ESG
Thematic Research
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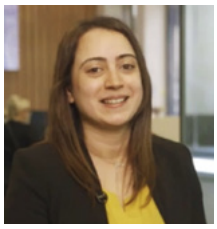
Clean hydrogen:

Opportunities beyond the hype



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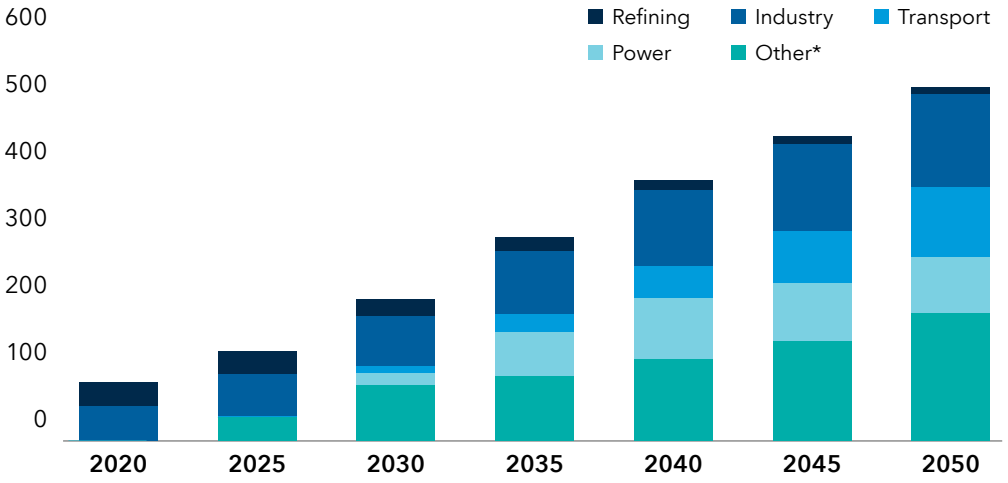
Key takeaways

- Blue and green hydrogen are poised to play a major role in decarbonizing heavy industry, supporting electrification and enabling more sustainable economic growth.
- The U.S. Inflation Reduction Act is a game-changer that should unleash a wave of capital expenditure, lifting supply and demand for clean hydrogen.
- The pace of decarbonization will be dependent on upgrading power grids and other advances. Low-cost renewable energy will be vital for clean hydrogen solutions to become cost-competitive with fossil fuels.
- Disruption among steel producers, commercial vehicles and generally across the energy complex are three areas of potential fertile ground for selective investors who can take a long-term view.

What is net zero? Put simply, it refers to a status where the amount of human-produced greenhouse gas (GHG) emissions is balanced by an equal reduction. Countless companies, industry bodies and over 150 countries have committed to, or are considering, net zero targets. Clean hydrogen is expected to play a crucial role in net zero efforts.

Global hydrogen demand is expected to more than double by 2030 in a net zero scenario



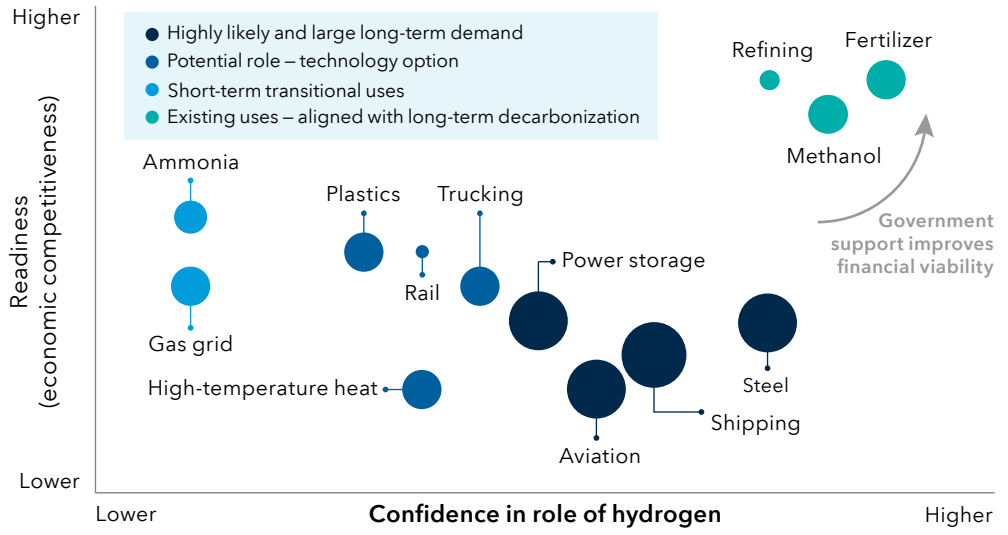
*Other includes ammonia, grid injections, buildings, NH_3 – fuel and synfuels.
Source: International Energy Agency. 2020 actual, 2025-2050 based on net zero scenario estimates, as of October 2021.

Why is hydrogen important for the energy transition?

Hydrogen can be used as a carrier of energy, and as an input into chemical and industrial processes. Clean hydrogen is, therefore, a crucial decarbonization tool for a range of industrial activities including steel, aluminum, iron and chemical production. We also see it as an option to decarbonize commercial transportation, and, notably, the energy and utilities sector.

Significant demand will likely initially come from today's users of grey hydrogen (see hydrogen rainbow on next page), such as oil refiners and chemicals producers. But as the world progresses toward net zero, that usage could eventually be overtaken and then dwarfed by growing demand from heavy industry and energy storage.

Steel, transportation, chemicals and power storage are likely to be sweet spots for clean hydrogen adoption



Source: SYSTEMIQ analysis for the Energy Transitions Commission 2021.
Note: Readiness refers to technical readiness, economic competitiveness and ease of sector use. High-temperature heat refers to industrial heat above 800 degrees centigrade. Current hydrogen use in refining is higher due to oil consumption.

The hydrogen rainbow

Grey	Brown	Blue	Green
This is currently the prevalent form; produced using fossil fuels – primarily steam methane reforming (splitting natural gas).	Produced via coal gasification (basically, heating coal to above 700°C, without combustion, alongside oxygen or steam).	Grey or brown production where the carbon dioxide is captured and permanently stored (carbon sequestration), significantly lowering net emissions from production.	Produced by electrolysis – separating water molecules into hydrogen and oxygen – using electricity that is generated by renewables or nuclear power.

The Inflation Reduction Act of 2022 looks set to be transformational. I expect we will see very large amounts of capital allocated to blue hydrogen (and green hydrogen) over the next five years."

– **Doug Upton**
Equity Investment Analyst

The Inflation Reduction Act is a game-changer

Clean hydrogen is only produced in small quantities today, but times are changing. Clean energy legislation and government financial support for hydrogen projects will help to establish infrastructure and to meet the high cost of transitioning away from existing fossil fuel solutions.

In the past decade, governments in Europe and Asia have mostly led the way – but now the U.S. is joining the party. The $369 billion clean energy spending package included in the Inflation Reduction Act will be transformational in both the U.S. and beyond.

Signed into law in August 2022, this landmark legislation includes massive clean energy-related financial incentives for individuals and businesses. Crucially, clean hydrogen supply and demand should be boosted by a 10-year production tax credit, an investment tax credit for energy storage technologies and a new tax credit for hydrogen fuel cell (and battery-powered) commercial vehicles.

The new measures come on the heels of the $8 billion earmarked in the 2021 Infrastructure Investment and Jobs Act for creating regional hydrogen hubs.

Hydrogen's role in the energy transition is still nascent, but has the potential to be a crucial aspect that will work hand in glove with electrification. Hydrogen can serve as a fuel for areas of the economy that are hard to decarbonize, like steel production and trucking. Furthermore, hydrogen offers another way to store energy in much larger capacities for industries such as long-haul transport where current battery technology has limited the adoption of electric vehicles.

Clean hydrogen can be labeled as blue or green within the hydrogen rainbow, an informal naming convention that connotes the relative greenhouse gas emissions arising in production.

"Everyone's focused on the explicit clean energy hydrogen subsidy, but the 70% jump in the carbon sequestration tax credit may prove even more consequential," says equity investment analyst, Gideon Spitzer. This specific credit is increasing from $50 per metric ton of stored CO_2 to $85 per metric ton. "In effect, blue hydrogen projects have now become financially viable as carbon sequestration becomes a cost-competitive technology on an after-tax basis."

We note that in several countries across Europe, explicit carbon price and taxing schemes have been deployed in an effort to help incentivize investment in alternative energies, including green hydrogen.

Three disrupted areas that we're keeping a close eye on

1. Cost-effective "green" steel is on the long-term horizon

The steel industry has relied on carbon-intensive industrial processes for production and is hard to decarbonize. Historically, steelmakers have used the blast furnace-blast oxygen furnace method (BF-BOF) which uses coal to "reduce" the iron ore and remove oxygen before it is converted into steel.

Steelmakers have, however, developed a new method whereby only hydrogen and renewable energy are required. With this approach, iron ore is reduced with green hydrogen in a direct reduced iron (DRI) plant. The iron is then sent to an electric arc furnace (EAF) and steel is produced in a process powered by renewable energy. In this way, the use of fossil fuels can (in theory) be eliminated and the production of steel generates no carbon dioxide (CO_2).

Use of green hydrogen in the DRI-EAF process is unlikely to be deployed at scale before 2035. Current economics, including the upfront capital required to transition the production process, are not that favorable.

Over the short term, consumers of steel will therefore need to be comfortable paying a premium for green steel. Demand is likely to come from customers such as automakers and infrastructure providers who increasingly wish to source CO_2-free steel to bolster the green credentials of their products.

"The tragic war in Ukraine continues to disrupt global energy supply," says equity investment analyst, Doug Upton. "In Europe especially, the need to decarbonize has been painfully underscored. One silver lining is that European governments are committing serious capital to funding green hydrogen projects."

There are already several pilot programs underway to further develop green hydrogen technology in steel production. Steelmakers in countries across parts of Europe, Asia and Canada have greater access to competitively priced renewable energy, and these countries will likely lead as hubs for green steel.

The potential benefits of using clean hydrogen to produce green steel come with costs and challenges

	Potential CO_2 reduction	Incremental production costs	Commercial horizon	Advantages	Challenges
BF-BOF with carbon capture	↓ 30%	↑ 30%-50%	5-10Y	Straightforward integration; benefits from extensive R&D	Large infrastructure investment for storage; difficult to capture all CO_2 emissions
BF-BOF with hydrogen	–	–	~10Y	Potential emissions reduction in coke plant (less coal required) and blast furnace	Difficult to maintain; operations' use of hydrogen reaches higher levels
Natural gas (DRI-EAF)	↓ 40%	–	Now	High energy and emissions savings	Profitability requires adequate and affordable supply of natural gas
Blue hydrogen DRI (DRI-EAF)	–	↑ 35%-55%	≥10Y	Flexibility; scalable blue hydrogen production in some regions	High production costs; does not address emissions from iron pellets
Green hydrogen DRI (DRI-EAF)	↓ 80%-95%	↑ 60%-90%	≥10Y	More flexibility as hydrogen and iron pellets can be stored	High production costs

Analyses and estimates from Ernst & Young Global Limited mostly based on transition to low emissions steel in Europe. Incremental production costs (operating expenditure and capital expenditure) compared with average annual net income of steel industry. Values compared for crude steel production.
Sources: BNP Paribas, BHP, IEA and ArcelorMittal as of June 2021.

Steelmakers with operations in countries with lower cost renewable energy – that are supported by government subsidies for clean hydrogen solutions – will be best positioned first movers.

The European Union granted €143 million to Sweden's Hydrogen Breakthrough Ironmaking Technology (HYBRIT) initiative, a joint project by the steel, mining and power companies, SSAB, LKAB and Vattenfall, tasked with developing a hydrogen-based production plant for CO_2-free steel. The plant should bring steel to market as soon as 2026 and is estimated to reduce Sweden's carbon emissions by up to 10%.

Future developments in carbon pricing may accelerate market adoption. China has the world's largest emissions trading scheme (ETS), a market-based approach to controlling greenhouse gas emissions that allocates a limited number of emissions permits to carbon-intensive sectors. Although China's ETS currently only covers power generation, by 2025 it's expected to also incentivize industrial sectors, including steel, to decarbonize their operations.

Decisions that energy firms are now making in regard to hydrogen and other renewables will shape their prospects in the coming decades. Though renewables are a lower return business today, there is a clear risk that failure to invest in infrastructure now results in them being disrupted and abandoned by some of their investor base."

– **Matthew Wolf**
Equity Investment Analyst

2. Hydrogen's role in the energy and utilities sectors will be crucial for the energy transition

Use of hydrogen across the energy and utilities sectors is currently negligible, but that seems unlikely to persist. As efforts to decarbonize continue across the global energy system, many companies seeking to survive and thrive could be reliant on a ramp-up in clean hydrogen production.

The versatility of hydrogen enables it to be produced, stored and moved in different ways, providing a potential solution for industries and processes where renewable electricity is not a viable alternative.

Clean hydrogen, therefore, presents a transition opportunity: the energy sector can exploit its existing asset base, raw materials and expertise to facilitate a mass increase in hydrogen production.

For green hydrogen to be a viable fuel, feedstock and energy storage solution, there must be a corresponding increased investment in renewables, electrification and an upgrading of the power grid. Blue hydrogen is also an option, especially as depleted oil and gas fields can be used for carbon storage.

The U.S. currently has few large-scale oil and gas company-led clean hydrogen projects underway. However, the Inflation Reduction Act's incentives should entice those companies already starting to scope out possibilities, to move off the sidelines.

"With an explicit tax credit of up to $3/kg for low-carbon hydrogen, the economics of blue hydrogen projects look a lot more compelling. Meaningful progress on development and execution are now much more likely," says Craig Beacock, equity investment analyst.

It is a similar story in Europe where action has not yet matched the rhetoric around new hydrogen production facilities and capacity. While there has been support from governments in funding green hydrogen projects, it's early days for the oil and gas companies, which are still doing trials to better understand electrolysis-related technology.

3. For commercial vehicles, hydrogen could overtake batteries

Advances in battery technology and charging infrastructure mean that hydrogen (fuel cell) models may remain a niche choice in the passenger vehicle marketplace.

For long-haul and heavy road transport, however, hydrogen fuel cells should prove a compelling option due to greater range and faster refueling times. The price of hydrogen and fuel cells, as well as the infrastructure build-out and government incentives, will influence just how quickly hydrogen becomes a competitive option.

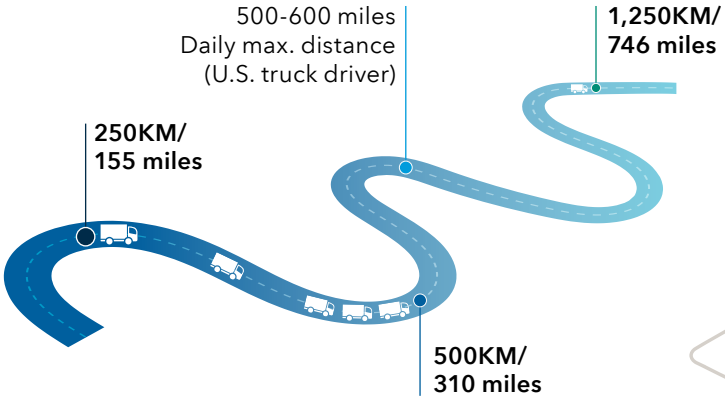
According to an analysis by the International Energy Agency (IEA), transportation could grow to become a leading consumer of clean hydrogen demand by 2050: Heavy trucks, marine ships and aircraft are anticipated to account for the lion's share of demand, with hydrogen used as a fuel itself, as well as to help make synthetic fuels and green ammonia (green hydrogen combined with nitrogen from the air).

Since hydrogen is likely to play a limited role in passenger transport, companies involved in the value chain may find larger longer term opportunities in other carbon-intensive transport sectors such as heavy trucking, marine and rail.

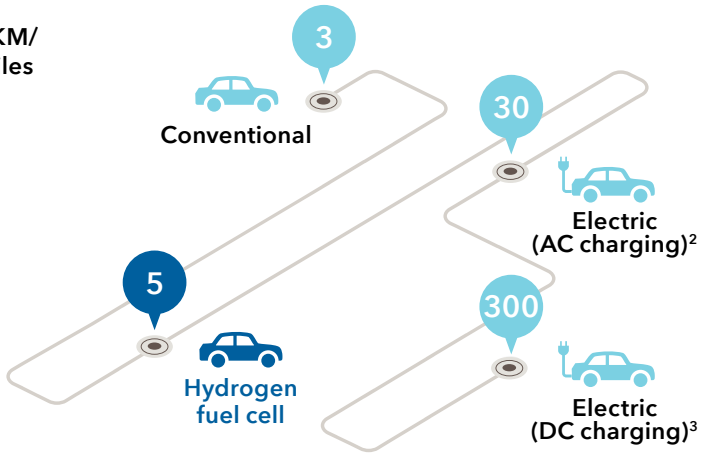
Legacy vehicle manufacturers and suppliers have an advantage in that they may be able to quickly scale production. However, as demonstrated with the passenger electric vehicles marketplace, startups may be capable of cultivating new demand and taking market share over time.

Range and refueling time are why hydrogen fuel cells could become dominant in commercial vehicles

Ranges for available and announced hydrogen truck models in the U.S. and Canada[1]



Typical vehicle refueling/ charging times (minutes)



Sources: International Council on Clean Transportation (hydrogen fuel cell truck ranges, from October 2020 report), Wishart, Jeffrey (2014). Fuel cells vs Batteries in the Automotive Sector and U.S. Congressional Research Service. Ranges and times are illustrative only. Within federal limits on hours of driving, 500 to 600 miles is the distance a U.S. truck driver can cover in a typical day.

[1]Ranges up to 400KM are currently in production in the U.S. and Canada; >400KM up to 1,250KM ranges have been planned but are currently in pre-production stages.

[2]AC= alternating current

[3]DC = direct current

Is it time to get ahead of the coming disruption?

Whether the net zero commitments of various governments, industries and companies are met remains to be seen.

What seems clearer is that making substantial progress toward meeting targets will be very challenging without widespread use of clean hydrogen. For instance, pledged clean hydrogen projects globally amount to less than one-tenth of the amount that is likely to be required to achieve net zero. The availability of low-cost renewable energy, in addition to government incentives, will be crucial to the successful deployment of clean hydrogen projects over the long term.

While net zero commitments are long term, fiscal incentives and other government support should help create early opportunities for long-term investors in the three areas we have highlighted.

But that's just the start. Over coming decades, assuming renewable energy costs become even more competitive with fossil fuels, use of clean hydrogen could flourish. From heating buildings to fueling furnaces, and from hydrogen-powered trains to ships fueled by green ammonia, clean hydrogen has the potential to reshape the investment landscape.

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