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The promise of hydrogen is a distraction from rapid decarbonisation, discuss.

Hydrogen generates energy by combining hydrogen and oxygen. The claim: no emissions, no waste, no environmental impact. Too good to be true? In a way, it is. Forecasted demand for hydrogen is massive, but its current carbon footprint is equally substantial. Hydrogen is abundant on Earth but bonded to oxygen in water and carbon in hydrocarbons. Breaking these bonds requires energy. The feedstock for hydrogen and the energy used for extraction is covered by a colour code. Grey hydrogen refers to methane-produced hydrogen, without carbon-capture, while brown hydrogen is extracted using coal. Both result in significant harmful emissions. Currently, 97% of hydrogen in industry comes from brown and grey sources.

Blue hydrogen refers to hydrogen extracted from methane alongside carbon-capture technology. This is essentially the same as grey hydrogen but limits carbon emissions by storing the byproduct CO_2 underground. But how green is blue hydrogen? Cornell scientists recently answered this, detailing in reality blue hydrogen only reduces emissions by 11.7% compared to grey due to inefficient capture of emissions. Additionally, the process of storing CO_2 requires energy, adding to harmful outputs. The study highlighted that blue hydrogen emissions are equivalent to directly using methane for electricity, rendering hydrogen obsolete.

Blue hydrogen is not all it promised to be, and grey hydrogen has no place in a carbon-neutral future. What about green hydrogen? Green hydrogen is produced from water using renewable sources. Sounds promising, right? Recently, engineers have enlisted solar power to extract pure hydrogen for a low-emission solution. However, it is not that simple. Under realistic conditions, Australian chemists for the Energy-Environmental journal concluded that when considering the inefficiencies caused by solar radiation and required energy to store hydrogen produced, carbon emissions are comparable to grey hydrogen in a worst-case scenario. This form of production could still apply, particularly where electricity is in surplus, such as in remote areas or during seasonal variations in energy usage. Here, it may be beneficial to store energy in another form, potentially as hydrogen to meet future supply gaps. However, existing systems suffer from inefficiencies and high costs, rendering them economically impractical. The little research into producing hydrogen through wind predicts the same issues seen with solar.

Governments worldwide intend to apply hydrogen power on an enormous scale, attempting to decarbonise many industries. Presently, hydrogen power globally, with its comparatively limited applications, produces an amount of CO_2 annually equivalent to combined emissions of Indonesia and the United Kingdom. It accounts for 2% of global emissions, on par with commercial aviation. This is unsurprising given just 1% of hydrogen production is carbon-neutral.

Imagine the issues with extracting hydrogen are solved, is the road clear for hydrogen driving a carbon-neutral future? Not quite. Hydrogen storage faces challenges due to low energy density, necessitating high-pressure storage. At high-pressure storage conditions, hydrogen per litre has a much lower energy density then gasoline. The energy density per mass is twice as high as from gasoline but is difficult to exploit given the pressures required. Furthermore, due to hydrogen atoms size, the molecule creeps into storage structures and destroys the chemical buildup through a process called hydrogen embrittlement. To avoid this, thick containers are required, which are heavy and expensive.

Fuel cells themselves present issues. Production heavily relies on availability of platinum and iridium, which are scarce globally and costly to obtain. South Africa, Russia and Zimbabwe dominate the industry, with South Africa holding 91% of global reserves. Estimates suggest iridium demand by 2030 will be three times supply. Supply issues became a reality in 2022 as large investors in hydrogen suffered due to market surplus of platinum falling by 47% in response to rising demand. Hydrogen will be limited by availability of materials, or development of new technology utilising different materials.

Lastly, the world does not have unlimited human or financial capital. Investing scarce engineering resources in hydrogen development may divert attention from more promising decarbonisation alternatives.

In conclusion, in the race for net-zero, capital and human investment in hydrogen may be preventing rapid decarbonisation rather than accelerating it. Reducing the carbon footprint of hydrogen presents significant challenges, alongside material limitations, and functionality of hydrogen fuel cells. Hydrogen power will create more problems than it can solve.