THE HYDROGEN ECONOMY

The increasingly severe and apparent impact of climate change is driving a movement to reduce our reliance on fossil fuels as a source of energy. One of the alternative fuel types being proposed is hydrogen (H_2) which is a combustible fuel, similar to fossil fuels like petrol, diesel and coal. Unlike these fossil fuels, hydrogen does not release carbon dioxide (CO_2 - a greenhouse gas) when combusted, with the only by-product being water. This makes it a much cleaner fuel.

However, CO_2 can be released in the production of hydrogen. Currently, there are three methods to produce hydrogen with different amounts of associated CO_2 emissions:

Grey hydrogen is currently the most common method, where hydrogen is produced from methane (CH_4), commonly known as natural gas. Combining natural gas and water vapour (steam) produces hydrogen and CO_2. The CO_2 produced in this process is released into the atmosphere, making this the least environmentally friendly method.

Blue hydrogen is produced in the same manner as grey hydrogen, but the CO_2 is captured during the production process and stored underground using Carbon Capture and Storage (CCS).

Green hydrogen is produced using electricity to electrolyse water. This electrolysis splits water (H_2O) into hydrogen and oxygen. The electricity which powers this production method can come from renewable energy sources like wind and wave power, making this the cleanest form of hydrogen production.

Ireland published its Hydrogen Strategy in 2023[1] with an aim to decarbonise the economy, enhance energy security and create new industrial opportunities. This strategy prioritises the scale up and production of renewable green hydrogen from excess grid electricity created from by both on- and offshore renewables like wind, solar, and wave energy. Hydrogen is expected to be used for hard-to-decarbonise areas including generating power, very large vehicles (such as trucks and buses) and heating in industry (like cement and pharmaceuticals). However, as hydrogen has a low energy density compared to natural gas, much higher volumes of the gas are required to provide the same energy, requiring more storage. Long duration storage is an essential part for the future use of hydrogen in Ireland, with geological storage representing the largest volume of storage.

Subsurface Hydrogen Storage

One of the biggest hurdles to the widespread adoption of renewable energy, particularly wind and solar, is smoothing out electricity production. For example, what is done when it's so windy that more energy is produced than required? Or, where does power come from when solar panels are not producing? The wind doesn't blow at a nice steady pace as required, nor can the sun shine at night. At the moment, renewable energy suppliers are forced to reduce their electricity production at times when supply exceeds demand, a process known as curtailment, and fossil fuel power generators are used to make up the gap when demand is higher than the supply of renewables.

Geological storage can be used as a temporary way of storing energy for later use. Batteries are typically capable of storing energy for hours, whereas subsurface geological storage has the potential to store energy for days or weeks in the form of hydrogen. This stored excess energy can be released when it's needed. Underground Hydrogen Storage (UHS) has already been established as a viable technology, in the UK for example. Ireland has favourable geology for geological storage and has the potential to be important for the future development of the hydrogen economy as a means of providing storable, transportable energy.

[1] https://www.gov.ie/en/publication/624ab-national-hydrogen-strategy/

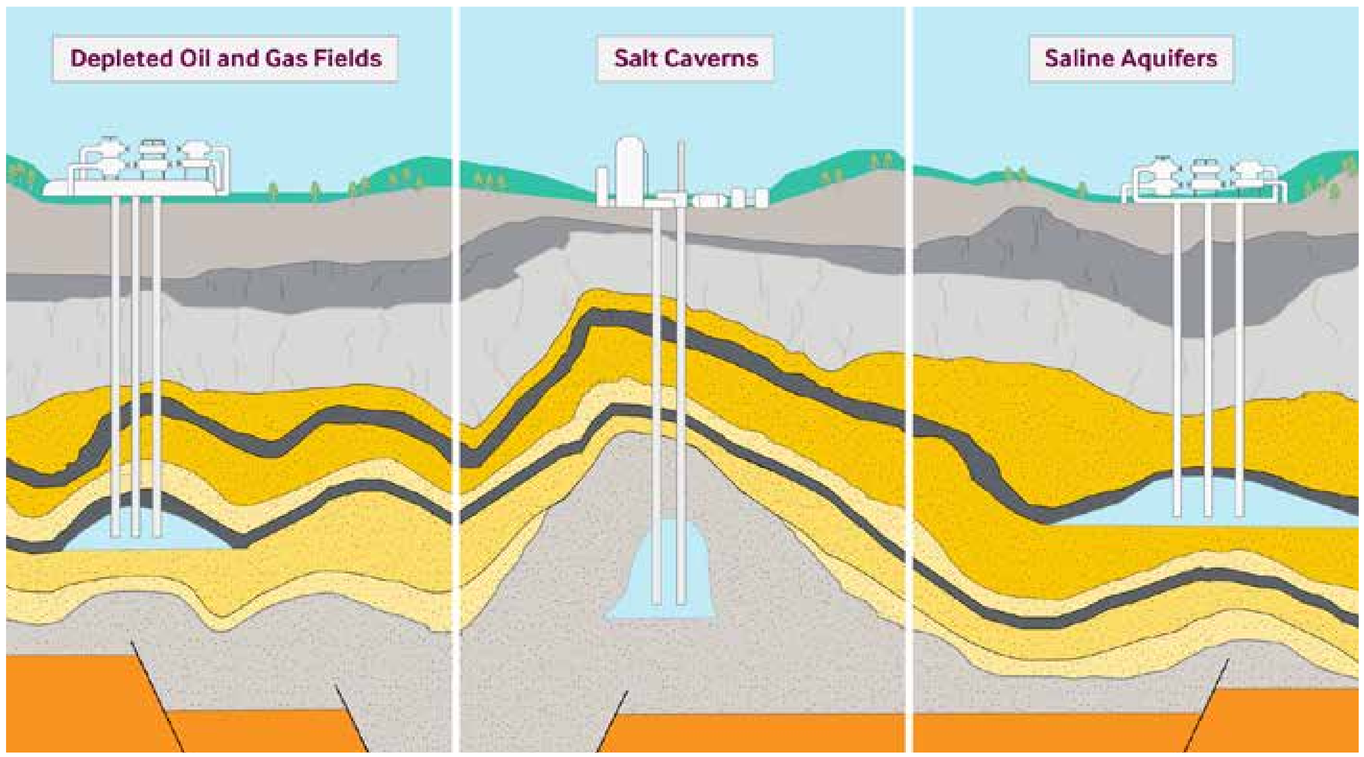
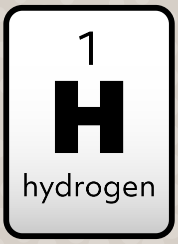


Figure 1 Geoscience and underground hydrogen storage from RPS

Hydrogen Storage & Geoscientists

Hydrogen can be stored in rocks where there are large man-made chambers (e.g. salt caverns) or in porous rock formations (such as sandstone aquifers or re-used oil and gas reservoirs) (Fig 1). Currently, solution-mined caverns, which have been used for many decades for natural gas storage, are the only commercially viable option. Geoscientists are crucial to the location, development and operation of salt caverns and other subsurface storage sites.



- Geoscientists will be needed to locate and describe the properties and characteristics of the geological formations of potential subsurface storage sites. They will also have to model how the rocks and fluids will behave when the pores or caverns are filled with hydrogen.
- Geotechnical engineers will be needed to design and develop both the subsurface and surface facilities of the storage site and understand how the changes in pressure during filling and emptying of these storage sites will impact the stability of the site during its lifetime.
- Production engineers will operate these sites during their lifetime, ensuring safe filling and production of stored hydrogen to be supplied to local and national markets.

Understanding how fluids behave in the subsurface is something geoscientists have extensive experience in from the study of resources such as groundwater and oil and gas, which exist naturally in underground in rocks. There are many skills, datasets, and lessons learned from forty years of resource exploration of Ireland's offshore underground reservoirs that will be essential for the development of both hydrogen and CO_2 storage.