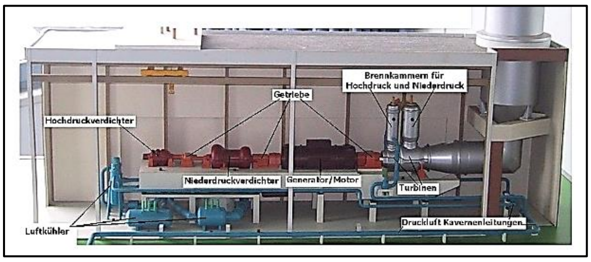
Storing gas underground: What can we store? How can we do it? How will it help?
A discussion on gas power sources that can be stored and the storage conditions needed

Three types of gas can be stored underground to help us with our energy needs. They all have the same purpose, to store energy until it is needed to even out our energy supplies, providing extra energy when required.

They are:

- **Compressed air** – air is pumped into an underground storage area and released when needed, mixed with natural gas, and used to drive a turbine to generate electricity. The burning of natural gas releases greenhouse gases to the atmosphere, so experiments are being carried out on using compressed air alone to drive turbines. Both types are called Compressed Air Energy Storage (CAES) systems. Since more energy is used in compressing the gas than is released when it decompresses, this is not efficient and is called a 'negative-gain' process – but may nevertheless be valuable for topping up during peak consumption periods.



Model of the commercial compressed air storage and gas turbine plant in Huntoff, Saxony, Germany, running since 1978. *(Public domain: Govgel)*

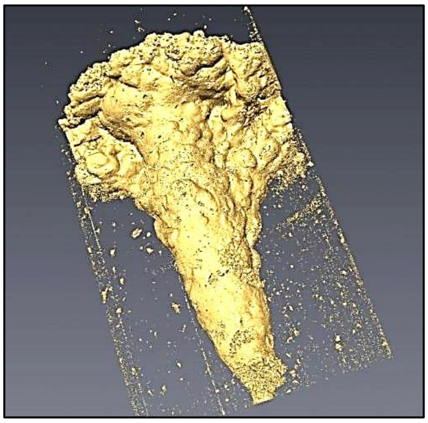
- **Hydrogen** – hydrogen gas is stored underground. This is so called 'brown hydrogen' (made from natural gas, with carbon emissions), 'blue hydrogen' (made from natural gas, but the carbon emissions are captured and stored) or 'green hydrogen' (made by the electrolysis of water, with no carbon emissions). The hydrogen is burnt, giving no waste products (apart from water) to drive electricity turbines.
- **Natural gas** or **methane** – this is stored when there is oversupply in the summer for use in the winter to drive electricity turbines.

Neither natural gas nor 'brown hydrogen' storage contribute to global 'net zero' targets.

Underground storage situations

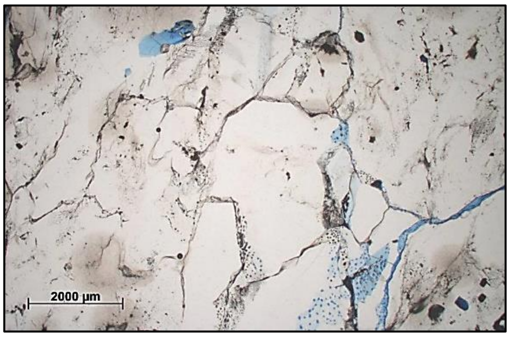
There are three different environments in which gases can be stored underground:

- **Buried rock salt deposits**. The gas is pumped into underground caverns in salt. The caverns may have been made in the past by miners extracting salt or by recovering salt by dissolving it in hot water and then pumping it out in the form of brine. Salt caverns for gas storage may also be deliberately made today by brine pumping.



3D image of a cavern formed in rock salt by brine pumping in Lancashire, England. *(© British Geological Survey).*

The commercial compressed air plants in Huntoff in Germany and in McIntosh, Alabama, USA, both use rock salt caverns. Rock salt is valuable for storage because, not only are caverns easy to make, but if they fracture, water can get in, dissolve salt, recrystallise it, and seal the fracture. Salt deposits are also plastic and so flow to seal cracks naturally as well so long as the gas pressures are not too great. So caverns in salt are gas-tight. Both natural gas and hydrogen are currently being stored in salt caverns in the UK.



Rock salt – self-sealing and so perfect for gas-tight caverns. *(© British Geological Survey).*

- **Old oil- and gasfields.** The oil and/or natural gas that had been trapped in these hydrocarbon fields for millions of years has now largely been extracted, allowing the pore spaces in the reservoir rocks to fill with groundwater. If gas is pumped into these, it displaces the groundwater and can be stored safely underground. This is the method used for natural gas storage.
- **Underground traps, which never became filled with gas or oil.** These have the requirements of an oil- or gasfield: a reservoir (permeable) rock capped by a cap (impermeable) rock in a shape that can trap gas underground. There never was a nearby oil or gas source, which is why these did not become oil- or gasfields but are simply aquifers with caps. Traps of this type are being explored for CAES potential in California, Washington State and Oregon, USA.

Underground gas storage in your area?
If you have rock salt deposits or underground traps in your area, there is potential for storing compressed air, hydrogen or natural gas in them. You can find out by studying geological maps or investigating possible sites. If gas could be stored underground in your area, the next question is: Should it be stored there? This is a key topic for discussion in your class, and then with industry, government and your local community.

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The back up

Title: Storing gas underground: What can we store? How can we do it? How will it help?

Subtitle: A discussion on gas power sources that can be stored and the storage conditions needed.

Topic: A focus on the three situations in which compressed air, hydrogen and natural gas can be stored underground.

Age range of pupils: 14 years upwards

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:
- explain why compressed air, hydrogen and natural gas are stored underground to generate power;
- explain the three situations in which gases can be stored underground: rock salt, ex-oil- or gasfields, capped aquifers;
- discuss which, if any of these might be viable in the local area.

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 is being, and might be, stored underground to even out power supplies.

The compressed air option is currently only being run commercially in two plants, one in Germany and the other in the USA. However, both hydrogen and natural gas are currently being stored underground. Current hydrogen storage is of ‘brown hydrogen’ and so is not part of the drive towards ‘net-zero’ and natural gas storage never will be.

Following up the activity:
In a class discussion to consolidate learning consider why the only three gases being considered for underground storage are air, hydrogen and methane. *(Air is used because it is abundant, both hydrogen and methane are fuels that can be burnt).*

Further discussion could focus on whether a capped aquifer can be called a trap if it has never trapped hydrocarbons.

Underlying principles:
- Compressed air can be stored in salt caverns underground and used (with added methane) to drive turbines when extra power is needed.
- Compressed air methods not using methane are being explored.
- Hydrogen can be stored in salt caverns underground; this is ‘brown’, ‘blue’ or ‘green’ hydrogen, as described above.
- Hydrogen can be burnt to drive electricity turbines directly, with water as the only waste product.
- Natural gas can be stored underground in salt caverns or depleted oil- or gasfields; it is burnt to drive electricity turbines.
- Both ‘brown hydrogen’ and natural gas release greenhouse gases into the atmosphere on burning; the other energy sources do not.
- Gases can be stored in underground salt caverns, depleted oil- or gasfields or capped aquifers.
- The capped aquifer option has not yet been used commercially.

Thinking skill development:
Developing ideas of the different gas power generation methods and the different storage options is a construction activity. Discussion of which, if any, of these might be appropriate in a locality involves cognitive conflict, metacognition and bridging skills.

Resource list:
- if discussed in the classroom – geological maps of the region; if discussed in the field, normal field equipment

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

Technical development of these potential options seems to be fast-moving, so keep up to date with recent developments using the internet.

Source: Chris King of the Earthlearningidea Team.