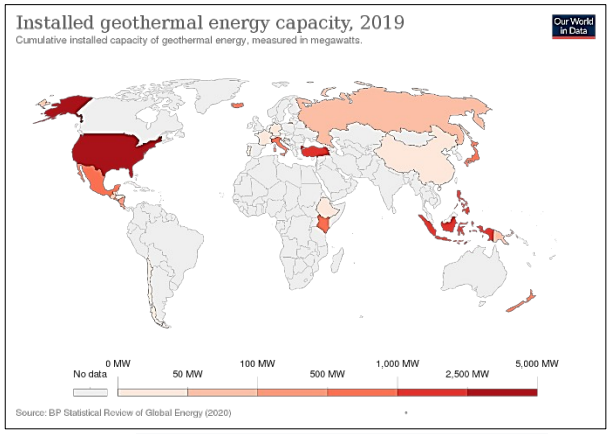
Deep geothermal power from 'hot dry rocks': an option in your area?
A discussion of potential for extracting 'hot dry rocks' geothermal energy locally

Deep geothermal energy

There are three sources of deep geothermal energy. They are:

- 'Hydrothermal power' available where there is active volcanic activity which heats water that rises to the surface. This energy can be tapped by power stations or used for household heating. The main countries using this type of geothermal energy are shown on this map:



(Source: https://ourworldindata.org/grapher/installed-geothermal-capacity released under the CC BY-SA 4.0 licence).

- 'Hot dry rocks' where rocks underground have been heated by the radioactive decay of the elements they contain, and the heat can be extracted by pumping water through them.
- 'Hot wet rocks' where the natural geothermal heat of the Earth has been trapped deep underground in the water of permeable rocks (aquifers) capped by impermeable rocks above. The heat can be extracted by pumping out the water.

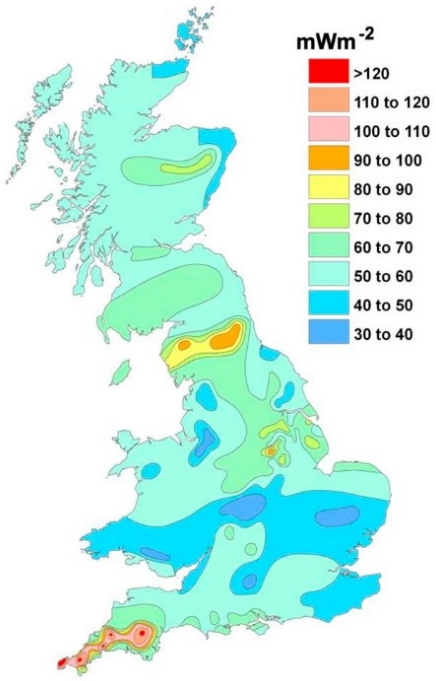
These three geothermal energy situations can be modelled in the school lab using the 'Rock power' Earthlearningidea at: https://www.earthlearningidea.com/PDF/95_Rock_power.pdf

Geothermal energy – renewable?

Remember that geothermal power, from any source, is not truly renewable, since the heat extraction rate is faster than the rate at which natural processes can replenish it. Even in hydrothermal energy sources, heat is usually extracted at a greater rate than it is being replaced.

'Hot dry rocks' in the UK

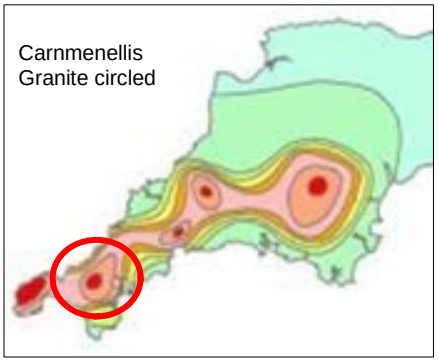
The UK map shows deep geothermal energy potential. The 'hot dry rocks' potential is in the areas with the highest heat flow. The hottest of these is within the South West peninsula of Devon and Cornwall, underlain by a granite batholith. Each pluton that rose from the top of the batholith is a potential 'hot dry rocks' geothermal target.



Heat flow map of the UK.
© British Geological Survey.

The United Downs Project

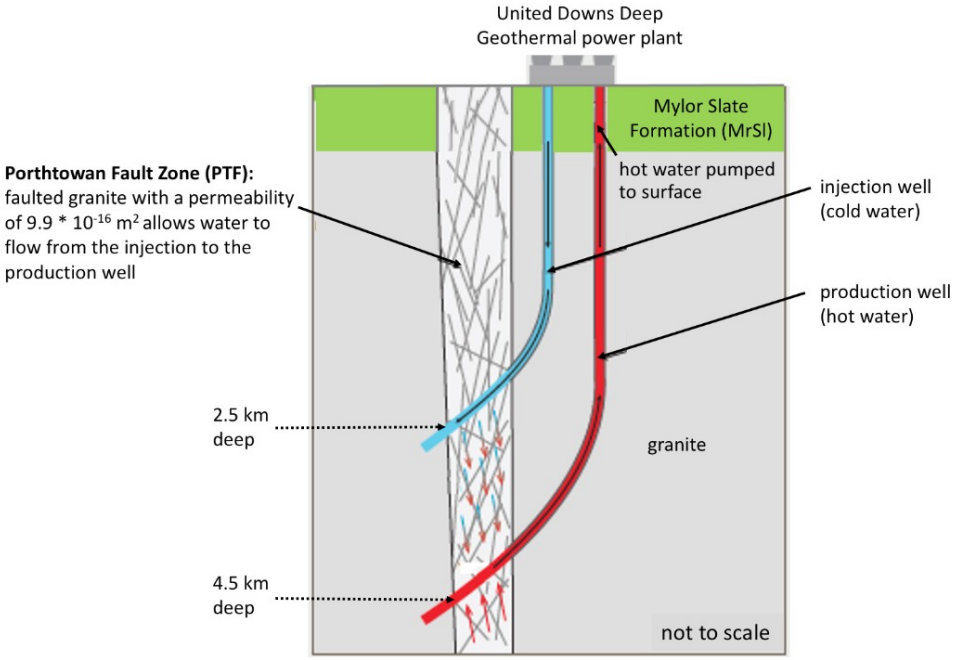
The United Downs Deep Geothermal Power Project (UDDGP) will be the first 'hot dry rocks' geothermal power plant in the UK. The project will produce power from the hot Carnmenellis Granite near Redruth in Cornwall.



Devon and Cornwall heat map, showing the Carnmenellis Granite.*© British Geological Survey.*

Water, pumped down an injection well will travel through fractures in the rock, becoming heated up as it does so, until it is pumped out of a production well as hot pressurised water. This is then converted into electricity by a steam turbine.

The two wells have successfully been drilled; a production well and an injection well. Both wells have cut the Porthtowan Fault Zone, where fractures in the zone increase the permeability of the granite. The fracturing allows water to circulate between the wells at a fast enough rate for the project to be successful.



(Redrawn from: https://www.geoscience.co.uk/post/45-years-of-geothermal-in-cornwall-some-unanswered-questions-from-tony-batchelor)

Temperature rises at a rate in the granite of 0.04°Cm^{-1}, so that the temperatures at the bottom of the wells should be ~190°C. This will give a predicted water temperature of ~175°C when it reaches the surface, which should produce up to 10MW of electricity. The water will then be reinjected at a temperature of approximately 80°C to complete the water flow system. If this is successful, the power plant will begin commercial operation in 2021.

Your country or region
Study a heat flow map of your country or region. Could 'hot dry rocks' geothermal energy be extracted there? If so, should it be extracted?

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The back up

Title: Deep geothermal power from 'hot dry rocks': an option in your area?

Subtitle: A discussion of potential for extracting 'hot dry rocks' geothermal energy locally.

Topic: Considering the 'hot dry rocks' geothermal potential in the UK though an experimental commercial project in Cornwall.

Age range of pupils: 14 years upwards

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:
- demonstrate they can interpret a heat flow map;
- explain how energy can be extracted from granite, a 'hot dry rock';
- discuss whether 'hot dry rock' geothermal energy might be exploited in their own country or region.

Context:
Government 'net-zero' targets will affect many areas across the world as they seek energy from non-fossil fuel sources. This Earthlearningidea explores how energy might be extracted from 'hot dry rocks'.

'Hot dry rocks': The granites of south west England are warmer than rocks in other parts of the UK because of the heating effect of the decay of the radioactive elements in some granite minerals. The heat has been accumulating for millions of years, so warming the rocks.

'Hot wet rocks': Energy is currently being extracted from 'hot wet rocks' in the Southampton area of the UK. The plant can be seen here:

(Peter Facey CC BY-SA 2.0)

A borehole was sunk into the deep warm aquifer where the water was found to have a temperature of 76°C. But the borehole was abandoned because the project was considered to be too small to be viable. However, the Southampton

City Council was able to use the borehole free of charge, and has been extracting geothermal energy ever since. The energy is currently being used to heat the Southampton Civic Centre, a nearby shopping centre, hospital, university and 1000 homes.

Following up the activity:
Search the internet for a map of the geothermal energy potential in your region. Then discuss its viability with your group.

Underlying principles:
- There are three potential sources of deep geothermal energy: hydrothermal, 'hot dry rocks' and 'hot wet rocks'.
- Energy can be extracted from 'hot wet rocks' such as granite, by pumping water down a borehole and extracting it from an adjacent borehole where the boreholes are linked by a fracture system.
- The 'hot dry rocks' geothermal energy option is only viable in areas where the underlying rocks are unusually warm.
- Heat is generated by the decay of radioactive elements contained in minerals in rocks such as granite.
- Since heat is extracted from both 'hot dry rocks' and 'hot wet rocks' at a greater rate than it is being naturally replaced, these resources are not renewable in the long term.

Thinking skill development:
Heat flow maps show patterns requiring construction to understand them. Using these to discuss the viability of 'hot dry rocks' options in a country or area involves cognitive conflict and metacognition, as well as bridging to a new context .

Resource list:
- geothermal heat maps of a region

Useful links:
Search for 'net-zero' on the Earthlearningidea website to find other Earthlearningideas relating to climate change mitigation or adaptation.

There are several diagrams on the internet showing the hot wet rocks geothermal option, but be wary, as some of these indicate that this is a renewable resource when, in the long term, it is not.

Source: Pete Loader in the *Exploring Geoscience across England* textbook, available at: http://www.igeoscied.org/teaching-resources/geoscience-text-books – with additions by Chris King.

This information was as accurate as possible in spring 2021.

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
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	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