

Hydrogen for transport

Buses, trains, HGVs, ships, planes

Nothing is simple, but a lot is happening.

Hydrogen Council: \$570bn was invested globally in 2023

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 or from solar panels – green hydrogen. (Large sums are spent in compensation to wind farms when they produce electricity that is not needed for the Grid.)

There is a lot of research on different ways of achieving this electrolysis. Using wind farms avoids the need for expensive cable connections. Can help to rescue the economies of sunny oil-producing countries.

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

And there are large reservoirs of underground natural hydrogen in a dozen countries, including France

Some recent developments

Canada signed an agreement to ship green hydrogen to Germany starting in 2025 from wind farms in Newfoundland, Labrador and Nova Scotia.

UK and Germany will work together to underpin the international trade in hydrogen

Dogger Bank Wind Farm has awarded contracts to engineering consultants to support the feasibility and optimization of a large-scale green hydrogen development option

UK government December 2023: 11 new green production projects will invest around £400 million up front over the next 3 years, using renewable energy to split water and deliver 125MW of hydrogen for business

A second hydrogen allocation round will aim for up to 875MW of production capacity

Email 19.1.24 from Anthony Browne MP

- I announced £7m new funding for a hydrogen refuelling station in Middlesbrough, as part of the Tees Valley Transport Hydrogen Hub. The new station will refuel 25 hydrogen-powered lorries, which will be taking deliveries across the North East, including taking food to supermarkets.

Teething problems

So far availability of green hydrogen is low

It is expensive: \$1.5 to \$5 per kilogram for blue hydrogen, \$3 to \$7 for green.

Green forecast \$0.5 to \$3 by 2050

And the market is only growing very slowly

January 2024: The UK has 8 public filling stations and 265 vehicles

Transport and storage

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

Can 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 -252°C

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

Risk

https://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/h2_safety_fsheets.pdf

Hydrogen is said to be no more or less dangerous than other flammable fuels

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

Adequate ventilation and leak detection are important

The air around a hydrogen flame is less hot than around a gasoline flame, but is mostly outside the visible spectrum

Hydrogen diffuses into metal, leading to cracks and embrittlement, so storage tanks are non-metallic

Clean buses and trucks

Hydrogen buses have been introduced in Aberdeen, Birmingham, Liverpool, London, Belfast, and Dublin

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 and cleaner to convert hydrogen into electricity within a fuel cell.

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

JCB powers heavy construction vehicles with hydrogen combustion engines



Clean flight

Energy density of hydrogen is 3 times that of gasoline but 4 times the volume

There have been numerous short hydrogen-powered flights.

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 and 5000-mile flights by 2040.

Airbus has constructed a prototype cryogenic hydrogen tank cooled to below -253C, with a view to installing one in an A380, and aims at commercial 2000-mile flights by 2035

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

Emphasis in storing hydrogen in ammonia, with twice the energy density of liquid hydrogen, and cracking it catalytically at temperatures 600C to 1000C

Cars

Hydrogen-powered cars are already available from several non-European manufacturers -- Honda, Toyota, GM, Kia and Hyundai have detailed plans to manufacture fuel-cell vehicles

But Volkswagen has abandoned its plans

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 ...