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Nuclear Decommissioning Authority

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Department for Environment Food and Rural Affairs




Radioactive Materials Not Reported in the 2007 UK Radioactive Waste Inventory

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Report prepared for the Department for
Environment, Food and Rural Affairs (Defra)
and the Nuclear Decommissioning Authority (NDA)
by Pöyry Energy Limited

PREFACE

The Department for Environment, Food and Rural Affairs (Defra)[1] and the Nuclear Decommissioning Authority (NDA) have commissioned the 2007 UK Radioactive Waste Inventory to provide information on the status of radioactive waste at 1 April 2007 and forecasts of future arisings in the UK. Its aim is to provide comprehensive and up-to-date data in an open and transparent manner for those interested in radioactive waste issues. It is part of an ongoing programme of research jointly conducted by Defra and NDA.

This report provides a summary of radioactive materials not reported in the 2007 UK Radioactive Waste Inventory. This includes nuclear materials not deemed to be waste (spent fuel, uranium and plutonium) and radioactively contaminated land and miscellaneous materials, some of which are deemed to be waste, but which are currently not sufficiently well characterised for inclusion in the 2007 UK Radioactive Waste Inventory.

This report has been prepared on the basis of information supplied to Pöyry Energy, the principal contractor for the production of the 2007 UK Radioactive Waste Inventory. This information was verified in accordance with arrangements established by Pöyry Energy.

The information given in this report represents the best available knowledge at the time of compilation of the 2007 Inventory based upon the processes, strategies and assumptions that were applicable at that time. Revision of the predictions, particularly of the long-term forecasts, may be necessary as plans change and estimates are refined.

2007 Inventory documents

Information collected for producing the 2007 UK Radioactive Waste Inventory is presented in a series of reports, as listed below.

- A summary of the 2007 UK Radioactive Waste Inventory;
- The main report for the 2007 UK Radioactive Waste Inventory;
- A summary of Information for International Reporting;
- A review of the processes contributing to radioactive wastes in the UK.
- Information on other radioactive substances that may require long-term management as radioactive waste in the UK is presented in a separate report (this document).

These reports are available in both printed and electronic format. Detailed information on the volumes, radioactive, physical and chemical content of the 1,269 separate radioactive waste streams reported in the 2007 UK Radioactive Waste Inventory is only available in electronic format.

The 2007 Inventory documents can be obtained on CD-ROM from the NDA (see contact details opposite) or via the UK Radioactive Waste Inventory website www.nda.gov.uk/ukinventory.

[1] The results of this work will be used in the formulation of Government policy, but views expressed in this report do not necessarily represent Government policy.

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Feedback & Queries

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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CONTENTS

1 INTRODUCTION

Radioactive material is defined in the Radioactive Substances Act 1993 [1] and the Exemption Order on Substances of Low Activity [2] as a substance falling within either or both of the following descriptions:

- A naturally-occurring substance containing an element (actinium, lead, polonium, protactinium, radium, radon, thorium or uranium) present at an activity level that is greater than a specified level;
- Any substances which are not naturally occurring, whose radioactivity is wholly or partly due to nuclear fission, neutron bombardment or ionising radiation.

Material that has no further use, and is contaminated by, or incorporates, radioactivity above certain levels defined in legislation is known as radioactive waste [1]. As one of the pioneers of nuclear technology, the UK has accumulated a substantial legacy of radioactive waste from a variety of different civil and defence-related nuclear programmes. Some of this waste is already in storage, but most of it still forms part of existing facilities, and will only become waste over the next century or so as these plants are shut down, decommissioned and cleaned up.

An inventory of radioactive waste in the UK is compiled periodically by the Department for Environment, Food and Rural Affairs (Defra) and the Nuclear Decommissioning Authority (NDA) to meet the UK's international reporting obligations, to provide up-to-date information for waste management policy development, and for the regulation and planning of waste treatment, storage and long-term management.

The 2007 UK Radioactive Waste Inventory is the latest public record of information on the sources, quantities and properties of radioactive waste in the UK at 1 April 2007 and predicted to arise after that date based on assumptions as to the nature and scale of future operations and activities [3].

As well as waste, past and existing nuclear programmes have produced an accumulation of radioactive materials such as spent (i.e. used) nuclear fuel, uranium and plutonium that are not currently classified as waste. In most cases this is because they have potential value. Spent fuel can be reprocessed to separate uranium and plutonium, which in turn can be used to manufacture fresh fuel. However, if it were decided at some point in the future, on the basis of economics, or environmental and safety issues, that these materials had no further use, they may need to be managed as wastes.

The UK Government recognises that its policy for managing radioactive materials should be as comprehensive and forward looking as possible, and that the UK waste management strategy should include a clear idea of which radioactive materials might come forward as waste. Consequently the Government's "Managing Radioactive Waste Safely" (MRWS) programme for developing and implementing a policy for managing the UK's higher activity wastes in the long-term is also considering radioactive materials not currently classified as wastes.

The independent Committee on Radioactive Waste Management (CoRWM) was appointed to oversee the review of long-term waste management options and recommend a strategy to the Government. CoRWM reported in 2006 with a package of recommendations including geological disposal, preceded by safe and secure interim storage. The UK Government has accepted that secure interim storage is essential, and has consulted on a framework for implementing geological disposal.

As part of its work, CoRWM identified an inventory that included both higher activity wastes and some radioactive materials - such as spent fuel, uranium and plutonium [4].

Civil nuclear facilities are subject to the UK's safeguards agreements with international bodies - the International Atomic Energy Authority (IAEA) and Euratom - and to the

safeguards provisions of the Euratom treaty. These are designed to detect diversion of material into clandestine weapons programmes, and involve accounting for material and submitting to international inspection. All civil plutonium and highly enriched uranium in the UK (whether separated or in spent fuel) is stored safely and securely under relevant national and international regulations including inspection by international safeguards authorities.

The UK Government has obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management to report in these areas. The UK's second national report for the Convention was provided to the IAEA in October 2005 [5]. This report contains an inventory of spent nuclear fuel in storage, as well as volumes of radioactive waste in storage and projected in future arisings.

The Government also publishes annual figures for the UK's stocks of civil plutonium and uranium, and in accordance with its commitment under the "Guidelines for the Management of Plutonium" provides figures to the International Atomic Energy Authority (IAEA). The latest figures are for 31 December 2006 [6].

The principal purposes of this report are to bring together in the public domain information required for the UK to meet its international reporting obligations in respect of civil nuclear materials, and as part of the UK Radioactive Waste Inventory process to provide a comprehensive inventory of UK radioactive substances that might have to be managed as waste at some time in the future. Nuclear materials from defence programmes are excluded for reasons of national security. Also excluded are small quantities of nuclear materials with very low concentrations of radioactivity typically from research establishments, universities and the non-nuclear industry (so-called 'small users').

This change in the nature and content of the UK Radioactive Waste Inventory will allow it to be used in future as a basis for open and transparent discussions within the MRWS programme, to facilitate the development of management strategies, and the planning of systems and facilities for managing radioactive wastes for the UK.

The structure of the remainder of this report is as follows. Chapter 2 describes materials included in this report. Chapter 3 presents material quantities in storage and projected to arise in the future.

Annex 1 presents the assumptions used in reporting nuclear material quantities. Annex 2 presents some detailed information about potentially contaminated land and miscellaneous wastes and materials. Annex 3 provides a glossary of terms and abbreviations.

2 TYPES OF RADIOACTIVE MATERIAL

2.1 INTRODUCTION

There are two categories of radioactive material included in this report:

- 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, but which are not well characterised. There is often considerable uncertainty in the quantities that might arise, and so they are not reported in the 2007 UK Radioactive Waste Inventory.

Nuclear materials from defence programmes[1] or from 'small users' are not included

2.2 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 most 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 power 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[2].

Until 1996 there was also spent fuel reprocessing at Dounreay in Caithness in support of the UK fast breeder 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 2007 UK Radioactive Waste 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.

[1] Information about nuclear materials can be found in the Ministry of Defence 1998 Strategic Waste review [7].
[2] The UK has contracts with other countries to reprocess their spent fuel. These contracts provide for the return of recovered uranium and plutonium and associated radioactive waste to the country of origin.

2.3 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.

2.4 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 breeder 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 breeder 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[3].

2.5 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:

Natural uranium (NU) 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[4].

Low-enriched uranium (LEU) 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).

[3] MOX fuel that is delivered to overseas reactors only contains plutonium that the overseas customer owns.
[4] Latterly some Magnox reactor fuel has been slightly enriched (<1% U-235) to offset the effects of reactor ageing.

High-enriched uranium (HEU) 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 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_6). DU is also a product of reprocessing spent Magnox reactor fuel. This is stored as UO_3.

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_4). The next process stage depends on the type of fuel to be manufactured. For Magnox reactor fuel UF_4 is converted to uranium metal. AGR fuel is fabricated from low enriched (UO_2). Here UF_4 is first converted to UF_6, which is enriched at Capenhurst in Cheshire. The enriched UF_6 is then converted to UO_2 at Springfields, which in turn is formed into ceramic pellets.

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_6 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.

2.6 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 2007 UK Radioactive Waste Inventory.

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

2.7 CONTAMINATED LAND WASTE

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 (contaminated land) 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 the fact that much characterisation work remains to be carried out. 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.

The 2007 UK Radioactive Waste Inventory includes contaminated land wastes, but only where the waste has been sufficiently well characterised. This report includes potentially contaminated land that is not yet well characterised, and where uncertainties in waste volumes may be significant.

As ground contamination surveys are extended and refined, volume estimates can be determined with increasing certainty that merits their inclusion in the UK Radioactive Waste Inventory.

2.8 MISCELLANEOUS WASTE AND MATERIALS

2.8.1 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 to facilitate 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 waste arisings are not yet available, and so the wastes are reported here rather than in the 2007 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.

2.8.2 Other 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 2007 UK Radioactive Waste Inventory. These wastes are reported here. Small quantities of uranic residues and some spent fuel are also included in this category. They are currently planned to be subject to uranium recovery and reprocessing respectively. However, this may change in the future, and these materials could become categorised as wastes.

3.1 INTRODUCTION

This chapter presents summary information on the quantities of radioactive materials in the UK. The information has been provided by the NDA and those organisations that operate sites in the UK where radioactive materials are stored and forecast to arise in the future.

Quantities of nuclear materials (nuclear fuel, plutonium and uranium) are given as masses expressed as tonnes of heavy metal (tHM). Quantities of waste that may arise from the remediation of radioactively contaminated land, and the miscellaneous wastes and materials, are given as volumes expressed as cubic metres.

Annex 1 sets out the assumptions used in reporting radioactive materials in the UK. Annex 2 provides more details on potentially contaminated land, and miscellaneous wastes and materials.

3.2 IRRADIATED FUEL

The UK's current stock of irradiated fuel consists mainly of Magnox, AGR and PWR fuels, but also includes smaller stocks of various irradiated experimental and research fuels. The UK also holds stocks of foreign owned LWR fuel awaiting reprocessing[1].

Table 3.1 gives the masses of UK owned irradiated fuel at 1 April 2007 and estimated in future arisings. The total mass of irradiated fuel at 1 April 2007 was about 10,700tHM, with estimated future arisings of about 3,570tHM. The figures for irradiated fuel at 1 April 2007 exclude about 750tHM of overseas owned LWR fuel at Sellafield, and 0.7tHM of overseas owned spent fuel at Dounreay.

It is planned that the stocks of Magnox, SGHWR fuels and other spent fuels at Sellafield will be reprocessed (apart from a small quantity that is unsuitable). It is also planned that future arisings of spent Magnox fuel will be reprocessed. A proportion of the fuel produced over the lifetime of the AGR stations will be reprocessed. It is assumed that about 5,500tHM of spent AGR fuel will remain in long-term storage. Actual quantities of fuel to be reprocessed and/or stored are subject to contractual arrangements to be agreed between NDA and its customers.

The Sizewell B PWR station is expected to generate about 1,200tHM spent fuel over its 40-year operating lifetime. It is currently assumed that this fuel will be held in long-term storage.

3.3 UNIRRADIATED FUEL

Table 3.2 gives the masses of UK owned unirradiated fuel in the UK. The total mass of unirradiated fuel at 1 April 2007 is estimated to be about 970tHM. This excludes 1.2tHM of overseas owned unirradiated fuel in storage at Dounreay. There will be future arisings of UK power reactor fuels to meet the fuelling requirements for projected reactor lifetimes, but these are not estimated.

[1] The UK has contracts with other countries to reprocess their spent fuel. These contracts provide for the return of recovered uranium and plutonium and associated radioactive waste to the country of origin.

Table 3.1: UK owned irradiated fuel Mass in stocks and estimated for future arisings (tHM)

Location	Description	Stock at 1 April 2007 (1)		Estimated future arisings
		In reactor	In storage	
Sellafield	Magnox fuel		~1,200	- (2)
	AGR fuel		~2,800	- (3)
	SGHWR fuel		~120	0
	Other fuels		~350 (4)	0
Dounreay	Various		13 (5)	0
Magnox power stations	Magnox fuel	3,900	180	570 (6)
AGR & PWR power stations	AGR & PWR fuel (7)	~1,700	~440	~3,000
Others	Various		8 (8)	0

(1) Fuel 'In reactor' is that in reactor cores; fuel 'In storage' has been removed from reactor cores to storage facilities.

(2) See Magnox power stations for future transfers of spent fuel to Sellafield.

(3) See AGR power stations for future transfers of spent fuel to Sellafield.

(4) Includes uranium residues that are also reported as uranium residues (stream 2D80) in Table A2.3. Excludes about 10tHM of uranic residues declared as waste and reported in the 2007 UK Radioactive Waste Inventory.

(5) Includes PFR and thorium fuels.

(6) Based on station operating lifetimes reported in the 2007 UK Radioactive Waste Inventory.

(7) Masses of fuel have been derived using the best available information in the public domain at the time of compilation of the 2007 Inventory.

(8) Comprises mainly low irradiated Zero Energy Breeder Reactor Assembly (ZEBRA) fuel as plutonium and natural uranium oxide plates on loan to Cadarache in France.

Table 3.2: UK owned unirradiated fuel Mass in stocks (tHM)

Location	Description	Stock at 1 April 2007
Sellafield	MOX fuel	~3
Dounreay	Various	18 (1)
All UK sites	Magnox fuel	720 (2)
All UK sites	AGR fuel	~200 (3)
All UK sites	PWR fuel	~30 (3)

(1) Includes PFR, plutonium and thorium fuels.

(2) More Magnox fuel has been manufactured to meet the current operating lifetimes of Magnox reactors than is forecast to be irradiated in these reactors. The estimated future arisings of spent Magnox fuel are 570tHM (See Table 3.1).

(3) Nominal figure available in the public domain corresponding to the approximate annual fuel usage.

3.4 PLUTONIUM

Table 3.3 gives the total masses of UK owned separated plutonium at the end of 2006. Separated plutonium is held mainly as plutonium dioxide from the reprocessing of Magnox and oxide fuel at Sellafield, with a small amount in other forms and fuel residues.

Table 3.3: UK owned separated plutonium Mass in stocks (tHM)

Location	Description	Stock at 31 December 2006 (1)
All UK sites	PuO_2	~81

(1) Latest figure published by the UK Government [6] at the time of compilation of the 2007 Inventory.

There are currently about 81tHM of separated plutonium in stock. This excludes about 27tHM from the reprocessing of overseas spent LWR fuel.

Forecast future arisings from reprocessing spent fuel at Sellafield are about 21tHM. This excludes about 7tHM from the reprocessing of overseas spent LWR fuel.

3.5 URANIUM

Table 3.4 gives the total masses of UK owned DNLEU (Depleted, Natural and Low Enriched Uranium) and HEU from all sources.

Table 3.4: UK owned uranium Mass in stocks (tHM)

Location	Description	Stock
All UK sites	DNLEU	~70,000 (1)
All UK sites	HEU	1.44 (2)

(1) Stock at 1 April 2007 based on best available information. The latest figure published by the UK Government [6] is ~93,000tHM. This is greater than the figure reported here because it includes DNLEU present in irradiated fuels as well as foreign owned uranium, both of which are reported separately in the 2007 Inventory (see Table 3.1 and text below).

(2) Stock at 31 December 2006. Latest figure published by the UK Government [6] at the time of compilation of the 2007 Inventory.

There are about 70,000tHM DNLEU in stock. This excludes about 11,000tHM of overseas owned material. The major components of UK owned uranium stocks are depleted uranium from enrichment in the form of UF_6, and from reprocessing of Magnox fuel in the form of UO_2.

DNLEU stocks are held at Capenhurst, Chapelcross, Springfields, Sellafield and other sites.

Future arisings of DNLEU are estimated at about 90,000tHM. This figure assumes the continuation of uranium enrichment operations up to 2030 and the reprocessing scenario

reported in the 2007 UK Radioactive Waste Inventory. It excludes approximately 700tHM of foreign owned DNLEU that is estimated to arise in the future.

The majority of future arisings are depleted uranium from enrichment operations. Future enrichment may utilise either existing uranium stocks or new uranium depending on the economics. Hence, there is uncertainty in the total quantities of DNLEU that will be produced.

There are currently about 1.44tHM of HEU in stock. This material comprises residues from reprocessing and fuel fabrication. No further arisings are expected.

3.6 THORIUM

There are no reported stocks or future arisings of thorium materials.

All significant thorium associated with the UK nuclear industry, including that existing as spent Dragon reactor fuel, is deemed to be waste and is reported in the 2007 UK Radioactive Waste Inventory.

3.7 CONTAMINATED LAND WASTE

The total reported volume of waste associated with potentially contaminated land is about 13,000,000m^3. This is made up of soil (about 98%) and building foundations (about 2%). Much of the waste, about 90%, is potentially contaminated VLLW soil from site clearance at Sellafield. Much of this soil may ultimately prove not to require remediation. Due to regulatory requirements, contaminated soil at Sellafield is reported as an existing stock, although excavation and remediation is not expected until the period 2045 – 2100.

A total of about 200,000m^3 of contaminated land waste is reported in the 2007 UK Radioactive Waste Inventory.

3.8 MISCELLANEOUS WASTE AND MATERIALS

New facilities are planned at Sellafield to facilitate implementation of the waste treatment, decommissioning and site clean-up programmes. Wastes that might arise from the operation of these facilities are reported (see Annex 2). Some broad volume estimates have been made but, because they are not robust, they are not presented in this report.

Miscellaneous wastes that are not yet well characterised and materials that might be recategorised as waste at Sellafield and Capenhurst are reported (see Annex 2). Estimated stocks and future arisings are 610m^3 and 1,460m^3 respectively. Major streams in term of volume include metallic waste, plant and equipment, sludges, resins and floc, lead and miscellaneous minor wastes.

4 REFERENCES

1 *Radioactive Substances Act 199*3.

2 *The Radioactive Substances (Substances of Low Activity) Exemption Order 1986.*

3 Pöyry Energy Ltd. *The 2007 UK Radioactive Waste Inventory - Main Report.* Defra/RAS/08.002, NDA/RWMD/004, ISBN 978-1-84029-388-3. March 2008.

4 Committee on Radioactive Waste Management. *CoRWM's Radioactive Waste and Materials Inventory – July 2005.* CoRWM Document No. 1279.

5 Defra. *The United Kingdom's Second 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.* February 2006.

6 HSE. *Annual Civil Plutonium and Uranium Figures as of 31 December 2006.* www.hse.gov.uk/nuclear/safeguards/civilplut.htm.

7 MoD. *Strategic Defence Review 1998*.

ANNEX 1 ASSUMPTIONS USED FOR REPORTING CIVIL NUCLEAR MATERIALS

All assumptions listed below are in line with those used in compiling data for the 2007 UK Radioactive Waste Inventory. These assumptions represent the planning positions at 1 April 2007 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 2007 there have been developments in the forward plans at a number of sites. This means that certain assumptions used in preparing data for the 2007 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.

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 irradiation spent fuel that are not planned to be reprocessed have already been designated as waste and are reported in the 2007 UK Radioactive Waste Inventory (i.e. excluded from this report).
- 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 2007[1]; 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 have been 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 2007 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 land reported in the radioactive materials inventory are in-situ volumes of potentially radioactively contaminated land and foundations that are not sufficiently well characterised for inclusion in the 2007 UK Radioactive Waste Inventory. Radioactive waste anticipated to arise from radioactively contaminated land and foundations that are well characterised are reported in the 2007 UK Radioactive Waste Inventory.

[1] Some information provided in the radioactive material inventory refers to the situation at 31 December 2006 (best information available at the time of compilation of the 2007 Inventory).

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 A1.1: Operational nuclear power stations in the UK

Station	Planned shutdown date
Magnox:	
Oldbury	2008
Wylfa	2010
AGR:	
Hinkley Pt B	2011
Hunterston B	2011
Hartlepool	2014
Heysham 1	2014
Dungeness B	2018
Heysham 2	2023
Torness	2023
PWR:	
Sizewell B	2035

- No new nuclear power stations are assumed to be constructed in the UK[2].
- UK has contracts with other countries for reprocessing some of their spent nuclear fuel.

Irradiated fuel management

- Nuclear fuel manufacturing in the UK is assumed to 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 49,000tHM had been reprocessed by 1 April 2007;
  - 3,300tHM from AGRs, of which about 2,000tHM had been reprocessed by 1 April 2007;
  - About 30tHM from WAGR;

[2] The Government is currently consulting on the potential future role of nuclear power in the UK and thus the potential construction of new nuclear power stations in the UK. *[Department for Business Enterprise & Regulatory Reform. Meeting the Energy Challenge. A White paper on Nuclear Power. January 2008].*

  - About 124tHM from SGHWR;
  - 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)[3].
  - 5,500tHM from AGRs;
  - 1,200tHM from PWR.

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 2012/13; other spent fuel reprocessing by 2011.
- All UK owned separated uranium and plutonium is assumed to be held in long-term storage in the UK.

[3] 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.

ANNEX 2 CONTAMINATED LAND WASTE AND MISCELLANEOUS WASTE AND MATERIAL STREAMS

This annex presents volumes of potentially contaminated land wastes and miscellaneous material streams that are deemed or may be deemed to be waste. These streams have not been included in the 2007 UK Radioactive Waste Inventory because they are not yet well characterised and there is considerable uncertainty in some of the quantities that might arise, or they have not been declared as wastes. Volumes held at 1 April 2007 and in future arisings are estimated. Information is given in a number of tables, listed below.

Table A2.1 lists potentially contaminated land waste (soil plus building foundations) streams at Sellafield, Capenhurst, Springfields and Aldermaston. Other UK sites with anticipated contaminated land waste have reported volumes in the 2007 UK Radioactive Waste Inventory. Also contaminated land at Sellafield and Aldermaston that is well characterised is reported in the 2007 UK Radioactive Waste Inventory.

At Sellafield, potentially contaminated foundations and soil wastes are expected to be excavated and remediated in the period 2045 – 2100. However, the soil streams are considered to be an existing stock, rather than a future arising, as the Nuclear Installations Inspectorate (NII) requires that these materials are adequately and safely managed throughout the lifetime of the site.

At Aldermaston, about 114,000m^3 of land associated with process buildings have been identified as having the potential to be contaminated. Further investigations will be carried out after building decommissioning.

Table A2.1: Potentially contaminated land Volume at 1 April 2007 and estimated for future arisings (m^3)

Site	Stream identifier	Stream description	Stock at 1 April 2007	Future arisings
Sellafield	2D150	Contaminated Soil ILW	1,610	0
	2D151	Contaminated Soil LLW	1,060,000	0
	2D152	Contaminated Foundations ILW	0	2,160
	2D153	Contaminated Foundations LLW	0	32,900
	2D154	Contaminated Soil from Site Clearance - HVVLLW	11,800,000	0
	2D155	Contaminated Foundations from Site Clearance - HVVLLW	0	200,000
Capenhurst	2B104	Contaminated Land - LLW	0	1,000
	2B105	Contaminated Land - HVVLLW	0	6,600
Springfields	-	Radioactive Contaminated Land	20,000	Not yet determined (1)
Aldermaston	7A33	Radioactive Contaminated Land	0	114,000
All sites		**Total**	**12,900,000**	**357,000**

(1) Volumes are uncertain, but will be established during ongoing contaminated land projects.

Annex 2 Contaminated Land Waste and Miscellaneous Waste and Material Streams

Table A2.2 lists radioactive wastes that might arise from the operation of new facilities at Sellafield anticipated to be required to facilitate implementation of planned waste treatment, decommissioning and site clean up programmes. Currently, only very broad information on volume estimates is available. As these programmes are confirmed, estimates for these wastes will become more robust and will be reported appropriately.

Table A2.2: Miscellaneous wastes and materials – new build on the Sellafield site

Stream Identifier	Stream description
2Y01	SDP Operational ILW
2Y02	SDP Operational LLW
2Y05	BEP Operational ILW
2Y06	BEP Operational LLW
2Y07	BEPPS 1 – 4 Operational LLW
2Y08	SPP1 Operational ILW
2Y09	SPP1 Operational LLW
2Y12	Pile Fuel Storage Pond LSTP Operational ILW
2Y13	Pile Fuel Storage Pond LSTP Operational LLW
2Y14	Pile Fuel Cladding Silo Treatment Plant Operational ILW
2Y15	Pile Fuel Cladding Silo Treatment Plant Operational LLW
2Y16	LP&S ERP General Maintenance Facility Operational ILW
2Y17	LP&S ERP General Maintenance Facility Operational LLW
2Y22	Future Local Effluent Treatment Plants – ILW
2Y26	Future LLW Treatment Plants - LLW
2Y27	ILW Rework Plant including Mobile Grouting - ILW
2Y28	ILW Rework Plant including Mobile Grouting - LLW
2Y36	SIXEP Waste Processing plant (SWP) - ILW
2Y37	SIXEP Waste Processing plant (SWP) - LLW
2Y40	SIXEP Waste Retrievals Facility - ILW
2Y43	Fuel Pre-conditioning Plant – ILW

Table A2.3 lists miscellaneous waste and material streams at Sellafield and Capenhurst. These include wastes that are not yet sufficiently well characterised to be reported in the 2007 UK Radioactive Waste Inventory and materials that are not yet classified as wastes but may be at some time in the future.

Table A2.3: Miscellaneous waste and materials Volume at 1 April 2007 and estimated for future arisings (m^3)

Site	Stream Identifier	Stream description	Stock at 1 April 2007	Future arisings (1)
Sellafield	2D64	Magnox interfacial crud - ILW	<10	10
	2D80	Uranium Residues in Magnox Fuel Storage Pond - ILW	16 (1)	0
	2D97	Miscellaneous Trench Silt ILW/LLW	43	430
	2F28	Interfacial Crud ILW/LLW	0.12	0.25
	2Y60	Miscellaneous Minor Wastes - ILW	~~40	~~10
	2Y61	Lead - ILW	~~0	~~50
	2Y62	Oils and Solvents - ILW	~~1	~~90
	2Y63	Metallic Wastes: Plant and Equipment - ILW	~~180	~~260
	2Y64	Sludges, Resins and Flocs - ILW	~~50	~~80
	2Y65	Miscellaneous Minor Wastes - LLW	~~130	~~100
	2Y66	Lead - LLW	~~10	~~100
	2Y68	Metallic Wastes: Plant and Equipment - LLW	~~100	~~310
	2Y69	Sludges, Resins and Flocs - LLW	~~1	~20
Capenhurst	2B13	Technetium Contaminated Uranic Residues	21.75	0
	2B14	Uranic Residues	8.5	0
All sites		**Total**	**~~610**	**~~1,460**

(1) Approximate volume derived by dividing the mass of fuel by the density of uranium. Stream 2D80 comprises uranic residues that are included in Sellafield other fuels in Table 3.1.

ANNEX 3 GLOSSARY OF TERMS AND ABBREVIATIONS

The glossary contains a list of specialised terms and abbreviations used in this report.

~	Approximately.
~~	Very approximately.
AGR	Advanced Gas-cooled Reactor.
BEP	Box Encapsulation Plant (at Sellafield).
BEPPS	Box Encapsulation Plant Product Store (at Sellafield).
CoRWM	The Committee on Radioactive Waste Management.
Contaminated Land	Contaminated land is defined as ground, soil, water and, potentially, underground structural materials such as building foundations which have been impacted by radioactive and/or chemical substances from past or present operations (including authorised discharges and disposals), and for which the level of the radioactive or chemical substance is above natural background.
Defra	Department for Environment, Food and Rural Affairs. The Government department which, with the environment departments of Wales, Scotland and Northern Ireland, sets policy for UK radioactive waste management.
Depleted uranium	Uranium where the uranium-235 isotope content is below the naturally occurring 0.72% by mass.
DNLEU	Depleted, Natural and Low Enriched Uranium.
Dragon	Experimental high temperature reactor project sited at Winfrith and funded by the Organisation for Economic Cooperation and Development (shut down in 1976).
DU	Depleted Uranium.
Enriched uranium	Uranium where the uranium-235 isotope content is above the naturally occurring 0.72% by mass.
Enrichment	The process of increasing the abundance of fissionable atoms in natural uranium.
Euratom	European Atomic Energy Community.
GLEEP	Graphite Low Energy Experimental Pile. Low energy, graphite reactor (at Harwell site; shut down in 1990).
Government	A collective term for the central government bodies responsible for setting radioactive waste management policy within the UK. It includes the Houses of Parliament and the Devolved Administrations.
HEU	Highly Enriched Uranium. Uranium where the uranium-235 isotope content is 20% by mass or more.
IAEA	International Atomic Energy Agency.
ILW	Intermediate Level Waste.
Irradiated fuel	Fuel that is being or has been used to power nuclear reactors.

LEU	Low Enriched Uranium. Uranium enriched in U-235 to less than 20% by mass.
LLW	Low Level Waste.
LP&S ERP	Legacy Ponds & Silos Early Remediation Project (at Sellafield).
LSTP	Local Sludge Treatment Plant (at Sellafield).
LWR	Light Water Reactor.
Magnox	An alloy of magnesium used for fuel element cladding in natural uranium fuelled gas-cooled power reactors. Also a generic name for this type of reactor.
MOX	Mixed Oxide. Refers to nuclear fuel consisting of uranium oxide and plutonium oxide for use in reactors.
NDA	Nuclear Decommissioning Authority. A public body set up by the Government in April 2005 with responsibility for the UK's public sector civil nuclear liabilities, and their subsequent management. In October 2006, the Government also gave the NDA the responsibility for developing and ensuring delivery and implementation of the programmes for interim storage and geological disposal of the UK's higher activity wastes. From March 2007, the NDA was also given responsibility for developing a UK wide strategy for managing the UK nuclear industry's LLW and for securing disposal capacity for LLW generated by non-nuclear industry users.
NU	Natural Uranium.
Nuclear fuel	Fuel used in a nuclear reactor. Most fuel is made of uranium, and produces heat when the uranium atoms split into smaller fragments.
PFR	Prototype Fast Reactor (at Dounreay site).
Plutonium	A radioactive element created in nuclear reactors. It can be separated from nuclear fuel by reprocessing. Plutonium is used as a nuclear fuel, in nuclear weapons and as a power source for space probes.
Pu	Plutonium.
PWR	Pressurised Water Reactor.
Reprocessing	The chemical extraction of reusable uranium and plutonium from waste materials in spent nuclear fuel.
RSA 93	Radioactive Substances Act 1993.
SDP	Sellafield Direct Encapsulation Plant (at Sellafield site).
SGHWR	Steam Generating Heavy Water Reactor (at Winfrith site). Shut down in 1990.
SIXEP	Site Ion EXchange Plant (at Sellafield).
Spent fuel	Fuel that has been used to power nuclear reactors that is no longer capable of efficient fission due to the loss of fissile material.
SPP	Sludge Packaging Plant (at Sellafield).

tHM	Tonnes of heavy metal. A unit of mass used to quantify uranium, plutonium and thorium including mixtures of these elements.
Thorium	Thorium is a naturally occurring radioactive element that can be mined, extracted and processed to make fuel for nuclear reactors.
U-235	Uranium-235 is the main fissile isotope of uranium. Natural Uranium typically contains 0.72% by weight of U235.
Uranium	A radioactive element that occurs in nature. Uranium is used for nuclear fuel and in nuclear weapons.
Unirradiated fuel	Fuel that has not yet been used to power nuclear reactors.
VLLW	Very Low Level Waste.
WAGR	Windscale Advanced Gas-cooled Reactor (shut down in 1981).
Yellowcake	Yellowcake is concentrated uranium oxide, obtained through the milling of uranium ore. Yellow cake typically consists of 70-90% U_3O_8 with the remainder consisting of UO_2 and UO_3.
Zenith reactor	A research reactor at Winfrith that has been decommissioned.

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