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Blue Hydrogen: Fact vs. Fiction

A paper based on a study by Cornell's Robert W. Howarth and Stanford's Mark Z. Jacobson entitled 'How green is blue hydrogen' was published on 12 August 2021 in the Energy Science and Engineering Journal. The contents were instantly picked up by several media outlets. Essentially, the authors sought to dispel blue hydrogen as a viable decarbonisation endeavour by citing the substantial amount of natural gas required to fuel the blue hydrogen production process, excessive residual CO_2 emissions from the CO_2 capture process, as well as high leakage of upstream fugitive methane emissions. However, there are a number of factors worth visiting that serve to undermine or, at least, call into question some of its main conclusions. It is worth noting that there has also been widespread rebuttal of the paper's claims by, among others, the UK's CCSA and Norway's Equinor.

Howarth and Jacobson state in their paper's abstract that, **''… far from being low, greenhouse gas emissions … particularly due to release of fugitive methane, from the production of blue hydrogen are quite high, … higher than for gray hydrogen because of increased use of natural gas to power the carbon capture.''** The assertions made result to a large degree from two primary assumptions. First, the authors' assumption regarding upstream methane leakage appears high. The Oil and Gas Climate Initiative (OGCI), a collaboration of major Oil and Gas producers responsible for over 30% of global O&G production, announced in their 2020 publication that their members' collective average methane intensity for 2019 stood at 0.23%. Equinor's published methane intensity for 2020 was 0.03%, with Shell's ranging from 0.01% to 0.6%. These values illustrate well what targets are achievable and contrast starkly with the value of 2.6% used by Howarth and Jacobson.

Secondly, the authors used a CO_2 capture efficiency of 65%, which does not represent capture efficiencies achievable today. In their paper, the authors state that **'… actual data from one of the two commercially operating facilities, the shell plant in Alberta, show a mean capture of 78.8%'**, which is actually very close to the 80% design capture rate for the plant. Other large-scale demonstration plants have also met their design values, e.g., 90% capture at both Boundary Dam and Petra Nova. More recent studies have indicated that efficiencies of about 99% are possible with only a modest increase in cost[1,2].

Furthermore, they use a Global Warming Potential (GWP) window of 20 years rather than the customary 100-year window employed by, among others, the US EPA[3] and the IPCC[4].

Based on the aforementioned information, the authors have:

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[1] IEAGHG, Towards Zero Emissions CCS from Power Stations using Higher Capture Rates or Biomass. Page 63. March 2019. (https://ieaghg.org/publications/technical-reports/reports-list/9-technical-reports/951-2019-02-towards-zero-emissions#_ftn1)

[2] P. Brandl et al. Beyond 90%: possible, but at what cost. International Journal of Greenhouse Gas Control, February. 2021. (https://www.sciencedirect.com/science/article/abs/pii/S1750583620306642)

[3] US EPA. Understanding Global Warming Potential (https://www.epa.gov/ghgemissions/understanding-global-warming-potentials)

[4] IPCC 5th Assessment Report (AR5), Greenhouse Gas Protocol: Global Warming Potential Values. Page 1. 2014. (https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf)

1. Used significantly higher fugitive methane emissions than those currently achievable;
2. Assumed significantly lower CO_2 capture rates than those currently achievable;
3. Employed a GWP of methane based on 20 years rather than the 100 years used more often in this type of analysis; and
4. Assumed the capture system is powered by unabated fossil fuels.

Based on these assumptions, the conclusions drawn in Howarth and Jacobson's paper are not surprising. One may also consider aspects of their sensitivity analysis …''**in which the methane emission rate from natural gas is reduced to a low value of 1.54%, greenhouse gas emissions from blue hydrogen are still greater than from simply burning natural gas''.** The value of 1.54% is still very substantially higher than standard practice achieved by many in the O&G community.

With regards to storage of CO_2, Howarth and Jacobson reported that **'… Our analysis assumes that captured carbon dioxide can be stored indefinitely, an optimistic and unproven assumption.'** Globally, millions of tonnes of CO_2 are already stored safely and securely in deep underground reservoirs[5]. The O&G industry has several decades of experience in the use of CO_2-EoR which can lead to permanent storage of CO_2. The Norwegians have decades of experience storing CO_2 securely in saline aquifers. With the backdrop of such experience, plus the ongoing research, demonstration and development around the world, there is widespread confidence in the ability to successfully store the billions of tonnes of CO_2 projected for CCS to make its contribution to the goals of the Paris Agreement. Provided appropriate protocols are followed, CO_2 can be safely and securely stored in geological formations, which is now widely proven at industrial scale.

Finally, it is important to reiterate the importance of blue hydrogen to global decarbonisation efforts. The IPCC has identified blue hydrogen among the 1.5^0C-consistent technological pathways in its Special Report. In its recent 'net-zero' report, the IEA recognises the importance of low-carbon (green and blue) hydrogen. S&P Global has reported that ''as economies across North America and Europe weigh various future energy market scenarios required to meet the Paris Climate Agreement's long-term temperature goals, blue hydrogen is emerging as one of the most viable off ramps from fossil fuels in a deep de-carbonization regime''[6]. The Oxford Institute for Energy Studies have reported that 'deploying blue hydrogen on a large scale is the only realistic approach to achieve early and deep decarbonisation of the non-electric sector'. The UK government is currently and ambitiously planning to build five gigawatts of what is described as ''twin track'' hydrogen (blue and green) capacity by 2030. This is expected to substitute some natural gas for heating homes and to power industries towards helping the UK to become a carbon neutral economy by 2050.

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[5] IPCC. Carbon Capture and Storage. Page 197. (https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf)
[6] S&P Global. Going big on blue hydrogen. June 2021. (https://www.spglobal.com/en/research-insights/featured/blue-hydrogen)