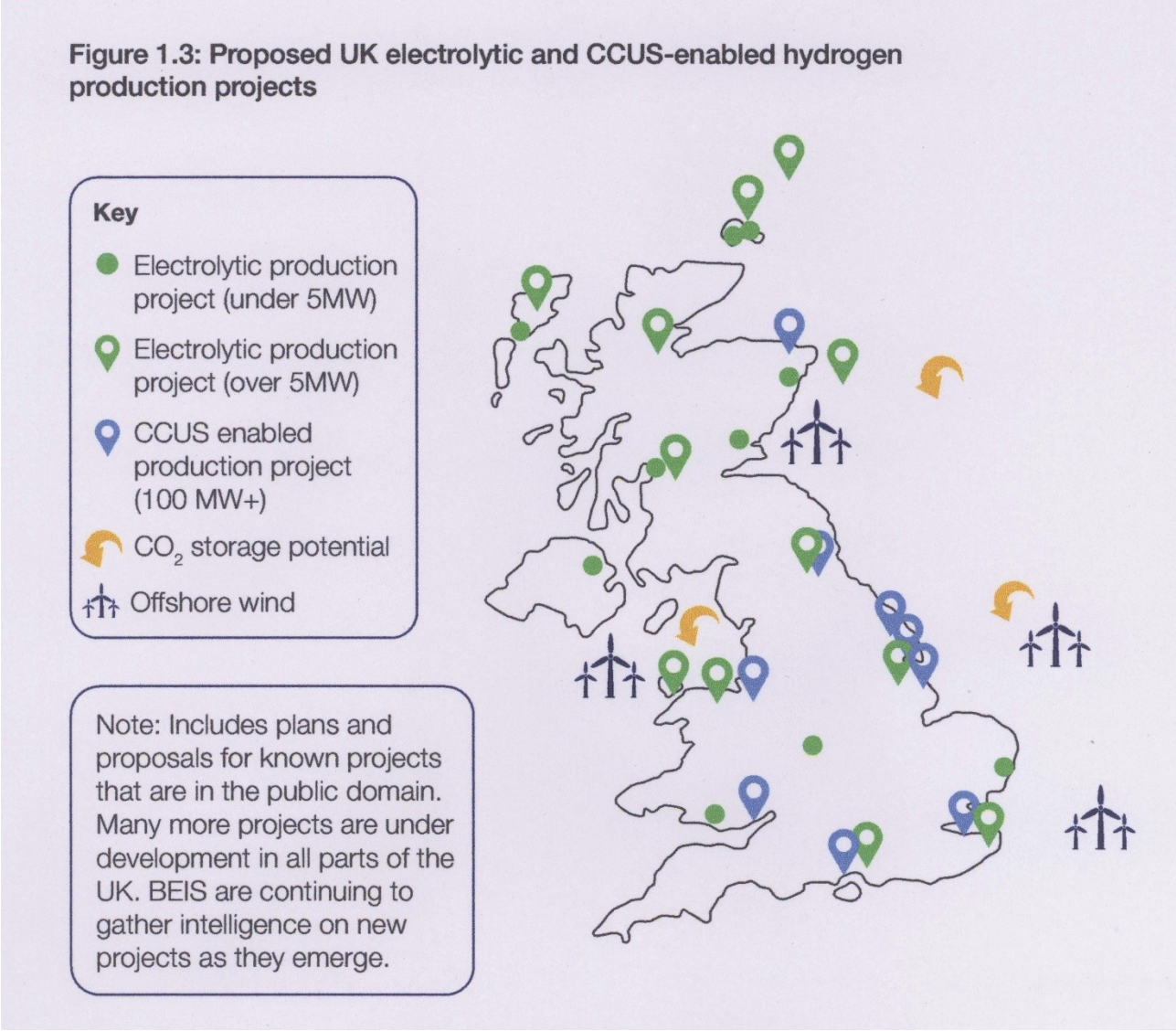
Hydrogen of many colours
The situation regarding hydrogen in the UK, October 2021

Earthlearningidea has recently published two activities on hydrogen as a fuel source, and on carbon capture usage and storage (CCUS, which is involved in one of the processes). Hydrogen has great potential for storing energy for use in vehicles, and in heating or cooking, among other functions. See: https://www.earthlearningidea.com/PDF/367_Net_zero_Blue_hydrogen.pdf https://www.earthlearningidea.com/PDF/374_Net_zero_Green_hydrogen.pdf and https://www.earthlearningidea.com/PDF/365_Net_zero_Carbon_capture.pdf

The UK Government published its very comprehensive Hydrogen Strategy in August 2021: https://www.gov.uk/government/publications/uk-hydrogen-strategy



Map from the Government's hydrogen report, showing the current location of UK hydrogen projects, August 2021

Hydrogen is a colourless gas, but in addition to grey, blue and green hydrogen, we now have pink, yellow and gold hydrogen to consider! So what do all these colours mean? All of them are convenient labels, with the implication that green hydrogen seems to be the least damaging to the environment in terms of its carbon footprint.

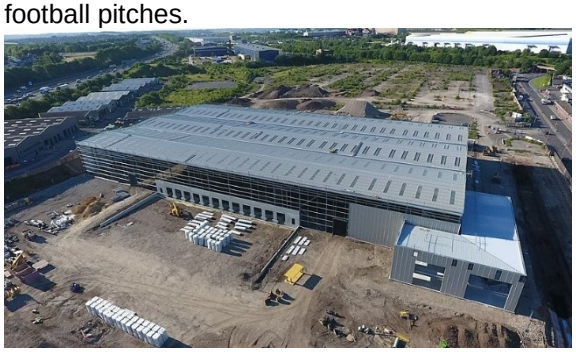
Grey hydrogen is manufactured from natural gas (mostly methane, CH_4) by a process known as steam reforming. Clearly, if the hydrogen is removed, this leaves the carbon, which is later released to the atmosphere as CO_2, a greenhouse gas, which is an unfavourable output. About 98% of the world's production of hydrogen is made in this way at present.

Blue hydrogen is also made by steam reforming natural gas, but the CO_2 is captured and stored underground, mostly in depleted oil or gas wells. Since such structures have safely held onto oil or gas for millions of years, they are also reliable places to store the unwanted carbon compounds.

The UK Government has recently (19th Oct 2021) approved further research into developing CCUS

(Carbon Capture, Usage and Storage) at three sites in England (Merseyside, Teesside and the Humber) with other projects in Scotland being held in reserve. https://questions-statements.parliament.uk/written-statements/detail/2021-10-19/hcws325

Green hydrogen is manufactured by the electrolysis of water, H_2O, so the only by-product is oxygen, with no carbon compounds being involved. However, electrolysis requires huge amounts of renewable electrical energy, notably from hydroelectricity or wind turbines. Such sources depend on the weather and so are frequently intermittent. The world's largest factory making the equipment for electrolysis is in Sheffield and occupies a site equivalent to 2 football pitches.



The ITM Power factory in Sheffield

A 2MW electrolyser module under construction

Yellow is the colour now being applied to the electrolysis of water using solar energy. Again, this only works when there is sufficient sunlight. It is however an efficient way of using solar power, which generates the Direct Current (DC) required for the process and avoids the losses in efficiency when the solar panels' output is converted to Alternating Current (AC) for most household and commercial purposes. Experiments have been carried out to make hydrogen from water by concentrating the sun's rays with mirrors, but no commercial development has happened yet.

Pink hydrogen is produced by electrolysis of water using electricity from nuclear energy. Nuclear generators provide a steady base load but are not well suited to reacting to sudden demand for power, so they could be used to make hydrogen when the weather suits the other sources of power such as wind, solar and hydro.

Gold is the colour applied to naturally occurring hydrogen, although the quantities are mostly too small for commercial applications.

Pupils could be asked to consider the descriptions given above and invited to discuss the relative merits of each method of manufacturing hydrogen. They could also carry out web-based research to find out how their local area might already be involved in the hydrogen story, or could be in the future.

Hydrogen is already being stored in former salt mines, and the UK has many former oil or gas fields, now disused, where hydrogen might be stored, and this could form another aspect for pupils' research.
If hydrogen eventually replaces coking coal as the reducing medium in making iron metal from iron ore, there would be a major impact on the location of a country's iron and steel industry – again a point for discussion.

The back up

Title: Hydrogen of many colours

Sub-title: The situation regarding hydrogen in the UK, October 2021

Topic: An update into the rapidly evolving development of hydrogen manufacture in the UK based on recent Government Reports.

Age range of pupils: 14+ years

Time needed to complete activity: depends on how much the update is linked to the earlier Earthlearningidea activities on hydrogen and carbon capture and storage.

For other aspects (Context, Pupil learning outcomes, Underlying principles) please see the original Earthlearningidea activities listed above.

Resource list: Access to the internet for detailed information about the developments outlined above.

Source: Written by Peter Kennett of the Earthlearningidea team, based on recent Government Reports and the abstract of a forthcoming lecture by Nick Riley, MBE, President of the Yorkshire Geological Society.

The table at the end lists the Earthlearningidea 'net zero emissions target' series

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