Hydrogen

Debunking the hype

A SENIORS FOR CLIMATE ACTION NOW! BRIEFING

For decades, hydrogen has been used as an industrial feedstock. In this role, it performs many useful functions in the petrochemical and chemical industries where, as a powerful reducing agent, it transforms many chemical compounds and elements into substances which are more commercially valuable. For example, it can be combined with nitrogen to produce ammonia, a chemical precursor of several forms of fertilizer and a valuable product itself.

Hydrogen is flammable and can be combusted to generate heat; and it can be combined with air in a device called a fuel cell to produce electricity. It is particularly this last attribute which has led the oil and gas industry to strongly promote its widespread use as an 'energy carrier' that could play a pivotal role in what has been called the 'hydrogen economy'. This is an imagined future economy where hydrogen is employed to power vehicles, ships, and aviation; heat homes, buildings, and industry; decarbonize steel and cement production; and be produced and deployed as a powerful form of energy that can substitute for fossil fuels and the electricity derived from them.

The hydrogen that the oil and gas industry envisions as powering the future hydrogen economy is produced from methane, which explains why the fossil fuel industry lobbies strongly for its greater production and deployment in all sectors of the economy.[1] However, hydrogen manufactured from methane generates substantial quantities of carbon dioxide (CO_2) --a greenhouse gas. The industry claims that the CO_2 can be separated, captured, and permanently sequestered using carbon capture and storage (CCS) technology. But as the SCAN Briefing note on CCS explains, the technology is far from perfect, and a significant fraction of the CO_2 is released into the atmosphere—where it contributes directly to global heating and climate change.

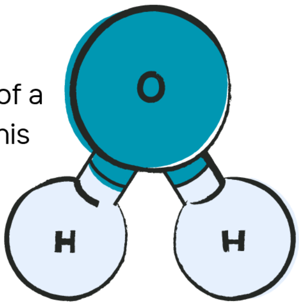
The Colour Schemes

Hydrogen comes in several colours. The two most common hues, and the ones discussed in this Briefing are blue hydrogen and green hydrogen. They are very different.

Blue hydrogen is manufactured from methane in a chemical reaction with steam at high temperatures and pressures. Producing a tonne of hydrogen via this chemical process generates between 7 and 9 tonnes of carbon dioxide as a byproduct, all of which must be separated from the hydrogen and disposed of.[2] Nearly all the hydrogen produced worldwide, about 90 million tonnes, is manufactured in this way, and most of the carbon dioxide byproduct is simply pumped into the atmosphere. If the fossil fuel industry is going to supply the future hydrogen economy, CCS technology must be capable of capturing and permanently storing extremely large of quantities of carbon dioxide. For instance, some industry forecasts envision hydrogen production reaching 600 million tonnes a year by 2050. This level of production implies that the CO_2 byproduct, which all needs to be captured and sequestered, will reach 4 to 5 billion tonnes a year. For comparison, the level of carbon capture and storage in 2024 was about 50 Mt/yr; one hundred times less.[3]

This brief assessment makes it clear that blue hydrogen: the production of hydrogen from methane with carbon capture and storage, will always produce emissions of greenhouse gases. The carbon dioxide byproduct can never be completely sequestered, and methane emissions from the upstream extraction and processing plants will always be present.

Green hydrogen is produced by electrolysis: the breaking down of a compound using electricity. In this case, electricity is used to split water into its constituent elements: hydrogen and oxygen. The electricity must come from clean, zero-carbon sources of energy. If not, it's not green.



H_2O

The problems here are more economic than physical. Electrolyzers are expensive (although their cost has been decreasing), and a lot of electricity is required to break the chemical bonds between hydrogen and oxygen. The figure generally quoted is 50 kWh of electricity to produce a single kilogram of hydrogen.[4] Electricity from renewable energy is cheap; from nuclear not so much, but the cost of the electrolyzer dominates the economics and the result is that green zero-carbon hydrogen is several times more expensive than blue hydrogen produced from methane.

The Hype about Hydrogen [5]

Is the 'hydrogen economy' a realistic vision of a global economy powered by hydrogen, releasing only water vapour as a harmless byproduct, as fuel cells generate electricity for the transport sector and agricultural production; and heat and electricity for buildings and industry?

Electricity can do everything that hydrogen can do...and then some.

The most important point to understand is that electricity can do everything that hydrogen can do...and then some. And much more efficiently and at much less cost. Except for one thing. The one trick that hydrogen is good at, that electricity cannot do, is when hydrogen is used as a chemical reagent in the chemical industries. Electricity cannot substitute for hydrogen in this role. But everywhere else, electricity is more efficient, more powerful, cheaper, and cleaner. There are no emissions when electricity is used to produce heat and to do work.

The major opportunity for hydrogen was always supposed be in powering up the transport sector. Fuel cell vehicles (FCVs), large and small, were going to take over: muscling aside internal combustion engine automobiles, and out-competing electric vehicles (EVs).

It's been death by a thousand cuts. Ten years ago in its Sustainability Report 2013/14, Ford covered two pages extolling the virtues of hydrogen FCVs. A decade later, the company devoted only two paragraphs to hydrogen and never used the term FCV.[6] The advertising for the Ford Focus FCV was soon replaced by the 'fully electric' version. Electric vehicles now outsell hydrogen FCVs by 1000 to 1. Battery electric technology is the clear winner, based on both its popularity and the more extensive infrastructure to support the vehicles. Over a million electric cars were sold in the U.S. in 2023 compared to just under 3,000 hydrogen fuel cell-powered cars.[7] To be sure, most vehicles that are sold in North America are conventional internal combustion vehicles but as the transport sector slowly electrifies, it is batteries that will be on board new vehicles not a heavy tank of hydrogen under intense pressure.

In Canada, only about 10 percent of new vehicle sales are battery electric or hybrids. Government support for the transition to EVs is currently weak and unreliable. The world leader is Norway, where in 2024 nine out of ten new vehicles sold in the country were electric.

Batteries will be on board new vehicles - not heavy tanks of hydrogen.

Large trucks were once considered a natural fit for hydrogen because the batteries needed for long-distance haulage were thought to be too heavy and therefore uneconomic. But batteries have become more powerful and less expensive. The BloombergNEF 2025 Factbook reported that almost 90,000 zero emission trucks were sold in the first half of 2025, more than in all of the previous year, and fully 97 percent of them were battery-electric.[8]

In Europe, electric truck sales grew more than 50% year on year in the first half of 2025. The EU is financing a billion-euro program to build megawatt-scale charging stations for trucks. The writing is on the wall, and it doesn't spell hydrogen.[9]

There can be absolutely no doubt that the complete electrification of the ground transport sector is underway. But the oil and gas industry is fighting an effective rearguard action.

Can hydrogen be used as a fuel to generate high temperature heat and would this be a cost-effective use of the gas? The answer is an emphatic, no. First, hydrogen doesn't burn cleanly; the combustion of any gas in air always produces nitrogen oxides which are greenhouse gases, and hydrogen is no exception. And then, once again, if you need high temperature heat electricity can do the job with absolutely no emissions. The same limitations apply to using hydrogen to heat a building. A heat pump can provide heating and cooling much more efficiently.

Physics and Chemistry

The difficulties with employing hydrogen as a large-scale energy carrier are not fundamentally related to economics or energy policy. It is simple physics and chemistry, characteristics that no amount of AI repackaging can change. Hydrogen is the smallest and lightest of all molecules. It is an escape artist; almost impossible to contain. And when it escapes, as it always does, it acts as an indirect greenhouse gas with a warming effect roughly 30 times higher than CO_2. Moreover, hydrogen leaks are very hard to detect, and undetected hydrogen leaks cause a significant fraction of accidents involving the gas.[10]

Hydrogen has a greenhouse gas warming effect higher than CO_2.

Hydrogen is also hazardous. A review of hydrogen safety issues published in 2021 noted that "It is difficult to maintain safety in production, storage, transportation, and utilization because of the inherent characteristics of hydrogen."[11] More importantly, there is still no practical and affordable way to store hydrogen--which makes transporting it over long distances expensive and energy intensive. Companies must liquify and supercool hydrogen to -253 C for less bulky transport, but liquefaction can consume as much as 40% of the hydrogen's energy.[12] Keeping the temperature that low in a tanker is difficult. The gas starts to boil off and the pressure rises dangerously. There is no alternative but to vent the gas into the air.[13]

Distributing hydrogen through pipelines is also a problem. Apart from the tendency to leak, the gas can cause the embrittlement and fracturing of the pipeline steel normally used for methane. Hydrogen concentrations are therefore kept to very low levels: 5% in California; 8% in France; 9% in Germany. Hydrogen also has a lower energy density than methane which means a greater volume needs to be combusted to obtain a given thermal output. All of which means that adding hydrogen to methane in concentrations considered safe has little impact on emissions.[14]

Ontario's Hydrogen Strategy

The Ontario government published its *Low-Carbon Hydrogen Strategy* in 2022.[15] The strategy paints a rosy picture of Ontario's 'low-carbon hydrogen economy', generating thousands of tonnes of green hydrogen powered by the electricity of its growing fleet of nuclear generating stations. In Ontario's vision, hydrogen generates economic development and jobs; reduces greenhouse gas emissions; promotes energy diversity; promotes innovation and investment; and strengthens collaboration with the private sector.[16] The Ontario strategy explicitly proposes that blue hydrogen can be produced from methane with carbon capture and storage technology employed to sequester the CO_2 emissions on Crown Land. Ontario's hydrogen strategy has been thoroughly de-bunked by Canadian energy expert Michael Barnard. His analysis is too lengthy and detailed to be summarized here.[17] But the bottom line is that Ontario's Hydrogen Strategy has been shown to be a "recipe for economic and climate failure". It's not hard to see why. Hydrogen has no future in ground transportation; it is completely unsuitable for heating and cooling buildiings (which will be increasingly all-electric); and has only limited application as an industrial feedstock in a handful of industries such as ammonia-based fertilizer and steel production. The future hydrogen economy envisioned by the Ontario government will prove to be yet another costly and wasteful policy.

> "a recipe for economic and climate failure."

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