The many colors and applications of hydrogen

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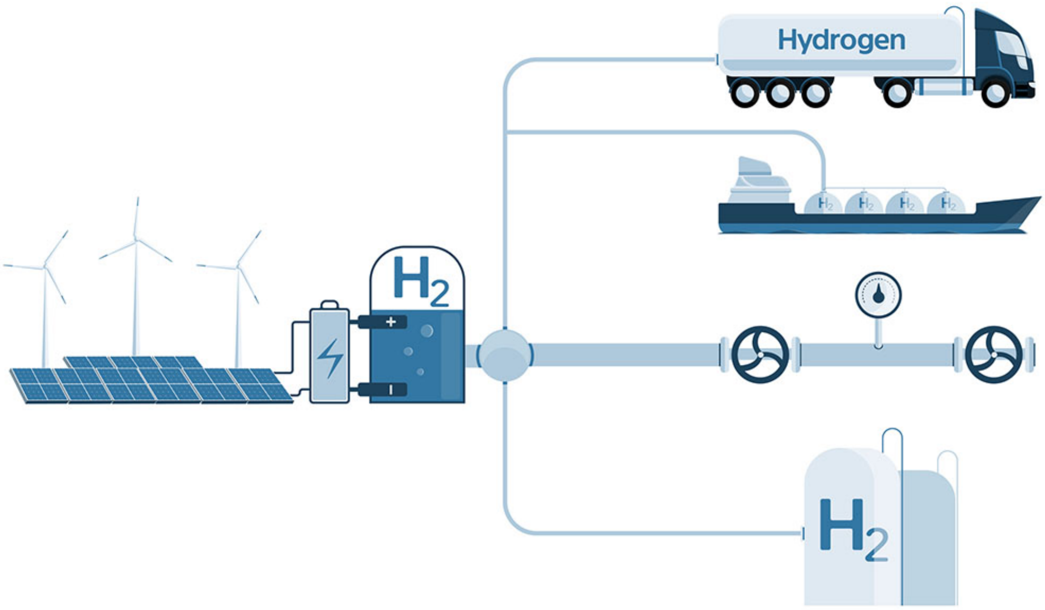
Four things you need to know about hydrogen use in industry

By Gregory Mirabella - November 29, 2022



Hydrogen is a renewable energy for clean future with multiple applications. (© istock.com/Scharfsinn86)

Elsevier recently held the fourth in its popular *Becoming Net Zero* webinar series on Hydrogen Fuel Cells in Commercial Transport & Logistics. Speakers covered the viability of hydrogen as a fuel source in ocean shipping, truck and rail, as well as in oil & gas and other applications.

John A Foote, formerly in procurement at Saudi Aramco and current Chief Technology Officer at REVchain, started with overview of hydrogen and the many ways it can be produced.

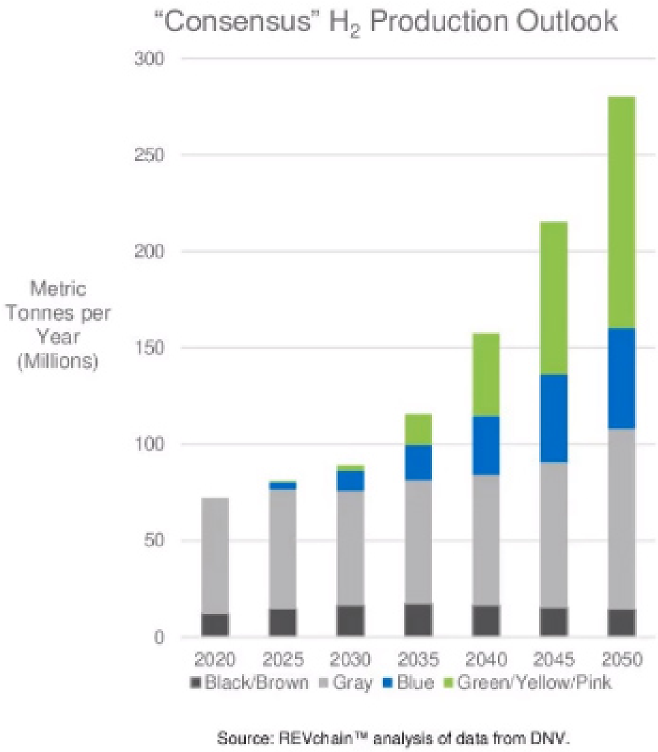
Watch the webinar

1. The hydrogen rainbow

How hydrogen is produced reveals a rainbow of varieties:

- ***Green* hydrogen** signifies that it is produced without greenhouse gas emissions (GHGs). It is made inside electrolyzers using electricity from renewable sources like solar or wind power.

- ***Blue* hydrogen** is made from natural gas via steam reforming. Natural gas and steam react to form hydrogen, but carbon dioxide is a byproduct. To earn the blue label, the carbon dioxide must be captured and sequestered. If not, it is called grey hydrogen.
- ***Black* and *brown* hydrogen** are either produced from black coal or lignite via partial oxidation gasification. GHGs are highest in this form.
- ***Pink* hydrogen** is generated using electricity from nuclear energy.
- ***Turquoise* hydrogen** uses methane pyrolysis to product hydrogen with solid carbon as a byproduct.
- **Yellow hydrogen** uses electricity directly from the power grid.



Source: REVchain analysis of data from DNV

Foote noted that most hydrogen produced today is a byproduct of oil & gas industry production. About 55% of that hydrogen is used to make ammonia, 10% is used to make methanol, and most of the rest is harnessed in various refining processes. For example, as natural gas is often available in large quantities in refineries, it is transformed into hydrogen via steam reforming.

2. Hydrogen characteristics

As the first element of the periodic table, hydrogen is the most abundant element in the universe, comprising about three quarters of all matter. It is very light, colorless, odorless — and highly flammable. When combusted, there are zero carbon emissions. Thus, it is seen as a key facet of achieving long-term net-zero goals.

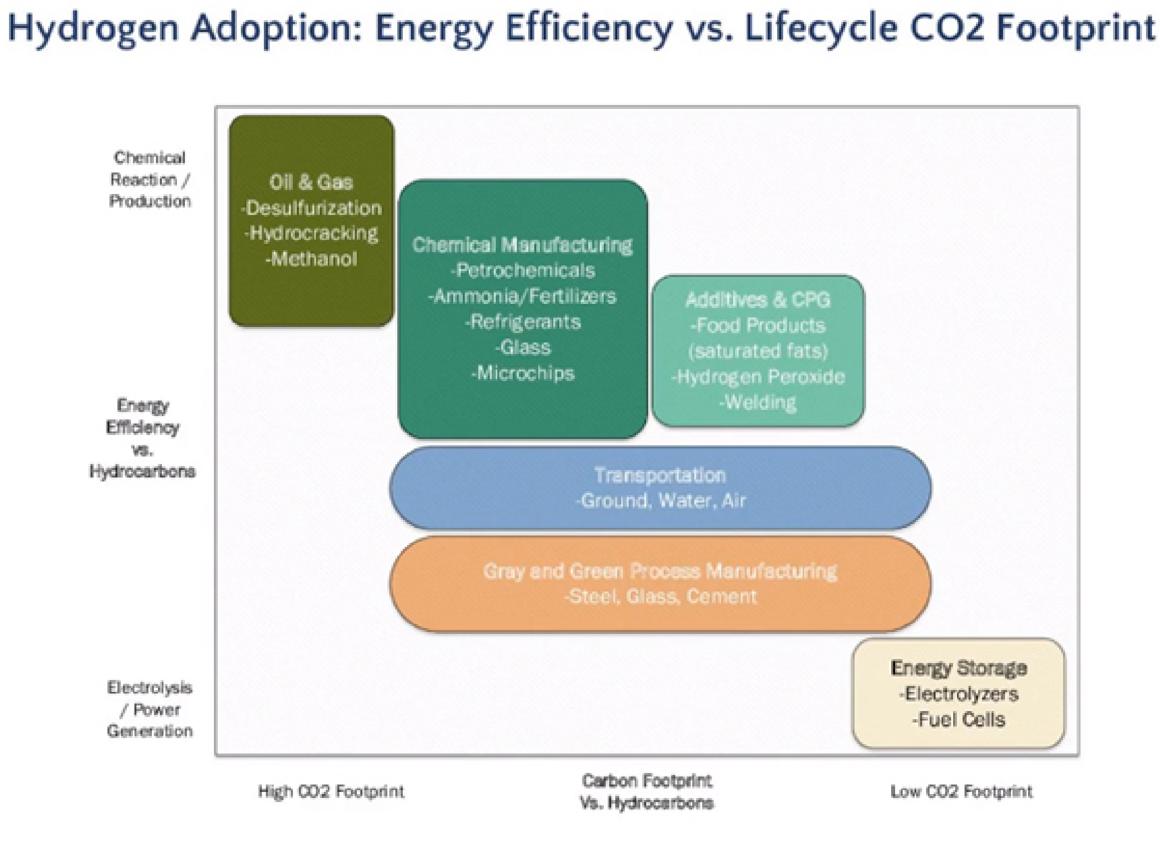
The flammability of hydrogen makes it an attractive alternative to the burning of coal and natural gas for power generation. Many hydrogen demonstration projects are ongoing to help engineers and scientists understand the best way to harness this precious molecule.

A big hurdle, however, is cost. Green hydrogen is priced at around $5 a kilo at the moment. Gray hydrogen costs $1.50 a kilo, and blue hydrogen is at around $2.50. However, current projections show green hydrogen prices falling below those of blue hydrogen by the end of the decade. That will open the door to widespread deployment of hydrogen across many sectors. By 2050, hydrogen is predicted to supply 13% of global energy demands.

3. The many applications of hydrogen

Just as hydrogen has many colors, it also has multiple applications. David Steven Jacoby, Senior Fellow at the Boston University Institute for Global Sustainability, author of *Reinventing the Energy Value Chain*, and CEO of Boston Strategies, detailed emerging applications in ocean shipping, truck, rail and others.

He reiterated that cost remains the major roadblock to broad deployment of hydrogen as a fuel source. It took many decades for those in oil & gas and other areas in the energy sector to bring costs down by 10% to 15%. A primary net-zero challenge is bringing green hydrogen costs down by 70% by 2030. That will require rapid progress on a number of fronts: modularization, supply chain efficiencies, economies of scale in manufacturing, assembly and distribution, and more. The progress of research and development will have to be greatly accelerated as well as information sharing and collaboration across disciplines.



The various hydrogen applications can be divided into categories based on their energy efficiency compared to hydrocarbons and their carbon footprint compared to hydrocarbons. (Source: REVChain)

As can be seen in the chart above, the various hydrogen applications can be divided into categories based on their energy efficiency compared to hydrocarbons and their carbon footprint compared to hydrocarbons. Processes that take advantage of a chemical reaction, such as desulfurization, hydrocracking and various other petrochemical and food industry products, are relatively energy efficient, but their carbon footprints vary. At the other end of the scale, current processes for the manufacture of green steel, glass and cement have relatively low energy efficiency. There is plenty of room for innovation and collaboration to make these processes more efficient and further lower their carbon footprint.

One promising application of green hydrogen is on floating offshore wind farms. It still has to be determined whether it would be better to produce the hydrogen beside the wind turbines and pipe it to the shore — or to feed the electricity from the wind farms to onshore electrolyzers. Some researchers are designing hydrogen-based floating production storage and offloading (FPSO) vessels similar to those used in various areas of the oil & gas value chain.

Jacoby believes hydrogen is likely to gain the most traction in large ships, container vessels, heavy trucks, material handling equipment and perhaps in rail transportation.

Forklifts, cranes and automated guided vehicles (AGVs) are already well into the early adopter stage. There are close to 40,000 fuel cell-based forklifts operating in the US. This will rise to 300,000 by 2030. Part of the reason for the popularity of hydrogen in material handling equipment is that it requires virtually no recharging time. That is one of the reasons Walmart is expanding its fleet to 9,500 hydrogen forklifts and Amazon has placed an order for its own fleet.

The trucking sector lags behind, however. There are 14,000 hydrogen-fueled vehicles in the US already. States such as California have opened dozens of retail stations that supply hydrogen. The likelihood is that green hydrogen hubs will achieve the greatest penetration in coastal states. This is where hydrogen trucking will probably be most prevalent.

While there are experimental hydrogen locomotive projects in existence, large ships, tankers, and container vessels are a more likely application of hydrogen transportation.

4. Barriers to hydrogen adoption

Translating many of these promising applications into reality and affordability largely depends on the maturity of the hydrogen ecosystem. Investors and developers need confidence that green hydrogen is going to scale and to know which areas are likely to mature and scale the fastest at a more granular level.

Take the case of pipelines. While some hope that pipelines can be transitioned rapidly from natural gas to hydrogen, the transition is likely to be slow and gradual. Existing pipelines are not built to contain a small molecule like hydrogen. Small amounts of hydrogen can be blended with natural gas without much difficulty. But once the percentage of hydrogen climbs, a new pipeline infrastructure is required. The likelihood, then, is that metropolitan areas will be early adopters of hydrogen pipelines. Over the long-term, national pipeline networks will lag behind but will eventually emerge.

Even greater barriers stand in the way of broad adoption of hydrogen in aircraft. R&D work is vitally needed on how to compress and store hydrogen in a way that is safe and light enough for flight. Once those problems are resolved, major work is needed to establish hydrogen refueling hubs around the world. Just as the electric car industry remains pegged back by charging station availability, hydrogen hubs must be set up even in less developed regions if global hydrogen flight is ever going to become a reality.

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