Green Hydrogen Hype or Reality….

Abstract

The potential of hydrogen remains largely unfulfilled, but times are changing thanks in part to the rising use of renewable energy. The discourse around the potential of hydrogen as a key player in the transition towards a greener future has reached new heights. Governments are increasingly recognizing its importance in their green industrial strategies, sparking a wave of interest and investment. However, the reality behind the hydrogen economy is complex and multifaceted, with various applications and business cases at play.

Recently, a client reached out to me with this question. They have inhouse engineering degree and MBA people from good schools, whom have worked at top consultancy companies, have done C-level strategy work, and currently have a decarbonization accountability for more than $1 billion annual revenue. They have the ability and background to foresee that hydrogen for energy is not going to work, as well as having skin in the game themselves.

Because they actually know the science, run the numbers on decarbonization solutions, and deal with otherwise bright, informed, competent people who have many of those attributes, they were deeply perplexed why they were getting hydrogen for energy questions and proposals multiple times a day. In their words, *"Is hydrogen a hype or reality"* They hoped OilXetra could shed some light on the subject to help them deal with the matter more effectively and efficiently.

They respect my complete disregard for people's feelings in my ruthless adherence to running the numbers in multiple domains, respect the outcomes in areas they understand, yet see the disconnect between the current hydrogen hype and my positions and analysis of hydrogen for energy. We are all bullish on hydrogen electrolysers and building lots of green energy to power them but are realistic about what off-takers actually exist for projects.

In my opinion you have different hydrogen advocate groups, and they all have their own motivation and reasoning to promote hydrogen as the new energy source. I have split them into two groups, there are the oil and gas companies. They have two motivations. Delaying the transition is one of them, of course. But if they can't convince everyone that hydrogen is required for energy, they won't be able to turn their hydrocarbon reservoirs into money via blue hydrogen, and they will be worthless. Companies like Shell and BP have 4–10 billion barrels of proven reserves, those assets will become almost worthless. And these firms treat these reserves as a fiscal tool for debt financing.

Financial institutions with big positions in oil and gas firms have a vested interest in those firms continuing to be healthy, they are filled with people with business degrees, but usually empty of people with Engineering and Science degrees. I've been in sessions with investment managers for multi-billion-dollar infrastructure investment funds, and when it got to hydrogen, I asked how many people had chemistry, physics, or other Science degrees. No one did. This doesn't make them bad people, but the lack of science in the room means that they are dependent on advisors and focused on due diligence on the business side, not the technical side. The oil and gas industry tells them hydrogen is the answer, fills their eyes with dollar signs, and then basic human nature turns them into boosters.

The next are people with a technology that makes hydrogen or uses it. They got invested in it at some point in the past, often prior to 2015 when batteries and renewables proven not to be the solution, and then confirmation bias just keep them from accepting reality, cutting their losses, and pivoting to something useful.

Bringing Hydrogen in perspective - An incredible 99 per cent of globally produced hydrogen is made from fossil fuels, according to the International Energy Agency – the same fossil fuels that are the largest contributor to greenhouse gas emissions and thus to the climate crisis. In 2022 global hydrogen production was responsible for over 900 million tonnes (Mt) of CO_2 emissions. That's more than was emitted by the global aviation industry (almost 800Mt).

The production of green hydrogen, on the other hand, remains tiny, despite all the hype. Green hydrogen is produced through a process called water electrolysis that uses electricity from renewable energy sources to split water into hydrogen and oxygen. In 2022, less than 0.1 per cent of global hydrogen (0.087 million of 95 million tonnes) was produced this way, according to the International Energy Agency. However, this figure also includes electrolysis powered with nuclear energy; so the actual share of green hydrogen from renewable electricity is likely to be even smaller.

Nevertheless, even green hydrogen, with its "super clean" image, comes with serious challenges and risks that are not widely known. The inconvenient truth is production of green hydrogen on a large scale requires vast amounts of land, water, and renewable energy (that could otherwise be used to meet local electricity needs).

Then there is 'blue' hydrogen, which is also produced from fossils, mostly gas. In 2022 it accounted for 0.6 per cent of global hydrogen production, according to the International Energy Agency. To create blue hydrogen, CO_2 from the production process is captured and stored underground (via carbon capture and storage). If the captured CO_2 is used further, it is called 'carbon capture, utilization and storage' (CCUS).

Due to the storing away of CO_2, blue hydrogen is often described as a low-carbon, low-emission, or even CO_2-neutral gas. But this framing ignores several truths, including the fact that the fossil fuel industry uses nearly three-quarters of all globally captured carbon for so called 'enhanced oil recovery' (EOR). EOR entails injecting the captured carbon into depleted oil and gas fields in order to pump out – and ultimately burn – previously un-extractable fossils. In other words: producing even more emissions.

But even without enhanced oil recovery, blue hydrogen's total greenhouse gas emissions are only moderately lower than those of grey hydrogen (created from fossil gas, or methane, using steam methane reformation). There are two reasons for this: first of all, carbon capture, utilization and storage technologies only capture a fraction of the produced CO_2; and furthermore, a great amount of additional fossil gas is used to power the technology, leading to increased methane emissions. Methane is an even more powerful greenhouse gas than CO_2, and escapes whenever fossil gas is extracted and transported.

When CO_2 and methane emissions are added up – including the upstream ones that occur prior to the CCS process – the climate footprint of blue and other fossil hydrogen is greater than burning fossil fuels directly.

Another alternative that is most often disregarded in environmental studies is turquoise hydrogen, i.e. hydrogen made from the pyrolysis of methane at high temperature for the co-production of hydrogen and carbon black. Turquoise hydrogen is based on direct methane decomposition (DMD), a process that has been put forward in 2000. The main advantage of turquoise hydrogen is that it is significantly less energy intensive compared to water electrolysis and from a thermodynamic perspective, and it benefits from the existing infrastructure of natural gas.

The process has the advantage of not creating any CO_2 molecules – a potent greenhouse gas – but does consume electricity. It is currently 3 times less energy intensive than water electrolysis (green Hydrogen), and this figure could theoretically rise 7 times with process improvements. In the future, turquoise hydrogen may be valued as a low-emission hydrogen, dependent on the thermal process being powered with renewable energy and the carbon being permanently stored or used.

Is turquoise hydrogen therefore the ideal solution for the energy transition? The reaction itself does not produce CO_2, unlike the other processes. Moreover, from one kilo methane, 250 g of hydrogen are produced and 750 g of solid carbon black. The latter can be used in many industries. So, the economic viability of turquoise hydrogen is based on carbon black – If all our current hydrogen were replaced by turquoise hydrogen, the market would be saturated very quickly, and we would end up with mountains of solid carbon. Carbon black could be used for massive new applications, such as in construction materials or soil improvement. The last solution would be to bury it. Rather than storing CO_2, storing carbon black could help reduce greenhouse gases (GHGs).

In the medium to long-term, turquoise hydrogen could play a major role in current hydrogen applications by replacing other processes. The current production of hydrogen used in the steel industry, agriculture, or refining, amounts to 60 million Mt each year. Turquoise hydrogen has a major role to play in decarbonizing the hydrogen industry. Despite the current craze for water electrolysis, this process is extremely energy-intensive and is not profitable today: turquoise hydrogen has reached technological maturity and an economic model that is already sustainable.

In the future, some hydrogen colors may fade in importance and others burn brighter. What's certain is that the hydrogen rainbow will play a significant role in reaching net zero, as we reduce our historical reliance on fossil fuels and look to green alternatives to power our homes, businesses and transport.

So, yes, the hydrogen lobby is a many-headed hydra. It's a self-reinforcing circle of people whose livelihood depends on hydrogen for energy replacing fossil fuels. There's some tribalism going on. There are a bunch of obvious cognitive biases that are keeping them from accepting reality, with the prospect theory being key among them.

In its most basic form, all prospect theory asserts that humans are more averse to potential losses than they are inclined to pursue potential gains. Consequently, leading to decision-making that is only partially rational. Contributing to this behavior are various biases. Confirmation bias involves ignoring conflicting information and giving authority to supporting beliefs. Availability bias stems from perceiving quickly generated examples as statistically representative of the world. Meanwhile, familiarity bias favors information heard or seen repeatedly over novel information, deeming it more reliable, all play a part too.

Hydrogen has a mixed future. Green hydrogen looks extremely promising for applications like steel making and flying jetliners. Using hydrogen to power personal EVs looks less enticing, although applications like city buses or heavy trucks traveling interstate highway corridors with strategically placed hydrogen stations could be economically feasible.

Although much has been made about the future of blue hydrogen, the technology to capture and store vast amounts of carbon dioxide has yet to be proven—meanwhile clean green hydrogen only makes up about 1 percent of current commercial hydrogen production.

One thing is certain: if oil companies can promote and point to their hydrogen programs as representing real progress toward fighting climate change and obtain government subsidies to fund their efforts, hydrogen will be around for a long time.

Conclusion – The hydrogen economy is a vast phenomenon with many application areas and business cases. Each application has its own opportunity, and alternatives. There is no doubt hydrogen will play a role in decarbonatization and low-carbon energy transition. However, one must admit that hydrogen alone is not "the silver bullet" as achieving the vast energy transition will require a combination of many solutions including hydrogen. Therefore, hydrogen must be regarded as a complimentary asset in the wider energy economy rather than being considered as the ultimate solution.

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