A future hydrogen economy?

Applications under active discussion:

- Power cars, buses, trains, HGVs, ships, planes
- Smelt steel
- Heat buildings

Nothing is easy with hydrogen – cost, storage, transport ….
But there is a lot happening

UK Energy Strategy 2022: “We will double our UK ambition for hydrogen production to up to 10GW by 2030”

IPCEI Hy2Tech: 41 EU hydrogen projects declared to be Important Projects of Common Interest with up to €5.4 billion in public funding

Production methods

Produce H and CO2 from methane and capture the CO2 – blue hydrogen

Split water into H2 and O using electricity from wind power at night or from solar panels – green hydrogen.

For 1MW this needs several megalitres of water a year.

There is a lot of research on different ways of achieving this electrolysis

There are tentative plans for an archipelago of wind farms in the North Sea to produce hydrogen

It is also possible to design bioreactors for large-scale hydrogen production using microorganisms – green hydrogen

Transport and storage

Transport by pipeline or cryogenic road, rail or barge tanker. Cost and leakage are issues.

Can transport in ammonia or mix with oil to transport as a liquid and recycle the oil.

Gas: need high compression to get reasonable energy per unit volume

Liquid: needs to be below -252C

There is also a lot of research in bonding hydrogen with solids

By weight, hydrogen contains 3 times as much energy as petrol, but even in liquid form, hydrogen storage needs much larger volume than petroleum

Hydrogen is highly combustible, but it is non-toxic and leaks disperse quickly into the air

Problems with batteries

The battery in a Tesla S weighs half a tonne, leading to wear on the road and tyres, so producing very small particles that get into our lungs and waterways

Present batteries need cobalt, which is scarce and toxic and mined under conditions that often violate human rights

Serious worries about future lithium supplies

When the batteries begin to wear out, will there be disposal problems?

Buses with batteries: range perhaps 300 km, but only about half that if electrically heated, or if cooled in summer

Clean buses and trucks

Aberdeen has 25 hydrogen buses; 144 on order in West Midlands.
China has more than 5000 hydrogen buses.
5000 hydrogen trucks have been ordered for Germany.

Hydrogen can be used in an internal combustion engine, but the burning converts the nitrogen in air to harmful nitrogen oxides.

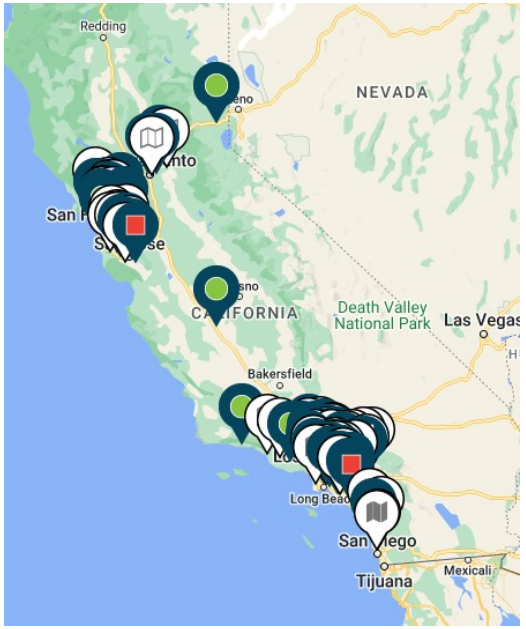
It is much more efficient to convert hydrogen into electricity within a fuel cell. (The hydrogen–oxygen fuel cell was first introduced in in 1932.)

But combustion engines are much cheaper. Can modify diesel engines to run mainly on hydrogen.

California already has 7500 hydrogen vehicles

Its Energy Commission is investing in an initial network of 100 public hydrogen stations

So far the UK has 15, mainly in The south-east



Clean flight

Startup ZeroAvia flew the first fuel-cell flight of a commercial light aircraft from Cranfield in September 2020 for 8 minutes; it reached 100 feet and 100 knots.

It plans 19-seater flights up to 300 nautical miles by 2024

United Airlines has agreement with it to retrofit its planes to fly 500-mile routes by 2028

Airbus has constructed a prototype cryogenic hydrogen tank cooled to below -253C, with a view to installing one in an A380

Rolls-Royce has tested a hydrogen engine, collaborating with EasyJet

Rail

Hydrogen needs considering for track that is not electrified. Unlike batteries, it can give a passenger train a range of a thousand kilometres

Trains are running in Austria, Germany and Italy. In Britain 3 trains are under development.

Shipping

3% of global CO2 emissions, plus sulphur dioxide, nitrogen oxides and particulate matter

Agreement at COP27 to begin conversion to green hydrogen

Projected to represent 15% of total green hydrogen demand by 2050

Cars

Hydrogen-powered cars are already available from several non-European manufacturers

But sales will be few until there is a network of filling stations

And there will not be a network of filling stations until there are many cars …

Volkswagen is producing a hydrogen car that is claimed to travel 2000km on one fill

Steel smelting

- Smelting with coke responsible for 9% of global emissions
- Hydrogen can be used instead to remove the oxygen from the iron ore
- Pilots under way in Sweden, Germany and Austria

Heating of buildings

Plan in 2023 20% blending of hydrogen into the gas distribution grid

Government plan: begin a large village hydrogen heating trial in 2025

National Grid intends creating a 2000 km hydrogen network by 2030, beginning with 100km around Teesside and Humberside

Many new gas boilers can take a hydrogen mixture, but 100% hydrogen gas boilers are not ready yet

Some recent investment decisions

August 2022: Canada and Germany agree to construct 164 onshore wind turbines in Newfoundland to produce green hydrogen

October 2022: Application to store hydrogen in a Cheshire salt mine and distribute it by a 25km dedicated pipeline

December 2022: Airbus and CERN collaborate on superconducting cryogenics

January 2023: £6.6m government grant to develop an autonomous hydrogen HGV

January 2023: Power station near Hull to run on hydrogen

February 2023: China is to mass-produce a hydrogen bike

February 2023: 60 buses ordered in Germany and more than 1300 in Korea

March 2023: EU aims at some 400bn euros investment in a hydrogen bank