Briefing Paper 17

The inventory for geological disposal

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nuleaf
nuclear legacy advisory forum

1: Introduction

Radioactive waste is any material that is either radioactive itself, or is contaminated by radioactivity, for which no further use is envisaged.

The UK has been generating radioactive waste for decades, with the great majority created by nuclear reactors used to generate electricity. A substantial amount also arises from nuclear research and development sites. Some originates from the Ministry of Defence, and small amounts are produced by medical, industrial and educational establishments.

Radioactive wastes are extremely diverse in nature and in terms of the level of risk they pose to people and the environment. There are also differences in the means by which they can be managed and disposed of. A definition of the categories of radioactive wastes and materials is provided in Appendix 1.

The UK and Welsh Governments have committed to a policy of geological disposal for the most challenging wastes in the UK inventory, referred to as **Higher Activity Wastes (HAW)**. In addition, there are some radioactive materials that are not currently classified as waste, but which would, if it was decided that they had no further use, need to be managed as wastes through geological disposal.

Local authorities and communities are likely to have questions about the range of materials that will or may be disposed of in a deep geological repository. This Paper explains the different waste streams in the inventory for disposal, including those not currently classified as waste. It outlines particular issues for discussion and alternative management options that are under consideration for parts of the Geological Disposal Facility (GDF) inventory. Finally, Nuleaf's view is set out.

Nuleaf has also prepared other papers which members may find useful in understanding geological disposal:

Policy Statement 3 – Geological Disposal, which sets out our agreed policy.[1]

Briefing Paper 5 – Geological Disposal and Retrievability, which explores the issues around the retrievability of waste from a GDF.

[1] http://www.Nuleaf.org.uk/wp-content/uploads/2019/06/PS3-Geological-Disposal-final.pdf

Briefing Paper 14 – Geological Disposal Facility Siting Process. This explains the various elements of the current siting process.[2]

Briefing Paper 16 – **Guidance on geological disposal from CoRWM,** which summarises the guidance on geological disposal provided by the UK Government advisory group, the Committee on Radioactive Waste Management (CoRWM).[3]

2: Radioactive waste in the UK

For over three decades the UK has been collecting detailed information on radioactive waste and materials. The **UK Radioactive Waste Inventory (UKRWI)**[4] is updated every 3 years with the most recent version being for 2019. It contains information about:

- radioactive wastes that exist now;
- radioactive wastes that will arise in future; and
- radioactive materials – these are radioactive items that are not classed as waste now but may be in future if no further use can be found for them.

The UKRWI excludes NORM (Naturally Occurring Radioactive Material). NORM is generated by the oil and gas industry and a range of other industrial processes.

The Inventory is based on the best available information on wastes and materials at a specific point in time (the 'stock date'). Even so, there are some uncertainties in the data, for example, around estimates of volumes where the waste is forecast to arise a long way into the future. As the UK decommissioning mission progresses, more is becoming known about the exact volumes of radioactive waste that will be generated. The figures in the inventory have therefore been amended over time and are likely to continue to change in future.

[2] http://www.Nuleaf.org.uk/document-library/briefing-papers
[3] http://www.Nuleaf.org.uk/document-library/briefing-papers
[4] https://ukinventory.nda.gov.uk/

Waste Category	Volume (m3)		
	As of 1st April 2019	Future arisings	Lifetime total
HLW	2,150	-760[5]	1,390
ILW	102,000	145,000	247,000
LLW	27,400	1,450,000	1,480,000
VLLW	1,040	2,830,000	2,830,000
Total	133,000	4,420,000	4,560,000

Table 1: Radioactive waste by volume (Source: UK RWI 2019[6])

Table 1 illustrates the amount of radioactive waste by category both in terms of current waste and estimates of future arisings. As can be seen, the great majority of waste from the decommissioning of the UK's nuclear stations has not yet been generated.

Most waste is classified as **Low-Level Waste (LLW)** and **Very Low-Level Waste (VLLW)**. These wastes comprise over 90% by volume of the inventory but contain less than 0.1% of the radioactivity. Recent years have seen a significant change in LLW management. Such waste is now dealt with in a variety of ways including recovery and recycling, incineration, super-compaction and disposal in appropriately licensed landfill sites. Only a small fraction is now sent to the national LLW Repository in Cumbria for disposal, conserving the limited space available.

While much smaller in volume (less than 10%), the most challenging material and that possessing the greatest radioactivity is Higher Activity Waste (HAW). HAW comprises a number of categories of waste – **High Level Waste (HLW), Intermediate Level Waste (ILW)** and a small portion of LLW not suitable for near surface management at the LLWR. These wastes, and potentially other materials, make up the inventory for disposal in a Geological Disposal Facility.

Figure 1 overleaf shows the major sites where radioactive waste (of all classifications) is currently produced and stored, and also the disposal sites for LLW.

[5] The volume of HLW is forecast to decrease due to treatment and repackaging and also because of the return of HLW to overseas reprocessing customers.
[6] https://ukinventory.nda.gov.uk/the-2019-inventory/2019-uk-data/

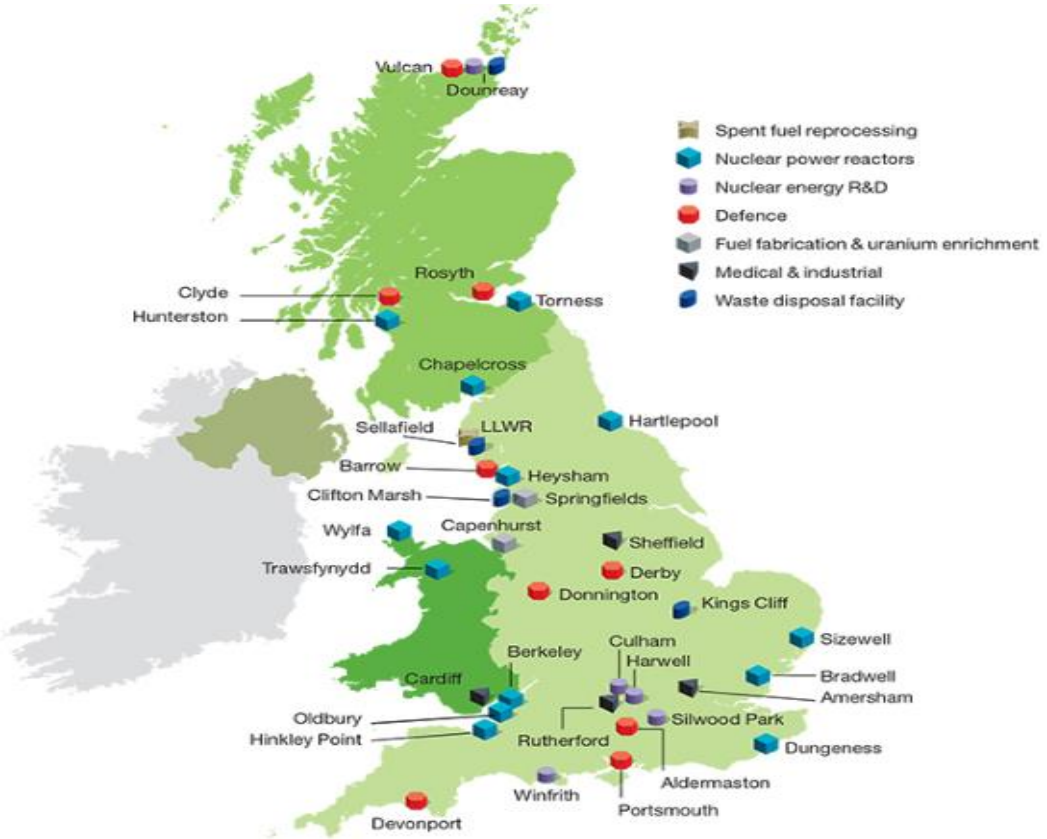

Figure 1: Current locations of radioactive wastes (Source: BEIS[7])

3: The inventory for geological disposal

UK Government policy[8] states that the specific types of higher activity radioactive waste which would comprise the inventory for disposal in a geological disposal facility are:

High level waste (HLW) resulting from the reprocessing of spent nuclear fuel at Sellafield. HLW is defined as waste that generates heat at a level that has to be taken into account when designing storage or disposal facilities. High Level Waste arises as a liquid and is then converted into solid glass through vitrification. It will be stored for decades to allow it to cool through natural radioactive decay, so it

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766643/Implementing_Geological_Disposal_-_Working_with_Communities.pdf
[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766643/Implementing_Geological_Disposal_-_Working_with_Communities.pdf

will be easier to transport and dispose of in a GDF. If declared a waste, spent fuel would also be categorised as HLW (see below).

Intermediate Level Waste (ILW) arises from existing nuclear licensed sites, defence, medical, industrial, research and educational facilities and will also be produced by new build reactors. ILW is defined as waste with radioactivity levels exceeding the upper boundary for LLW, but which does not require heat to be taken into account when designing storage or disposal sites. It is typically treated in solid form, packaged and stored.

A small proportion of **Low-Level Waste (LLW)**. This waste is not suitable for disposal in the national Low-Level Waste Repository, due primarily to the concentrations of specific radionuclides.

The inventory also includes the following nuclear materials that could be declared as waste in future:

Spent Fuel (SF) which arises in the reactors of operational nuclear power stations. Spent fuel from each of the three main types of reactors in the UK is handled differently.

- Spent fuel from Magnox stations was reprocessed at Sellafield. This ended in 2022 with the closure of the reprocessing plant. A small amount of material was left unprocessed.
- Reprocessing of SF from Advanced Gas-cooled Reactor (AGR) stations ended in 2018. Remaining and future SF arising from the AGRs will be stored pending decisions about disposal.
- SF from Pressurised Water Reactors (PWRs) is stored pending decisions about its future disposal.

There is also some SF from research reactors that operated at sites such as Harwell, Sellafield and Dounreay which is currently stored awaiting decisions on disposal. SF will also arise from new nuclear stations. Irradiated Fuel has also arisen from the UK defence programme and may also need to be disposed of in the future.

Plutonium arises from reprocessing Spent Fuel (SF) after irradiation in a nuclear reactor. Current UK Government policy[9] on the long-term management of civil plutonium is that it could be reused as mixed oxide fuel (MOX) subject to further work being carried out in support of final decisions. However, a portion of the inventory cannot be reused as MOX and both re-use as new fuel and immobilisation are being considered.

[9] https://www.gov.uk/government/collections/managing-nuclear-materials-and-spent-fuels#plutonium

Uranium typically arises from enrichment and fuel fabrication activities or from reprocessing SF after irradiation in a nuclear reactor. Uranium is currently stored, in different forms, on fuel manufacture, enrichment and storage sites.

Nuclear Waste Services (NWS), the body tasked with delivery of a Geological Disposal Facility (GDF), publishes the **Inventory for geological disposal (IGD)**[10] which is informed by the UKRWI. The IGD sets out information on the characteristics and estimated packaged volume of each group or type of waste and nuclear materials that may be destined for a GDF, at a sufficient level of detail for use in NWS's design and safety and environmental assessment work. The IGD covers current wastes, nuclear materials that may in future be classified as wastes, and waste and materials that would be expected to arise from an assumed future new build nuclear programme of 16 Gigawatt (GW) equivalent.

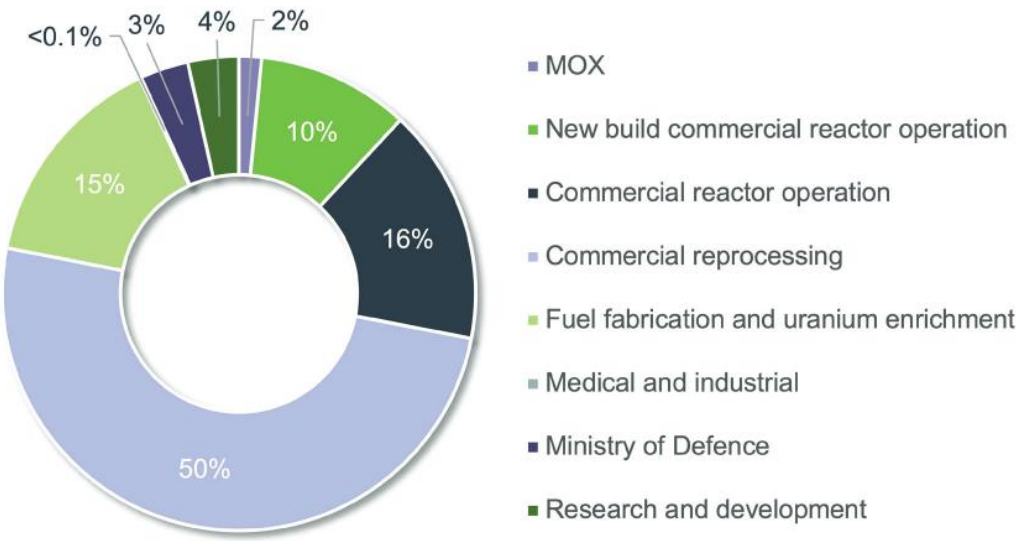

Figure 2: Breakdown of packaged volume by origin (Source: NWS[11])

The most recent IGD was published in 2021 and is based on the 2019 Radioactive Waste Inventory.

In terms of wastes and materials potentially destined for a GDF (Figure 2), half (50%) originates from reprocessing with significant amounts arising from commercial reactor operation (16%) and fuel fabrication and uranium enrichment (15%). The assumed new build nuclear programme will contribute 10%, with smaller amounts from the MOD (3%), Research and Development (4%) and MOX

[10] https://www.gov.uk/government/publications/2019-inventory-for-geological-disposal
[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835814/Inventory_for_geological_disposal_a.pdf

Spent Fuel (2%). Medical and industrial radioactive wastes make up less than 0.1% of the inventory.

HAW arising from civil nuclear sites in Scotland is excluded from the IGD given the separate policy of the Scottish Government which is to manage such wastes near site and near surface. It should be noted however that some Scottish HAW is not suitable for near surface management and there is currently a lack of clarity as to how this issue will be addressed.

4: The Committee on Radioactive Waste Management

The UK has one of the largest and most complex inventories of radioactive wastes and nuclear materials in the world. Current UK Government policy on geological disposal is informed by the recommendations made by the Committee on Radioactive Waste Management (CoRWM) (See Nuleaf Briefing Paper 16[12]) in their 2006 Managing Radioactive Waste Safely (MRWS) Report. It states that:

'Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for … long term management ... when compared with the risks associated with other methods of management.' [Recommendation 1]

At the same time CoRWM recognised that:

'The commitment to ensuring flexibility in decision making should leave open the possibility that other long-term management options (for example, borehole disposal) could emerge as practical alternatives. Developments in alternative management options should be actively pursued through monitoring of and/or participation in national or international R&D programmes.' [Recommendation 5]

The best options for the management of different elements of the current GDF inventory are therefore under constant review.

CoRWM's recommendations were made with specific reference to the existing inventory of legacy waste at that time and explicitly excluded new build. The UK Government subsequently carried out consultation on new build, including the issue of how waste should be managed. In response, more recent iterations of CoRWM's work have supported GDF for new build wastes as well.

[12] https://www.Nuleaf.org.uk/document-library/briefing-papers

5: Uncertainties related to the GDF inventory

Given that a GDF will not be ready to receive waste for a number of decades, decisions could be taken to manage elements of the current GDF inventory in alternative ways.

Of particular significance at present is work by the Nuclear Decommissioning Authority (NDA) on the potential for Near Surface Disposal (NSD). This is being investigated as a possible disposal route for the small portion of the current GDF inventory that would be suitable for this form of management. Near Surface Disposal would see radioactive waste emplaced in vaults or silos at depths to several tens rather than hundreds of metres. More information on this work is expected in the coming years.

Significant volumes of material (Spent Fuel, Plutonium and Uranics) may be reclassified as waste in future. In parallel, new techniques may be developed that enable some current or possible future wastes to be reused or managed in different ways.

Regarding Plutonium, the NDA published an update paper in March 2019[13]. This underlined the commitment of Government to consolidate all plutonium at Sellafield for safe and secure storage pending the development of a long-term disposition solution to put separated plutonium beyond reach.

Two options for this have been identified, either (a) reuse of the bulk inventory as fuel (with immobilisation of non-recoverable material) or (b) immobilisation of the entire plutonium inventory. Options for reuse include as MOX fuel in CANDU, PRISM or Light Water Reactors (LWR). In all cases the waste arisings would then be disposed of in a GDF. The 2019 paper committed to additional work on both reuse and immobilisation that would result in further informed advice to government in 2020. There are different views on whether reuse of plutonium as fuel is desirable.

Other issues have been raised in relation to the final GDF inventory. Those opposed to new nuclear power have questioned whether wastes from new stations should be included in the inventory. They have suggested that, while communities may accept legacy wastes and the development of a GDF as an end point to the nuclear industry, they are less likely to accept further wastes. Others

[13] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/791046/Progress_on_Plutonium.pdf

dispute this, seeing no evidence that host communities differentiate between legacy and new build wates or have particular concerns on this issue.

Current policy[14] (para 6.54) emphasises that dialogue around the inventory should be undertaken with potential host communities. Given the uncertainty about the exact scale of any new nuclear development there is the potential for it to exceed the 16GW programme included in current inventory projections. Policy (para 6.55) recognises that any increase in Spent Fuel and ILW resulting from a new nuclear programme that exceeds current expectations would have to be discussed and agreed with communities engaged in the siting process.

6: Nuleaf's view

Nuleaf has an agreed policy on geological disposal (**Policy Statement 3**[15]). This sets out our members belief that the GDF should be for UK wastes only, and that further clarification on the inventory for disposal should be provided.

Our Policy also states that:

'Government should undertake regular reviews of policy to consider alternatives, informed by both physical and social science research, and practical learning from the UK and across the globe. A strong commitment should be made to undertake R&D to reduce uncertainties about long-term safety.'

We believe that NWS and regulators should engage with all local authorities and communities involved in the siting process to discuss the inventory and explore the range of materials that it is proposed should be disposed of in a geological repository.

We also believe that full engagement is required in relation to proposals for alternative options for the management of any element of the current GDF inventory.

At present, this is most relevant to the work of the NDA and Government on the potential for Near Surface Disposal (NSD) for part of the HAW inventory. Our policy states that:

[14] https://www.gov.uk/government/publications/implementing-geological-disposal-working-with-communities-long-term-management-of-higher-activity-radioactive-waste
[15] https://www.Nuleaf.org.uk/wp-content/uploads/2019/09/Policy-Statement-3-Geological-Disposal-Aug-2019.pdf

'Nuleaf believes that any siting process for NSD facilities must be based on voluntarism and community consent.'

Finally, it is clear that a GDF will not be ready to receive waste for many decades to come. In the interim, communities across the UK will continue to host waste storage facilities. We believe that the NDA should provide community benefits for all such communities as part of a wider package of support for areas impacted on by nuclear decommissioning sites and legacy waste management. Our views are set out in **Policy Statement 7**[16].

[16] https://www.Nuleaf.org.uk/wp-content/uploads/2020/02/Nuleaf-Policy-Statement-7-Community-Benefits-final.pdf

APPENDIX 1: Classification of Radioactive Waste

Radioactive waste is any material that is either radioactive itself, or is contaminated by radioactivity, for which no further use is envisaged. Most radioactive waste is produced by nuclear power station operators and associated fuel-cycle facilities. A substantial amount arises from nuclear research and development sites. Some also arises from Ministry of Defence sites, and small amounts are produced by medical, industrial and educational establishments.

In the UK, radioactive waste is classified under the following broad categories:

High Level Wastes (HLW)

These are highly radioactive and generate substantial amounts of heat. HLW is a product from reprocessing spent nuclear fuel at Sellafield in Cumbria. It arises as highly radioactive nitric acid, which is converted into glass within stainless steel containers ('vitrification') at the Sellafield site. If declared a waste, spent fuel would also be categorised as HLW.

Intermediate Level Wastes (ILW)

These are wastes where the radioactivity levels are higher than for Low Level Waste, but which do not require heat to be taken into account in the design of management facilities. ILW is sufficiently radioactive to require shielding and containment. It arises mainly from the reprocessing of spent fuel and from operations and maintenance at nuclear sites, including fuel casing and reactor components, moderator graphite from reactor cores, and sludges from the treatment of radioactive effluents.

Low Level Waste (LLW)

These are radioactive wastes other than that suitable for disposal with ordinary refuse, but not exceeding 4 gigabecquerels per tonne of alpha activity, or 12 gigabecquerels per tonne of beta or gamma activity[17]. Unlike HLW and ILW, LLW does not normally require shielding during handling or transport. Currently, LLW consists largely of paper, plastics and scrap metal items that have been used in hospitals, research establishments and the nuclear industry. In future there will be large volumes in the form of soil, concrete and steel, as nuclear plants are decommissioned.

[17] A Becquerel is the unit of radioactivity, representing one disintegration per second. A gigabecquerel is 1000 million becquerels.

LLW represents about 90% by volume of UK radioactive wastes but contains less than 0.0003% of the radioactivity. Government and the NDA are currently moving towards a change in legislation that will enable some LLW (particularly VLLW and LALLW–see below) to be disposed of on site where this is seen as the best option. If this legislative change is approved, it could lead to significant changes in the management and disposal of the lowest level radioactive material generated by decommissioning.

Very Low-Level Waste (VLLW)

This is a sub-category of LLW, consisting of the same sorts of materials, and divided into Low Volume ('dustbin loads') and High Volume ('bulk disposal'). Low volume VLLW can be disposed of in unspecified destinations along with municipal, commercial or industrial waste. High volume VLLW can be disposed of in specified landfill sites and controls are necessary as specified by the environmental regulators[18].

Low Activity Low Level Waste (LALLW)

A sub-set of LLW which is below a certain threshold of radioactivity.

Out of scope wastes

Material that is so low in radioactivity that the risks to humans and the environment can be classed as negligible.

Non-nuclear LLW

A range of processes and industries outside the nuclear industry produce LLW. These include hospitals, research facilities, military uses and certain industries. There is a separate Government strategy to manage non-nuclear LLW.

Naturally Occurring Radioactive Material (NORM)

NORM consists of materials, usually industrial wastes or by-products, which contain naturally occurring radioactive materials which have been concentrated by the nature of certain industrial processes. Within the UK a range of industries including oil and gas, produce such NORM wastes. There is a separate Government strategy for the management of NORM.

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[18] For low volume VLLW, each 0.1 m cubed of waste must contain less than 400 kilobecquerels of total activity or single items must contain less than 40 kBq. For high volume VLLW, the maximum concentration should be 4 MBq/tonne. Different activities are specified for wastes containing Carbon 14 and Tritium.