Nuclear Waste Services

Geological Disposal Review of Alternative Radioactive Waste Management Options

Summary Report

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1. Introduction

The vision of Nuclear Waste Services is to make nuclear waste permanently safe, sooner. By doing so, we will support the Nuclear Decommissioning Authority group of operating companies in acceleration of safe, secure, and sustainable nuclear decommissioning, delivering value and savings for the nation.

Nuclear Waste Services manages and operates the Low Level Waste Repository site, focusing on Repository development and the safe, compliant, and effective management of waste management infrastructure. We also manage the delivery of a Geological Disposal Facility (GDF), through a consent-based siting programme, as the final end point for the most hazardous radioactive waste. These programmes are supported by our development of an integrated approach to nuclear waste management, commercial access to waste management solutions, and provision of expert advice to waste producers across the Nuclear Decommissioning Authority group and beyond.

2. Geological Disposal

In England, Wales and Northern Ireland government policy is for geological disposal of the most hazardous radioactive wastes, comprising: high level waste (HLW), intermediate level waste, and a small amount of low level waste not suitable for disposal at the Low Level Waste Repository. The current GDF siting process is taking place in England and Wales only (1). Provision is also made for spent nuclear fuel, plutonium or uranium that may in future be declared as waste. In January 2025, The Department for Energy Security and Net Zero announced that it will work with the Nuclear Decommissioning Authority (NDA) to immobilise the UK-owned civil separated plutonium inventory at Sellafield (2). Scottish Government policy is that the long-term management of higher activity waste at civil nuclear sites (excluding HLW, which is not located in Scotland) should be in facilities which are located as near to the site where the waste is produced as possible, and in the near-surface environment (3).

Geological disposal involves isolating radioactive waste deep inside a suitable rock volume to ensure that no harmful quantities of radioactivity ever reach the surface environment. This is achieved using multiple barriers, that work together to provide the necessary containment and protection, including:

- The form of the radioactive waste itself, for example solid HLW glass.
- The waste packaging, including the container and any overpack.
- The engineered barriers (buffer, backfill, plugs and seals).
- The stable host rock, within which the facility is developed.

Delivery of a GDF, up to the point of closure, will be coupled with safe and secure interim storage of wastes and ongoing research and development to support optimised implementation.

Development of a GDF will be achieved through a consent-based siting process, with willing community partners as set out in government policies for England and Wales (1). Policy also recognises that it is appropriate to investigate and remain aware of alternative options to geological disposal where there could be the potential to improve the overall management of the Inventory for Geological Disposal:

> *"…NDA [Nuclear Decommissioning Authority] and NWS [Nuclear Waste Services] continue to review appropriate solutions including learning from and engaging with overseas programmes, which could have the potential to improve the long-term management of some of the UK's radioactive waste."* (1).

This report summarises the consideration of Nuclear Waste Services on alternative options to geological disposal for managing the Inventory for Geological Disposal, in accordance with the published strategy of the Nuclear Decommissioning Authority (4). It seeks to update our last consideration in 2017 (5), reflecting the Working with Communities policies, recommendations from the Committee on Radioactive Waste Management, and the UK policy framework for managing radioactive substances and nuclear decommissioning, which identify the need to maintain an understanding of alternatives to geological disposal.

The scope of the review has been limited to highlighting some key developments in:

- Alternative disposal options for some wastes destined for geological disposal. These include near-surface disposal and deep borehole disposal concepts.
- Alternative treatment techniques for radioactive wastes which could alter the nature and/or reduce the volume of waste requiring geological disposal (referred to in this report as "Waste Treatment Techniques").

3. Key findings

The following sections summarise the position of Nuclear Waste Service on these technologies, supported by the review and synthesis presented in the counterpart main report (6).

3.1 Near-Surface Disposal

Near-surface disposal facilities have been operated by several nations to manage Low Level Waste and shorter lived Intermediate Level Waste in their radioactive waste inventories. Although several such facilities are operational globally, Centre de la Manche in France is the only facility, managing Intermediate Level Waste, to have completed its disposal mission and have been brought to a state of closure. In the UK, near-surface facilities are currently operated for the disposal of Low Level Waste, primarily the Low Level Waste Repository. However, the Nuclear Decommissioning Authority is currently exploring the benefits of developing further near-surface facilities for disposing of a proportion of the less hazardous waste in the Intermediate Level Waste category. Development of such facilities in England and Wales was

enabled by the UK policy framework for managing radioactive substances and nuclear decommissioning, published in May 2024 (1). Therefore, whilst near-surface disposal does not remove the need for a GDF, a proportion of the less hazardous waste in the Intermediate Level Waste category, currently destined for geological disposal, could potentially be re-routed to near-surface disposal. This may enable earlier hazard reduction and overall cost savings, subject to a rigorous safety case. We recognise the need to further optimise use of the disposal capacity at the Low Level Waste Repository site, in parallel with capping of the Repository which commenced in 2024.

3.2 Deep Borehole Disposal

Progress in deep borehole technology has comprised primarily laboratory and concept based studies, and the approach remains at an early stage of technical maturity. Strategic studies have considered the potential application against some national radioactive waste inventories. Our assessment is that deep borehole disposal could not displace the need for a GDF in the UK as it could not realistically accommodate the entire inventory for disposal. At the time of writing, deployment of deep borehole disposal in a nuclear environment would require further policy and legislative consideration, both of which would be a matter for government, and subsequent strategy development. Regulatory approaches would also have to be developed to ensure proper regulation of operational safety and security alongside long-term environmental protection. Nevertheless, in nation states with a smaller inventory of higher activity waste, comprising primarily spent nuclear fuel, deep borehole disposal may be a future alternative to development of a GDF. However, deep borehole disposal remains conceptual and has no licensing basis at the current time. Nuclear Waste Services will maintain its position of keeping a watching brief on future developments in deep borehole disposal.

3.3 Waste Treatment Techniques

Notable progress has been made in development of alternative treatment options for radioactive wastes, particularly using thermal treatment and enhanced encapsulation technology. These technologies are compatible, in principle, with treatment of a significant fraction of the Intermediate Level Waste inventory, in particular, problematic waste streams for which no, or sub optimal, treatment options are currently available. Thermal treatment methods have the potential to reduce the volume of some wastes requiring interim storage and emplacement in a GDF, and achieve improvement in passive safety. Inactive and active variants of the technology have been operated at full scale, or demonstrated at pilot scale, for radioactive waste management. Together with laboratory proof of concept work, this research has established an understanding of the key benefits, opportunities and challenges of deployment of thermal treatment technology in a UK context. Nuclear Waste Services will continue to develop the evidence base for confidence in disposability of the products of thermal treatments to meet the needs of the NDA group.

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4. Conclusions

Notwithstanding the advances in all the alternative radioactive waste management options discussed, none remove the need for a GDF. Therefore, a GDF continues to be required for the disposal of significant portions of the UK's Radioactive Waste Inventory. The alternative radioactive waste management options reviewed here may, in the future, enable the Inventory for Geological Disposal to be further optimised or reduced. The associated cost savings clearly need to be considered against the marginal cost of emplacement of the waste inventory in a GDF, in addition to due consideration of potential earlier waste emplacement, whole lifecycle costs and other strategic drivers. In developing alternative radioactive waste management options, it will be important to engage public awareness and understanding of technology developments.

Nuclear Waste Services maintains a watching brief on the development of technologies that might have the potential to reduce the Inventory for Geological Disposal and/or act as alternative management/disposal options. If any such technologies emerge and reach a suitable level of maturity then Nuclear Waste Services will initiate an internal process to engage with and actively support their development, if it is felt that they offer suitable potential benefits to the management of the Inventory for Geological Disposal. The development of potential thermal treatment and near-surface disposal options has followed this process.

5. Looking Forward and Next Steps

Nuclear Waste Services has updated its awareness of alternative options for management of the Inventory for Geological Disposal, to potentially optimise disposal of radioactive wastes to any future near-surface and deep geological disposal facilities. It is evident that these alternative options cannot fully displace the need for a Geological Disposal Facility but may enable earlier hazard reduction and overall cost savings, without any compromise on safety, and a more optimal end point for the decommissioning mission. Going forward, we will establish a dedicated horizon scanning capability to ensure that awareness of alternative options, and technology developments more generally, have dedicated leadership across the business, to achieve greater effectiveness and realise potentially transformative benefits.

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