Gaffney Cline

Focus on Blue Hydrogen (August 2020)

Overview

To strengthen the global response to the threat of climate change, the COP21 Paris Agreement set a target to keep global temperature increase this century to below 2 degrees Celsius (above pre-industrial levels), and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. As a consequence, a significant reduction in anthropogenic Green House Gas (GHG) emissions is required. Hydrogen has the potential to contribute significantly to the decarbonization of the energy and industrial markets, and therefore to assist global efforts to meet emissions control requirements.

In simple terms, the World needs low or preferably zero-carbon energy supplies, and a focus on electrification of the energy market. Electrification, however, doesn't lend itself to all applications, and Hydrogen provides a solution to those market gaps where a liquid fuel can optimize energy usage in a low or zero-carbon model.

Hydrogen has been defined into a color palette to reflect environmental credentials. Green Hydrogen (where the Hydrogen is produced from renewable energy) is the ultimate panacea of the energy mix, but in terms of achievable practicalities, many commentators currently promote the dual utilization of Green Hydrogen with Blue Hydrogen (produced from hydrocarbons with carbon abatement technology).

This article delves into the apparent sector driving-force, Blue Hydrogen, and assesses the strengths and weaknesses of this proposed short to mid-term carbon-reducing technology.

The Hydrogen Promise

Hydrogen is an attractive option to decarbonize parts of the energy sector in which it would be problematic to implement electrification. Hydrogen being utilized for 15-20% of the overall energy supply in the mid-term is widely mentioned by many commentators.

Hydrogen's promise though relates to its potential utilization in the energy mix as an energy vector and not a primary energy source. Its main areas of usage as a decarbonization tool are:

- Can be added to Natural Gas to reduce carbon content in direct combustion including the domestic heating market.
- Can be used in fuel cells as a zero-carbon replacement transportation fuel.
- Can be used as feedstock for industrial/chemical purposes instead of hydrocarbons.
- Can be used to store excess (renewable) energy.

There is much discussion about a complementary position with battery usage for some motor transportation requirements; Hydrogen, due to its energy density, lends itself to a stronger application in long distance and heavy duty vehicle utilization, in addition to provision of liquid fuels for use in shipping/bunkering.

The Hydrogen Palette

Green Hydrogen's credibility currently suffers due to its being untested at the industrial level, whereas Blue Hydrogen suffers from the association with continued usage of fossil fuels and resultant GHG emissions (although significantly reduced).

Forecasts from international bodies, the Hydrogen Council and IRENA, see potential for 78 EJ (ExaJoule = x10^{18} Joule) of total Hydrogen production in their forecast for 2050. This includes only 19 EJ (~7000 TeraWatt-hours, assuming 80% electrolysis efficiency) from Green Hydrogen. These forecasts are noteworthy due to the expectation that nearly 60 EJ (~75%) of Hydrogen by 2050 will result from processes utilizing fossil fuels.

The European Union (EU) recently accepted, in the European Commission's Hydrogen Strategy, that Blue had a part to play in the Hydrogen market, if only for the short to mid-term. Others, however, still see Blue Hydrogen as an energy anomaly, maintaining a foothold in the future energy mix for the fossil fuel industry (whilst transitioning to full implementation of a Green Hydrogen model).

In addition to Green and Blue as described above, there are also Brown or Grey varieties - produced from hydrocarbons with significant and unabated carbon emissions, but forecast production of these varieties sees significant decline. Obviously, the future focus is very much on Green and Blue Hydrogen only.

Blue Hydrogen Production

There are a number of methods for current industrial production of Hydrogen, but most are based on fossil fuel usage. The most common today is methane reformation in a Steam Methane Reformer (SMR) or Autothermal Reformer. In addition, Hydrogen can also be produced via partial oxidation, gasification or pyrolysis of hydrocarbons.

Where the Hydrocarbon reforming process is coupled with Carbon Capture, Utilization and Storage (CCUS), this is the basis of Blue Hydrogen.

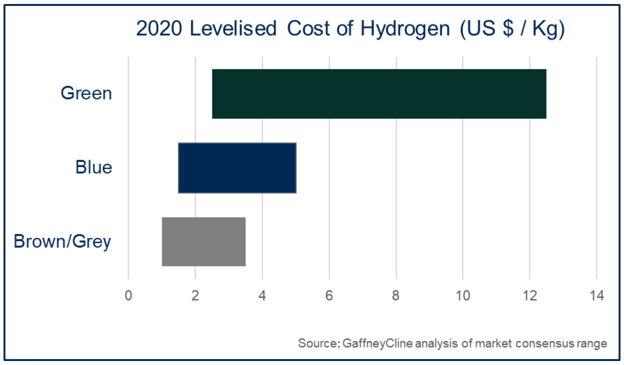
There are differing levels of CO2 capture between the technologies, but values ranging between 65-90% for CO2 capture are common in a Blue Hydrogen configuration, meaning that there are significantly reduced, but evident, CO2 emissions.

The other significant industrial source of Hydrogen is from electrolysis, in which an electrolyzer simply separates water into Hydrogen and oxygen constituent elements, using an electrical supply. If the electricity is produced through renewable resources, this is considered Green Hydrogen (zero carbon).

Commercial Position

Blue Hydrogen Pricing

Brown/Grey Hydrogen, as a baseline has a current Levelized Cost of Hydrogen (LCOH) ranging from circa US$1.00 to US$2.50 per kg, whereas Green Hydrogen's LCOH is currently estimated to range between US$2.50 to US$10.00 per kg depending on technologies.



Source: GaffneyCline analysis of market consensus range

For Blue Hydrogen, we are bolting on CCUS to Brown/Grey Hydrogen facilities. There is consequently an incremental LCOH, typically of US$0.50 to $1.00 per kg, and thus we derive an overall Blue Hydrogen levelized cost in a range between US$1.50 and US$3.50 per kg. Future forecasts suggest a levelized cost of Blue Hydrogen which is expected to go as low as US$1.25 to US$2.00 per kg. The costs for Green Hydrogen will also reduce with increased investment and technology improvements.

Blue Hydrogen Cost Variation

As noted above, Blue Hydrogen levelized cost estimates vary significantly across different market opinions. This variation has much to do with location factors assumed.

The component elements of Blue Hydrogen levelized cost, based on a typical SMR plus CCUS configuration, is dependent on: Natural Gas prices, Capital Expenditure (CAPEX), and then Operating Expenditure (OPEX) in descending order.

Natural gas price and CAPEX each account for approximately 40% of the LCOH in global locations with access to low-cost Natural Gas such as in the North America, Middle East and Russia, with about 20% associated with OPEX. In regions with generally higher Natural Gas prices, Natural Gas can equate to up to circa 60% of Hydrogen production costs, with CAPEX circa 25% and OPEX circa 15%. (Based on IEA (iea.org), "Hydrogen production costs using natural gas in selected regions, 2018.")

Is There Significant Uncertainty in Blue Hydrogen LCOH?

Blue Hydrogen is only likely to see commercial development in regions where there is both low price and readily available Natural Gas, in addition to suitable infrastructure and locations for CO2 sequestration. Blue Hydrogen projects currently tend to be large-scale regional projects, typically based around an industrial hub, with existing pipeline-based gas transportation infrastructure and also nearby carbon sequestration facilities. Re-purposing infrastructure and facilities in an industrial hub is a common theme for Blue Hydrogen. Saltend in the UK and H-Vision at Rotterdam are examples.

Beyond such easy-win industrial hub locations, Blue Hydrogen from a standalone project is likely to be at the mid to higher end of the LCOH range and potentially uneconomic without other incentives.

Given the dependence of Blue Hydrogen levelized cost on Natural Gas pricing and CAPEX, the risk factors for Blue Hydrogen commerciality are reasonably clear.

Uncertainty around the CAPEX of Blue Hydrogen developments due to a transient engineering market will be key assessment parameters. Experience in related sectors suggests CAPEX escalation will trend with industrial activity based on simple supply and demand drivers. Further, the ability to rapidly ramp-up proposed Blue Hydrogen project developments to the level forecasted will require commensurate engineering and construction capability increases, which will tend to exert upward pressure on costs.

Experience also dictates that projects will need to consider and provide an ever-increasing focus on Environmental, Social and Governance (ESG) considerations, as well as GHG emission monitoring and reporting. Carbon emissions from operational activities, plus fugitive methane emissions from transporting Natural Gas, will both require enhanced design, engineering and operational excellence, beyond current performance, which again will create commensurate upward pressure on costs.

On a positive note, however, there is nothing exceptional about the rate of proposed market growth that would suggest industry could not meet such growth requirements.

In addition, Natural Gas forecast pricing from a range of commentators suggests a stable and relatively low price baseline globally for the next 10 years at least. Consequently, a major uncertainty to the Blue Hydrogen commerciality equation, in the near to mid-term, could be considered as relatively low risk, supporting confident investment in Blue Hydrogen projects.

Keys to a Successful Blue Hydrogen Project

As mentioned previously, a robust and accurate understanding of Natural Gas pricing expectations, project CAPEX, and particularly an assessment of the range of uncertainty (P10 to P90) for both parameters, is important to minimize the levelized cost of Blue Hydrogen.

A Blue Hydrogen project will require the melding together of the best practices for petrochemical, midstream, downstream and upstream sectors. The complexity associated with successfully integrating these disciplines cannot be overstated. An optimized project will consider many integrated elements including:

- A resilient and technically detailed conceptual basis of design;
- An appropriate overall contracting strategy to the project Engineering, Procurement and Construction (EPC) requirement;
- Confirmation of subsurface volume capacity for CCUS requirements and an accurate assessment of the potential uncertainty range;
- Carbon intensity reviews and fugitive methane emissions monitoring and management;
- Detailed petrophysical and geotechnical assessment to ensure reservoir integrity during reservoir re-pressurization;
- Well design and construction requirements for access to reservoir and to provide secure carbon sequestration. A review of the suitability to reuse existing infrastructure;
- Commercial models to mitigate variations in gas pricing;
- Clear government policies and regulations on the CCS/CCUS.

Summary

In summary, Blue Hydrogen will be with us for many years to come and will likely dominate parts of the energy markets as well as develop into a key part of the engineering sector. Successful Blue Hydrogen project delivery, however, still carries risk and uncertainty; a dependence on Natural Gas pricing, a reliance on EPC markets to deliver competitive project CAPEX, not to mention the need for historically different market sectors to amalgamate into one project delivery team all requiring appropriate risk management to allow for industrial-scale Blue Hydrogen commerciality.

Author

Drew Powell, *Projects Director at GaffneyCline*