The place of hydrogen in a net-zero energy economy

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Production

H_2

Most H2 used by in industry is ‘grey’: it’s made by steam methane reforming (SMR) using natural gas. SMR is an endothermic reaction and requires significant input of energy to provide the necessary heat and pressure. Some 6% of global natural gas production is used for SMR.

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$

This is another source of grey H2.

THE ENGINEER NEWS IN-DEPTH OPINION JOBS SE

UK's first waste plastic to hydrogen plant moves step closer to construction

25th August 2020 9:48 am

Plans to build the UK's first waste plastic to hydrogen facility have moved a step closer to fruition with the completion of a Front-End Engineering Design (FEED) phase.

Production

H_2

‘Blue’ H2 is also made by SMR, but the CO2 is captured and does not enter the atmosphere. There are only a few industrial-scale plants, but blue H2 features in UK and US govt plans to get to net zero.

It may prove not to be not so good for the environment.

Energy Science & Engineering

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MODELLING AND ANALYSIS | Open Access

How green is blue hydrogen?

Robert W. Howarth, Mark Z. Jacobson

First published: 12 August 2021 | https://doi.org/10.1002/ese3.956

Funding information:

Funding was provided by the Park Foundation and by Cornell University

“We see no advantage in using blue H2 powered by natural gas compared with simply using the natural gas directly for heat.”

Cracking CH4

This is another source of blue H2.

hydrogen

MDPI

Article

Natural Gas Pyrolysis in a Liquid Metal Bubble Column Reaction System—Part I: Experimental Setup and Methods

Christoph Michael Hofberger [1,*], Benjamin Dietrich [2], Inés Durán Vera [1], Ralf Krumholz [1], Leonid Stoppel [1], Neele Uhlenbruck [1] and Thomas Wetzel [1]

By Jon Cartwright

Production

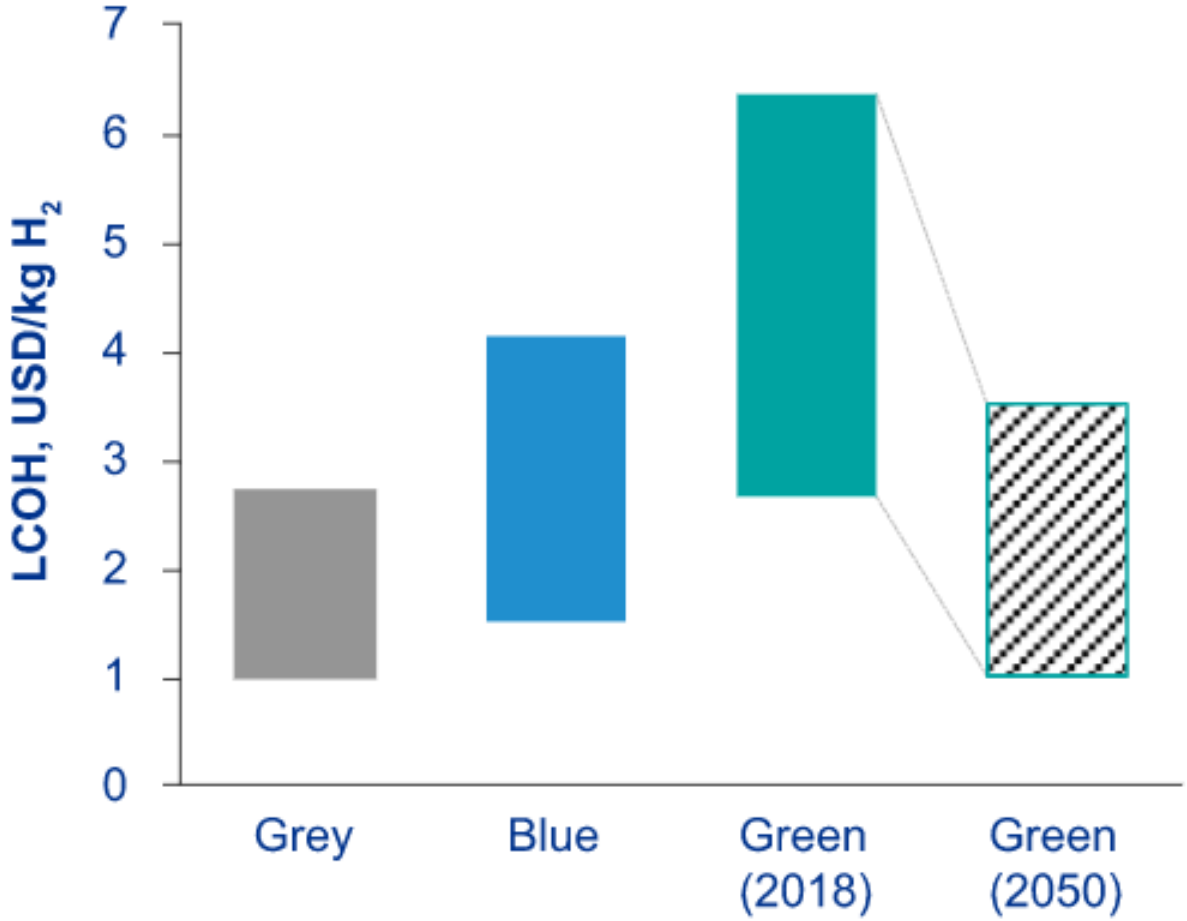
Green H2 is made by electrolysis using renewable electricity in a device called an electrolyser. The UK's largest electrolyser (20 MW) is planned for the 539 MW Whitelee wind farm near Glasgow. It will produce 8 tonnes of H2 per day.

H_2

Efficiency

- An electrolyser is (say) 80% efficient – best case
- Storage and transport let's say 90% (pumping, compression etc)
- Using it in a fuel cell say 60%
- So 80% x 90% x 60% = 43% of the energy produced by the wind turbine is delivered to the engine

Costs



Green H2 predicted to be cost-competitive with blue by 2030.

Source: KPMG

UK Hydrogen Strategy

Presented to Parliament
by the Secretary of State for Business, Energy & Industrial Strategy
by Command of Her Majesty

August 2021

https://www.gov.uk/government/publications/uk-hydrogen-strategy

Strategy

- Our *ambition* is for 5GW of low-carbon H2 production capacity by 2030; *hope to see* 1GW capacity by 2025
- H2 neighbourhood trial by 2023 … large village trial 2025 …. town pilot before end of decade
- Working with HSE to *assess the potential for* 20% H2 blending into the gas network
- *Supporting* the development of … 'H2 ready' appliances
- Actions to bring forward H2 demand across industry, power, heat and transport
- 'Twin track ' approach using both green and blue H2
- Need for enabling infrastructure (networks, storage) and integration with CCUS, gas, and electricity networks
- Coordinate supply and demand – chicken and egg

Source: UK Hydrogen Strategy

Heating and cooking

Zero-carbon hydrogen injected into gas grid for first time in groundbreaking UK trial

Blend of hydrogen and natural gas is being used to heat homes and faculty buildings at Keele University

Jessica Murray

Fri 24 Jan 2020 10.07 GMT

Energy efficiency

Low income UK homes 'should be given free heat pumps' to meet climate targets - but hydrogen ruled out

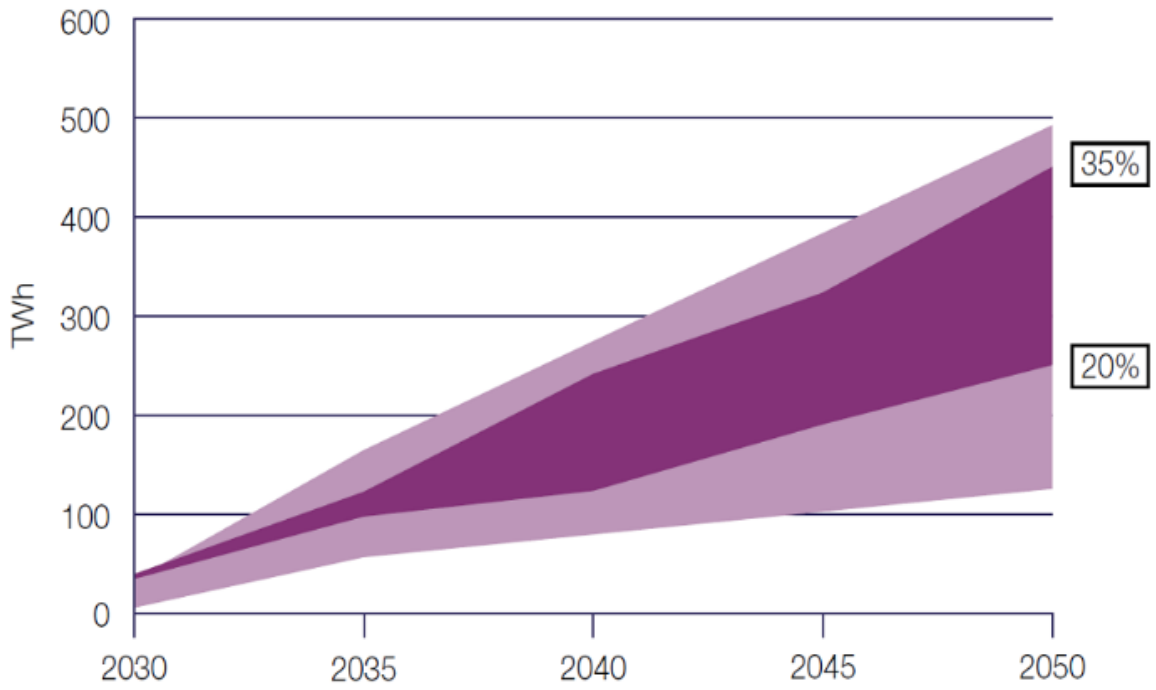
Jillian Ambrose

Wed 18 Oct 2023 00.01 BST

We are saying, unambiguously, that we do not see any role for hydrogen in the future of home heating.

Demand (1)

Figure 1.2: Hydrogen demand and proportion of final energy consumption in 2050



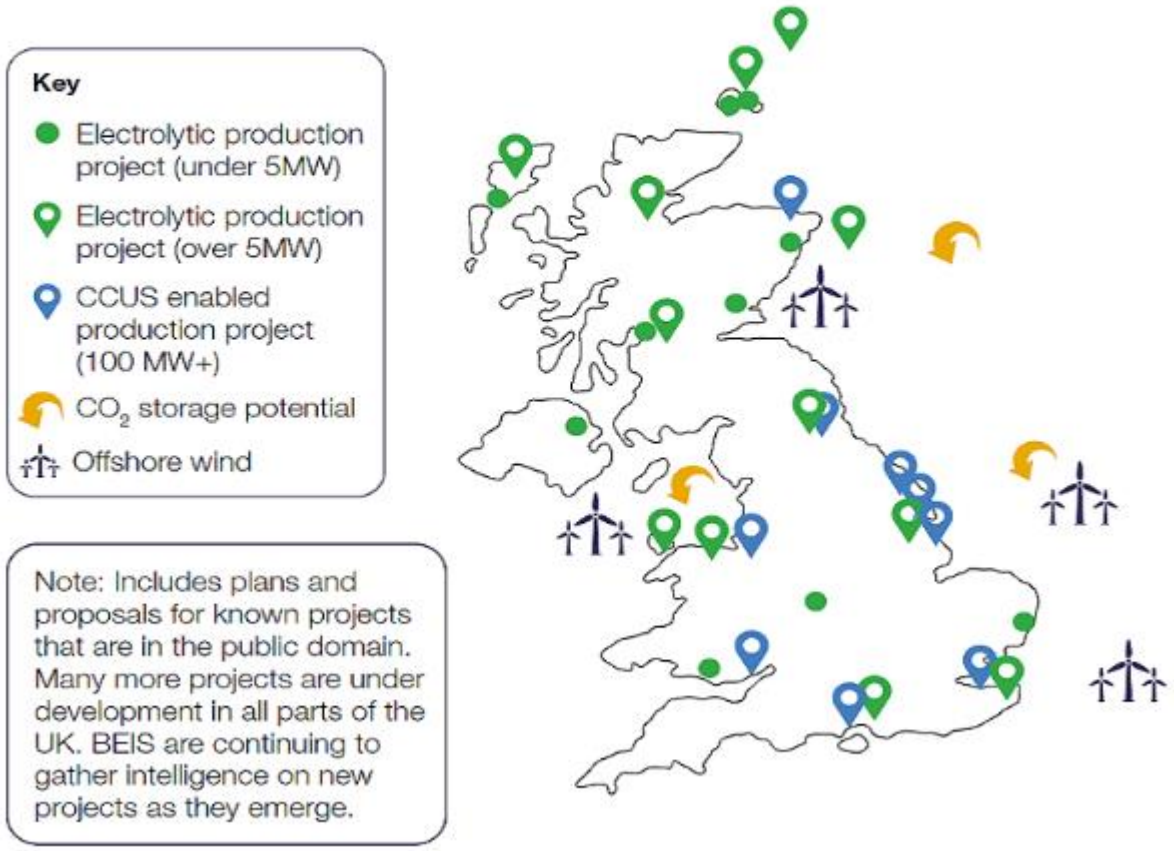
% = hydrogen as proportion of total energy consumption in 2050

Source: Central range – illustrative net zero consistent scenarios in CB6 Impact Assessment. Full range – based on whole range from UK Hydrogen Strategy Analytical Annex. Final energy consumption from ECUK (2019).

Source: UK Hydrogen Strategy

Production

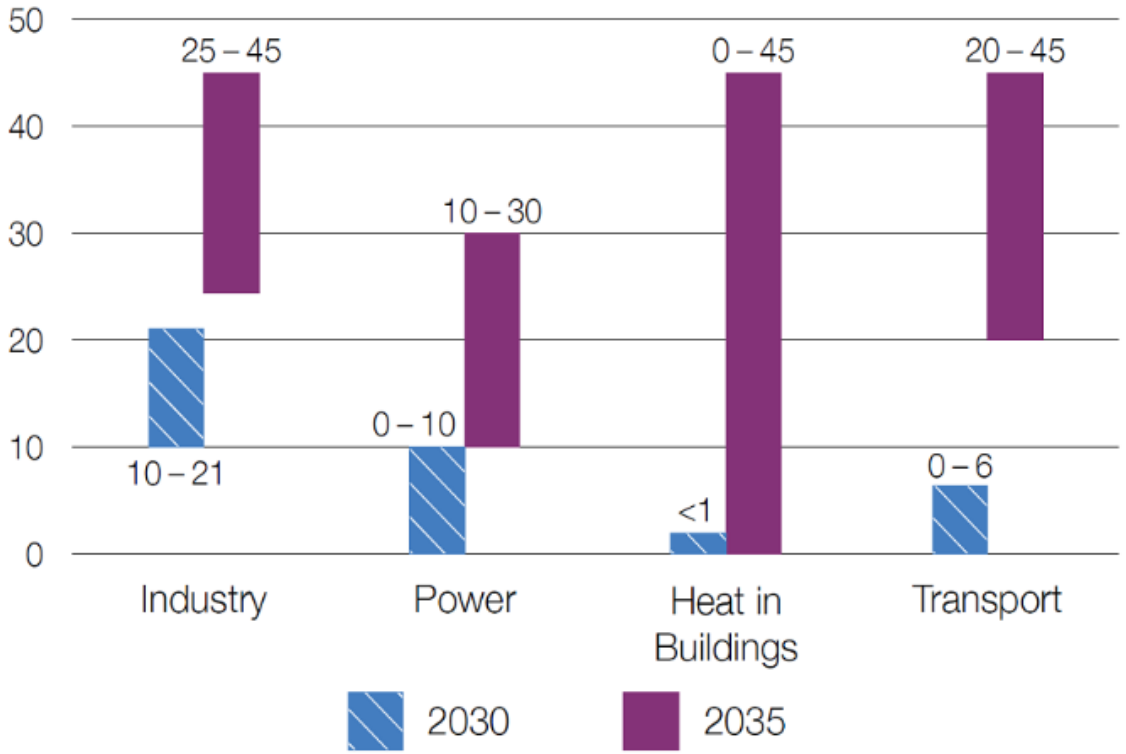
Figure 1.3: Proposed UK electrolytic and CCUS-enabled hydrogen production projects



Source: UK Hydrogen Strategy

Demand (2)

Figure 2.4: Illustrative hydrogen demand in 2030 and 2035



Source: BEIS analysis (see analytical annex). Note: figures do not include blending into the gas grid.

Source: UK Hydrogen Strategy

Schedule

- The first movers in the **early 2020s** will be small (up to 20MW) electrolytic H2 projects, with production and end use closely linked
- By **mid-2020s** we could start seeing larger (100MW) e-H2 projects and the first CCUS-enabled H2 production facilities in industrial clusters
- By **end of decade** multiple large CCUS-enabled (500MW+) facilities integrated with the wider energy system
- Analysis suggests that in 2050, H2 will be supplied through a mix of SMR with CCUS, electrolysis from renewable electricity, and biomass gasification (BECCS) – consistent with CCC's CB6 advice

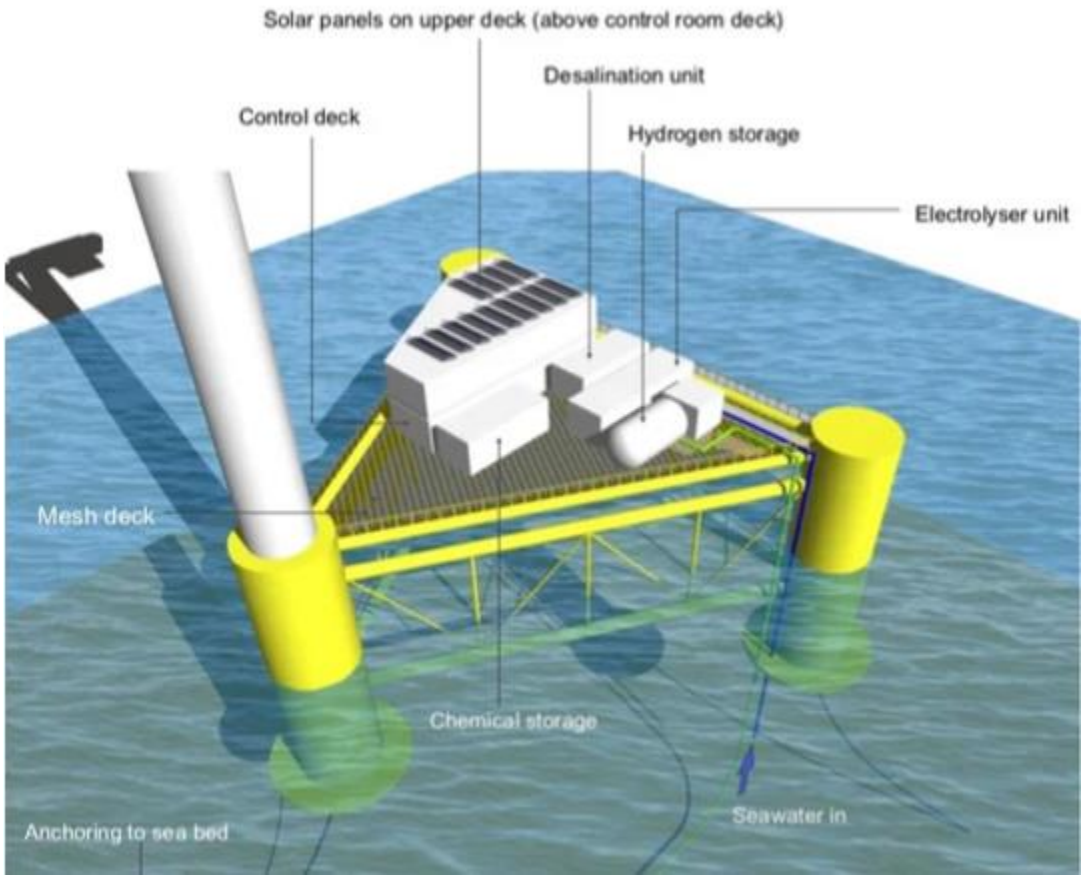
Source: UK Hydrogen Strategy

Storage

- H2 storage a key part of future network infrastructure:
  - Specialist tanks and storage vessels
  - Salt caverns
  - Depleted gas or oil fields
  - H2 carriers – ammonia, liquid organic hydrogen carriers (LOHCs) eg toluene, cryogenic liquid, metal hydrides
- Between 12 TWh and 51TWh of storage will be needed in 2050

Source: UK Hydrogen Strategy

H2 at the turbine



Steel

Climate change

‘Green steel’: Swedish company ships first batch made without using coal

Hybrit sends steel made with hydrogen production process to Volvo, which plans to use it in prototype vehicles and components

Reuters in Stockholm

Thu 19 Aug 2021 02.57 BST

▲ A piece of iron produced as part of the green steelmaking process. Photograph: Hybrit

Aviation

Liquid H2 has 25% of the energy density of conventional jet fuel.

Newsletter

u3a Climate Change & Environment Network

Bulletin 007 - Halloween Issue

Second Nature is a newsletter sent by the u3a Subject Adviser on Climate Change and Environment to subscribers in the u3a Climate Network. The name reminds us that it should be second nature to think about environmental impact when we take decisions, and as instinctively as we think about the financial impact.


Please leave the planet as you would expect to find it !

References

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H2 from waste: https://www.theengineer.co.uk/waste-plastic-hydrogen-plant-uk/

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Green H2: 8 tonnes of H2 is about half a Hindenburg. I've shown the front half because the back has a swastika on it.

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Green Steel: https://www.theguardian.com/science/2021/aug/19/green-steel-swedish-company-ships-first-batch-made-without-using-coal

Aviation: https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html. According to Airbus, H2-powered planes could be in the air by 2035.

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