Green Hydrogen is Happening: How to Navigate the Hype

Understand the excitement around green hydrogen and the factors that contribute to its global success, now and in the future

Investors and stakeholders across the global energy, mining and infrastructure sectors have been barraged with a mixture of news and hype about the role of hydrogen in the ongoing energy transition. But significant questions remain in deciphering what can happen now versus the distant future, what has a home in the marketplace, what is financially lucrative and how investors can put capital to work. We have identified some of the key issues and analysed the interplay of proximity, policy, and production — drawing conclusions on where we see green hydrogen playing a significant role and presenting an attractive investment opportunity.

The rapid change of solar photovoltaics from “hippie dream” to one of the cheapest sources of electricity production is a good analogy for the complex interplay of geography, policy and technology in reaching various thresholds of “parity.” What makes hydrogen exceptionally interesting for investors today is the combination of significant simultaneous changes in technology, related costs, new applications and policies.

Hydrogen is Growing Across the “Rainbow”

A combination of industry and government are leading the charge for a new global energy mix that dramatically reduces CO_2 in a quest for net-zero greenhouse gas emissions. Hydrogen is at the forefront of many of these plans, with demand projected to grow over four times to almost 300MM tons by 2050[1], with applications spanning industry, transportation and energy storage. Evaluating the intersection of hydrogen applications, electricity cost, natural gas cost, geography, policy and infrastructure are paramount in making investing decisions. Clean Energy Ventures (CEV) has developed a total cost of production model, detailed in this report, to assess where green hydrogen could be used in industry and to inform investment opportunities.

Market Trends Raise Questions on How Investors Should Play the Market

There has been significant investor interest in supporting hydrogen development, with public market equity investment activity seeing inflows of approximately $4 billion (raised in 2021 YTD) compared to $2.7 billion (raised in all of 2020), and shares in fuel cell companies up over 300% in the last twelve months. This is not to say current publicly-listed companies are not and will not develop successful positions in the market; however, they represent only a small portion of the opportunity investors should be evaluating.

So, Where Will Green Hydrogen Grow Now, Later, or Never?

We believe green hydrogen (and its value chain) will be attractive for investment when used as a reactant to perform some type of chemistry – not simply as an energy carrier. We believe replacing steam methane reforming with green hydrogen and ammonia production from green hydrogen are both ripe for growth **NOW**. Decarbonizing steel, transportation fuel and methanol with green hydrogen will be viable within **10 YEARS or more**. Glass making and residential heating will likely **NEVER** be viable. There are expected to be additional niche applications for green hydrogen in distributed storage and transportation over the coming decades.

Research and data in this report is based on extensive internal research and investigation by Clean Energy Ventures, including evaluation of numerous external reports, expert interviews and detailed internal modeling. Information can be shared upon request.

About the authors

This paper is a joint publication of Clean Energy Ventures and Hannam & Partners.

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[1] IEA, Global hydrogen demand by sector in Sustainable Development Scenario, 2019-2070. Note: There are a range of estimates depending on assumptions and specific scenarios.

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Existing Hydrogen Markets

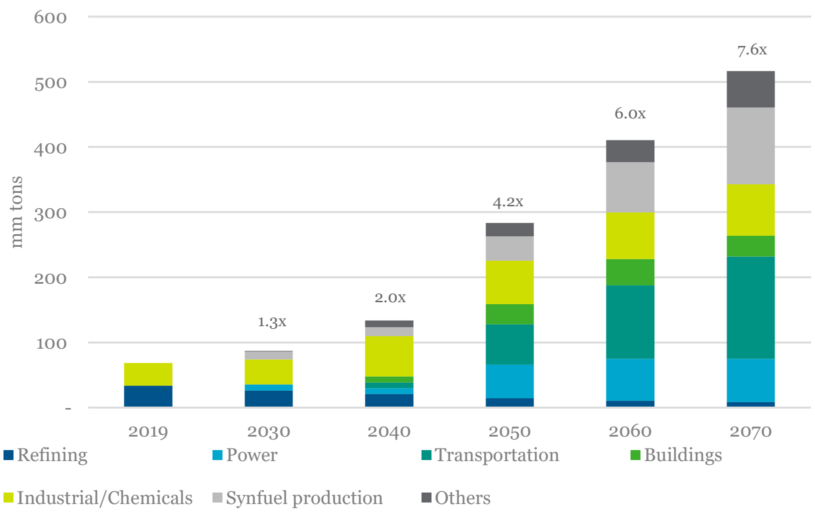
Incumbent hydrogen markets are relatively simple to describe. The vast majority of production comes from steam methane reforming (SMR) of natural gas. Primary uses include oil refining and fertilizer production. Relevant small niches exist for opportunistic utilization of hydrogen co-production from chlor-alkali processes (which use gigawatt-scale electrolyzers to make chlorine and sodium hydroxide, and off gas hydrogen as well) and from other locally cost-effective feedstocks, but other markets are small, fragmented, and have prices largely decoupled from production costs. The delivered costs for applications co-located (or attached by pipes) with SMR are extremely low and look very much like tolling natural gas prices.

A Framework for Investment

In the vision of the future hydrogen economy, hydrogen serves as the primary energy source for transportation, storage and industrial applications. Currently, hydrogen accounts for a negligible share of global energy consumption, primarily used as a process input in applications ranging from hydro-desulfurization in refineries to fertilizer production and metallurgy.

In 2018, approximately 119MM tons of hydrogen were produced, and production is expected to grow at a CAGR of 3.8%, reaching 148.8MM tons in 2024. Globally, around 80% of hydrogen is produced directly from natural gas and other hydrocarbons by various thermal, electrolytic, and photolytic processes. Hydrogen demand is expected to double by 2040 and see five-fold growth 40 to 50 years from now. Decarbonization of existing SMR hydrogen production would be a significant additional investment opportunity.[2]

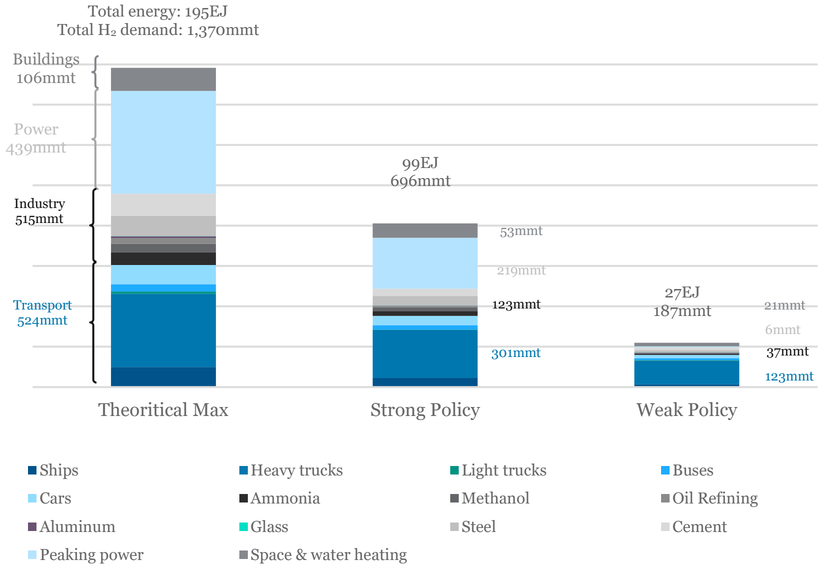
Global Hydrogen Demand to See 4x Growth by 2050, with Over 50% of Demand Coming from Transportation, Synfuel and Industrial Sectors



Source: IEA, Global hydrogen demand by sector in the Sustainable Development Scenario, 2019-2070. IEA, Energy Technology Perspectives 2020

[2] McWilliams, Andrew. Ref EGY055E, BCC Research, 2019, *Global Hydrogen Economy: Merchant Hydrogen and Hydrogen Purification Technologies.*

Potential Demand for Hydrogen in Different Scenarios, 2050



Source: BloombergNEF Hydrogen Economy Outlook, March 30, 2020.

In 2018, approximately 63.1MM tons of hydrogen, or 53% of the total production, was consumed by ammonia production. The second largest consumer of hydrogen was the refining industry with about 20% of the global consumption. Methanol production (7%) along with other various chemical and metallurgical applications (20%) consume the remaining available hydrogen available.[3]

Segmenting the industrial hydrogen market into captive, by-product, and merchant hydrogen is important in understanding how the hydrogen is used:

- **The captive segment** is the largest hydrogen segment (49.0% by mass) and includes all hydrogen produced on-purpose for self-use by the producing entity.
- **The by-product segment is the second largest segment**, which accounts for 43.8% of the hydrogen market and consists of the hydrogen produced as a by-product from other industrial processes, such as chlorine production or caustic soda production through hydrolysis.
- **The merchant segment** includes hydrogen produced at a central production facility and transported and sold to a consumer by a bulk tank, pipeline or cylinder truck. The merchant segment accounts for the remaining 7.2% of the market.

Global investments in building the hydrogen economy were more than $14.8bn in 2018, with investments expected to grow with a CAGR of 13.8%, reaching $31.7bn by 2024. For reference, global investment in upstream oil and gas in 2019 was $483bn, so hydrogen investment remains small, but growing at a significant rate.[4]

Increasing the green hydrogen supply and electrochemical conversion have been the largest segment of investments in the hydrogen market and are expected to be the main area of focus over the next five years.

[3] McWilliams, Andrew. Ref EGY055E, BCC Research, 2019, *Global Hydrogen Economy: Merchant Hydrogen and Hydrogen Purification Technologies*. (Continued in sub-bullets below).
[4] *IEA World Energy Investments 2020*

To build a significant position in the market, we believe there needs to be an investment framework, which to be successful will address 1) geography; 2) feed costs, such as natural gas and electricity; 3) infrastructure, such as pipes and transmission; and 4) policy, such as tax and mandates. Applying this framework thoughtfully will show that now (or soon), green hydrogen can "win" in applications such as:

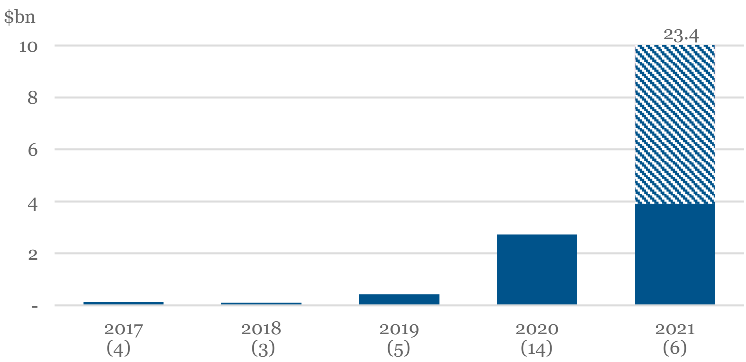
- Steel making in select Asian markets based on new direct reduction of iron ore
- Ammonia production in the EU
- Desulfurization in refineries in the EU
- Trucks in Switzerland due to aggressive tax policy

Green hydrogen is much less likely to "win" for:

- Anything near the Houston shipping channel without decarbonization mandates (sequestration of carbon from SMR is more likely)
- Glass production
- Domestic or industrial heating
- Light vehicle transport without mandates

We have seen significant investor interest in finding niches in today's markets to support hydrogen development. Public market investment activity alone has seen significant growth with almost $4bn raised in 2021 (YTD).

Equity Capital Raising Are Growing Significantly for Hydrogen-focused Companies (No. of Deals)



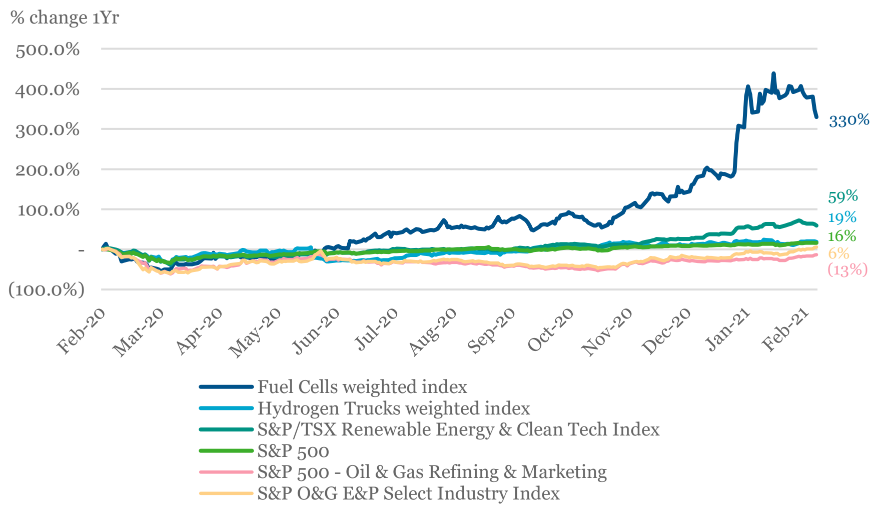
Much of Capital Being Raised has Come Through SPAC Transactions

Date	Name of SPAC	Acquisition	Capital raised ($mm)	Hydrogen Sector
9-Feb-21	Decarbonization Plus Acquisition	HYZON MOTORS	626.0	Trucks and buses
13-Oct-20	AMCI Acquisition	ADVENT	158.3	PEM fuel cells
8-Jun-20	HL Acquisitions	FUSION FUEL	70.0	Green hydrogen production
3-Mar-20	VectoIQ Acquisition	NIKOLA	700.0	Hydrogen-EV
		Total	**1,554.3**	

Source: S&P Capital IQ, as of 17 February 2021. 2021 estimate was projected assuming capital raised continues at Jan-Feb pace for the rest of the year

The "pure play" hydrogen companies that are listed on the public markets have also seen share prices skyrocket as the combination of growth prospects and scarcity of supply drive investors towards the opportunities at hand.

Total Performance of Hydrogen-Focused Companies vs the market



Note: Fuel Cells' constituents include Plug Power, FuelCell Energy, ITM Power, Bloom Energy Corp., Nel ASA, Ceres Power, Doosan Fuel Cell, Beijing SinoHytec, PowerCell Sweden, and Everfuel. Hydrogen Trucks constituents include Cummins Inc, Nikola Corp., and HYZON Motors.
Source: CapitalIQ as of 17 February 2021

Share prices of companies in the industry have soared in the past year, driven by the rising adoption of zero-emission vehicles, a deadline set by many countries to go carbon-neutral by 2050 and lately US President-elect Joe Biden's support for clean energy.

There's an uptrend in the number of listed hydrogen related companies around the world. While a lot of focus has been on hydrogen's role in the automotive sector, its usage is growing far beyond that, including energy storage and industrial sectors. However, this only addresses a small portion of the hydrogen market. The total market cap of all hydrogen related companies is around $1.4tn with the largest company (i.e., Plug Power) having a market cap of only $25bn. Cummins' acquisition of Hydrogenics in 2019 for an enterprise value of $290mm was the only notable industry M&A activity.

But, for investment to really take off and be sustainable for the long term, investors need to make judgements on future policies, future commodity prices, technology deployment and technological advances. Recent history in the solar PV industry has shown that the European Union (and its members) is willing and able to implement policies that force parity between "dirty", low-cost technologies and "green" ones that cost two or three times as much. The European Commission's 2030 Hydrogen Strategy published last summer was an important step in putting the policy framework in motion.

Learning curves can also accelerate by more than a decade due to Chinese industrial policy. Natural gas and other commodity prices can and will swing wildly (gas at Henry Hub from $2/MMBtu to $13/MMBtu, for example) over the design life of an SMR installation, so it is therefore both impossible to ignore the opportunity in green hydrogen or the real risks of any project or initiative failing completely.

Usually, this uncertainty freezes investment, but it can also create the conditions for large returns. We have laid out our view of the market, our guiding principles to frame "what you must believe will happen" for green hydrogen to potentially be a good bet and the subsectors we feel are ripe for investment.

The Hydrogen Rainbow

Grey, blue and green are names prefixed to "hydrogen" to distinguish the methods of hydrogen production by their greenhouse gas (GHG) impact.

Grey Hydrogen

Before it was called "grey hydrogen", the under-$1/kg (at current natural gas prices on the U.S. Gulf Coast) output of steam methane reforming (SMR) was simply called "hydrogen." In this process, all the carbon that was in the methane is vented as CO_2. The EU has made it clear that it intends to end this practice.

Blue Hydrogen

If the CO_2 generated in SMR is captured, the hydrogen produced is called "blue hydrogen." Technically, CO_2 from this relatively pure waste stream is among the easiest to capture and can be done using proven technologies on the industrial scale. The costs are difficult to estimate, but separation is often quoted as $20-$40/ton of CO_2. One issue which remains poorly elaborated is where to put the CO_2 after separation. There are demonstration projects and tax incentives to place the CO_2 from blue hydrogen production into beverages and old oil fields, especially if located in the U.S. Gulf Coast where there is ample nearby injection opportunity. It is, however, fraught with risks. Conversion to fuels or other products (so-called "carbontech") are desirable sequestration options but not technically advanced.

Green Hydrogen

"Green hydrogen" describes hydrogen produced from electrolysis of water with renewable electricity. Mature electrolyzers running as little as half the time (we even modelled as low as 20% capacity factor) have hydrogen production costs dominated by electricity costs, so economic viability will be driven by the location of renewable power and alternative market opportunities. For example, tenders for gigawatt-scale photovoltaics near the equator are based on sub-$15/MWh costs of electricity, while commercial electric rates in Germany are well over $100/MWh and require a premium for renewable electricity (a firming premium).

Current capital investment projections for large alkaline electrolyzers are well-founded because they are only slight modifications to mature chlor-alkali plants. Projections for other technologies such as polymer electrolyte membranes (PEM), a.k.a. proton exchange membranes, presume learning and an n^{th}-of-a-kind plant. Development of new technologies such as these is often fraught with plateaus in learning and deployment-stalling if short-term economics of more-costly early plants are worse than planned for. On the other hand, since energy feed costs dominate production costs, one can make fairly well-reasoned projections about future costs of green hydrogen. A wide array of analysis seems to be converging on $2/kg as likely and sufficient to win.

Applying the framework above, we've considered the most impactful assumptions an investor would need to believe to be true in the future in order to deploy capital for PEM electrolysis producing green hydrogen. These assumptions include:

- SMR without carbon capture and storage will be banned or prohibitively expensive in key markets (EU, U.S., Japan)
- SMR with high-purity carbon capture and storage will cost more than $2/kg
- Scaled electrolysis will be technically credible, low-cost, safe and reliable, and near $2/kg based on access to off-peak, low-cost renewable electricity including transmission and other costs (less than $30/MWh)

Or:

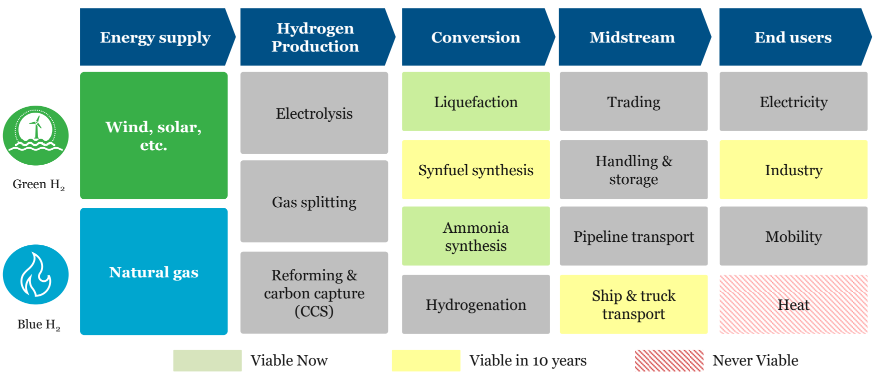
- We will see a carbon pricing in the range of $40 to $60/ton
- We will see demand in locations geographically far from access to low-cost natural gas, but with access to low-cost renewables

Or, various combinations of the above.

The Promise of Green Hydrogen

Green Hydrogen Scenarios

CEV has developed a total cost of production model for several scenarios where green hydrogen could be used in industry and have concluded that green hydrogen is viable only when used as a reactant in certain chemical processes. Influencing factors were found to be a combination of electricity cost, natural gas cost, geography, policy, and infrastructure. Under our assumptions and without incentives, there were no viable cases found for green hydrogen when hydrogen was used primarily as an energy carrier (i.e., for heat).



Source: Uniper, with additional analysis from CEV and Hannam & Partners

Viable Applications Now

Replacing SMR with Green Hydrogen

Grey hydrogen is produced through SMR, accounting for 77% of 11.4MM tons of hydrogen produced by SMR in 2018[5]. Our projections indicated that regions with high natural gas costs, such as Europe, could have lower electrolysis costs than SMR costs with no price on carbon, thus attaining cheaper green hydrogen than grey hydrogen.

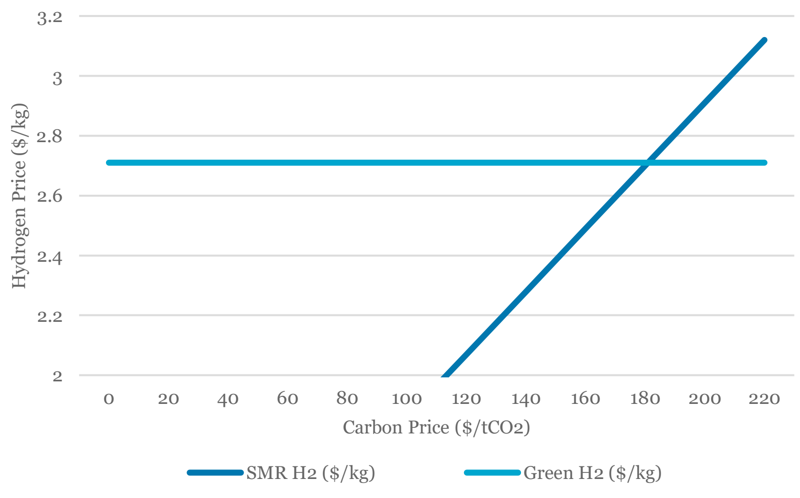
Large companies have started to announce projects to produce and utilize green hydrogen in their refineries. Two examples include:

- BP and Orsted launched the Lingen Green Hydrogen project (Nov 2020) to build an initial 50 MW electrolyzer at BP's Lingen refinery in north-west Germany, utilizing power generated by Orsted's offshore wind farm in the North Sea, with the project initially replacing 20% of natural gas-based hydrogen used at the Lingen refinery.

- Repsol and Saudi Aramco are building a 10 MW electrolyzer combining green hydrogen with CO_2 emissions from the refinery to produce 3.6MM litres a year of synthetic fuels.

However, other refineries across the globe have responded to pressure from low margins by taking significant steps to optimize SMR plants in order to reduce the costs associated with their hydrogen supply. Nonetheless, even with optimized plants and low costs, replacing grey hydrogen produced by SMR with green hydrogen could be possible through policy. When considering the U.S. Gulf Coast, which has very low-cost natural gas, a price of about \$180/tCO_2 was needed to make green hydrogen price-competitive with grey hydrogen.

H_2 Production Costs Using SMR vs. Electrolysis Under Different Carbon Prices (U.S. Gulf)



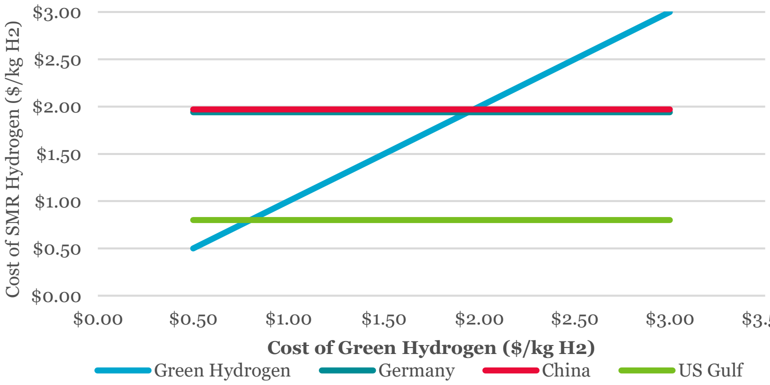
Source: CEV internal analysis. Assuming no carbon price in the immediate future and based on a price of SMR-based H_2 today and reasonable future price of electrolysis in the U.S. Gulf Coast. In our projections, countries like Germany will have electrolysis costs lower than SMR so carbon price will have no effect.

[5] IEA, 2019, *The Future of Hydrogen Report: Seizing Today's Opportunities.*

Ammonia Production from Green Hydrogen

Since ammonia production uses primarily grey hydrogen from SMR, the competitiveness of green hydrogen in ammonia production varies based on regional natural gas cost. In the U.S. Gulf Coast region, the cost of green hydrogen from electrolysis would need to compete with the cost of grey hydrogen from SMR, which is approximately $2/kg H_2 after transportation costs. China and Germany's SMR hydrogen costs are over double that of the U.S. Gulf Coast region, due to high natural gas prices. Therefore, it is plausible that the electricity costs required to produce green hydrogen for ammonia production in Germany could be low enough to compete with grey hydrogen. China, as an outlier, still relies heavily on cheap gasification of coal for hydrogen production and would need to abandon this path.

Cost of Hydrogen from SMR vs. Cost of Green Hydrogen



Source: CEV internal analysis.

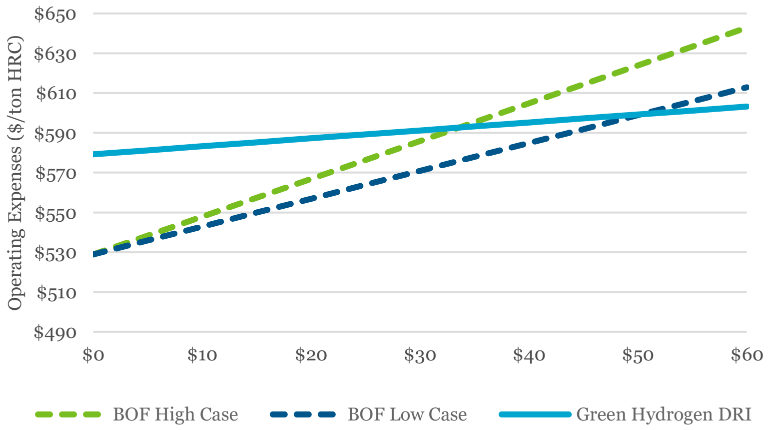
Viable Applications in 10 Years

Decarbonized Steel

Steel-making is another industrial application of green hydrogen. While a carbon-neutral steel industry will likely involve a host of decarbonization methods, hydrogen could play a role. Companies such as Fortescue and SSAB have developed technologies to replace coal with hydrogen today. One technology that could be a large consumer of hydrogen in steel-making is direct reduced iron (DRI). DRI is formed from the direct reduction of iron ore pellets using natural gas or hydrogen as the reductant. A case study on the Dutch steel industry[6] led CEV to a price range of $35 to $50/t$CO_2$ needed to make DRI with green hydrogen competitive in the regions on an operating-cost basis. In 2019, the average price of CO_2 in Europe was about $30/ton, and Germany has already announced prices in the ranges of $60 to $70/ton after 2026.[7] One-hundred percent hydrogen-based steel is unlikely in the near term because of the energy requirements and lack of electrolysis plants capable of supplying hydrogen to hydrogen-based steel mills. However, this case study does provide the pathway to decarbonized steel in the foreseeable future that other major players in the industry, such as China, could adapt.

[6] "Decarbonisation options for the Dutch steel industry", PBL Netherlands Environmental Assessment Agency; The Hague, 2019
[7] 2020, 18 Dec, et al. "Germany's Carbon Pricing System for Transport and Buildings." *Clean Energy Wire*, 8 Jan. 2021, www.cleanenergywire.org/factsheets/germanys-planned-carbon-pricing-system-transport-and-buildings.

Dutch Steel Operating Cost vs Carbon Tax

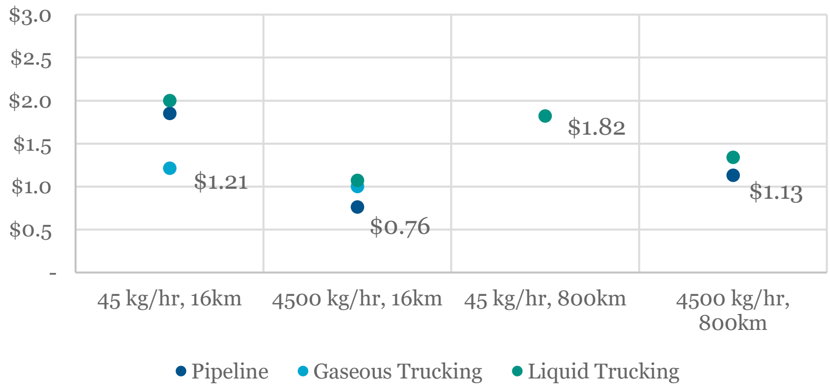


Source: CEV internal analysis based on Decarbonisation options for the Dutch steel industry", PBL Netherlands Environmental Assessment Agency; The Hague, 2019.

Green Hydrogen for Transportation Fuel

Adjusting the breakeven price between green hydrogen and diesel at the pump to a commercially viable range will require policy intervention. When simply moving hydrogen, pipelines are best for high volumes. For short distances and low volumes, gaseous trucking is typically preferred. For long distances and low volumes, liquid trucking is the most efficient. In December 2020, Kawasaki Heavy Industry announced[8] a Memorandum of Understanding (MOU) with both Fortescue and Iwatani to increase the supply of clean energy through the establishment of liquified-hydrogen supply chains. Under the MOU, green liquified hydrogen will be distributed in Japan after being produced from renewable electricity sources in Australia, such as solar and wind. Most recently, Hyzon Motors (a global supplier of zero-emissions hydrogen fuel cell powered commercial vehicles) announced[9] the merger with Decarbonization Plus Acquisition Corporation, a special purpose acquisition company (SPAC), alongside a $400mm Private Investment in a Public Enterprise (PIPE) investment. Hydrogen Refueling Solutions, a French company specializing in hydrogen refuelling stations, also went public in Paris raising €97.3 million including €73.6 million in new shares.[10]

Combined Storage & Transportation Costs (2019, $/kg)



Source: CEV internal analysis.

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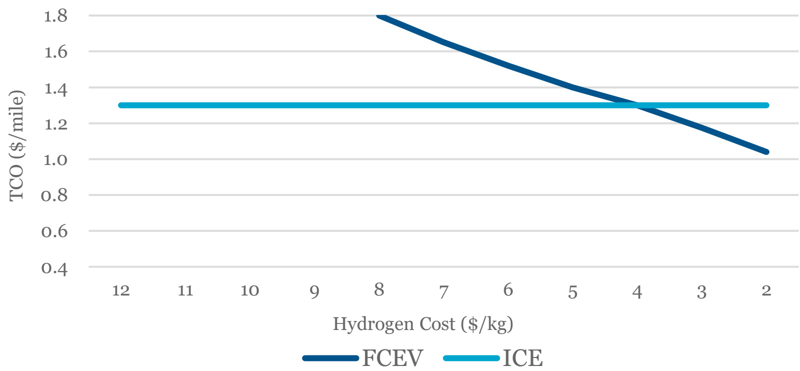
[8] "News & Events." *Kawasaki Heavy Industries, Ltd.*, 14 Dec. 2020, global.kawasaki.com/en/corp/newsroom/news/detail/?f=20201214_7696.
[9] Adler, Alan. "Hyzon Motors to Get $570M from SPAC Backing Fuel Cell Technology." *FreightWaves*, 9 Feb. 2021, www.freightwaves.com/news/hyzon-motors-to-get-570m-from-spac-backing-fuel-cell-technology.
[10] "AP Ventures Participates as Cornerstone Investor in Hydrogen-Refueling-Solutions' (HRS) IPO on Euronext Growth Paris." *AP Ventures - News*, apventures.com/news/ap-ventures-participates-as-cornerstone-investor-in-hydrogen-refueling-solutions-hrs-ipo-on-euronext-growth-paris.

When hydrogen is used to enable transportation at the pump, there's about $2 to $3/kg of additional cost for hydrogen fuel station customers over the diesel status quo. While we expect the value generation at the pump to decrease in the next several years, Switzerland was able to use policy to tax diesel and heavy goods vehicles, resulting in a competitive breakeven price for hydrogen in the country. Such technology enablement through policy is encouraging.

Break-Even Prices of Hydrogen at the Pump



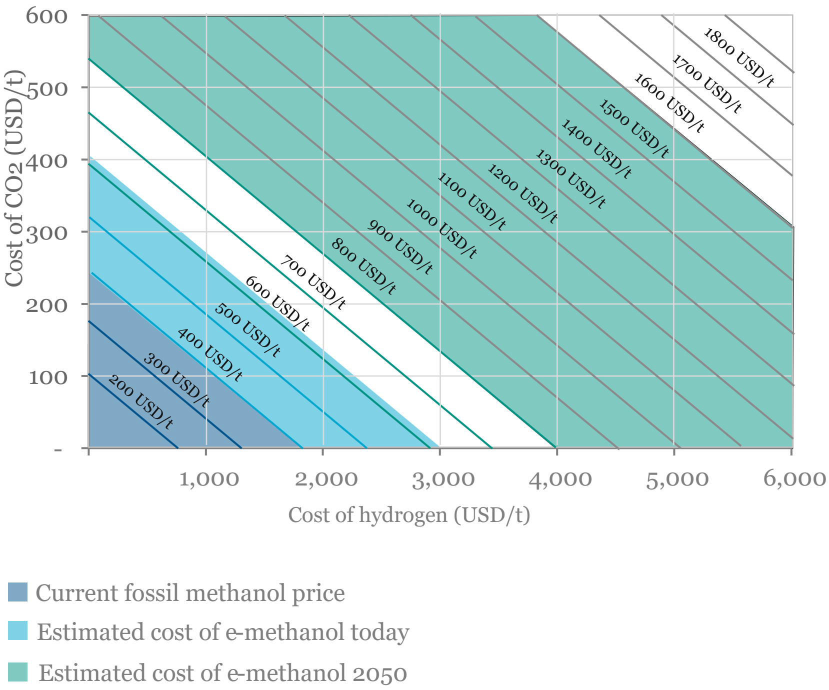
Source: CEV internal analysis.

Methanol with Green Hydrogen

Replacing traditional or "brown methanol" with green methanol seems more challenging in the near future. Around 98 MM tonnes[11] of methanol are produced annually and serve as a key input in the chemical industry to produce formaldehyde, acetic acid, and plastics. On a comparable basis, the cost of green methanol is at least three times the cost of brown methanol across all regions.[12] Green methanol's cost is largely due to the electricity cost associated with green hydrogen production and the need for a large compressor used in the process. Policy could make the costs comparable, but it seems unlikely that policy can make a significant impact within the next five years. Liquid Wind, the Swedish company, announced plans to establish several plants by 2030 which combine green hydrogen with captured CO_2 to produce green methanol, further suggesting the window for green hydrogen and methanol is not in the current decade.

[11] IRENA AND METHANOL INSTITUTE, 2021, *Innovation Outlook: Renewable Methanol, International Renewable Energy Agency.*
[12] IRENA AND METHANOL INSTITUTE, 2021, *Innovation Outlook: Renewable Methanol, International Renewable Energy Agency.*

Cost of Methanol as a Function of Hydrogen and CO_2 Cost



Source: Recreated from IRENA AND METHANOL INSTITUTE, 2021, *Innovation Outlook: Renewable Methanol, International Renewable Energy Agency*.

We'll say it: Never Viable Applications

Glass with Green Hydrogen

Green hydrogen could act as the heat source in glass-making processes, delivering the extreme heat required to achieve molten glass. However, the efficiency of heat transferred by hydrogen combustion is far less than the heat transfer efficiency delivered by an electric furnace. As a result, green hydrogen furnaces in the glass industry cost about 35 percent more than both electric or natural gas furnaces. We believe hydrogen furnaces are unlikely to compete in this space and renewable electricity will be more competitive than using hydrogen.

Residential Heating from Hydrogen

Moving to 100 percent residential heating using hydrogen is simply infeasible for both cost and safety reasons, not to mention the lower energy density compared to natural gas. Mixing less than 20 percent hydrogen by volume could be viable with no significant risks associated with the gas blend in end use or infrastructure modification instances. Cost viability with mixing hydrogen will vary based on proximity to a natural gas source. There is also a significant regulatory risk associated with residential heating with hydrogen due to safety concerns; the likelihood of a pipeline fatality increases non-linearly as the fraction of hydrogen in a gas pipeline increases.[13] After considering regional cost differences and safety concerns, it seems unlikely that hydrogen will be used to supply residential heat in the near future. Instead of pursuing hydrogen as fuel for directly heating homes, companies such as Siemens intend to use liquified green hydrogen to

[13] Khalil, Ph.D. Sc.D., Y. (John) F., "Hydrogen safety considerations for the power-to-gas (P2G) conversion process", *United Technologies Research Center*, Nov 4 2019, cslforum.org/cslf/sites/default/files/documents/Chatou2019/Khalil_Hydrogen-Safety-for-the-Power-to-Gas-Conversion-Process.pdf

store energy, which could then be converted to electricity using a hydrogen-ready turbine and offer a competitive option to electro-chemical storage.

Predicting the Future

Predicting the future of green hydrogen with certainty is challenging.

There are several scenarios where we found that the gap in high natural gas and lowering electricity prices could lead to economically viable green hydrogen when used in an application requiring active hydrogen chemistry. Policy has proven it can make green hydrogen cost-competitive with supportive infrastructure in place, but policy can be a very fickle tool on which to base investment decisions.

The framework outlined in this paper can be useful for understanding how the green hydrogen market could develop. The examples chosen attempt to clearly illustrate each component in the green hydrogen framework at a high level; in practice, these interactions in the framework can be coupled with many other variables that could impact an investment decision both on a local and global level. In order to make a good investment decision there are still other significant factors that should be considered, including, but not limited to, specific technology, location, policy landscape, scale and use-case. In particular, Clean Energy Ventures is continuously evaluating new electrolyzer technologies that could have favorable impact on the cost of production over the next decade.

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