Capturing carbon?

Can we capture and store carbon from burning fuel, cement- and steel-making? Should we?

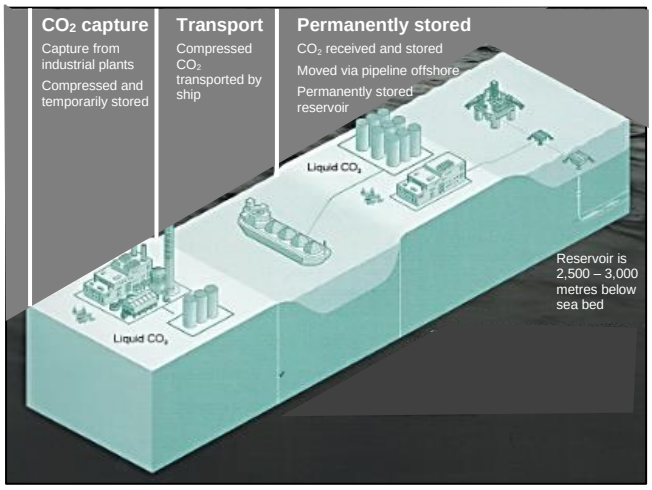
Capturing carbon

Today about 70-80% of the carbon dioxide released into the atmosphere by humans comes from burning fossil fuels, whilst the rest comes from cement- and steel-making, and other industry. We are unlikely to reduce fossil fuel use to zero soon, while other industries will continue adding carbon to the atmosphere. So what can we do to stop releasing carbon and move towards 'net-zero'?

One answer to this question is carbon capture and storage (CCS) otherwise known just as carbon capture or as carbon sequestration.

This has three steps, shown in this diagram:

- capturing carbon dioxide at the industrial plants where it would otherwise be released;
- compressing the gas to liquid and transporting it to where it could be stored;
- storing the carbon underground permanently.



(© NERC, *Planet Earth*, 2020.1, p40).

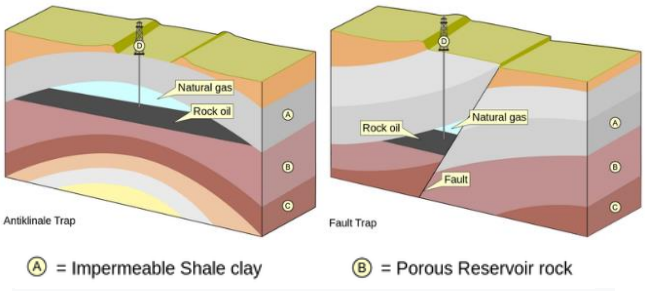
Pilot projects have successfully been run of all these steps, including storing liquid carbon dioxide in two gas fields under the North Sea.

Storing carbon

Three places where carbon dioxide could permanently be stored underground are:

- caverns in salt deposits that have been made by mining or by pumping out the salty brine water; this method is being explored in the Cheshire Salt Field in north west England;
- old oil and gas fields, where the oil and gas was trapped, but has now been extracted, so that they are mostly now filled with water;
- underground potential traps that might have been filled with oil or gas if there had been a nearby source producing these fluids.

Using the 'trap' method means that carbon could be stored anywhere where there are the right conditions to form gas traps. These potential carbon storage spots need the four things shown in the diagrams of oil/gas traps opposite, as described below them.



(*MagentaGreen CC BY-SA 3.0*).

- a rock with gaps between the grains that can store the liquid or gas, i.e. a permeable rock – called a reservoir rock (because it can hold a reservoir of oil/gas);
- a rock that will not allow fluids to flow through, i.e. an impermeable rock – called a cap rock (because it holds fluids capped in the pore spaces of the reservoir rock beneath it);
- shapes in the rocks that can hold fluids underground, like the upfold or anticline and the fault shown in the diagrams here – called traps because they trap the fluids underground;
- these things being in the right places, with the upfolded/faulted reservoir rock trap being sealed by a cap.

<u>Could</u> carbon be stored underground near you?

To discover if carbon dioxide could be stored in a trap near you, you need to find out:

- if there are permeable rocks nearby, that could be reservoir rocks – you can test if a rock is permeable by adding a few drops of water to see if they sink in, or by putting a specimen into a container of water and watching to see if bubbles rise from it;
- if there are impermeable rocks nearby, that could be cap rocks – by testing using water drops or putting a specimen in water;
- if the rocks are shaped like traps – you can explore the shapes of the local rocks nearby by making a geological map or by checking a published geological map, looking for anticlines or faults;
- your map will tell you if the key features are in the right order – a reservoir rock in a trap shape, sealed by a cap rock.

This exploration will show if carbon <u>could</u> be permanently stored underground locally.

<u>Should</u> carbon be stored underground near you? What do you think?

If your exploration shows that carbon <u>could</u> be permanently stored underground locally, then the next step is a discussion between companies, the government and local people about whether this <u>should</u> be done.

The back up

Title: Capturing carbon?

Subtitle: Can we capture and store carbon from burning fuel, cement- and steel-making? Should we?

Topic: A review of methods of carbon capture and storage leading to the question of whether this could happen locally. If it could, should it happen locally?

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 minutes if indoor rock testing and map study is carried out; more time if these are done in the field

Pupil learning outcomes: Pupils can:

- explain why carbon capture and storage might be needed;
- explain how liquified carbon dioxide gas could be stored underground;
- explain the rock features necessary for gas to be stored underground;
- explore and explain local data to find out if carbon could be stored locally;
- discuss whether carbon should be stored locally.

Context:
This Earthlearningidea is one of a series exploring the options as countries move towards 'net zero' carbon release within the next few years. The carbon capture and storage option is reviewed. Then explorations can be made locally to see if this could and should happen.

Permanent carbon dioxide storage underground may be helped if the carbon dioxide reacts with the rock to make new minerals. This possibility is called carbon mineralisation and is currently being researched.

Following up the activity:
An alternative to storing unwanted carbon dioxide is to use it. You could explore the internet for potential uses for this carbon (*Possibilities include: pumping it into old oil/gas fields to extract more oil/gas; pumping it into plant greenhouses to increase growth rates; curing concrete; feeding algae to make biomass for fuel.*)

Explore the internet to find the progress that is being made in developing industrial plants to remove carbon dioxide directly from the atmosphere. If this becomes commercially possible, then countries will be able to go beyond 'net zero' and actually reduce the carbon in the atmosphere.

Underlying principles:

- Carbon dioxide gas can be captured from industrial processes where it is currently released, such as fossil fuel burning and cement- and steel-manufacture.
- This gas can be compressed into liquid and transported efficiently.
- It can be stored underground either in rocks which have caverns and are naturally impermeable, like rock salt mines/brine pumping areas, or in natural traps.
- To form a natural underground trap for buoyant fluids (gases or liquids), a reservoir rock, a cap rock and a trap are needed in the right order to trap gas.
- It is possible to explore locally whether the geological conditions could be right for storing carbon, then to have the debate about whether it should be stored locally.

Thinking skill development:
Exploring locally for the right conditions for a gas trap involves constructing the appropriate scenarios based on the information provided. Assessing whether these do apply locally involves cognitive conflict. Discussions around this are likely to involve metacognition and bridging skills.

Resource list:

- to test rock permeability, either a dropper bottle of water or a container of water in which to submerge specimens

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

Explore six ways to remove carbon pollution from the sky at: https://www.wri.org/blog/2020/06/6-ways-remove-carbon-pollution-sky

Source: Chris King of the Earthlearningidea Team.

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
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		'Blue' hydrogen	Blue hydrogen: the fuel of the future?
		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?
		Hydro – storage	Storing the power of 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