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Hydrogen: State of Play in the GCC

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Much has been written about the role of hydrogen in the context of energy transition and the path to net zero. Putting aside for the moment the degree of investment and innovation required to get from where we are now to where we need to be by 2050 (or, indeed, 2030), the potential of hydrogen as a fuel of choice for industries looking to decarbonise is, on its face, immensely exciting. It is therefore not at all surprising that hydrogen is undergoing a renewed sense of "hype" amongst developers, governments and regulators alike. The Middle East, with its vast hydrocarbon resources and ambitious plans for decarbonisation, is no exception.

HYDROGEN IN TODAY'S ECONOMY

The global industry has been successfully utilising hydrogen in areas such as petroleum refining, glass purification, pharmaceuticals and fertiliser production for decades. The key issue is that around 95% of hydrogen has historically been grey, i.e. hydrogen produced from fossil fuels, using steam methane reformation (SMR). Aside from the high degree of carbon dioxide (CO2) emissions, the production of grey hydrogen also results in a significant leakage of methane (CH_4), the concentrations of which in the atmosphere are now 2.5 times higher than in the 1850s.[1]

Accordingly, the Middle Eastern market is now primarily focused on the prospects for blue and green hydrogen. Like grey hydrogen, blue hydrogen is produced using SMR but with the added benefit of carbon capture, storage or alternative use technology, which is used to capture and store CO2. This in turn results in minimal atmospheric leakage, rendering blue hydrogen a low carbon fuel.

However, it is green hydrogen, produced from renewable energy using electrolysis, that is the ultimate goal of the industry. Unlike other forms of hydrogen, it does not have residual emissions of greenhouse gasses and is a carbon neutral fuel. While only around 0.1% of hydrogen produced globally is currently green[2], the aspiration is to shift this significantly in the coming decade.

HYDROGEN AND ENERGY TRANSITION

In order to achieve a net zero economy, all current sectors, including electricity, steel, cement, transport systems and fertiliser production, need to be decarbonised. There is no precedent for the immense transition the world is required to make in the next thirty years.

Given the scale of the challenge ahead, the key questions for hydrogen are how big a role it can play in energy transition and how can it be implemented in a way which is cost efficient, sustainable and effective. While some claim that the initial focus should be to decarbonise existing hydrogen production, others argue that much wider and more ambitious investment is needed to yield results over the medium to longer term.

Either way, it is evident that the scope for both green and blue hydrogen development in the Middle East is set to grow rapidly. However, this will only succeed with the right level of political support, requiring clear policies and economic incentives to attract private sector investment.

THE CHALLENGES FOR HYDROGEN

Arguments against green hydrogen typically centre around its comparatively high price. At present, the cost of green hydrogen is estimated to be two to three times higher than fossil fuels. For this to change, a number of things need to happen, including standardisation of electrolyser design and synchronisation of best practices across the industry. This would assist with developing the economies of scale, which would in turn reduce the per unit cost.

Hydrogen is often said to lack efficiency. This is because relatively large amounts of energy are required to isolate it from natural compounds, before packaging, compressing and transferring to end user. A certain amount of energy is also lost by converting it to usable electricity. However, this is mitigated by the rapidly growing availability of renewables in the region and is likely to be addressed over time through innovations in manufacturing.

Finally, as a low-density fuel, hydrogen can be more difficult to transport. Conversely, the ability for it to be stored physically as gas or liquid could facilitate much needed flexibility in the power system.

Notwithstanding the associated challenges, there is a clear (and rapidly growing) increase of interest in carbon neutral or low carbon hydrogen across the region from policy makers, governments, developers and technology manufacturers alike. In light of the ambitious NDC targets in the GCC, including the submission of a revised NDC by the United Arab Emirates (UAE) in December 2020 which aims to decrease emissions by 23.5% below business as usual (BAU) by 2030, there would seem to be an exciting road ahead for the industry.

CARBON CAPTURE, UTILISATION AND STORAGE TECHNOLOGY

Green hydrogen forms a crucial piece of the energy transition puzzle; however, the high reserves of hydrocarbons in the Middle East mean that blue hydrogen will also play an important role. Indeed, the UAE is already targeting carbon capture hydrogen to reduce greenhouse gas emissions and become a major hydrogen producer, with Asia and Europe being the potential markets for exports[3].

While carbon capture, utilisation and storage (CCUS) technologies are not new, they have historically been slow to take off. As with green hydrogen, one of the primary reasons for the slow uptake is the high cost. Notably, the costs of carbon capture can also vary significantly depending on the source. For example, capturing pure or highly concentrated CO2 streams in industrial processing ranges from USD 15-25/t CO2, while the cost associated with "dilute" gas streams, such as cement production and power generation, could rise to around USD 40-120/t CO2.[4]

Notwithstanding this, the momentum behind CCUS is clearly growing. As the only group of technologies capable of removing CO2 from the atmosphere in order to balance emissions that are hardest to prevent, it forms an inherent part of net zero emissions strategies of governments globally. Industry heavy-weights, such as Occidental Petroleum, are already working on direct air capture technology, which captures CO2 directly from the atmosphere and injects it into the oil and gas fields, where it displaces the oil and gas trapped in the rock and moves it toward a producing well, with the CO2 itself being permanently trapped underground. This Enhanced Oil and Gas Recovery technology is expected to produce low or carbon neutral (or even carbon negative) oil.

Most recently, Saudi Aramco announced a partnership with South Korea's Hyundai Heavy Industries Holding Company to cooperate on blue hydrogen production and use of carbon-based Enhanced Oil Recovery technology in the Kingdom's oil fields. Aramco expects its hydrogen business to become world scale by 2030.

There are currently around fifteen such carbon capture projects worldwide. Indeed, if plans for the facilities announced globally in the last three years successfully go ahead, the amount of global CO2 capture capacity is projected to triple to around 130 Mt per year.[5]

The prospects for application of CCUS across the various industrial processes is vast; however, new and improved technologies continue to be required so as to enable a reduction of costs. This is particularly significant for industries such as mining, steel and cement, where CCUS is regarded as a relatively developed and cost competitive option for decarbonisation. For cement production, where most of the emissions result from chemical reactions inherent in heating limestone, CCUS is arguably the only scaleable solution to achieve a substantial reduction of emissions.[6]

Similar conclusions are being reached in the context of both iron and steel, where incorporating carbon capture is expected to result in approximately a 10% cost increase to the current production costs versus a 35-70% increase that could arise from methods based on electrolytic hydrogen. The same applies to fertiliser, where the base costs increase associated with CCUS equipped ammonia production from natural gas is estimated to be an additional 20-40% versus an increase of 50-115% for electrolytic hydrogen.[7]

However, assuming sufficient and sustained R&D and innovative industrial processes design, IPCC expects CCUS associated costs soon to see a reduction of around 20-30%.[8] This will be significant for the GCC, where decarbonising oil production is one of the key energy transition challenges and priorities.

ELECTROLYSIS-POWERED GREEN HYDROGEN PRODUCTION

The production of green hydrogen through electrolysis relies on water as the key feedstock and renewable energy as a power source to split hydrogen and oxygen from water in an electrolyser. Like fuel cells, electrolysers consist of an anode and a cathode separated by an electrolyte but differ depending on the type of electrolyte material used.

At present, there are four different types of electrolysers. The first two, the Alkaline electrolysers and Polymer Electrolyte Membrane electrolysers (PEM), are produced commercially, while the anion exchange membrane (AEM) and solid oxide (SOEC) are being trialled on a lab scale.

Each of these technologies presents its own challenges. Conventional alkaline units are more mature, with lower capital costs and 80% efficiency across a broad range of current densities. On the other hand, PEM has a 90% efficiency at low current densities, requires less maintenance and is better suited to high pressure electrolysis. In any event, it is clear that the doors remain open for further R&D and innovation to drive down costs.

To that end, the rapidly decreasing cost of wind and solar has given electrolysis a renewed sense of momentum. Indeed, some speculate that, once properly scaled up, electrolysis will establish hydrogen as a key energy vector in the net zero transition. A report from Hydrogen Council, for example, has predicted that the declining costs of renewable electricity generation and the scaling up of electrolyser manufacturing will reduce the cost of green hydrogen production for the end user by as much as 60% in the next decade.[9]

Notwithstanding the current cost of electrolytic hydrogen, a number of projects reliant on electrolysis are already being piloted in the region. In the UAE, in February 2019 the Dubai Water and Electricity Authority (DEWA) announced the construction of its solar-driven hydrogen plant at the Mohammed bin Rashid Al Maktoum Solar Park.

The MENA Hydrogen Alliance was launched in 2020 by Dii and its partners, including Acwa Power, NEOM, thyssenkrupp, Abu Dhabi Future Energy Company (Masdar), MAN Energy Solutions, MASEN and Fraunhofer. This was followed by the Abu Dhabi Hydrogen Alliance, established earlier this year, as a joint effort between Mubadala Investment Company (Mubadala), The Abu Dhabi National Oil Company (ADNOC), and ADQ, with the intention of positioning Abu Dhabi as a leader in low-carbon blue and green hydrogen.

Masdar has in early 2021 also partnered up with the Abu Dhabi Department of Energy, Etihad Airways, Siemens Energy, Marubeni, the Khalifa University of Science and Technology, and Lufthansa Group to develop a pilot green hydrogen project in Masdar City, Abu Dhabi. The focus of the project is on building a solar-powered electrolyser, intended to eventually produce green hydrogen and sustainable fuels for road transport, aviation and shipping. The first phase appears to center around production of green hydrogen to supply passenger cars and buses within Masdar City, while the later part will explore the possibilities around producing decarbonised fuels for the maritime sector. With this project, Masdar aims to create the initial domestic demand for hydrogen and help build a local green hydrogen economy.

In Saudi Arabia, a joint venture between Air Products, Acwa Power and NEOM last year announced a $5 billion, 4 GW green ammonia plant, expected to be operational by 2025. It envisages the integration of around 4GW of renewable power from solar, wind and storage, together with the production of 50 tons per day of hydrogen and nitrogen by electrolysis and air separation respectively, and the production of 1.2 million tons per year of green ammonia, for which Air Products will be an exclusive offtaker and distributor globally. ACWA Power is expected to build solar and wind farms required to supply power to electrolysers and feed an associated desalination plat. The plant will also incorporate direct air capture, a technology which captures CO2 directly from the atmosphere, whether for storage in deep geological formations or use in production of fuels and other products containing CO2, in order to harvest nitrogen. A reactor is expected to convert hydrogen into ammonia that will then be liquified and loaded onto purpose-built carriers for export as transportation fuel for the heavy transport industry.

GOVERNMENT STRATEGY AND POLICY SUPPORT

One of the key challenges to large scale commercial blue and green hydrogen production stems from the level of economic sustainability. Green hydrogen in particular requires a large degree of private sector investment, together with clear government policies able to provide a favourable economic and legal environment for R&D, pilot projects and scaling up of technologies and associated infrastructure.

Globally, further thought is now also being given to the allocation of green premium, creation of government subsidies and industry taxation, and establishment of hydrogen focused strategies In 2020, eight jurisdictions declared such strategies and at least ten more are expected to do so in 2021.[10] This includes the UAE, where the Abu Dhabi Department of Energy and Marubeni signed a Memorandum of Understanding (MoU) with a view to exploring energy efficiency and hydrogen related opportunities.

Similarly, the European Union in July 2020 announced its ground-breaking Hydrogen Strategy, envisaging large scale deployment of green hydrogen across all hard-to-decarbonise sectors, with expected cumulative investment of between EUR 180-470 billion for renewable and EUR 3-18 billion for low-carbon fossil fuel based hydrogen. As of last year, South Korea is operating hydrogen projects and hydrogen fuel cell production units under its Hydrogen Economy Development and Safe Management of Hydrogen Act 2020. In Japan, the basic hydrogen strategy was announced as early as 2017. Finally, earlier this year, India has confirmed its National Hydrogen Energy Mission initiative, with a focus on generating hydrogen from renewable power resources.

The GCC countries are already active participants in the international hydrogen discussions at both governmental and private sector levels. Other things that would be helpful include setting further green hydrogen related investment goals, defining export targets, establishing clear national policies and hydrogen production priorities, and creating a green hydrogen ecosystem through boosting its social and economic value.

PRIVATE SECTOR INVESTMENT IN HYDROGEN

Given its potential for a variety of uses and applications, green hydrogen lacks a single point of investment. Contrary to solar and wind, for example, it also lacks commercial competitiveness and does not therefore have an established project finance market. Indeed, compared to grey hydrogen, which is estimated to cost around $1-1.8/kg, the costs of green hydrogen are much higher, at approximately $3-6/kg. This makes attracting bank financing particularly challenging.

Conversely, while developers have sought some bank financing for the newer applications of hydrogen, the relatively small project size typically does not have capacity to absorb the high cost of due diligence required to achieve bankability. In addition, the absence of an established market, pricing certainty and clear demand projections do not lend themselves to clear and reliable financial forecasting.

The banks remain interested in green hydrogen; however, like any other project, green hydrogen needs to present a commercially sound proposition to both equity investors and financiers. This can be difficult to achieve, since commercial viability is highly dependent on pricing, which in turn relies on developing economies of scale and clear demand from offtakers.

Financial institutions continue to focus on projects in the sectors with clear long-term offtake strategies and a wide array of credit-worthy buyers. In order for green hydrogen developments to be project financed, an offtake agreement that passes the muster of bankability will be key.

The risks associated with the supply chain will also need to be mitigated. For example, the existing pipeline network could not be used reliably to carry pure hydrogen without the risk of cracking steel, permeating plastic and causing reactions with lubricants and seals. As such, the pipeline network would need to be retrofitted to enable hydrogen transportation.

While hydrogen can also be stored in a cryogenic state as liquid and delivered using a ship tanker, unlike natural gas (which has a boiling point of -160 °C), it only turns liquid once cooled to -252.8 °C. As such, equipment for storing and handling it is more expensive than that which is used for LNG. Boil off can also be an issue, so the tanks and storage facilities must be properly insulated to control evaporation caused by heat.

While green financing is becoming increasingly common in the market, for the time being at least, the key drivers remain the same. To facilitate a limited recourse financing, the developers will need to secure a long-term, fixed price offtake arrangement with a creditworthy buyer and demonstrate the robustness of the projected revenue stream. In that sense, the structure is likely to be similar to that which is typically seen on power and utility projects in emerging markets. Depending on the nature and sector of the project, it may also be necessary to structure around volume and/or price risk, as seen in oil & gas or commodity-based financings.

Whatever the structure, it is clear that, in order for hydrogen to become a serious contender for private sector financing, the sector needs to begin operating at scale.

WHAT’S NEXT FOR HYDROGEN IN THE UAE?

If deployed correctly and as part of a balanced energy profile, hydrogen can no doubt help tackle some of the critical energy challenges and provide an accessible way to decarbonise a number of challenging industrial sectors.

The prospect of a green hydrogen economy assumes that hydrogen can move through economies of scale in a way similar to how both solar and wind have done over the past decade. If the hydrogen "hype" continues accelerating at the same rate, this may well be possible.

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