes are those in operators' existing corporate plans. However, market conditions or technical and safety issues could result in revisions to lifetimes.

A White Paper on Nuclear Power published in January 2008 set out Government's decision that "*new nuclear power stations should have a role to play in this country's future energy mix*" and that "*it would be in the public interest to allow energy companies the option of investing in new nuclear power stations; and that the Government should take active steps to facilitate this*" [1]. In November 2009 the Government published its draft Nuclear National Policy Statement (NPS), which named ten sites suitable for new nuclear deployment by the end of 2025. Having considered the responses to the public consultation and the outputs of the parliamentary scrutiny process, the Government has issued a revised draft Nuclear NPS listing eight potentially suitable sites [2].

A number of operators have plans to construct new nuclear generation in the UK, and two reactor designs are being considered in the Generic Design Assessment (GDA) process. However it is anticipated to be mid-2011 before the GDA process will be completed, first site licences/construction consents are given, and decisions on planning applications are made.

Possible alternatives to current lifetime assumptions for the remaining operational Magnox stations (Oldbury and Wylfa)<sup>5</sup>, the AGR stations<sup>6</sup> and the PWR station are early closure or extended operation. To illustrate the impact of power station lifetime changes, the authors have estimated waste volumes from one year's operation of Magnox, AGR and PWR stations (see Table 3.7). The figures do not include wastes from the reprocessing of one year's discharged fuel.

Longer or shorter operating lifetimes for power stations would not have a significant effect on overall future waste volumes from the stations, which are dominated by wastes from decommissioning.

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<sup>5</sup> Since the 2010 Inventory data were compiled, NDA has announced it is engaging with nuclear regulators and Government to secure short-term life extension for Oldbury and Wylfa, subject to business and safety case approvals.

<sup>6</sup> Since the 2010 Inventory data were compiled, EDF Energy has announced operational life extensions for Heysham 1 and Hartlepool of 5 years to 2019.

**Table 3.7: Predicted waste volumes from 1 year's operation of power station**

Waste type	Station	Volume arising (m <sup>3</sup> )	When all waste has been packaged	
			Packaged volume (m <sup>3</sup> )	Conditioned volume (m <sup>3</sup> )
ILW	Magnox <sup>(1)</sup>	15	21	19
	AGR <sup>(2)</sup>	21	46	36
	PWR <sup>(3)</sup>	8.1	17	14
LLW	Magnox <sup>(1)</sup>	61	61	49
	AGR <sup>(2)</sup>	50	44	35
	PWR <sup>(3)</sup>	35	91	73

1. Average annual arisings for remaining periods of operation at Oldbury and Wylfa

2. Average annual arising for period 2010-2014 at AGR stations

3. Average annual arising for period 2010-2011 at Sizewell B

### 3.9.3 Reprocessing of Spent Fuel from Nuclear Power Stations

#### UK waste

Waste volumes in the 2010 Inventory are based on a scenario that assumes the reprocessing of all spent Magnox fuel, SGHWR and WAGR fuel, about 5,500tU of AGR fuel and about 4,400tU of overseas LWR fuel.

This does not include about 3,100tU of AGR fuel that are forecast to arise over UK power station lifetimes, and Sizewell B fuel. There are no current plans to reprocess fuel from Sizewell B. It is assumed that these fuels will be held in long-term storage. However they could be treated in a number of ways, including reprocessing. To illustrate the impact of such reprocessing, the authors have estimated waste volumes using 2010 Inventory data for reprocessing operations in Thorp.

If the 3,100tU of AGR fuel were to be reprocessed, packaged waste volumes are estimated to be about 170m<sup>3</sup> of HLW, 10,000m<sup>3</sup> of ILW and 5,000m<sup>3</sup> of LLW. Additional volumes of LLW will arise from waste treatment and site services facilities.

If Sizewell B fuel were to be reprocessed, packaged waste volumes are estimated to about 90m<sup>3</sup> of HLW, 2,700m<sup>3</sup> of ILW and 3,400m<sup>3</sup> of LLW. These figures assume the reprocessing of 1,049tU of fuel. Additional volumes of LLW will arise from waste treatment and site services facilities.

#### Waste from overseas materials

A proportion of the waste from the Thorp and Magnox reprocessing plants at Sellafield results from reprocessing overseas spent fuel. All reprocessing contracts with overseas customers signed since 1976 include a provision to return packaged wastes back to the country of origin.

Government policy is that wastes resulting from the reprocessing of overseas spent fuel should be returned to the country of origin, and HLW should be returned as soon as practicable after vitrification. The policy allows "waste substitution" arrangements that ensure broad environmental neutrality for the UK. Waste substitution is the process whereby an additional amount of HLW from reprocessing would be returned, which is smaller in volume but equivalent in radiological terms to customers' ILW and LLW that would otherwise be returned.

Exports of vitrified HLW started in January 2010 and are scheduled to continue for about ten years. In total about 1,850 canisters of vitrified HLW (about 278m<sup>3</sup>) is planned for export, and this volume

assumes that substitution arrangements are implemented. Future arisings of HLW are net of exports to overseas reprocessing customers, so that the total volume/number of containers represents only the HLW that is a UK liability.

During the 1990's about 1,000 tonnes of materials test reactor fuel was reprocessed at Dounreay for customers in Europe and Australia. The contracts for this work require that the radioactive wastes produced be returned to the countries of origin within 25 years of reprocessing. The contracts are backed by inter-governmental letters. The radioactive waste will be returned as cemented raffinate. The UK and Scottish Governments are currently consulting on the arrangements for returning wastes. The arrangements for returning wastes are currently being finalised. The Inventory includes 75m<sup>3</sup> of raffinate (210m<sup>3</sup> when packaged) subject to return.

### **3.9.4 Nuclear Research and Development**

Nearly all of the major facilities built in the UK over more than 50 years to undertake research and development in support of nuclear energy generation and fuel cycle operations have been closed down, and have either already been decommissioned or are currently being decommissioned.

The JET fusion facility is assumed to operate until the end of 2013. However, the extent of future operations is uncertain, and JET could well operate beyond this date for several years in support of ITER. Because annual operational arisings are low, any change to the 2013 date will not have a significant effect on overall radioactive waste volumes.

### **3.9.5 Ministry of Defence Activities**

Spent fuel from nuclear powered submarines has not been declared as waste. It is held in long-term storage at Sellafield.

While MoD has stated that Eskmeals will be maintained for the foreseeable future, no comment has been made about the future of the battery. There have not yet been any steps taken to estimate the volume of defence wastes likely to arise from decommissioning of the battery.

MoD's Project SDP (Submarine Dismantling Project) addresses the process for deciding and implementing future policy for managing the hulls, and particularly the reactors, of decommissioned nuclear submarines. Any change in this programme would affect future waste arisings.

The MoD Estate is subject to a rolling programme of prioritised Land Quality Assessment (LQA). This assessment includes the potential for radioactive contamination. In light of the ongoing LQA programme, the current volume estimate for arisings associated with the remediation of contaminated ground in the UK is subject to potential significant change.

### **3.9.6 Nuclear Materials**

In addition to commercial spent fuel for which there are no current plans to reprocess (see Section 3.9.3), the UK has large stocks of spent nuclear fuel from research and demonstration reactors with no current reprocessing route. There are also uranic materials, plutonium (from the reprocessing of spent nuclear fuel), Magnox Depleted Uranium (MDU – a by-product of Magnox spent fuel reprocessing) and "Hex tails" (a by-product of the uranium enrichment process).

Government in consultation with NDA and other stakeholders will consider the most effective management strategies for nuclear materials, including what proportions of these materials should be retained as a strategic stock and what proportions might be regarded as waste.

The quantities of UK civil nuclear materials will be given in a separate document.

## **4 TYPES OF RADIOACTIVE MATERIALS**

### **4.1 Introduction**

There are two categories of radioactive material included in the UK Inventory:

- Civil nuclear materials that are not currently deemed to be waste. This category comprises irradiated fuel, unirradiated fuel, uranium, plutonium and thorium.
- Land that is potentially contaminated and miscellaneous materials some of which are deemed to be waste. There is often considerable uncertainty in the quantities that might arise, and as a consequence some waste producers have chosen to report volume estimates here rather than in the 2010 UK Radioactive Waste Inventory.

Nuclear materials from defence programmes<sup>7</sup> or from ‘small users’ are not included in the UK Inventory.

### **4.2 Irradiated Fuel**

Irradiated fuel is nuclear fuel that is being or has been used to power nuclear reactors. When it has reached the end of its life, and is no longer capable of efficient fission, it is termed spent fuel. Spent fuel still contains large amounts of uranium (and some plutonium), which can be separated out through reprocessing and used to make new fuel. It is because of the potential value of the uranium and plutonium that it contains that some spent fuel is not classified as radioactive waste.

Currently, civil UK nuclear fuels are used in Magnox reactor, Advanced Gas-cooled Reactor (AGR) and Pressurised Water Reactor (PWR) power stations. Typically the spent fuel is made up of 96% unreacted uranium, 1% plutonium and 3% waste products, although the precise composition depends on the type of reactor and the amount of energy produced by the fuel.

Spent Magnox and AGR fuel is stored at the station for a short cooling period before transfer to Sellafield in Cumbria. Magnox spent fuel and a proportion of AGR fuel is reprocessed at Sellafield. The remaining spent AGR fuel is held at Sellafield. Spent PWR fuel from Sizewell is currently stored at the station. Some spent LWR fuel from overseas is also held and reprocessed at Sellafield<sup>8</sup>.

Until 1996 there was also spent fuel reprocessing at Dounreay in Caithness in support of the UK fast reactor programme and overseas customers, but on a much smaller scale than at Sellafield. Some spent fuel remains in storage at the site.

Other spent fuels have arisen from research, experimental and prototype reactors. Spent fuel from the Windscale Advanced Gas-cooled Reactor (WAGR) and the Steam Generating Heavy Water Reactor (SGHWR) is stored at Sellafield pending reprocessing.

Small quantities of relatively low irradiation spent fuel that are not planned to be reprocessed have already been designated as waste and are reported in the 2010 Inventory. These comprise spent fuels from the Windscale Piles, Graphite Low Energy Experimental Pile (GLEEP), Dragon and Zenith reactors, plus small quantities of mainly prototype commercial fuels.

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<sup>7</sup> Information about nuclear materials can be found in the Ministry of Defence 1998 Strategic Waste Review.

<sup>8</sup> The UK has contracts with other countries to reprocess their spent fuel. These contracts signed since 1976 provide for the return of recovered uranium and plutonium and associated radioactive waste to the country of origin.

### 4.3 Unirradiated Fuel

Unirradiated fuel is nuclear fuel that has not yet been used to power nuclear reactors. It includes fuel at fabrication plants awaiting shipment, and fuel at nuclear power stations awaiting loading into reactors. There are also small quantities of research fuels.

### 4.4 Plutonium

Plutonium is a radioactive element that does not occur in nature. Plutonium is created in nuclear reactors as a result of ‘burning’ (i.e. irradiating) the uranium in nuclear fuel. It is contained within spent nuclear fuel when it is removed from the reactor, but can be extracted by reprocessing the fuel. Separated plutonium is stored in purpose built facilities within high integrity containers at reprocessing sites as plutonium oxide powder.

Plutonium is a potentially valuable energy source. The original intention of recovering plutonium was to reuse the material in a future fast reactor programme. It was believed in the 1950s and 1960s that a closed nuclear fuel cycle was the most desirable option for future energy supply in light of the scarcity of uranium at the time. Fast reactors make more efficient use of nuclear materials – effectively generating more fuel than they consume. The UK fast breeder reactor programme was cancelled in the early 1990s as the forecast uranium supply shortage did not occur, therefore closing this option for the use of recovered plutonium.

However, plutonium can be used as a component of mixed oxide (MOX) fuel – a mixture of uranium and plutonium. Some countries are using MOX fuel in their reactors, but MOX fuel (and hence UK owned plutonium) is not currently used in UK reactors<sup>9</sup>.

### 4.5 Uranium

Uranium is a naturally occurring radioactive element that is the raw material used for making fuel for nuclear reactors. Uranium ore is processed to concentrate the uranium content, which is imported into the UK as triuranium octoxide ( $U_3O_8$ ) – commonly referred to as yellowcake. This product is then further processed to produce uranium in a physical and chemical form suitable for fabricating into nuclear fuels.

There are different types (or grades) of uranium:

<b>Natural uranium (NU)</b>	Uranium in nature has a U-235 content of about 0.72% by mass. Natural uranium is used in its metallic form in Magnox reactor fuel <sup>10</sup> .
<b>Low-enriched uranium (LEU)</b>	Uranium enriched in U-235 to less than 20% by mass. LEU as uranium dioxide ( $UO_2$ ) is used in the manufacture of AGR and PWR fuels. Power reactor fuels have a typical U-235 content of between 3 and 5% by mass. LEU uranium (with a reduced U-235 content) is also a product of reprocessing these fuels. This is stored as uranium trioxide ( $UO_3$ ).
<b>High-enriched uranium (HEU)</b>	Uranium enriched in U-235 to 20% or more by mass. HEU is used in the manufacture of specialist nuclear fuels (e.g. for research

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<sup>9</sup> MOX fuel that is delivered to overseas reactors only contains plutonium that the overseas customer owns.

<sup>10</sup> Latterly some Magnox reactor fuel has been slightly enriched (<1% U-235) to offset the effects of reactor ageing.

reactors). In the past it has also been recovered by the reprocessing of these fuels.

### **Depleted uranium (DU)**

Uranium with U-235 content less than in natural uranium. DU is a by-product of the uranium enrichment process used in the manufacture of nuclear fuels for AGR and PWR power stations. This is currently stored as uranium hexafluoride (UF<sub>6</sub>). DU is also a product of reprocessing spent Magnox reactor fuel. This is stored as UO<sub>3</sub>.

In the UK, fuel for civil nuclear reactors is manufactured at Springfields in Lancashire. Yellowcake is first converted through chemical processing into uranium tetrafluoride (UF<sub>4</sub>). The next process stage depends on the type of fuel to be manufactured. AGR fuel is fabricated from low enriched (UO<sub>2</sub>). Here UF<sub>4</sub> is first converted to UF<sub>6</sub>, which is enriched at Capenhurst in Cheshire. The enriched UF<sub>6</sub> is then converted to UO<sub>2</sub> at Springfields, which in turn is formed into ceramic pellets. For Magnox reactor fuel UF<sub>4</sub> is converted to uranium metal: the manufacture of the fuel has now ceased.

Uranium recovered from the reprocessing of spent fuel can be re-enriched and re-utilised in new nuclear fuel. Some reprocessed uranium from the Magnox programme has in the past been used to manufacture new AGR fuel. Depleted uranium UF<sub>6</sub> can be enriched to provide feed stock for new fuel. Depleted uranium can also be mixed with plutonium to make MOX fuel.

Radiation shielding applications and limited other industrial applications make use of specific properties of uranium.

## **4.6 Thorium**

Thorium is a naturally occurring radioactive element that can be mined, extracted and processed to make fuel for nuclear reactors. In the UK only experimental reactors have used thorium based fuels. The Dragon high temperature helium-cooled reactor at Winfrith, which operated from 1964 to 1975, used a mix of uranium and thorium fuels. Dragon reactor fuel has already been designated as waste, and is reported in the 2010 Inventory.

Non-nuclear industrial uses of thorium are in illuminants, electron emitters, ceramics and glass, catalysts and specialist alloys.

## **4.7 Contaminated Land**

Ground and building foundations at nuclear sites may become contaminated with low concentrations of radioactivity as a result of lifetime site operations. The removal of contaminated foundations and the remediation of contaminated ground will generate radioactive wastes. These wastes comprise principally soil and concrete/rubble, and most will arise during the final stage of site decommissioning and clean-up.

There is greater uncertainty in the future arisings of waste from the remediation of contaminated land than in facility dismantling and demolition wastes. This is particularly the case for radioactive wastes at the lower end of the activity range referred to as Very Low Level Waste (VLLW). Estimation of volumes of these wastes can be somewhat speculative due to uncertainty about regulatory requirements and disposal routes, lack of definition of site decommissioning and clean-up plans, and that much characterisation work might remain to be carried out and that this work may indicate that remediation is not required. Furthermore the benefit of decontamination that might allow waste

volume to be below the lower threshold level for radioactive waste must be considered against the cost and dose detriment.

At some non-nuclear defence sites low level radioactive contamination may be present as a result of historic production, maintenance, storage and disposal of luminised instruments. The peak period for luminising was from the 1930s to the 1970s. The luminising paint used originally contained radium, though more recently promethium and tritium were used. The Ministry of Defence has a continuing programme of land quality assessment.

Some contaminated ground is reported as radioactive waste in the 2010 Inventory. However because of the uncertainties described above, some waste producers have chosen to report potentially contaminated land here until contamination surveys are extended and refined, and there is more certainty on volumes.

## **4.8 Miscellaneous Wastes and Materials**

### **4.8.1 Miscellaneous wastes and materials**

There is a limited number of radioactive wastes for which no final treatment, packaging or disposal route has yet been identified, and which are not sufficiently well characterised to be reported in the 2010 UK Radioactive Waste Inventory. These wastes are included here.

### **4.8.2 Waste generated from planned future facilities**

This comprises radioactive wastes that might arise from the operation of new facilities that are anticipated to be required for facilitating implementation of planned waste treatment, decommissioning and site clearance programmes. These wastes arise from the treatment of existing wastes, and so no 'new' radioactivity will be generated.

Plans for these future waste retrieval, treatment and packaging plants are not yet fully developed. Consequently, robust estimates of these secondary waste arisings are not yet available, and so the wastes are reported here rather than in the 2010 UK Radioactive Waste Inventory.

Waste generated from planned future facilities excludes radioactive wastes associated with any new programmes for further nuclear power stations, fuel manufacturing and spent fuel reprocessing in the UK.

## **5 2010 INVENTORY SCENARIO FOR ARISING OF RADIOACTIVE MATERIALS**

All assumptions listed below are consistent with those used in compiling data for the 2010 UK Radioactive Waste Inventory. These assumptions represent the planning positions at 1 April 2010 of the organisations that operate sites where radioactive waste and materials are generated or held. Projections may need to be amended as plans and arrangements are developed or are changed for commercial, policy or funding reasons, or if improved data become available.

Since the 1 April 2010 there have been developments in the forward plans at a number of sites. This means that certain assumptions used in preparing data for the 2010 Inventory have already been revised or are being reviewed, and there will be or are likely to be some changes to waste and material estimates. Revisions can affect either or both the quantity and timing of future arisings.

### **5.1 Generic Assumptions**

- Plutonium, uranium and irradiated nuclear fuel from UK civil nuclear power stations have potential value as they can be reused for manufacturing fresh nuclear fuel. These materials are not currently classified as waste.
- Small quantities of relatively low irradiated spent fuel that are not planned to be reprocessed have already been designated as waste and are reported in the 2010 UK Radioactive Waste Inventory (i.e. excluded here).
- Most irradiated fuel arising from UK reactors has been or will be reprocessed (see assumptions below). To report this irradiated fuel, as well as plutonium and uranium that has or will be produced by reprocessing the fuel, would result in double counting of radioactive materials. In addition some materials recovered from these (reprocessing) operations have been reused to manufacture fresh fuel. To prevent double counting, the radioactive materials inventory includes quantities of plutonium, uranium and spent fuel that were held in the UK at 1 April 2010; and future arisings of irradiated fuel. The estimated quantities of plutonium and uranium that will be produced by future fuel reprocessing are given for information.
- The radioactive materials inventory reports UK materials. Quantities of overseas owned materials currently held in the UK are given for information.
- The radioactive materials inventory does not include nuclear materials owned by the Ministry of Defence or 'small users' i.e. universities and research establishments.
- The 2010 UK Radioactive Waste Inventory includes radioactive waste that is expected to be produced when all the UK spent fuel that is planned to be reprocessed has been reprocessed - see assumptions below.
- Volumes of contaminated ground reported in the radioactive materials inventory are in-situ volumes of potentially radioactively contaminated ground and foundations that are not well characterised for inclusion in the 2010 UK Radioactive Waste Inventory. Radioactive wastes anticipated from radioactively contaminated ground and foundations where there is more certainty in the quantities that might be produced are reported in the 2010 UK Radioactive Waste Inventory.

## 5.2 Irradiated Fuel Arisings

- In addition to the spent fuel already generated from the nine shut down power stations in the UK, irradiated fuel will arise from the operations and final defuelling of the following nuclear power stations:

**Table 5.1: Operational nuclear power stations in the UK**

Station	Planned shutdown date <sup>11</sup>
<b>Magnox:</b>	
Oldbury	2011
Wylfa	2011
<b>AGR:</b>	
Hinkley Pt B	2016
Hunterston B	2016
Hartlepool	2014
Heysham 1	2014
Dungeness B	2018
Heysham 2	2023
Torness	2023
<b>PWR:</b>	
Sizewell B	2035

- No new nuclear power stations are assumed to be constructed in the UK<sup>12</sup>.
- UK has contracts with other countries for reprocessing some of their spent nuclear fuel.

## 5.3 Irradiated Fuel Management

- Nuclear fuel manufacturing in the UK will continue until 2030.
- The following spent fuel that has been produced or is forecast to arise from UK reactors is assumed to be reprocessed at Sellafield:
  - 55,000tHM from Magnox reactors, of which about 51,000tHM had been reprocessed by 1 April 2010.

<sup>11</sup> Since the 2010 UK Radioactive Waste Inventory data were compiled, NDA has announced it is engaging with nuclear regulators and Government to secure a short-term life extension for Oldbury, subject to business and safety case approval. In October 2010 it was announced that Wylfa Power Station will continue operating for up to two additional years beyond December 2010. Extended generation will be subject to safety case approval. In December 2010 EDF Energy announced operational life extensions for Heysham 1 and Hartlepool of 5 years to 2019.

<sup>12</sup> While the UK Government has stated that it supports new nuclear power stations and some operators are planning new stations, it is not yet clear how many reactors and of what design might be constructed.

- 5,500tHM from AGRs, of which about 2,500tHM had been reprocessed by 1 April 2010.
- About 28tHM from WAGR.
- About 120tHM from SGHWR.
- About 44tHM from DFR.
- Small amount of Post Irradiation Examination (PIE) type materials.
- 4,400tHM of foreign owned LWR spent fuel is assumed to be reprocessed in the UK.
- The following spent fuel that has been produced or is forecast to arise from UK reactors is assumed to be held in long-term storage in the UK (i.e. there are no current plans for reprocessing these fuels)<sup>13</sup>.
  - 3,100tHM from AGRs;
  - 1,049tHM from PWR.

#### **5.4 Separated Uranium and Plutonium Arisings & Management**

- Separated uranium and plutonium is assumed to arise in the UK from the reprocessing activities listed above. Magnox fuel reprocessing is assumed to be complete by 2016; other spent fuel reprocessing by 2021.
- All UK owned separated uranium and plutonium is assumed to be held in long-term storage in the UK.

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<sup>13</sup> Although plutonium, uranium and spent fuel are not classified as waste, these materials are considered in the Government's "Managing Radioactive Waste Safely" programme for developing and implementing a policy for managing UK's higher activity wastes in the long-term.

## 6 PRINCIPAL CHANGES FROM THE 2007 INVENTORY SCENARIO

There have been a number of changes to assumptions that have impacted on estimates of future waste arisings in the 2010 Inventory. Table 6.1 lists the principal differences in the assumptions for the 2010 Inventory and the 2007 Inventory.

**Table 6.1: Principal differences in the 2010 and 2007 Inventory scenarios**

Site / Item	2010 Inventory	2007 Inventory
<b>Sellafield</b>		
Thorp total AGR throughput	~ 5,500 tU	~ 3,300 tU
AGR fuel for long-term storage	~ 3,100 tU	~ 5,500 tU
Thorp total overseas LWR throughput	~ 4,400 tU	~ 4,400 tU
Reprocessing of DFR breeder material	~ 44 tU	Waste stream 5B23
<b>Springfields</b>		
Magnox fuel production ends	Completed	2008
Final recovery of legacy natural and enriched uranium residues	Completion 2017/18	Completion 2009/10, legacy stocks 2015
Decommissioning residue facilities	Complete 2017	Complete 2012
Decommissioning Hex Plant, Oxide Fuels Complex and site remediation	Hex Plant and Oxide Fuels Complex 2017, Site remediation ~2100	Hex Plant 2020, Oxide Fuels Complex 2028, Site remediation 2031
<b>Dounreay</b>		
PFR / DFR decommissioning	Complete 2025	Complete 2028 / 2024
DMTR decommissioning	Complete 2023	Complete 2014
MTR fuel reprocessing plant decommissioning	Complete 2014	Complete 2010
Development laboratory decommissioning	Complete 2021	Complete 2027
Historic High Beta Gamma Storage Facility decommissioning	Retrieval & packaging 2017 – 2021 Decommissioning 202-2024	Retrieval & packaging 2019 – 2024 Decommissioning 2024 onwards
Silo decommissioning	Retrieval & packaging 2017 – 2023 Decommissioning 2023-2024	Retrieval & packaging 2019 – 2024 Decommissioning 2024 onwards
<b>Harwell</b>		
BEPO decommissioning	No longer accelerated (complete 2023)	Complete 2015
DIDO / PLUTO decommissioning	No longer accelerated (complete 2031)	Complete 2015 / 2013
Radiochemical building decommissioning	No longer accelerated (complete 2023)	Complete 2015
<b>Windscale</b>		
Pile 1 / Pile 2 decommissioning	No longer accelerated (complete 2036 / 2044)	Complete 2023 / 2020
WAGR decommissioning	No longer accelerated (complete 2030)	Complete 2015

Site / Item	2010 Inventory	2007 Inventory
<b>Winfrith</b>		
SGHWR decommissioning	No longer accelerated (complete 2038)	Complete 2015
Dragon decommissioning	No longer accelerated (complete 2032)	Complete 2015
<b>Culham</b>		
JET operation	To end 2013	To end 2010
<b>Magnox stations</b>		
Oldbury life extension	Operates to 2011	Operates to 2008
Wylfa life extension	Operates to 2011	Operates to 2010
Final site clearance	Up to 85 years after shutdown	Up to 100 years after shutdown
<b>LLWR</b>		
Operational life	Operates beyond 2080	Operates to 2050
<b>AGR stations</b>		
Hinkley Point B 5-year life extension	Operates to 2016	Operates to 2011
Hunterston B 5-year life extension	Operates to 2016	Operates to 2011
<b>Ministry of Defence</b>		
Naval Reactor Test Establishment Vulcan	Decommissioning 2020-2050	Decommissioning from 2040

## 7 REFERENCES

1. Department for Business Enterprise & Regulatory Reform. *Meeting the Energy Challenge: A White Paper on Nuclear Power*. Cm 7296. January 2008.
2. Department of Energy and Climate Change. Revised Draft National Policy Statement for Nuclear Power Generation (EN-6). October 2010.