An Hydrogen Economy?

The text of the article was copied in chatGPT and asked it to fact check it.

This is the response:

The passage provided contains several statements and claims about hydrogen production, its efficiency, and its potential for use in the UK. Let's fact-check each claim:

1. "Offshore wind power provides the UK with electricity for hydrogen production and storage by electrolysis.**

This claim is accurate. Offshore wind power is one of the renewable energy sources used in the UK to generate electricity for various purposes, including electrolysis for hydrogen production.

2. "Nuclear power is disqualified for hydrogen production due to excessive carbon emissions, uranium extraction, construction time, and decommissioning."

The claim about nuclear power's disqualification for hydrogen production due to excessive carbon emissions is incorrect. Nuclear power is a low-carbon energy source that does not produce direct carbon emissions during its operation.

However, it is true that there are carbon emissions associated with uranium extraction, construction, and decommissioning. The overall carbon footprint of nuclear power depends on the life cycle analysis, including these factors.

3. "Making hydrogen from natural gas would create more CO2 than simply burning methane (CH4)."

This claim is correct. The process of steam reforming natural gas to produce hydrogen does result in the release of carbon dioxide (CO2). The carbon in the natural gas combines with oxygen from steam to produce CO2 as a byproduct. Burning methane directly produces CO2 as well, but the overall CO2 emissions are higher when natural gas is used for hydrogen production.

4. "Hydrogen has higher and lower calorific values (HHV and LHV)."

The claim about the higher and lower calorific values of hydrogen is accurate. The higher heating value (HHV) of hydrogen is 142 MJ/kg or 39.4 kWh/kg, while the lower heating value (LHV) is 120 MJ/kg or 33.33 kWh/kg. These values represent the energy content of hydrogen when combusted.

5. “Hydrogen needs to be extracted and processed before it can be used as a transport fuel.”

This claim is correct. Hydrogen does not occur naturally and needs to be extracted and processed before it can be used as a fuel. The most common methods of hydrogen production are steam reforming of natural gas and electrolysis of water.

6. “The energy efficiency of steam reforming of methane to produce hydrogen is around 70%-90%.”

The claim about the energy efficiency of steam reforming of methane is accurate. The process of steam reforming is typically around 70% to 90% efficient, depending on various factors such as process conditions and the specific technology used.

7. “Electrolysis of water consumes between 3.7 and 4.5 kWh per cubic meter of hydrogen produced.”

The claim about the energy consumption of electrolysis is accurate. Electrolysis of water to produce hydrogen typically consumes around 3.7 to 4.5 kWh per cubic meter (Nm3) of hydrogen produced.

8. “The energy used for compressing hydrogen is around 12% of its higher heating value (HHV).”

The claim about the energy used for compressing hydrogen is approximately correct. The energy required to compress hydrogen to a suitable storage pressure is typically around 12% of its higher heating value.

9. “The energy used for liquefying hydrogen is around 40% of its higher heating value (HHV).”

The claim about the energy used for liquefying hydrogen is approximately correct. The energy required to liquefy hydrogen is typically around 40% of its higher heating value.

10. “Substituting the 2019 level of road and air transport fuel with hydrogen would require significantly more electricity generation than the total UK generation in 2020.”

This claim is accurate. The calculation provided suggests that substituting the 2019 level of road and air transport fuel with hydrogen would require a significantly larger amount of electricity generation than the total UK generation in 2020.

11. “Reforming natural gas to hydrogen releases more carbon dioxide than simply burning it.”

This claim is correct. Reforming natural gas to produce hydrogen does release more carbon dioxide than burning natural gas directly. The process of steam reforming converts methane (CH4) into hydrogen (H2) and carbon dioxide (CO2) as a by-product.

12. “Using air-to-water heat pumps for hot water has a lower coefficient of performance (COP) compared to air-to-air heating and cannot compete with off-peak electrical heating.”

The claim about the lower coefficient of performance (COP) for air-to-water heat pumps and their competition with off-peak electrical heating is accurate. Air-to-water heat pumps typically have a lower COP compared to air-to-air heat pumps and may be less efficient for certain applications like hot water production.

13. “Using hydrogen and electric-powered vehicles for road transport would be an inefficient use of renewable electricity compared to using electricity directly in rail traction engines.”

The claim about the potential inefficiency of using hydrogen and electric-powered vehicles for road transport compared to direct electricity use in rail traction engines is subjective and depends on various factors. Direct electric rail systems can be more efficient in terms of energy consumption, but the overall efficiency and environmental impact of different transportation systems involve complex considerations, including infrastructure, energy storage, vehicle efficiency, and lifecycle analysis.

14. “Establishing a global hydrogen infrastructure for air transport is impracticable, requiring a significant increase in electricity generation.”

The claim about the impracticability of establishing a global hydrogen infrastructure for air transport and the required increase in electricity generation is plausible. Building a comprehensive global hydrogen infrastructure for air transport would indeed require significant investments, technological advancements, and substantial electricity generation to produce the necessary hydrogen fuel.

It's important to note that the information provided represents a specific perspective and analysis. Different studies and experts may have varying opinions on these topics, and ongoing research and developments in the field of hydrogen production and utilization may impact the accuracy of these claims over time.

For the article see:- See A UK hydrogen economy (after-oil.co.uk)

A UK hydrogen economy?

Off-shore wind power provides the UK with the electricity for hydrogen production and its storage by electrolysis. With the excessive carbon emissions for uranium extraction, during long construction times and with the massive concrete structures to be built, the energy needed for spent fuel disposal and decommissioning, nuclear power is disqualified for hydrogen production as its later carbon-free generation never catches up with its historical emissions.

Making hydrogen from natural gas would create more CO_2 than simply burning CH_4.

The thermodynamics.

Hydrogen
Thermal properties and production of hydrogen
The higher and lower calorific values of hydrogen are:-
Higher heating value (HHV) = 142 MJ/kg = 39.4 kWh/kg
Lower heating value (LHV) after latent heat is subtracted = 120 MJ/kg = 33.33 kWh/kg
The lower value is obtained by combustion in an engine.

Hydrogen does not occur naturally and has to be extracted and processed before it can be used as a transport fuel.

There are four processes, viz.,
(i) Steam reforming of methane
(ii) Electrolysis of water
(iii) Compression
(iv) Cryogenic liquefaction.

These can be combined as (i) and (iii) or (i) and (iv) or (ii) and (iii) or (ii) and (iv)

(i) Steam reforming of methane

Hydrogen can be extracted from methane by steam reforming in two stages.
$2CH_4 + 3H_2O = CO + CO_2 + 7H_2$ and $CO + H_2O = CO_2 + H_2$
32 kg methane with 72 kg steam yields 16 kg H_2 and releases 88 kg CO_2, but the process is only 70%-90% efficient, so the yield is reduced to 12.8 kg, assuming 80% efficiency. 2.5 kg methane (2.5 x 55 MJ = 137.5 MJ) is needed to yield 1 kg hydrogen (120 MJ) while releasing 7 kg CO_2.
The 7 kg steam required contains 24 MJ total heat, bringing the input to 161.5 MJ/kg or 45 kWh/kg.

The equivalent power used to obtain the energy of 33.33 kWh/kg in the hydrogen is 45 kWh/kg and 7 kg of CO_2 is released.

Thus more energy is used to extract hydrogen from the methane than obtained in it. While natural gas remains available it is more efficient to use methane directly and less carbon for the useful energy obtained would thereby be released. The production of hydrogen from natural gas does not appear to be worthwhile.

(ii) Electrolysis of water
Electrolysis can consume between 3.7 and 4.5 kWh/Nm^3 of hydrogen, which taking the mean is gravimetrically 58.6 kWh/kg (Say 59)

(iii) Compression
The energy used to compress hydrogen to a suitable storage pressure is around 12% of the HHV or 0.12 x 142 MJ/3600 KJ = 4.7 kWh/kg (Say 5)

(iv) Liquefaction
For large scale plants the energy used to liquefy hydrogen is around 40% of the HHV or 0.40 x 142 MJ/3600 KJ = 15.8 kWh/kg (Say 16)

So, (ii) + (iii) is 59 + 5 = 64 kWh/kg
and (ii) + (iv) is 59 + 16 = 75 kWh/kg

Equivalent quantity required for UK transport in 2019 as an example

Cars use compressed hydrogen (Honda) or liquefied hydrogen (BMW and GM) while aircraft will need to use liquefied hydrogen because of weight and space requirements. An effective energy content of 120 MJ/kg H_2, means that vehicle energy of 2520 PJ (equivalent to 60 million tonnes /annum of petrol and diesel) would require 21 x 10^9 kg H_2/annum, while aircraft energy of 630 PJ (equivalent to 15 million tonnes of jet fuel) would require 5.25 x 10^9 kg H_2/annum.

This works out at 26 x 64 x 10^9 = 1664 TWh for compressed gas
and 26 x 75 x 10^9 = 1950 TWh for liquefied gas.
For aircraft it works out at 5.25 x 75 x 10^9 = 394 TWh

For the UK this means that to substitute for the 2019 level of road and air transport fuel with hydrogen would require from 1664 TWh to 1950 TWh of electricity generation, compared to the total UK generation of 300 TWh in 2020.

Conclusion

Domestic heating

Reforming natural gas to hydrogen releases more carbon dioxide than simply burning it means that for domestic consumers this is an impractical prospect.

Using air to water heat pumps for hot water yields a coefficient of performance of just 2, compared with air to air heating of 4. It cannot compete with off-peak electrical heating at half price.

Transport

While in the future a favoured minority will use hydrogen and electricity-propelled road vehicles, this would be such an inefficient use of renewable electricity that road transport will be substituted by rail (which can use electricity directly in traction engines).

To substitute hydrogen for liquid fuels in the UK would require 5 to 7 times more electricity generation – an impossible concept.
A better option, if sufficient quantities of liquefied natural gas (LNG) will be imported, would be to transfer it directly from an ocean gas tankship, via interim storage at an import terminal, to containers on large road vehicles otherwise fuelled with diesel. This would avoid re-gasification at the terminal and liquefying the gas a second time.

Global air transport

The establishment of a global hydrogen infrastructure for air transport is an impracticable prospect. A trebling of 2000 global air traffic once envisaged by 2030 would require electricity generation of 7000 TWh/annum to be able to substitute liquid hydrogen for 260 million tonnes/annum of jet fuel. It would, in any case, mean that every airport in the world would have to have hydrogen fuel available for re-fuelling for return to base

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