

Nuclear waste disposal Investigating geological disposal facilities (GDFs)

Nuclear technology has been a part of our lives for more than 60 years and is used in power generation, industry, medicine and defence. Today, nuclear energy provides almost a fifth of the UK's electricity and leaves little carbon footprint. Nuclear power is an important part of the energy mix in many other countries too, but there is the on-going problem of what to do with the radioactive waste.

At the moment in the UK, all radioactive waste is stored in storage facilities at or near the surface but these require constant maintenance; we need a long-term solution which will dispose of the waste permanently and safely.

There is international consensus that the safest permanent solution to manage radioactive waste is geological disposal, which involves putting the waste in a Geological Disposal Facility (GDF) beneath several hundred metres of solid rock. This is already the chosen approach in countries including Canada, Finland, France, Sweden and Switzerland. Some of these countries are well on the way to developing their own GDFs.

Building a GDF involves:

- isolating the radioactive waste in sealed vaults and tunnels deep underground, between 200m and 1000m below the surface;
- containing the radioactivity while it decays naturally over time;
- preventing radioactivity from ever reaching the surface in levels that could cause harm.



Possible appearance of a GDF at the surface © RWM

Ask the pupils to:

- watch the video clip:
https://www.youtube.com/watch?v=D_pcklo_H7A
- in small groups decide the factors that must be considered for suitability of any GDF site. Depending on the group, hints like rock type, rock structure, hydrology, public opinion, can be given.

Possible answers:

- *rock type - must be high strength with low permeability e.g. hard rocks in lowland areas*
 - *rock structure - uncomplicated structure is best*
 - *natural processes - must be considered e.g. earthquakes, sea level rise, future glaciation?*
 - *groundwater - sites require that deep groundwater is absent, or where deep groundwater systems are slow-moving with long return times to the surface, e.g. low permeability deep rocks under sedimentary rocks or inland sedimentary rocks in a basin or syncline where flow would be trapped in the centre;*
 - *resources - exploitation of natural resources past, present and future could affect the isolation and containment capabilities of a GDF*
 - *a willing community*
- assume that geological conditions are perfect in or near your area for a GDF. Hold a debate where the motion is '**A high level radioactive waste geological disposal facility should be built near this area**'. A small team of people should represent RWM (Radioactive Waste Management), which is a public organisation established by the UK government, and another small team should represent the local community who don't know much about GDFs but are against the idea of radioactive waste being in their area, (NIMBYism - not in my back-yard). The pupils can decide to have speakers for specific aspects on either side, e.g. disruption in the construction phase, impact on wildlife, long term plans and so on.

The following information may be useful:

In 1982 the UK government set up the Nuclear Industry Radioactive Waste Executive (NIREX) to explore the options in the UK it was decided that the best place to investigate further was the area near the Sellafield Nuclear Power station in Cumbria. This was because there were low permeability deep rocks under sedimentary rocks there, and also because, as most of the UK high level radioactive waste was already in near surface storage there, it would not be necessary to transport the waste, with the linked safety issues, if the deep repository were nearby. NIREX applied to the government to construct an underground laboratory to further investigate these rocks. At the following

public inquiry, permission was refused, and NIREX appealed. The Secretary of State turned down the appeal in 1997, after which NIREX was

closed down. In 2003, the UK's Committee on Radioactive Waste Management (CoRWM or RWM) was established.

Back up

Title: Nuclear waste disposal

Subtitle: Investigating geological disposal facilities (GDFs)

Topic: Discussion about how a GDF might affect the local area.

Age range of pupils: 14 years upwards

Time needed to complete activity: 60 minutes depending on the levels of discussion

Pupil learning outcomes: Pupils can:

- explain that, once built, nuclear power generation does not emit any greenhouse gases;
- realise that there is a problem with long-term disposal of the radioactive waste;
- realise that GDFs provide a solution to the problem of radioactive waste disposal;
- describe a GDF;
- list the ideal geological conditions needed to build a GDF;
- realise that GDFs require no ongoing maintenance but will need ongoing monitoring;
- explain that GDFs are less vulnerable than surface storage to human activities such as terrorism or war and to natural processes such as climate change;
- realise that there must be public consultations and the public made aware of GDFs before any sites are considered.

Context:

Government 'net-zero' targets will affect many areas across the world. Nuclear power generation provides a solution but there is an on-going problem of how to dispose of the radioactive waste permanently and safely.

This activity explores geological disposal facilities (GDFs) as a solution to the problem.

Following up the activity:

Evaluate the possibilities for energy sources alternative to fossil fuels using the Earthlearningidea, 'What is/are the least bad option(s) for plugging the future global energy gap?' at

https://www.earthlearningidea.com/PDF/343_Plugging_energy_gap.pdf

for other ideas of what could be developed in your area.

Search 'net-zero' on the Earthlearningidea website to find other Earthlearningideas relating to climate change mitigation or adaptation. Use a search engine like Google to explore the internet for more information about likely global impacts of 'net-zero'.

Underlying principles:

- Nuclear power generation does not emit any greenhouse gases.
- Currently in the UK, radioactive waste is stored at or near the surface which is not a long-term solution.
- Geological disposal facilities (GDFs) provide a solution to the problem of radioactive waste disposal.
- High level radioactive waste will take hundreds of thousands of years to decay and become safe.
- Only geologically stable areas with suitable rock types can be considered for GDFs.
- GDFs require no ongoing maintenance.
- GDFs are less vulnerable than surface storage to human activities such as terrorism or war.
- GDFs are less vulnerable than surface storage to natural processes such as climate change.
- GDFs can only be built in areas where there is a willing community.
- The GDF site will be very busy at first while the facility is being built but once it is full and sealed, the land will be reclaimed for public use.
- Planning for a GDF takes between 15 to 20 years.

Thinking skill development:

There is a pattern to developing the idea of GDFs and how they work. Discussion about the factors needed for building a GDF and about whether one should be built in the local area involves both metacognition and cognitive conflict.

Understanding GDFs and then trying to imagine one in the local area involves bridging.

Resource list:

- screen and projector to view a video clip
- a view, either from a hill, a window or on a screen, preferably of a nearby area
- space to hold a debate

Useful links:

UK government website:

<https://www.gov.uk/guidance/geological-disposal>

UK government video clip:

<https://www.youtube.com/watch?v=QCRT7DIP2PU>

You can access a tool to help visualise how climate change might affect your local area at:

<https://www.bbc.co.uk/news/resources/idx-d6338d9f-8789-4bc2-b6d7-3691c0e7d138>

Source: Elizabeth Devon of the Earthlearningidea Team with reference to material from RWM and Exploring Geoscience across the globe, IGE0

<http://www.igeosci.org/teaching-resources/geoscience-text-books/>

This information was as accurate as possible in spring 2021.

A full list of related Earthlearningidea activities may be seen below:

The ‘How will the ‘net-zero’ target affect your local area?’ series of Earthlearningideas

Topic		Earthlearningidea title	
Introduction		How will the ‘net-zero’ target affect your local area?	
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		‘Blue’ hydrogen	Blue hydrogen: the fuel of the future? Also: Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from ‘hot dry rocks’: an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		‘Green’ hydrogen	Green hydrogen used to even out renewable energy supplies? Also: Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
	Provide raw materials for new technologies	Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
		Electric vehicles	Electric vehicles: the way to go?
	Remove carbon from the atmosphere	Insulation	How do I choose the best insulation?
		Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let’s plant some trees
Possible adaptation measures	Coastal flooding	How will rising sea level affect our coastlines?	
	Inland flooding	Inland flooding: a Sheffield case study	
	Landslides	Landslide danger	
	Agriculture	The future for global agriculture	

© Earthlearningidea team. The Earthlearningidea team seeks to produce a teaching idea regularly, at minimal cost, with minimal resources, for teacher educators and teachers of Earth science through school-level geography or science, with an online discussion around every idea in order to develop a global support network. ‘Earthlearningidea’ has little funding and is produced largely by voluntary effort. Copyright is waived for original material contained in this activity if it is required for use within the laboratory or classroom. Copyright material contained herein from other publishers rests with them. Any organisation wishing to use this material should contact the Earthlearningidea team. Every effort has been made to locate and contact copyright holders of materials included in this activity in order to obtain their permission. Please contact us if, however, you believe your copyright is being infringed: we welcome any information that will help us to update our records. If you have any difficulty with the readability of these documents, please contact the Earthlearningidea team for further help.

