DEEP BOREHOLE DISPOSAL: AN ALTERNATIVE TO THE MINED & ENGINEERED REPOSITORY FOR HIGH-LEVEL WASTES

WHAT  HOW  WHY

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GEOLOGICAL DISPOSAL

Emplacement in the Earth’s crust with no intent to retrieve

- Near-Surface
  - Sub-Sea Bed
  - Mined Repository
    (= Deep geological disposal)
    - Disused Mine Workings
  - Deep Boreholes
    (= Very deep disposal)
Active near-surface flow

Sluggish flow or diffusion at depth

Increasing groundwater salinity/density

Disposal zone

Lateral hydraulic flow
~ 30m in 10^5 years

Adapted from Chapman & Gibb, 2003
SNF & HLW
3a Spent UO$_2$ Fuel
3b Spent MOX
2 Pu
SNF & HLW

1 Vitrified HLW
2a Spent UO$_2$ Fuel
2b Spent MOX
3 Pu

Low T° VDD

High T° VDD

VERY DEEP DISPOSAL
a.k.a. DEEP BOREHOLE DISPOSAL

Important differences in detail between versions
Creating the borehole

- Drill the first stage of the borehole
- Insert the casing.
- Pour a cement base-plug.
- Drill the next stage of the borehole.
- Insert the casing.
- Pour the cement base-plug
- Drill the next stage of the borehole

And so on, down to > 4 kms

0.5 - 0.6 m diameter
Low Temperature Very Deep Disposal

**Vitrified waste**

- Insert the final run of casing (Surface to TD)
- Emplace the first batch of HLW canisters
- Pump in the special grout and allow it to set
Low Temperature
Very Deep Disposal

Vitrified waste

- Insert bentonite clay (*Optional seal*)
- Insert another batch of canisters, pour the grout & allow to set

Repeat until the bottom km of the borehole is filled
Sealing the borehole

- Insert some backfill (crushed granite)
- Insert heater and melt backfill & wall-rock to seal the borehole
- Pour in more backfill and seal the borehole again
- Repeat as often as required then fill the rest of the borehole with backfill

3 km deep (topmost canister)
Advantages of Deep Boreholes

1. SAFETY
2. COST EFFECTIVE
3. ENVIRONMENTAL IMPACT
4. SMALL ‘FOOTPRINT’
5. SITE AVAILABILITY
6. SECURITY
7. INSENSITIVE to HLW COMPOSITION
8. LONGEVITY
9. EARLY IMPLEMENTATION
SAFETY CASE

1. PRE-DEPLOYMENT
   - Removal from store
   - Overpacking *(Stainless ? + Deployment fittings)*
   - Transport to well-head *(Horizontal ?)*
   - Transfer to well-head facility *(Shielded)*

2. OPERATIONAL
   - Reorientation to vertical *(If transported horizontally)*
   - Insertion into borehole
   - Lowering to final position
   - Release of waste package
   - Grouting/support matrix
   - Sealing borehole

3. POST-CLOSURE
   - Near field
   - Far field
LTVDD-1 HEAT-FLOW MODEL

Vitrified HLW  1 Container  10 years storage

Temperature (°C)

Time (days)

After Gibb, Travis, McTaggart & Burley (2008)
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COST EFFECTIVE (LTVDD-1)

0.5 m Borehole to 4 km = £25 - 35 M
With up to 50% savings for multi-borehole programme (J. Beswick, 2008)

No. of packages per hole = 650 - 700

UK Total HLW containers = 7,250
(2007 UK Inventory, current & future arisings)

No. of 4 km holes required = 10 - 11

Approximate cost = £210 - £330 M
(Assuming minimum savings per hole of 15%)

NDA R.R.C. (ILW + HLW) = ~ £14 Billion
SITE AVAILABILITY

Suitable basement underlies much of the continental crust

Within 3 km of surface in many places

Potentially good site availability

Small footprint

Waste producers (e.g. NDA, MoD) could already own, & volunteer, suitable sites.
**EARLY IMPLEMENTATION**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
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<tbody>
<tr>
<td>Small diameter test drillings (Incl. geological &amp; hydrogeological evaluation)</td>
<td>1 – 2 years</td>
</tr>
<tr>
<td>Disposal borehole to 4 km</td>
<td>~ 1 year</td>
</tr>
<tr>
<td>HLW emplacement</td>
<td>~ 2 years</td>
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<tr>
<td>Sealing &amp; Backfilling</td>
<td>&lt; 1 year</td>
</tr>
<tr>
<td>Time to first completion</td>
<td>~ 5 – 6 years</td>
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10. ACCEPTABILITY ?
DBD is an option we can’t afford to ignore for the HLWs to which it is especially suited.

It is not a technology that can be dismissed as “immature” requiring decades of development.

Thank you.