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The Central Role of Hydrogen in the UK's Green Industrial Revolution: Opportunities and Challenges

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In recent years, the UK's energy sector has increasingly been viewed as one of the cleanest and most innovative industries in the world. Last November, with a view to the 26th UN Climate Change Conference due to take place in November this year, the UK government outlined its 10-point plan for a "Green Industrial Revolution", which includes the aim to drive the growth of low carbon hydrogen. More recently, the UK Hydrogen and Fuel Cell Association ("**UKHFCA**") announced that on 3 March 2021 it will publish a paper titled "*The Case for Green Hydrogen*". This paper will urge the UK government to take immediate action in order to be a leader in hydrogen energy and to become the world-leading exporter of electrolysis and green hydrogen technologies.

Hydrogen is widely seen to play a critical role in a move to clean energy in various sectors, and the UKHFCA paper looks to provide a clear roadmap for a green hydrogen strategy up to 2050. It also seeks to consider how hydrogen and the wider hydrogen economy can become a core part of the post-COVID 'build back green' economic recovery. While details of the paper are currently sparse, based on information published so far, by 2050 the plan is to have 80 GW of deployed power capacity derived from green hydrogen with the UK gas grid completely made up of hydrogen. Alongside this, the plan aims for London to be a major European trading hub for green energy and for over 40% of heavy mobility to be powered by hydrogen. There seems to be less certainty about storage solutions as it leaves open the options of ammonia, salt caverns or liquid hydrogen.

Against this backdrop, the UK Government has recently unveiled a number of ambitious plans, including promoting the construction of a UK-wide network of hydrogen stations, with the aim to reduce the cost of hydrogen by more than 20%, and facilitating a drive by natural gas network operators to deliver the UK's first hydrogen heated town by 2030.

Different types of hydrogen and its expected use

Hydrogen is one of the most abundant elements in the universe, but it does not naturally occur in an isolated state on earth. As a result, it must be created through another process, be that the burning of fossil fuels or the use of renewable energy. The high versatility allowed in its creation is touted as a real benefit, as it ensures there will always be a way to create it. This has led to a classification system of hydrogen based on how they are produced: (a) **brown hydrogen** is created through the gasification of brown coal, (b) **grey hydrogen** is produced by applying steam to natural gas which causes hydrogen to be produced, (c) **blue hydrogen** occurs when the CO_2 produced through brown or grey hydrogen production is captured and stored, and finally (d) **green hydrogen** is produced by splitting water into its molecules using electricity from renewable sources. Green hydrogen is still in its infancy and expensive to produce (as against other processes) but there has been increasing year-on-year investment in research and development in this area. Currently industry produces 70% of the global production of hydrogen through grey hydrogen processes, with blue hydrogen making up another 29%, (blue hydrogen being viewed, when utilising associated carbon capture and storage, as an integral step in the energy transition). Ultimately most industry participants are aiming for green hydrogen (currently around 1% of total global production) to be the sole produced type.

Many see hydrogen, which can be used as fuel, heat and feedstock, as the replacement of fossil fuels, particularly in heavy industry where high energy density is required. It has also been suggested that hydrogen can be a benefit to heavy transport where hydrogen fuel cells are likely to be more economically feasible due to their greater power density. This has been seen in the recent drive to create hydrogen fueled transport ships whereby any range concerns can be easily addressed by adding more hydrogen tanks to the same fuel stack; this also has the additional potential benefit of reduced costs over other battery cells. Finally, within power generation, hydrogen is believed to have a use as both a feedstock for hydrogen-fired turbine power stations to generate clean power and, where combined with large scale geological storage and renewable energy facilities, to capture excess renewable energy and then this in turn be used for grid stabilisation or feedstock (the 'power-to-gas' prospect). Beyond these main areas there have also been suggestions that hydrogen could be used to power rail (where electrified) and in marine passenger ships.

A comparison of hydrogen strategies in the UK, Europe and Asia

The UK Government committed, through its 10-point plan, to a number of different actions involving hydrogen. Of particular note in the plan is the aim to facilitate the creation of a 5GW production capacity for blue hydrogen. This is something the UK is particularly well suited to due to its existing large-scale production of natural gas, the second largest in Europe. Key to the strategy is carbon capture, usage and storage ("**CCUS**") with an aim to capture 10Mt of carbon dioxide by investing £1bn to establish four industrial clusters of CCUS, such as Teesside and South Wales. The first stages of this can be seen by the investment of £750m into two plants as part of the HyNet scheme to create an industrial neutral zone in north-west England by 2040. It is believed that developing this infrastructure in the short to medium term will create the building blocks for a transition to green hydrogen in the future.

The plan also tacitly touches on the development of hydrogen or hydrogen blends to heat housing within the UK. The plan involves using a blend of hydrogen and natural gas, and studies show it may be possible to inject up to 25% or so of hydrogen into the mixture without significant upgrades to the network. Beyond that ratio, gas network providers will need to significantly upgrade existing infrastructure (due to the comparatively smaller hydrogen molecules being able to escape the system).

Beyond the 10-point plan, the UK government as well as devolved country governments (e.g. the Scottish Government) have been supporting (through use of grants) the development of a fledging green hydrogen industry in areas such as Scotland's Orkney Islands where a localised hydrogen economy has been successfully set up (from the 'Surf and Turf' scheme through to the HyDIME project) with plans in the future to have their cars, ferries and boilers all running on hydrogen. The UK government's focus on research & development for sustainable fuels includes hydrogen, but this has been criticized for not providing enough investment, with these projects not being as well established as those in places like France, Germany and the Netherlands. Potential participants are also awaiting the long-delayed hydrogen strategy ("**UK Hydrogen Strategy**") due to be published by the UK government in spring this year, as the report is intended to provide greater clarity as to what exactly the UK's full hydrogen investment plans are for the future. With the imminent release of the UKHFCA paper, it will be interesting to see how much of the plans within the paper are met by the government's own strategy.

Comparing the UK's vision to that of the EU, there appears to be a significantly greater focus on green hydrogen as part of the EU Green Deal. Take for example the key document *'Hydrogen Strategy for a Climate-Neutral*

Europe' which contains spending on increasing electrolyser capacity up to 40GW by 2030 and renewable energy generation up to 120GW by 2030 at a cost of €340bn with a further expected cost of €470bn by 2050. The ultimate aim of the EU Green Deal is to make hydrogen meet 24% of Europe's final energy demand by 2050, in the process creating 5.4m jobs. Germany has also announced its own separate target of 5GW of electrolysers by 2030 as part of its €130bn pandemic recovery. This is significantly more than has currently been committed by the UK government.

Looking towards Asia, both South Korea and Japan have made hydrogen a cornerstone of their long-term energy strategies. Japan spent US$303m in 2019 on hydrogen and fuel cell research and was the first country to adopt a national hydrogen framework with its *'Basic Hydrogen Strategy'*. Japan has also started to produce hydrogen through facilities such as the Fukushima Hydrogen Energy Research Field. The field can produce hydrogen from 180km^2 of solar panels and the water electrolyser installed can produce enough hydrogen to fill up 560 fuel cell vehicles a day through its 10MW capacity. Even with this investment, Japan is likely to be a net importer of hydrogen and so has sought to partner internationally with Australia through the '*Hydrogen Energy Supply Chain*' project which will produce and ship brown hydrogen. Australia is seen to be well placed for the use of green hydrogen due to its abundance of natural resources and strong LNG exporting infrastructure. It has created a national hydrogen strategy with the aim to scale up infrastructure by coordinating government, industry and the community. Furthermore, it has several large hydrogen export projects in the pipeline, including the Asia Renewable Energy Hub that aims to produce 14GW of electrolysers for green hydrogen production and export. When compared to the current state of the UK government's policy, the UK seems to be in some way behind a number of countries in developing its hydrogen policy.

<u>Challenges facing the UK in a move to hydrogen</u>

The move to hydrogen is not without its challenges. The focus of development is predominantly on both blue and green hydrogen. The primary issue surrounding this development is cost. Currently green hydrogen is expensive to produce due to the cost of the electrolysers and the setup of the ancillary renewable energy. While these costs are expected to fall over time as investment increases, it is at present uneconomical to produce. The issue of cost is not one that solely impacts green hydrogen as blue hydrogen has the additional cost of storage which itself is not yet fully developed and requires significant investment to build. Furthermore, it is difficult to obtain traditional project financing due to the fact that the technology is uncertain and not yet proven at scale, along with the lack of any framework or business model. If it is possible to obtain financing, it is likely to be expensive and could make projects commercially unviable. To reduce the costs of hydrogen projects and to encourage private investment, the UK government will need to introduce subsidies and production incentives to improve the technology and allow scalability. This is an expensive proposition for a country which has borrowed heavily to cope with the COVID-19 pandemic and the burden of the financial risk of these projects may be something the UK government is unwilling to be saddled with.

Building into this is the question over the commercial viability of hydrogen projects, particularly green hydrogen projects. Many sectors are likely to find renewable energy alternatives to be significantly cheaper and more available due to the maturity of those technologies. Alongside this is the concern over transport as there is currently no easy way to transport hydrogen for long distances, with most regulation only covering short haul transport. Suggestions of liquifying the hydrogen or converting it to ammonia add additional costs to its production and rely on sufficient technology to be present through the whole supply chain in order to convert the hydrogen back to a usable gas. This does not even take into account that the conversion of renewable electricity to hydrogen is currently not as effective as just directly consuming the renewable energy. The creation of green hydrogen additionally requires a large amount of pure water to produce, with every 1kg of hydrogen requiring 9kg of high purity water unless a deionizer is used.

Furthermore, a challenge which will take time to overcome is that of regulation and risk management. Hydrogen is a highly flammable gas when exposed to oxygen and so requires extensive safety precautions to be in place. The UK is currently determining the safety case for hydrogen and the current infrastructure's ability to tolerate a hydrogen blend with HyLaw (a flagship project aimed at boosting the market uptake of hydrogen and fuel cell technologies).

Ultimately, the UK does not at present have a specific hydrogen framework, so production currently involves Town & County Planning Act approval and the requirement for environmental impact assessments. This, for example, has an impact on hydrogen refueling stations as they are not separated from large scale industrial production which means onerous restrictions are placed on them which ultimately could prevent their creation. With the UK focusing on blue hydrogen, there is the additional requirement of regulating the proposed salt caverns in which the hydrogen will be stored. It is hoped these issues will be addressed in the UK Hydrogen Strategy.

Looking ahead

Hydrogen presents a host of benefits and opportunities for the UK economy and has the potential to play a pivotal role in the UK's decarbonisation agenda. The country is particularly well placed to become a leader in the use of blue hydrogen, but this currently suffers not only from a lack of sufficient investment, especially when compared to other major countries, but also a lack of a clear regulatory framework. Many within the UK expect the UK Hydrogen Strategy to set out details of the government's plan to develop and utilise hydrogen to achieve its goal of net-zero by 2050.