Net zero costsheet 3

COST OF GREEN HYDROGEN

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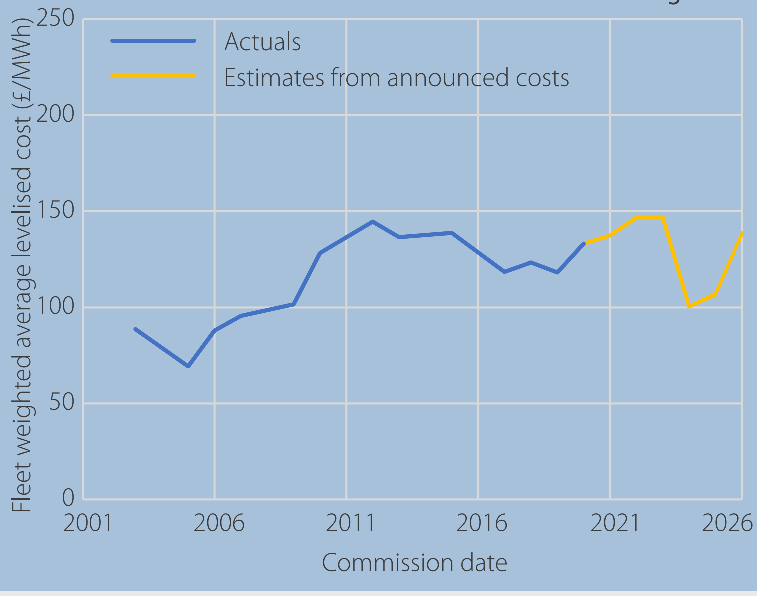
Introduction

Hydrogen is widely claimed to solve many of the problems associated with decarbonisation. It is said that it can be used as a bulk energy store, and also to replace natural gas in homes for heating and cooking. Some even propose that it could fuel cars and freight vehicles.

At present, 'grey' hydrogen is made from natural gas, in a process that gives off carbon dioxide. If the carbon dioxide is captured, the hydrogen is referred to as 'blue'. In a decarbonised economy, however, 'green' hydrogen would likely be made via electrolysis of water, using zero-carbon electricity delivered from offshore windfarms.

Figure 1



Costs and prices

Windfarms are frequently paid to switch off during times of high winds, since transmission capacity can be inadequate to deliver power to where it is needed. It is said that a hydrogen economy would be able to use this electricity for free (or nearly nothing). However, this argument conflates prices and costs. An otherwise constrained windfarm might have to sell its electricity to a hydrogen plant for a very low price, but that would simply mean it had to charge more on the power it sold to the grid, so as to cover its costs, which would be approximately the same whatever it did.

Conflation of costs and prices is also seen when looking at the cost of electricity from offshore windfarms, which has been between £120–150/MWh for well over a decade (Figure 1).[1] Announcements of costs for future windfarms shows the levelised cost is unlikely to fall much in future. Although some windfarms have bid to supply power to the grid at much lower *prices*, the costs still have to be covered. Who pays this difference is unclear, but there is now no doubt that such a bill will have to be paid somehow.

This factsheet considers the *costs* involved in using hydrogen for domestic heat and for electricity generation.

Production of green hydrogen

We can divide the cost of green hydrogen into two parts: the cost of the electricity used to produce it and the other costs. As noted above, the input electricity costs at least £120/MWh. It takes 0.05 MWh of electricity to produce 1 kg of hydrogen,[2] so the electricity cost of 1 kg of green hydrogen is at least £6.

The other costs – the capital cost of the electrolyser and its non-fuel operational costs – are smaller, at around £1.26/kg, and the details are therefore not covered here. In addition, in reality seawater would be the most likely feedstock, and would require desalination. These costs are not considered here either.

Thus the total cost of a kilogram of green hydrogen is at least £7.26.

A kilogram of hydrogen contains a maximum of 39 kWh of heat, so it is simple to calculate a minimum cost of 19p/kWh.

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Green hydrogen for domestic heat

Hydrogen is considerably more expensive to store and transport than natural gas. A new distribution network would probably be needed too. However, for simplicity's sake these costs will be ignored in this analysis.

We can simply observe that natural gas is typically priced at around 4p/kWh,[3] so we should expect the cost of domestic heating via hydrogen to be roughly five times more than it is at present. That would take the typical heating bill of around £500 today to nearly £2500.

Green hydrogen for electricity generation

Burning hydrogen (or natural gas) in a condensing boiler extracts virtually all the heat from it. However, when these gases are burnt in a gas turbine in order to generate electricity, much of the energy is wasted. Typical plant efficiencies for closed-cycle gas turbines are of the order of 50%.

It is therefore relatively easy to calculate that the fuel element of electricity generated from green hydrogen will be around 38p/kWh. This compares to a fuel cost of around 2p/kWh when a natural gas is used.

Calculating the overall cost of the electricity produced by these hydrogen-fuelled gas turbines is more complex, and would depend on how much these power stations were used, and in turn on weather patterns and patterns of demand. It therefore involves a complex modelling exercise, involving examination of patterns of wind power generation and electricity demand as adjusted for future changes due to EV and heat pump use (here we assume that hydrogen will not be used for domestic heat because of the costs outlined in the previous section).

There are many possible solutions to the model, with the key inputs being the size of the hydrogen store and the size of the offshore wind fleet. It is necessary to adjust these input parameters to eliminate power cuts at minimum cost.

In this scenario, the hydrogen-powered gas turbines would deliver electricity at over £600/MWh, a function of the very high hydrogen fuel costs noted above and the fact that the plant would operate at very low load factors – a large fleet would be required for the rare times when demand was high but there was no wind.

However, electricity from hydrogen would only supply the grid when the wind was not blowing. The majority of power supplied to homes and businesses would come straight from the windfarm at £120/MWh (as compared to the £30/MWh that might be delivered by a gas-fired power station running flat out).

The future system price – essentially a weighted average of the two prices noted above – would be around £200/MWh.

In terms more relevant to the consumer, this is 20p/kWh. Conservatively allowing 12p for transmission, supplier and other costs, this would give a total retail price of 32p/kWh, approximately double what consumers pay today.

Green hydrogen for personal transport

It is frequently suggested that cars powered by hydrogen are an alternative to battery electric vehicles as a low-carbon replacement for petrol and diesel vehicles. Transferring the costs for green hydrogen as calculated above suggests this is not the case. Hydrogen vehicles would use a fuel cell to turn the hydrogen back into usable energy.

A fuel cell is 40–60% efficient,[4] so of the 39 kWh of energy in a kilogram of hydrogen (costing at least £7.26), only a maximum of 23 kWh of usable energy is delivered. As a result, motive energy via green hydrogen will cost 31p/kWh.

Petrol engines are inefficient, and deliver only 20–40% of the energy in the fuel. This means you may only get 4 kWh from a litre of fuel. At 67p/litre (ignoring taxes), energy from petrol might cost 17p/kWh, which is just over half the likely cost of green hydrogen.

Notes

1. Updated from Montford A. Offshore Wind: Cost Predictions and Cost Outcomes. Briefing 52, Global Warming Policy Foundation, 2021.

2. https://www.euractiv.com/section/energy/opinion/what-is-the-real-cost-of-green-hydrogen/

3. https://www.viessmann.co.uk/heating-advice/how-much-gas-does-a-boiler-use-per-hour

4. https://www.californiahydrogen.org/wp-content/uploads/files/doe_fuel-cell_factsheet.pdf

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