Meeting the challenge: Geological disposal of UK higher activity radioactive waste

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Electricity supplied by fuel type, 1980 to 2011
Energy demand, 2010 to-date

Baseload energy
- Oil and gas
- Nuclear
- Biofuel
- Geothermal
- Hydropower
- Tidal

Peak load energy
- Wind
- Solar
- Hydropower
Nuclear Power

Advantages: Doesn't depend on fossil fuels, isn't affected by fluctuating oil and gas prices, not reliant on foreign energy imports.

- Nuclear Energy Institute estimate the power produced by the world's nuclear plants would normally produce 2 billion metric tons of CO$_2$ per year if they depended on fossil fuels

Disadvantages: Current technology produces nuclear wastes that must be managed to 10,000s to 1,000,000s of years
Tough decisions

• Need to meet baseload energy demand
• Need to meet targets for greenhouse gas emissions
  • Carbon capture and storage technology immature
  • Need energy storage solution for baseload renewables

Datchet, Berkshire, Feb 2014
What is radioactive waste?

Low Level Waste
• Mostly building rubble, soil and steel

Intermediate Level Waste
• Nuclear fuel casing, sludges from treatment of radioactive liquids, graphite from reactor cores

High Level Waste
• Heat generating wastes derived from nuclear fuel reprocessing
How much waste do we have and where does it come from?

- 4,500,000 m$^3$ (4 times the volume of Wembley Stadium)
- Most wastes stored at existing nuclear facilities
- New build nuclear power

![Diagram of waste origins](image)

- Medical & industrial
- Defense
- Nuclear energy research
- Nuclear power reactors
- Fuel fabrication and uranium enrichment
- Spent fuel reprocessing

NDA, 2013 waste inventory

*Inside the ILW Store at Hunterston A*

*Inside the Vitrified High Level Waste Store*
What should we do with the waste?

- In 2003, UK Government set up an independent Committee for Radioactive Waste Management (CoRWM)
  - Contained non-technical experts
  - Very extensive public consultation including citizens panels
CoRWM reconstituted as expert technical committee
• New membership
• Independent scrutiny and advice to Ministers
• I joined CoRWM in 2009
What is Geological Disposal?

- A nuclear waste repository is an *engineered facility* deep below the ground
  - UK policy is 200 m - 1000 m below surface
  - Uses the waste form, the waste package, specially designed engineered seals and stable geology to ensure safety
  - Provides a high level of long-term isolation and containment without future maintenance
Technology to-date

13 countries currently pursuing geological disposal for a variety of waste types
- 4 sites in operation
- 3 site under construction
- 2 sites have submitted the license application
- Other sites in discussion
Safety Case

• A safety case is a “formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe”. (Nuclear Energy Authority, 2013)

• Early safety cases
  – during site characterisation
  – general assumptions about the host geology and the layout of the repository

• Safety case for authorisation of repository construction
  – sufficient factual detail to provide the necessary confidence for the regulator to determine that the repository will be safe.
Safety case

- Assessed by the independent regulators
- Post-closure safety case
  - examples of crystalline rock, clay rock and salt
- Construction and operational safety case
Sweden/Finland

KBS3 – Safety concept for fractured granite

Multi-barrier approach
Sweden/Finland
KBS3 – Safety concept for fractured granite

For spent nuclear fuel

Safety criteria: Annual risk of harmful effects must be less than a one in a million chance

Safety relies on ensuring no radionuclide release from the waste cannister over first million years

• Low flow rates keep stable groundwater chemistries at repository depth – stops breakdown of engineered barriers
• Engineered barriers protect cannisters from earthquakes and from copper corrosion

Safety case assumes instantaneous transport from depth to surface – doesn’t rely long times-scales for contaminant migration through fractures
US
WIPP – Operating since 1999 in salt rock

**For transuranic waste**

Safety criteria: 10,000-year radionuclide containment and isolation of the waste

- Salt ‘flows/creeps’ so holes (and cracks) in the rock close under the weight of the rock above
- Salt is dry as no holes, but also water is incorporated into the salt - mobile phones!
- Water cannot flow hence waste cannot travel to the surface
France
Andra - clay rocks

For High Level and Intermediate Level Long-Lived Waste

Safety criteria: “wastes must represent no increased risk for human beings and the environment” Andra

- Clay rock very impermeable to water so travel times for radionuclides to reach the surface are extremely long
- Experiments at Bure show fractures heal (close up)
- No conflict with shale-gas due to high clay content
UK Siting Process

• Volunteer communities
  – Communities first express an interest
  – Local consultation
  – Decision whether to participate

• Community benefits package

• Data (including geology) not gathered until after a community decides to participate
Siting process – 2009 to 2013

• Only Cumbria County Council, Allerdale District Council and Copeland District Council express an interest
• Extensive public consultation through a siting partnership with members from each council
• Moray Poll shows net support within each region
• Copeland and Allerdale vote to participate, Cumbria vote against

Process fails to deliver a UK site
NGO and Local Campaign Claims

Claimed geology already known to be unsuitable

- Two geologists presenting evidence for campaigners
- Misleading and simplistic arguments about groundwater flow
NGO and Local Campaign Claims

Lake district boundary fault will divert flow

Courtesy of David Smythe’s web site
NGO and Local Campaign Claims

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Freshwater ‘floats’ on salty water as less dense

Saline interface at ~350 m depth

Lake district boundary fault will divert flow
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No plausible reason to drive flow far below sea level – what is the driving force?

• Large vertical exaggeration - Scafell Pike ~16km from the sea

Courtesy of David Smythe’s web site
NGO and Local Campaign Claims

- Large vertical exaggeration - Scafell Pike ~16km from the sea
- Layers of permeable and impermeable sediments

No plausible reason to drive flow far below sea level – what is the driving force?

Sedimentary layers – some impermeable

Freshwater ‘floats’ on salty water as less dense

Saline interface at ~350 m depth

Lake district boundary fault will divert flow

978 m
NGOs and Local Campaign Groups

- Claims that community benefits were a *bribe*
- Claims that government always planned to return to 1995 site
- Anti new-build nuclear power
  - ‘Nuclear dump’ used by national and local press
    - Even *Costing The Earth* (Feb 2014)
      - Radio 4

Don’t forget Moray Poll showed public in favour!
My views…

• Responsibility to minimise public risk
  – Waste at the surface is vulnerable and more hazardous

• Ethical and moral responsibility
  – Our generation used the energy, so we should pay for the solution

• Future power?
  – A tough choice between energy shortages, nuclear power and climate change
  – Carbon capture and storage technology is unproven at an industrial scale
Lessons-learned

- News reporters are not experts and simple statements make good headlines

A safety-case takes 10-20 years to build
  - Safety arguments are complex and technical
  - Public cannot weigh one expert argument against another (e.g. MMR)

BUT... International experience shows public support is necessary for success
So how can a geological disposal siting process succeed?
New siting policy development

- Public consultation ended Dec 2013

Some key issues

- Geological screening?
  - Very sparse data at depth
  - Still need volunteers
  - Focus should be safety NOT GEOLOGY

[Images of tunnels and construction equipment]
New siting policy development

Some key issues

• *When* do we need net of public support?
  – In Sweden public confidence grew as the safety case was developed
New siting policy development

Some key issues

• Who should the decision-making body be?
  – Previous process failed to find a site, despite substantial local support
    Copeland - YES 68%, NO 22%
    Allerdale - YES 51%, NO 37%
    Cumbria - YES 50%, NO 35%

• Who should receive community benefits?
How can we engage the public and the press in an *informed* debate?

For legacy waste at the very least, the UK needs a siting process that delivers...
Our Energy Future?!