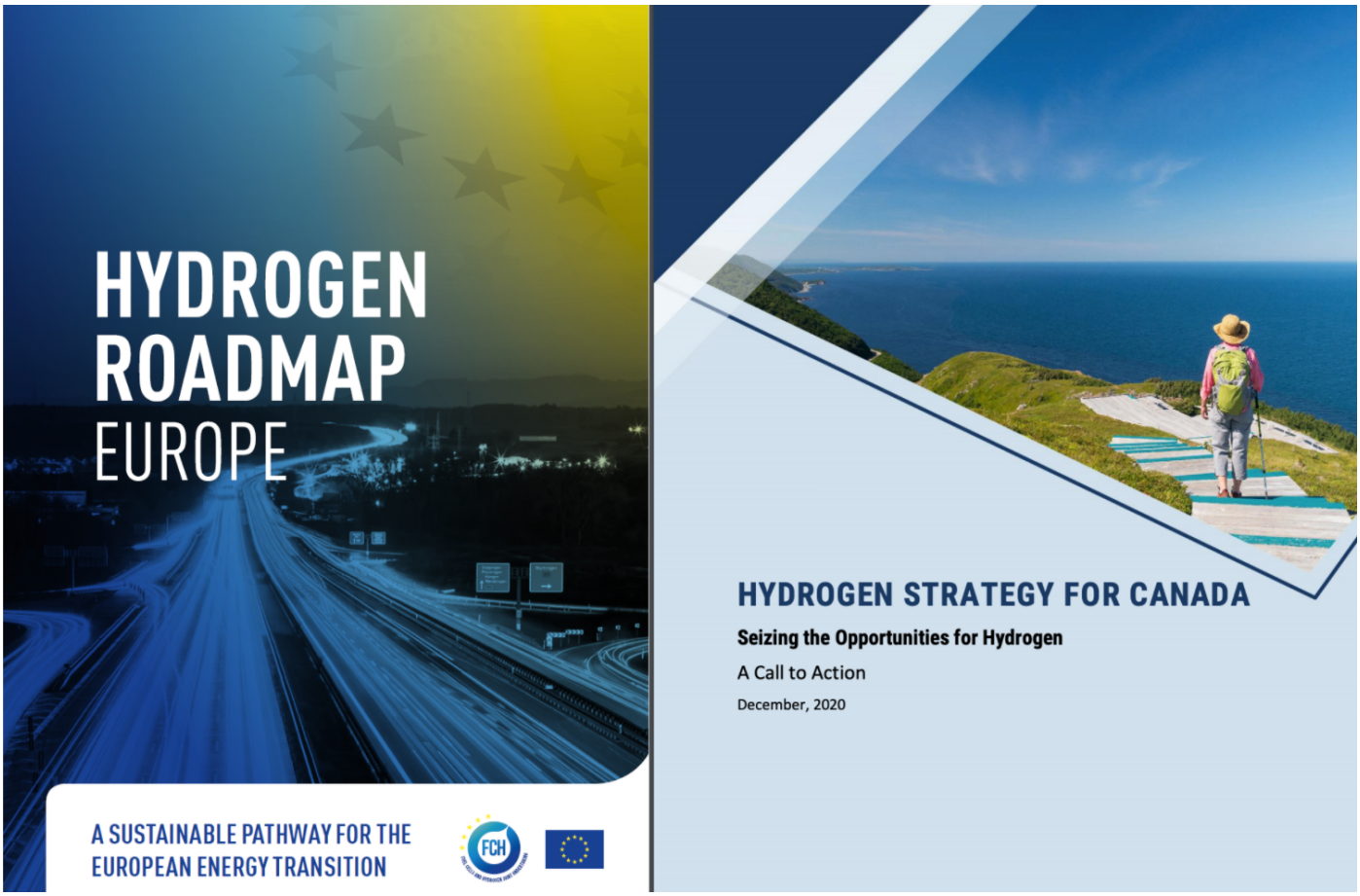
# Latest “Hydrogen Economy” Round Is Hype, But There Is A Place For Hydrogen

Michael Barnard December 23, 2020

There’s been a recent emergence of the ‘hydrogen economy’ nonsense globally. *CleanTechnica* has not been immune to this, and has had to yank articles that got out over their skis, either permanently, or to edit them to a more nuanced perspective. In aid of *CleanTechnica’s* efforts to establish a clear policy on hydrogen-related reporting, and for the benefit of others, this is my take on where hydrogen will be valuable, might be valuable, and won’t be of use at all.



Covers courtesy EU and Government of Canada

In part, this emerged from the recent Columbia University Sustainable Finance Seminar I was asked to provide as part of its series on the subject. Mark Townsend Cox of New Energy Fund II, LP in Manhattan is co-chair of the series, and he asked me to contribute. The title of my 90-minute talk, which turned into closer to 2.5 hours with the excellent questions from participants, was Green washing, sustainability scams and clean cons: How to spot 'em. The slides I spoke to are linked under the title for those interested.

I hadn't included a slide specifically on hydrogen, an oversight on my part, but did have a slide on an outright hydrogen perpetual motion long con I talked about with Canada's national broadcaster, CBC, as part of its investigations, and written about in *CleanTechnica* once the story broke. I should have had a slide on hydrogen more generally, as it's an area rife with greenwashing.

This isn't to say that green hydrogen — hydrogen electrolyzed from water with renewable energy — doesn't have a vital role to play. But that role isn't nearly as big as many governments and industry groups are asserting. It's certainly not nearly as big as the governmental efforts being spent around it suggest.

In summary, green hydrogen will be necessary to displace the existing fossil-fuel sourced hydrogen used today, but it will have limited additional niche applications. It will not be a major economic driver, it will not be seasonal grid storage, it won't be piped into homes instead of natural gas and it won't make a difference if mixed with natural gas. As with mechanical carbon capture and sequestration, it's best thought of as a fossil fuel industry PR and lobbying push to perpetuate their industry and the gas utilities.

## Existing Industrial Market For Hydrogen

This doesn't mean that there isn't a major need for green hydrogen. The global market for hydrogen was $117.49 billion in 2019. The large majority of global hydrogen production comes from steam reformation of natural gas, the vast majority of the remainder comes from coal gasification, and a tiny fraction comes from electrolysis. Eliminating the 98% that comes from fossil fuel sources and is used in industrial processes today is job #1. Those industrial uses include alloying metals, production of flat glass, in the electronics industry, for etching, for cleaning, and for reduction processes, among other things.

This area requires serious attention and focus. Shifting to green hydrogen production for existing uses is by far the largest market opportunity.

The additional areas where hydrogen has a part or the potential to play are niches, but big niches. All three require substantial investment in R&D and governmental support, but most of the attention isn't on these niches, but on areas where hydrogen should not be considered seriously.

## Low-Carbon Steel & New Industrial Processes

Reduction of iron ore into steel is a high-carbon process. A hydrogen process is much lower carbon. This is useful for new steel that must be manufactured, but in North America we already mostly use electric mini mills to process scrap into new steel, an industry which gave its two largest US companies $3.7 billion in profits between them in 2018. Electric mini mills can simply be powered with a grid decarbonized by renewables, as I've discussed with Mark Z. Jacobson. Given the vast amounts of fossil fuel infrastructure which is going to be rusting in the coming century, my assumption is that the majority of steel used globally will be scrapped

existing steel mostly from that source, but I also haven't run the numbers (it's on my list for 2021, but it's a long list).

Siemens is engaged in a demonstration site in Salzgitter, Germany with steel-maker Salzgitter Flachstahl GmbH (SZFG) for this purpose. They are putting in place a PEM electrolysis unit for onsite creation of hydrogen for steel making using renewable electricity to run the process. The science is sound, but I haven't run the economic numbers as I have with low-carbon cement (once again, on my list).

Low-carbon industrial solutions are an area I'm still investigating. I've already found (and am working with) a negative-carbon, strongly profitable replacement for bicarbonate manufacturing to replace the Solvay process with its 2.74 tons of CO2 per ton of bicarbonate, commodities with a $44 billion annual market. There are undoubtedly other industrial applications I'm unaware of where the chemistry can work with low-carbon hydrogen instead of higher-carbon alternatives, and the researchers and companies striving in this area should be the ones gaining attention.

## Long-Distance Oceanic Shipping

Freight ships use bunker oil, which in addition to CO2 produces black carbon — unburnt hydrocarbons with a global warming potential (GWP) of 4,470 times that of CO2 over the short term. Biofuels and synthetic fuels also produce black carbon, and are lower CO2, but not zero CO2. Short- and medium-haul shipping will be battery electric. There are already too many battery electric vessels in play to count running short hauls, so this will just persist. Cycles for loading and offloading along with typically good electricity supplies to ports make this completely feasible, but for long-haul, the energy density equation doesn't work as well. Hydrogen has a strong potential play here.

The largest power fuel cell, however, is still a ways off from the scale of the engines of the largest long-haul freight ships. The good news is that many marine drivetrains are already diesel electric, so displacing the diesel with fuel cells is a relatively straightforward proposition. Ships also have massive volume and carrying capacity, so the room and carrying capacity necessary for hydrogen is present. Smaller scale efforts that develop into the largest scale should be supported, but it's unlikely that hydrogen would be economical for short- and medium-haul simply because the round trip efficiency is so far below battery electric.

This area has potential, but it should be treated with reserved skepticism.

## Long-Haul Flights

High-altitude passenger and freight flights have very strong global warming impacts, beyond the basic amount of CO2 emitted. CO2 emitted in the stratosphere has a higher early impact in its lifecycle in the atmosphere. Planes create contrails which have very strong radiative forcing impacts at night, and they emit nitrous oxides in the stratosphere, which has additional GHG impacts. The combination requires both operational changes to minimize contrails, but a zero-emissions powertrain.

Short- and medium-haul flights will once again be battery electric, with the Nordic countries leading the way. Long-haul flights have the energy density problem, and hydrogen is a potential solution, but once again much development is required.

ZeroAvia is a promising startup with a hydrogen-fuel cell powertrain and plans to get to long-haul powertrains in a decade. It needs support to get there as it won't be able to compete in shorter flight categories with battery electric, but a fuel cell electric drivetrain for long-haul still has potential.

This area has potential, but it should be treated with reserved skepticism.

## Now For The Areas Where Hydrogen Won't Work

### Hydrogen as a store of grid energy makes no sense.

Round-trip efficiency from electricity to hydrogen to electricity again is about 43%. The math is simple. 80% efficiency for PEM creation of hydrogen from water (theoretical maximum is 86%, but industry average is lower). 10% distribution, compression, and leakage efficiency loss. 60% efficiency fuel cells to turn it back into electricity.

Lithium-ion, redox flow, and pumped hydro storage are all over 80% for often lower capital costs. Hydrogen is incredibly lossy as a store of electricity, and there's no way to square that circle. Redox flow and pumped hydro both scale massively and will dominate storage beyond lithium-ion's 4-8 hour window. I'm engaged with a firm with a redox flow solution with a capital cost per MW that's about half of Lazard's current LCOE for redox flow, so I know that there's substantive room for improvement in the space.

### Hydrogen in existing natural gas lines makes no sense.

Hydrogen embrittles hard steel. As a result, it's limited to roughly 20% of volume in European gas lines and about 4% in North American ones. However, its energy density by volume is much lower, as Paul Martin recently explained in *CleanTechnica*, so the actual energy that gets to the other end is a fraction of either the 20% or the 4%. This isn't a case of cutting 20% or 4% of CO2 emissions from the use of natural gas, it's a case of cutting a tiny handful. It's greenwashing.

### Piping pure hydrogen into homes makes no sense.

As Martin explains, hydrogen requires 3x the power to move hydrogen as natural gas. Hydrogen is also a much more finicky gas around electrical equipment as well. Basically, no existing pipelines are fit for purpose and any new ones are much more expensive. This means that ripping out all natural gas distribution lines and replacing them with more expensive hydrogen lines would be required.

Instead, induction stoves and heat pumps are the path forward. Electrical connections in homes are much cheaper and safer, electric appliances are much more efficient users of renewable electricity than turning it into hydrogen and there are no commercially available hydrogen appliances. SGN in Scotland is going to fail miserably to convert a town to hydrogen in its attempt to find a reason for its continued existence, but it's last-ditch flailing. Gas utilities are going to go the way of the dodo bird, not convert into H2 utilities.

**Shipping hydrogen as an energy store between countries makes no sense.**

HVDC transmission of electricity is going to be the dominant energy pathway. There's already a major solar farm being constructed in Australia which will ship its electrical generation to Singapore using underwater HVDC cables, a distance of some 4,400 kilometers. Northern African solar could cross the Mediterranean incredibly cheaply underwater or strung under the 15 July Martyrs Bridge at the Bosphorus Strait. China has seriously proposed a global HVDC grid.

Compressing flammable physical substances and putting them on ships has a limited runway. Global LNG shipping is already running into major headwinds, so there's no future for global hydrogen shipping.

**Hydrogen for ground transportation has already lost.**

Hydrogen cars are dead on arrival, having been vastly outcompeted by electric cars. Hydrogen buses failed, and battery electric buses are dominant. Tesla is in the S&P 500 and Nikola has been determined to be a complete sham. Every form of wheeled road vehicle is going to be battery electric, not hydrogen.

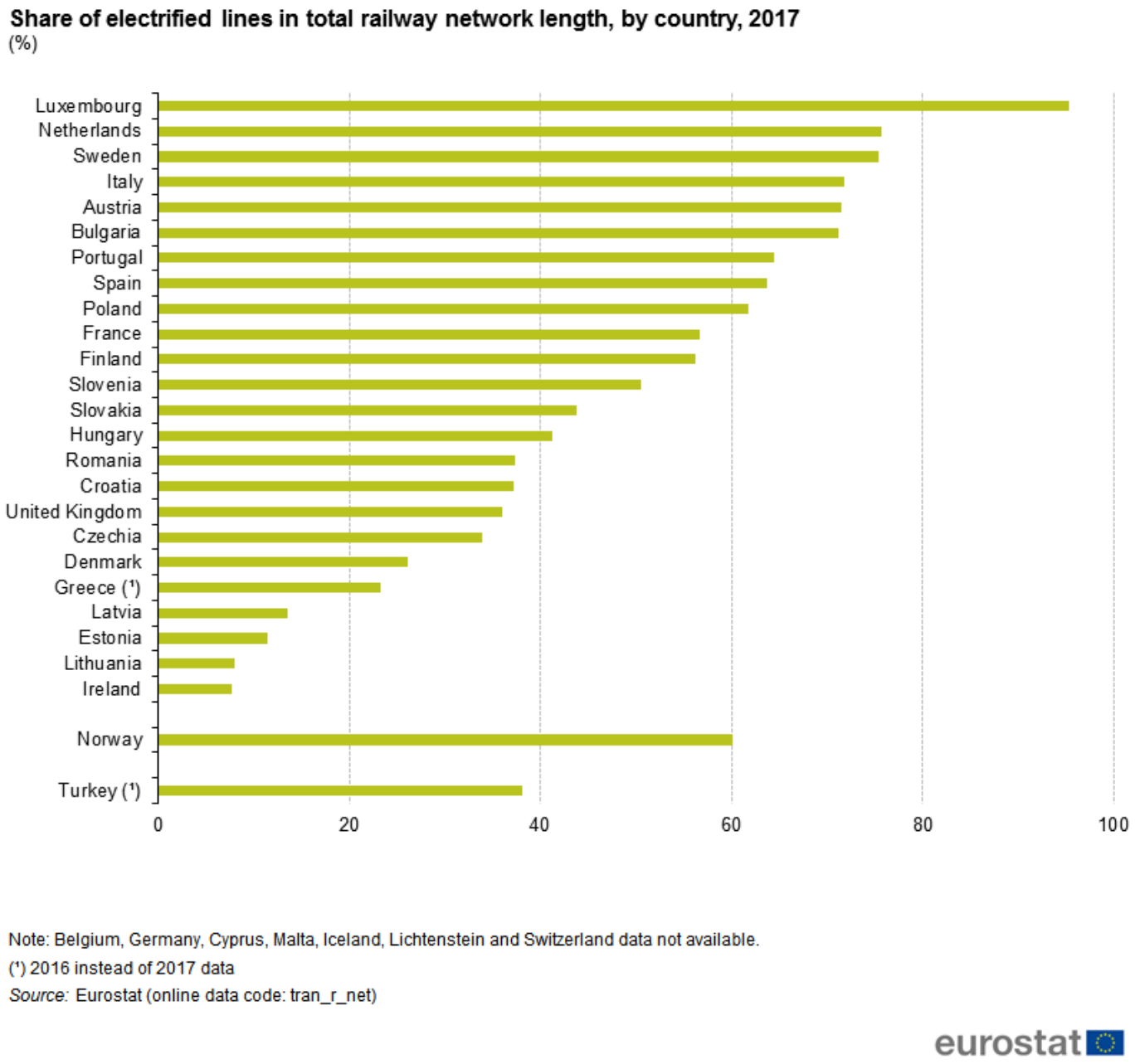



Chart courtesy EU

Rail is vastly electrified already. Every urban rail system, the vast majority of

regional rail systems, all high-speed passenger trains, and a great deal of freight rail is already electrified with grid electricity. 30,000 kilometers of high-speed rail in China are fully electric, with another 8,000 pending. Hydrogen fans like to point to a hydrogen train running in Europe, but ignore the vast numbers of fully electric trains that already exist, and the strong growth of battery electric trains. It's trivial to add a freight car or three full of batteries behind a locomotive when freight trains run up to 2.8 kilometers long already.

Hydrogen fuel cell forklifts represent <1% of the global forklift market and battery electric models dominate and will continue to eat market share from diesel.

There are some claims that a place for hydrogen drivetrains in ground transportation is for heavy vehicles with very heavy load cycles, ones that run 24/7 or close to it. I'm personally not seeing it with high speed charging, but there's a small chance that a segment of the market might exist. That's something to be skeptical about, but open to at least the possibility that it might be viable.

## Why Are Governments Getting Behind Obviously Failing Hydrogen Economy Models?

*CleanTechnica* reported on a major study out of Europe which shows clearly where the impetus is coming from: fossil fuel industry lobbying and PR efforts. This is clear to every rational observer of the effort. Gas utilities such as Fortis in BC and SGN in Scotland are trying desperately to find a reason to continue to exist. Fossil fuel companies want to sell more and more fossil-fuel sourced hydrogen with the pretense that the massive CO2 emissions related to it will be captured and sequestered, a model known as 'blue hydrogen'.

Let's look at some numbers though. Every kilogram of hydrogen created with steam reformation of natural gas has 8-12 kilograms of CO2 emitted. Coal gasification creates 18-20 kilograms of CO2 for a kilogram of hydrogen. There's nowhere to store that CO2. A kilogram of hydrogen is the equivalent of a gallon of gasoline, which creates 9 kg of CO2 when burned. The fossil fuel industry wants to replace diesel, gasoline, and natural gas with hydrogen, which is just as carbon intensive.

There are no industrial processes that need that CO2. Globally, carbon capture and sequestration projects are funded by the fossil fuel industry to provide social license for their continued ability to operate, and barely scratch the surface of their emissions. The best carbon capture and sequestration facility in the world results in 25x the CO2 emissions as the CO2 as sequestered, and the CO2 is only captured because it's present in the natural gas they pump out and Norway has provided about $1.7 billion in tax breaks to not just vent it. The fossil fuel industry spends about 0.03% of its annual revenue on carbon capture. All the money spent on carbon capture would have had much greater CO2 reduction emissions if spent on wind and solar instead. The vast majority of carbon sequestration is for enhanced oil recovery, resulting in 2-3 times the CO2 emissions with net extraction and burning.

That's 'blue hydrogen'. It's just as black and dirty as oil, gas, and coal. It's failing coming out of the box. The current push for a 'hydrogen economy' is just more of the fossil fuel industry trying to perpetuate itself.

## So What Should CleanTechnica's Policy Be For Reporting On Hydrogen?

- Strong on displacement of fossil-fuel sourced hydrogen for existing industrial uses with green hydrogen powered by renewables.

- Strong on new industrial uses that displace high-CO2e intensity processes such as steelmaking from iron ore.
- Open to but somewhat skeptical about long-haul aviation.
- Open to but somewhat skeptical about long-haul oceanic shipping.
- Deeply skeptical about everything else in the hydrogen space.
- Never reference the 'hydrogen economy' without quote marks indicating its intentional use in the 2020s as a PR item.
- Never reference 'blue hydrogen' without quote marks and a phrase indicating that it's a greenwashing term used by the fossil fuel industry.

There's a $120 billion global hydrogen industry that we have to kick the fossil fuel companies out of. 3-4% of global petroleum use is for long-haul shipping and aviation. About 8% of CO2e emissions globally are from steelmaking. That's more than enough for *CleanTechnica* to report on. Boosterism for hydrogen outside of those spaces is just perpetuating the wrong industry.



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