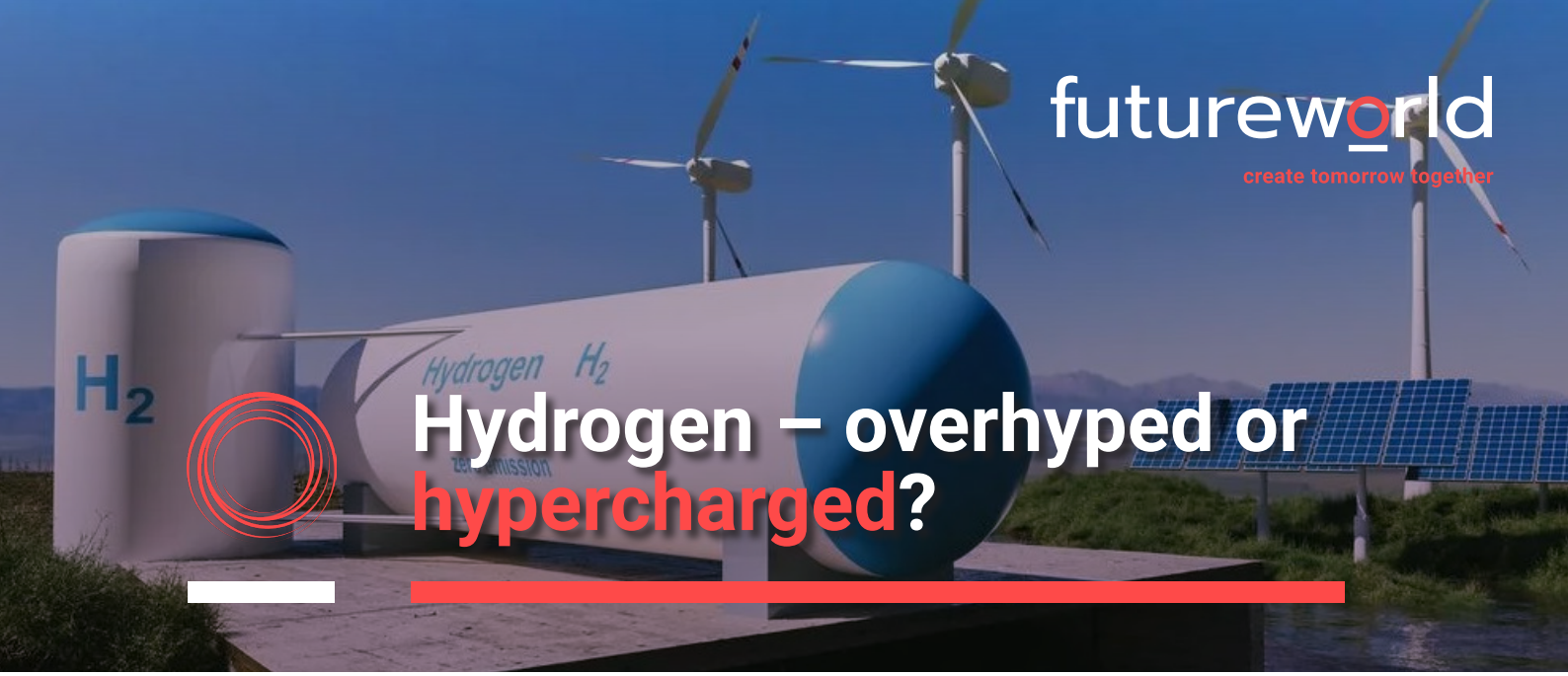

Hydrogen – overhyped or hypercharged?

Green hydrogen is touted as the clean fuel of the future. ***Doug Vining*** *explores whether its challenges outweigh its potential.*

Hydrogen gas is one of the smallest molecules in the universe, made up of two hydrogen atoms bound together. It's extremely energy dense and it only takes a spark to make it combine with oxygen in the air to produce water vapour. Hydrogen is explosive.

	Grey Hydrogen	Blue Hydrogen	Truquoise Hydrogen**	Green Hydrogen
Process	SMR*	SMR* or gasification with carbon cature (85-95%)	Pyrolysis	Electrolysis
Source	Methane or coal	Methane or coal	Methane	Renewable energy
				

* SMR = Steam Methane Reforming
** Turquoise hydrogen is an emerging decargonization option.
Source: International Renewable Energy Agency

Elemental hydrogen is also abundant in the universe, and found in many compounds, from the oceans to natural gas, sugars and alcohol, and of course fossil fuels. Hydrogen is also the source of our Sun's energy, a gigantic nuclear fusion reactor, continuously radiating solar energy in all directions.

But here on Earth, hydrogen gas does not occur naturally, and has to be synthesized from feedstocks, or extracted from water by electrolysis. And if your energy source is not renewable, well, that's not green.

Not all hydrogen is created equal

Hydrogen which is produced by steam reformation of gas or coal gasification is termed 'grey' hydrogen, and 'blue' if some of the carbon emissions are mitigated. 'Green' hydrogen is produced by electrolysis from water, using renewable electricity such as solar or hydropower.

The ultimate fuel

Because hydrogen is so energy dense by weight and doesn't produce any toxic pollutants, it's often considered the ultimate fuel, and was used by NASA to power Apollo moon rockets and the Space Shuttle. Hydrogen burns at a very high temperature, which can be problematic for rocket engines or gas turbines, but is perfect for the direct reduction of iron ore to produce green steel.

Hydrogen can also be electrochemically combined with oxygen (air) in a fuel cell, producing electricity and heat. Again, the only by-product is water vapour. It's essentially the reverse of electrolysis. Fuel cells are almost silent and can be turned on and off on demand, effectively acting like a refillable battery, which makes hydrogen a potential store of green energy, and a fuel for electric vehicles.

With ever-increasing concerns over climate change and a focus on clean energy, hydrogen is seen as the ultimate solution, if it can be made economically viable. Goldman Sachs estimates green hydrogen will become a US$12 trillion industry by 2050. They make the case that hydrogen gas could be used as a substitute for methane for heating and power generation, and transform Europe's natural gas grid.

What about the energy cost?

Hydrogen production from methane and coal is fairly efficient, and adequately covers the industrial and commercial demand for hydrogen. Green hydrogen is far more costly to produce at scale, requiring specialised electrolysers and vast amounts of solar power capacity, as well as 100% purified water. Catalysts including platinum and other rare metals add to the cost of both electrolysers and fuel cells.

But the real issue is efficiency. Only about 65% of the energy put into an electrolyser will be available as hydrogen, which reduces to about 60% after storage and compression. If that in turn is fed into a fuel cell – typically 60-65% efficiency – we realise only 35-40% of our original energy input as electricity! According to Stefano Marani, when you consider the upfront energy (and resource) costs to build the solar farm and electrolyser plant, it makes no sense to use hydrogen as an energy store – with current technology.

Elon Musk, the world's richest man, recently reiterated his longstanding position, saying that because of the amount of energy needed to produce it, hydrogen is "the most dumb thing I could possibly imagine for energy storage." On the other hand, mining billionaire Andrew Forrest is forging ahead with establishing green hydrogen production facilities and is promoting the fuel world-wide.

In the future, with more efficient systems and cheaper catalysts, and faced with masses of curtailed solar and wind power that would otherwise be wasted, it might become viable to convert the excess energy into green hydrogen, especially if there is onsite demand for the hydrogen gas for say, smelting or turbines.

Storage and transport challenges

Being such a tiny molecule, hydrogen gas is notoriously difficult to handle, and will permeate steel, turning pipes and cylinders brittle over time. Storing sizeable quantities by weight requires large volumes and lots of energy to compress or chill the gas. Hydrogen pressurised to 300bar can be stored in cylinders (4,200L per 100kg) or liquified at -252°C for cryogenic storage (1,400L per 100kg). Transporting compressed or liquified hydrogen over long distances is even more costly, and can be as much as three times the cost of producing it in the first place.

The first ship to carry liquid hydrogen, the 116-metre Suiso Frontier, was launched in 2019 and can carry up to 88 tonnes from Australia to Japan. As Australia uses brown coal gasification to produce the hydrogen, it's not green, and the economics of the pilot project are not remotely feasible, but there is significant demand for zero-emissions fuel in Japan and Korea.

Many researchers and companies are working on solutions to these problems, and I'm sure that in decades to come, we will see innovations that are as yet unknown and undiscovered that will transform the industry and launch the hydrogen economy. Here are some examples:

- Tennessee company Gloyer-Taylor Laboratories (GTL) has been working for many years now on developing ultra-lightweight cryogenic tanks made from graphite fibre composites, which would be ideal for electric aircraft running on fuel cells, possibly even extending their range over conventional jets.
- Nanotechnology researchers, based at Deakin University's Institute for Frontier Materials, claim to have found a super-efficient way to mechanochemically trap and hold hydrogen (and other gasses) in powders, with potentially enormous and wide-ranging industrial implications.
- Spanish startup H2SITE can filter hydrogen at 99.9% purity from a pipe carrying between 5% and 30% hydrogen with the rest being natural gas. Its reactors can also filter hydrogen from ammonia and methanol, which are convenient liquid carriers for the fuel.
- EPRO Advance Technology's (EAT) Si+ powder product could revolutionise the burgeoning hydrogen industry, offering a safe means of producing, storing, and shipping hydrogen, akin to transporting sand, making use of existing transportation infrastructure.
- Nu:ionic, a start-up based in Atlantic Canada, has a new take on hydrogen production. Their process uses catalytic microwave reforming of methane to generate hydrogen. Methane consumption is reduced by about 30% compared to conventional reforming techniques. The result is low cost, low-carbon hydrogen.

The future will be disruptive

With natural gas prices currently at such highs, clean energy research group BloombergNEF finds that green hydrogen is now cheaper than natural gas in eight European countries. While this may be a temporary consequence of the conflict in Ukraine, Europe is determined to become less dependent on Russia for its energy needs, and also determined to pursue low carbon strategies toward a 'net zero' world.

Renewable energy and green hydrogen are not that green, when you include all the environmental and energy costs of producing (and eventually recycling) the solar panels, converting from electrical to chemical energy and back again, and all the associated costs of distribution. Despite all that, the appetite for investment and for funding innovation in this space is increasing, and we could be on the brink of breakthroughs that will launch the hydrogen economy from a dream into reality.

But this arena is not for the faint hearted; it's for the bold. There will be disruption, and failures, and possibly incredible success, and exponential returns. The future is ours to create.

Futureworld has decades of experience understanding the forces shaping the future, and helping our clients to imagine and create an exponential future for their businesses. Please reach out to us if you'd like to explore some alternate futures for your business.

About the Author

Doug Vining is a futurist, author, and international keynote speaker.

As Futureworld's tech guru and the Editor of Mindbullets: News from the Future, Doug is constantly scanning for signals and trends, to identify challenges – and opportunities – presented by emerging technologies. Never afraid to adopt a contrarian viewpoint, Doug believes an open mind and an appetite for continuous learning is the only way to survive the future.

When not imagining disruptive future scenarios for industries and businesses, Doug can often be found swimming upstream on Twitter and LinkedIn.