Gaffney Cline

Blue Hydrogen to Support Decarbonisation
September 2020

The Need for Zero or Low Carbon Hydrogen

It is widely acknowledged that Hydrogen has the ability to contribute to the decarbonisation of the energy and industrial markets and therefore assist with global efforts to meet emissions control requirements.

Debate is ongoing whether State/Government policies should reflect balanced investment and support, in the short to medium-term, for development of both Blue and Green Hydrogen markets, or whether any focus on Blue Hydrogen slows the ultimate move to a zero-Carbon Green Hydrogen solution.

Given the current market dominance of lower cost unabated Grey Hydrogen, some commentators perceive that Blue Hydrogen facilitates a rapid development of a Hydrogen-based economy by providing the required volumes in a cost and environmentally effective manner, particularly given some of the practical constraints associated with the build-out of renewable energy. In most situations, renewable power generation is expected to face challenges to replace forecasted electricity grid demand, let alone having “spare” renewable capacity to use in Green Hydrogen production; pragmatism therefore suggests support for short- to medium-term demand in Blue Hydrogen. Even the Hydrogen Council and IRENA, who estimate global potential for 78 EJ of Hydrogen production in their forecast for 2050, see the majority coming from Blue Hydrogen.

Looking at Europe as an example, the EU is targeting carbon neutrality by 2050 and states hydrogen is a key part of the European Green Deal. The EU recognizes, in the short- to medium-term, significant volumes of Hydrogen would need to be produced from natural gas with carbon capture and storage (CCS), i.e. Blue Hydrogen, as a bridging technology.

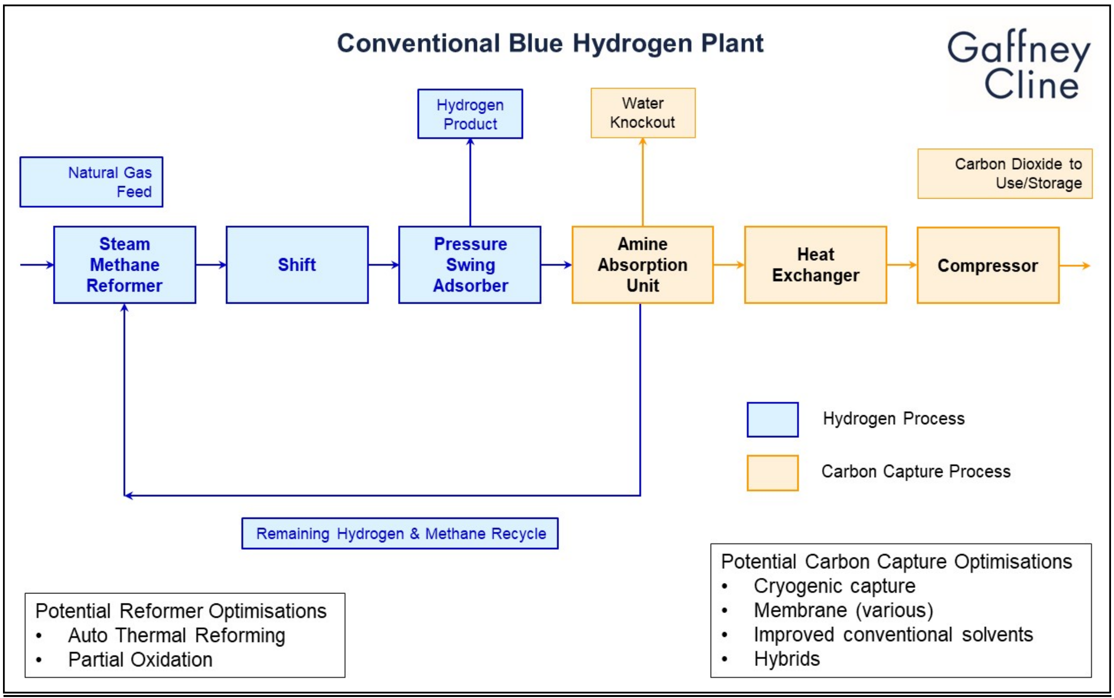
In terms of Green Hydrogen context, the EU hydrogen strategy phase 1 (covering the years 2020-24) plans for 6 GW of electrolyzer capacity, with 40 GW in phase 2 (covering the years 2025 to 2030). Currently, the EU has the capacity to build a little under 1 GW of electrolyzer capacity annually.

Blue Hydrogen Development

Hydrogen production cost is typically quoted in LCOH (levelised cost of hydrogen) terms, which relates to the average cost of hydrogen generation over the lifetime of the considered project.

Blue Hydrogen is primarily produced using a combination of Steam Methane Reformers (SMRs) with the addition of CCS. There are a total of seven Blue Hydrogen operating projects today producing circa 0.4 Mt/yr of hydrogen and capturing nearly 6 $MtCO_2$/yr; of the seven projects, four are at oil refineries and three are at fertilizer plants. A conventional process flow scheme for Blue Hydrogen is shown in Figure 1. The current standard carbon capture 'reference' method uses amine absorption separation technology; the Shell Quest project in Canada is an example of an operating Blue Hydrogen plant with conventional amine technology.

Figure 1: Blue Hydrogen Flow Scheme



SMR technology is mature and there is limited scope for improvements in efficiency. CCS, a key part of the Blue Hydrogen LCOH, appears at first view to be a new and novel technology but the component parts, CO2 extraction, compression, transportation and finally injection into an underground geological formation represent a number of mature industries combined together.

Current Blue Hydrogen Pricing

A consolidation of industry views suggests a current Blue Hydrogen LCOH of between $1.50 and $3.50/kg depending on variations such as natural gas prices and cost of labour.

At current natural gas prices, SMR lifecycle costs makes up around 30% of the Blue Hydrogen LCOH (in low gas cost locations). Carbon capture lifecycle costs also account for approximately 30% of LCOH with transportation and storage typically only forming up to circa 5% of the LCOH, with feedstock cost comprising the balance.

Future Blue Hydrogen Pricing

Recent analysis by GaffneyCline suggests that the focus for cost savings, assuming flat feed gas pricing, will be a reduction in costs for the new carbon capture facilities retrofitted to existing SMRs as well as some limited improvements to the base efficiency of SMRs.

Potential technologies include physical capture through cryogenic and sorbent technologies, along with membrane separation. Beyond design changes to the SMR process itself, other continuous process and thermal efficiency improvements will likely result in additional minor SMR unit cost reductions.

GaffneyCline analysis to 2030 anticipates that the lifecycle costs of SMRs can be reduced by between 10% and 25% and that the lifecycle costs of carbon capture can be improved by up to 20%. This results in an overall improvement in total Blue Hydrogen unit cost of circa 15% to 20% resulting in a 2030 forecast of approximately $1.25 to $3.00 per kg (based on a range of assumptions) for Blue Hydrogen.

Green Hydrogen Production Cost

Green Hydrogen, as with all novel technologies, is moving from a predominantly R&D development phase to a mainstream industrial development phase and therefore will exhibit a unit cost reduction curve, similar to that achieved by PV solar, wind turbines, high capacity batteries etc; all these technologies showed a significant unit cost reduction over the years of development. Some of this unit cost saving came from economies of scale and/or from a move to a "production-line" type construction. There were also efficiencies in design, construction and installation in addition to actual technology efficiency gains.

The Green LCOH comprises three building blocks: electrolyzer cost, renewable electricity pricing and other operating cost charges. Typically, electrolyzer cost accounts for approximately 20-25% of the LCOH today, with electricity contributing the lion's share of approximately 70-75% of LCOH. Operating cost is relatively small and typically is no more than circa 5%.

Renewable energy pricing (mostly unsubsidized utility PV solar and wind) has fallen remarkably over the last 30 years and is already within similar levelised cost of energy (LCOE) as coal-fired electricity production (circa $30-50/MWh) and will continue to become more cost competitive. However, when looking at the cost decline curves from a range of sources, and recognizing a continuation of recent circa 10%/year cost declines in renewables, there appears to be a potential LCOE trend to about $20/MWh by about 2030.

Aside from operating cost, which is unlikely to move significantly, we also need to review the trend in electrolyzer unit cost. Forecasting electrolyzer cost is difficult as with all developing technologies although GaffneyCline expects that electrolyzers will exhibit a new-technology learnings-based cost curve similar to PV solar or wind.

PV solar was originally developed in the 1970's, but if we consider a more recent history from 2010, PV solar LCOE was at about $500/MWh. Since then LCOE has seen a significant fall and LCOE is currently circa $30-50/MWh. A similar percentage reduction in LCOE for PV solar from 2000 to 2010 was also evident. It would be logical that electrolyzer technology could follow a similar trajectory in terms of unit cost from 2020 to 2030, given a similar industrial baseline to PV solar cell production. However to allow for uncertainty in such analysis, if we also consider wind power as a second data set, a reduction in wind LCOE is also evident over the last 10 years but at a lesser percentage (circa 50% for offshore and 60% for onshore).

Current LCOH for Green Hydrogen is estimated to range between $2.50 to $10.00 per kg. Therefore, Green Hydrogen could easily be priced in 2030 near to half of the current LCOH at a range of circa $1.25 to $5.00 per kg. Green Hydrogen could also see enhanced regulatory support as well as government incentives as carbon reduction demands increase, further strengthening the commerciality of Green Hydrogen.

Summary

Expectations of Green Hydrocarbon being a major player in the energy mix requires some careful consideration. Growth requirements from renewable sources to decarbonize the existing power sector are significant and pragmatic reasoning in the short- to medium-term therefore has an emphasis on Blue Hydrogen for commercial reasons. However, the rate of the Green LCOH downward curve will dictate the date at which Green Hydrogen surpasses Blue Hydrogen on a price basis commercially and this commercial overtake date could be quite soon, albeit market scale will be limited by availability of renewable energy.