UK HFCA

# The case for Blue Hydrogen

## UK Hydrogen and Fuel Cell Association Position Paper

# Key messages:

Blue hydrogen is essential to the UK government's Net Zero ambitions

The UK can deploy 10GW of blue hydrogen by 2030 and reach up to 80GW by 2050 with the right policy support.

The UK oil & gas industry has contributed greatly to the UK's economy, both in terms of tax revenues and employment – blue hydrogen provides a route to ensure similar levels of support for communities as we transition towards Net Zero.

Investing in blue hydrogen today will create significant long-term economic opportunities for UK Plc – the UK has the infrastructure, natural resources, geology, skills and experience to be a world leader in blue hydrogen.

The UK can become a significant blue hydrogen producer, as well as an importer of CO2 from other countries, thus supporting decarbonisation of other markets and generating income for the UK economy.

Short term thinking must be avoided to prevent the errors that encouraged offshoring of manufacturing opportunities for the wind industry. With ambition, the UK can become an exporter of key skills, services and materials.

A UK hydrogen strategy must have low carbon hydrogen, irrespective of whether it is blue or green, at its core

# Executive Summary

Blue hydrogen is essential to the UK's transition to low carbon energy as part of the 2050 net zero targets. The potential for low carbon hydrogen is particularly high in industrial processes and in hard to abate sectors, especially heavy-duty vehicles, shipping, heating, aviation and energy storage.

The UK is well placed to take advantage of the opportunities from low carbon blue hydrogen given the existing, historic large-scale production of natural gas, and the Government's commitment to the technology as part of the energy transition, including the investment in carbon capture, utilisation and storage (CCUS) across four industrial clusters.

But if we are to maximise the potential of blue hydrogen in the UK, we need clearer direction and support from Government including:

- **Low carbon hydrogen standards need to be set and implemented for the carbon content of hydrogen**, maximising the contribution to emissions reduction. In order to help make hydrogen the fuel of the future, it is critical that emissions standards are both standardised and trusted - a crucial step towards achieving the net zero targets.
- To enable low carbon hydrogen production at scale and across all colours, Government will need to provide **business models and targeted support mechanisms**, complementary to carbon pricing to facilitate the transition away from fossil fuels.
- Clarity and greater certainty around the support available for blue hydrogen projects will drive innovation and investment. Confirmation on the way forward for hydrogen blending into the gas grid and the implementation of certification schemes are two examples of where clear direction from Government will be key.
- **Ambitious targets for blue hydrogen production equivalent to those for green hydrogen** are also critical - with an emphasis on the need to grow all types of low carbon hydrogen to scale. This is crucial to incentivising investment in the UK hydrogen sector and aligning to the various hydrogen needs for different sectors and end users.
- Given the potential for the UK to be a world leading producer of hydrogen, **the Government should develop an industry wide plan for international co-operation, including boosting hydrogen exports and imports**. There is also huge scope for exporting technologies, products and services.
- Finally, there is a need for **support to enable the transition from the traditional roles for oil and gas, with blue hydrogen playing an important role in the 'just transition'**. This offers a route to securing workers' employment and leveraging skills from a legacy sector into a new energy sector - across hundreds of thousands of jobs[1] as we transition to Net Zero.

1 https://www.heraldscotland.com/business_hq/17856099.north-sea-supply-chain-job-numbers-increase-first-time-years/

# Blue hydrogen is essential to achieve Net Zero

## Background

There is little doubt that low carbon hydrogen[2] is an essential component of the future net zero economy, particularly to decarbonise hard to abate sectors, such as high temperature industrial processes, heavy duty transport, aviation, shipping, non-electrified train lines, heating, dispatchable power and energy storage.[3]

We define "Blue hydrogen" as the process of converting natural gas to hydrogen and CO2, with the CO2 being sent to geological storage sites. Currently there is no internationally accepted definition of what counts as blue hydrogen, but in the UK all projects are setting a high bar with >95% CO2 removal from the process being considered a minimum.

It is possible for bio-methane to be converted in the same process which, when coupled with CCUS, will lead to negative emissions.

In the near-term, blue hydrogen will be the fastest way to deploy large volumes of low carbon hydrogen and will pave the way for the ramp up of green hydrogen production in the longer term – including opening up new distribution systems that can be utilised for all types of hydrogen across the range of applications. The UK HFCA supports the UK Government's strategy of a twin-track or technology agnostic approach, recognising that both blue and green hydrogen will play a key role in achieving our ambitious decarbonisation goals.

Today, the majority of hydrogen manufactured globally is from the conversion of natural gas to hydrogen, with the resulting CO2 - amounting to ~3% of global industrial sector CO2 emissions[4] - being emitted into atmosphere; this is known as grey hydrogen. Most current hydrogen production is either integrated into a large process, for example in the manufacture of ammonia or methanol, or is supplied to refineries to improve the quality of liquid fuels. There is therefore not currently a large merchant market for hydrogen. The key role for low carbon hydrogen going forward, as an energy vector, brings with it not only many opportunities – particularly in our transition to 'net zero' – but also challenges that need to be overcome if it is to reach its potential.

As mentioned earlier, there are multiple sectors where low carbon hydrogen will be vital for decarbonisation. Many of the initial projects are focused around industrial clusters, where blue hydrogen can be produced and service multiple sectors. This cluster approach allows the critical CCUS infrastructure to be shared with other industrial producers and users of CO2,

2 Low-carbon hydrogen is hydrogen that is made in a way that creates little to no greenhouse gas emissions.
3 See Annex B for more details areas where hydrogen can play a key role in decarbonisation.
4 https://www.researchgate.net/publication/267623573_Assessment_of_CO2_capture_options_from_various_points_in_steam_methane_reforming_for_hydrogen_production

thereby driving decarbonisation of surrounding industries, generating new $CO_2$ exploitation opportunities and lowering the unit cost of such CCUS infrastructure.

What is critical is that there are synergies between blue and green hydrogen, with applications and markets differentiated both temporally and geographically. Both blue and green hydrogen enable the decarbonisation of hard-to-abate sectors, whilst creating skilled jobs, new products and services - and commercialising technologies that the UK can export internationally.

## A reliable energy system

One element that is often taken for granted, particularly in the UK, is the stability and availability of our energy system. A major contributor to this is our extensive gas infrastructure. We have an energy system that can deal with the extremes of demand, particularly driven by rapid changes in weather. Not only does the existing gas network cover the entire country and supply energy to both industrial and domestic customers, but it also connects storage facilities that can store gas over long timeframes and in quantities far in excess of anything that batteries can currently economically achieve.

**28,000km**

of pipeline in the UK and we are fortunate that, due to the Iron Gas Main replacement work, much of this has now been converted to polyethylene piping that can carry hydrogen

Whether we are talking about the high-pressure transmission system, the backbone of our gas infrastructure, or the local gas distribution systems that connect over 85% of UK dwellings, the system is extensive, reliable and an asset that we have invested in extensively for many years. There are over 28,000km of pipeline in the UK and we are fortunate that, due to the Iron Gas Main replacement work, much of this has now been converted to polyethylene piping that can carry hydrogen without the risk of metal embrittlement.

Blue hydrogen can help to decarbonise the gas network and, thus, prolong the economic life of our existing gas infrastructure. This has benefits both from a financial perspective, as it delays the costs of decommissioning the existing gas infrastructure, and also from an environmental perspective, as it can reduce and / or avoid the emissions associated with constructing new infrastructure (e.g. a massive expansion of the electricity distribution network as a result of increasing electrification). We should look at how to optimise the existing assets we have and maintain a stable energy system with contributions from both decarbonised electricity and decarbonised gas.

# Cluster map

For blue hydrogen to be deployed, CCUS infrastructure is needed and the UK is very well positioned to be a world leader in the technologies, services, use and deployment of CCUS. With the targeting of Net Zero there are very few credible early pathways that do not include a large volume of $CO_2$ storage[5,6]. The UK Government has committed in its 10 Point Plan to establish CCUS in two industrial clusters by the mid-2020s, and aims for four of these clusters by 2030, capturing up to 10Mt of $CO_2$ per year. It is clear, therefore, that CCUS will soon form a part of the UK's energy infrastructure irrespective of the development of the blue hydrogen market. It would therefore be a real missed opportunity if hydrogen did not benefit from the development of this CCUS infrastructure, given the decarbonisation potential of blue hydrogen.

Cluster sequencing will be key to defining which of the world leading blue hydrogen projects accelerates most quickly to deployment. The main contenders (in no particular order) are:

**1 Acorn**
Through the Acorn Hydrogen project, North Sea natural gas would be reformed into clean hydrogen, with $CO_2$ emissions safely mitigated through the Acorn CCS infrastructure. Hydrogen would be used in transport applications, and in the gas grid to decarbonise heating in homes and industries.

**2 HyNet**
HyNet North West is based on the production of hydrogen from natural gas. The hydrogen will be produced in bulk at a central plant using established, proven technology. A HyNet North West consortium has just received significant Government funding to enable the plant to become 'investment-ready'.

**3 Humber – H2H Saltend**
Hydrogen will be produced at scale from natural gas and delivered to the nearby chemical plants (replacing natural gas) and power station (blended with natural gas), reducing their emissions. The $CO_2$ by-product will be captured and stored safely and permanently offshore. The Humber is the closest industrial hub to the Endurance storage site in the Southern North Sea.

**4 Teesside**
The Teesside project would be the largest in the UK, producing up to 1GW of blue hydrogen (20% of the UK Government's hydrogen target) by 2030 and supporting the development of the region as the UK's first hydrogen transport hub.


However, it should be clear that this is not an exhaustive list and there are a number of other projects that are under consideration. Some of these are considering transporting $CO_2$ by ship to a $CO_2$ store, so it should not be seen as only CCUS clusters that can host blue hydrogen plants.

5 https://www.theccc.org.uk/publication/sixth-carbon-budget/
6 https://www.irena.org/newsroom/pressreleases/2021/Mar/Fast-Track-Energy-Transitions--to-Win-the-Race-to-Zero

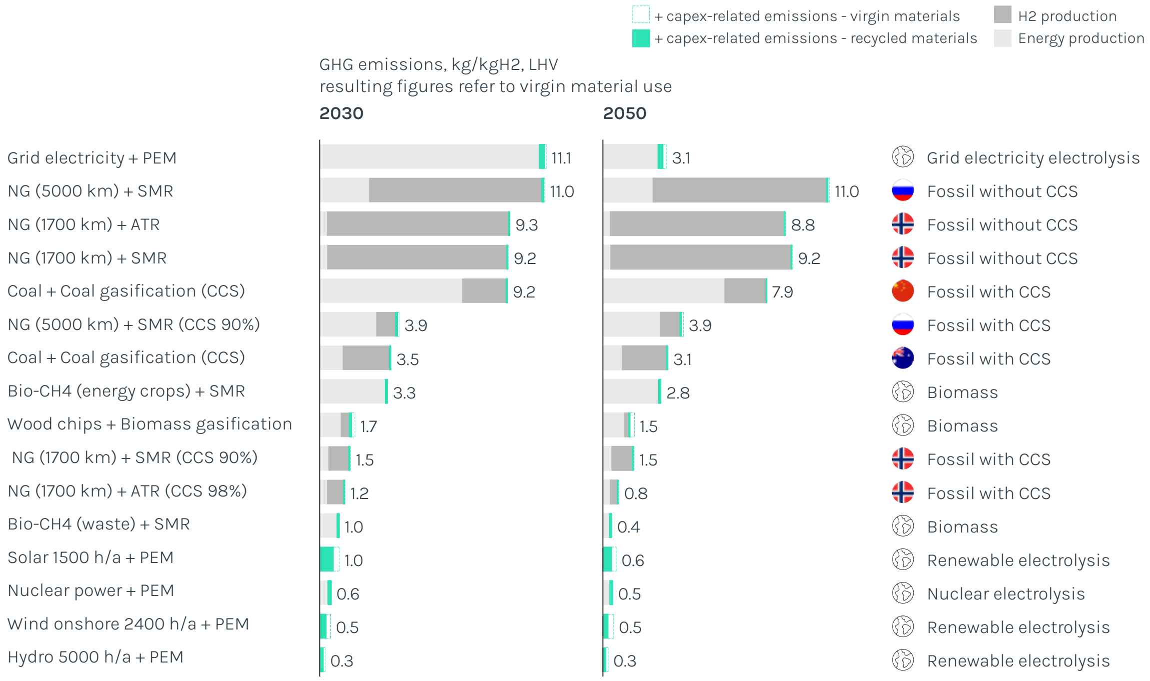
## Stringent standards should be set for blue hydrogen

Standards should be set to maximize CO2 capture from blue hydrogen processes. When considering any technology options, we should be cognisant of all emissions involved. If blue hydrogen is to play a role in decarbonisation in the UK and globally, then minimising emissions at the point of production of hydrogen will be critical. However, we must be clear that reducing upstream emissions is equally important. Many upstream producers have made public commitments to reduce emissions from their natural gas supply chains this decade, but more will need to be done. It should be recognised that not all sources of natural gas are the same. Factors such as the field from which gas is extracted, the method of production, the natural gas composition and the type and distance of transportation and the capturing and processing of any by-products will all contribute to the life cycle emissions analysis of the produced blue hydrogen.

> There are a number of technologies for producing blue hydrogen that can achieve the target emissions. That said, there are technologies that can do so more cost effectively when higher levels of CO2 capture are being targeted. Currently processes with an autothermal reformer at the core are the frontrunners, but in certain situations other technology choices may be preferred.

Using the highest efficiency an lowest carbon footprint technologies, which consume the least natural gas per unit of hydrogen produced, and sources of natural gas with lower emissions profiles can lead to blue hydrogen production with lifecycle emissions at very low levels when compared to grey hydrogen and, if some of the feedstock were biomethane, the production could be zero or negative emissions[7].

### Carbon-equivalent emissions by hydrogen production pathways, 2030 and 2050




*(Image courtesy of the Hydrogen Council – Hydrogen Decarbonisation Pathways: A lifecycle assessment, January 2021)*

7 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911268/potential-of-bioenergy-with-carbon-capture.pdf

## Policy and regulatory challenges to the development of blue hydrogen

One of the key challenges to the development of blue hydrogen worldwide has been the lack, in many jurisdictions, of a clearly defined legal and regulatory regime in respect of CCUS. The UK has a clear advantage in this respect as, for over a decade now, since the coming into force of The Energy Act 2008 and The Carbon Dioxide Regulations 2010, the UK has had an established and settled legal and regulatory regime for CCUS. What the UK still lacks, however, is certainty around the Government support that will be available for blue hydrogen projects.

The Department for Business, Energy & Industrial Strategy (BEIS) has published a number of different papers setting out its proposed business models for CCUS projects – most recently in May 2021. Whilst these papers have provided a lot of detail around the likely commercial structures for CCUS projects, it is important to note that at this stage these are just indicative proposals. In addition, the focus to date has been on the business models for transportation and storage (T&S), the Dispatchable Power Agreement (DPA) and Industrial Carbon Capture (ICC), and very little detail has been given as to the business model for low-carbon hydrogen, which is still very much in the consultation phase.

A blue hydrogen project is a complex undertaking with many different parts, each of which has its own particular risk profile. There is therefore significant scope for cross-value chain or “project-on-project” risk, and appropriate allocation of these risks will be key to the successful development of a blue hydrogen project. If the UK is going to ramp up low-carbon hydrogen production capacity significantly by 2030, with a large percentage expected to comprise blue hydrogen projects, then certainty is needed as to the Government support that will be available for these early projects and how these projects will be structured.

## Certification of blue hydrogen

The development of the blue hydrogen market will require confidence from purchasers and end consumers that the hydrogen they have purchased or indirectly consumed is low carbon. With the first blue hydrogen projects expected to be developed around industrial clusters - with dedicated hydrogen transportation infrastructure between the producer’s facilities and the facilities of its customers - verification of the blue or low-carbon nature of the hydrogen supplied should be relatively straightforward.

However, as the hydrogen economy develops, the utilisation of hydrogen will be increased, the market for hydrogen will expand beyond its regional clusters, and there will need to be a robust mechanism for certifying low carbon hydrogen; an approach involving ‘book and claim’ or similar to the UK’s Renewable Energy Guarantees of Origin (REGO) scheme.

The great benefit of such a scheme is that it can decouple the low-carbon attribute from the physical flow of the product and make blue hydrogen available independently from its production sites. This will greatly assist in expanding the market for blue hydrogen, as it will allow consumers to purchase blue hydrogen throughout the UK, irrespective of whether there exists blue hydrogen production in the relevant location.

Given that the EU has already made good progress on its CertifHy scheme, the UK Government should consider adopting a similar scheme ideally, in the future, with reciprocal recognition between the UK and EU of the guarantees of origin issued under their respective schemes. In any event, any UK a scheme must be such that it enables certificates to be recognised in the EU.

## Actions to unlock blue hydrogen

Robust business models will be key to unlocking low carbon hydrogen deployment for both blue and green hydrogen. Currently the front runner is to use business models that have been used previously to deploy offshore wind in the UK, and to focus on producer subsidies in the near term until the carbon price is high enough to make low carbon hydrogen cost competitive with the fossil fuels used today. The contracts for difference (CfD) scheme for supporting low-carbon electricity generation has been very successful in stimulating uptake and at the same time driving down cost to consumers.

Besides the business models, other critical steps to achieving the goals laid out in the 10 Point Plan and positioning the UK as a world leader in clean hydrogen are:

1. Blending of hydrogen into the gas network.
2. Proof points for fuel switching in industries such as glass, steel and cement via industrial trials.
3. Building the infrastructure required for hydrogen-powered vehicle (and wider transport) refuelling.

Since 1996, all gas appliances sold in the UK must be able to operate on a natural gas blend containing up to 23% hydrogen. In the UK, there are a number of initiatives underway to show that blending hydrogen into natural gas to a level of 20% by volume does not require any changes to domestic appliances. However, in order to allow for blending of hydrogen in the UK's gas distribution network, the current maximum limit of 0.1% hydrogen by volume would need to be revised. HyDeploy is a UK project which has successfully introduced 20% hydrogen into the Keele University private gas grid with consumers not noticing a difference in heating or cooking with the blend. The next phase of the project will deliver a blend to 670 homes, a church, primary school and several businesses in the North-east of the UK on the public network.

**20%**
Hydrogen introduced into the Keele University private gas grid with consumers not noticing a difference in heating or cooking with the blend

There are challenges around hydrogen blending, in particular with respect to the measurement of energy consumption, as currently metering is done on a volumetric basis and not on a calorific value basis. The ability of various types of pipework to safely handle hydrogen needs to be confirmed across all affected parts of the gas network. A further consideration is the need to ensure that the hydrogen blending stays within the permitted levels. Whilst 20% sounds like a good start, it should be acknowledged that this only leads to a 7% reduction in CO2 emissions. However, the really key benefit of hydrogen blending is its ability to kick-start the wider hydrogen industry, as it will allow the gas network to be used as an additional off-taker for initial projects, thereby reducing the demand-side risk and making projects much more investible.

Trials are underway to prove the applicability of 100% hydrogen as a part of reducing domestic emissions. One example is the work at Spadeadam as part of the H21 project; here, a microgrid has been built and a 100% hydrogen home tested to undertake hydrogen safety and customer duty of care investigations.

Returning to the topic of the scale of growth in blue hydrogen deployment, we consider the UK target of 5GW by 2030 to be lacking in ambition given the plans already in place to deploy and scale up blue hydrogen. We anticipate that the UK can deploy 10GW of blue hydrogen by 2030 and reach up to 80GW by 2050 with the right policy support. This support will be defined by the business models which Government sets in place, with carbon taxes expected to have an increasing role in accelerating the transition away from fossil fuels over time.

Alongside the business models for hydrogen and given the potential for the UK to be world leading producer of hydrogen, the Government should also develop an industry wide plan for boosting hydrogen exports and imports. There is huge scope for exporting skills and services, providing a further boost to the UK economy.

Finally, there is a need for support to enable the transition away from the traditional roles for oil and gas, with blue hydrogen playing an important role in the 'just transition'. The sector currently supports around 147,000 jobs; blue hydrogen will help to secure these jobs as we transition to Net Zero[8]. More specifically, the North Sea Transition Deal expects to support up to 40,000 high quality direct and indirect supply chain jobs in UK industrial heartlands, particularly through hydrogen and CCUS. Many of the current skillsets in the oil and gas industry, such as geologists, project managers, a wide variety of engineers, and fabricators, are key to the roll-out of hydrogen and its growth will help to ensure a prosperous future for the communities affected and that the UK economy retains people with these key skillsets. It will also enable UK businesses to capture increasing international demand for hydrogen goods and services.

**80GW**
of blue hydrogen could be deployed by the UK by 2050

**40,000**
high quality direct and indirect supply chain jobs in UK industrial heartlands

8 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972520/north-sea-transition-deal_A_FINAL.pdf

# Next steps

There has been significant support from Government for both hydrogen production and CCUS over recent years, with hundreds of millions of pounds invested in engineering studies. However, this is insignificant when compared to the investment that will be required from Government and the private sector to deploy low carbon hydrogen at the level needed. The next critical step is to deploy technology at scale and ensure that demand grows in tandem.

For all colours of hydrogen, the business models to support deployment will be key and the sooner that Government can move to contracting the first projects the better. The UK has the opportunity to lead in this area. In contrast to new industries, such as off-shore wind, where we have deployed large quantities of wind turbines, but import most of the high value items, with blue hydrogen we also have the potential to develop a strong robust UK supply chain if the sector is supported correctly. We have a good basis to build from here, not only in terms of getting early projects deployed as soon as possible, but also the breadth of existing supply chain capability, including carbon capture, the design of sorbents and system design at various scales.

Having the policy landscape with the correct signals for cross-party support of hydrogen will attract investment into the UK in a sector in which many countries will compete. We only have to look at the announcements from multiple EU countries to see that hydrogen will be an area receiving large investment over the next few years and the route to maximising value to the UK is by attracting investment for manufacturing in the UK of high value items. We should not try to manufacture everything in the UK, but with targeted investment and clear growth ambitions we can make sure that we do not leak value out of the UK.

The UK has world-leading projects and, with speed of deployment, these will be the first plants producing blue hydrogen at scale. There will be a lot to learn from these initial projects that will inform the future roadmap and allow us to prove the use of hydrogen in multiple sectors.

# Annex A: About the UK HFCA

The UK Hydrogen and Fuel Cell Association (UK HFCA) aims to ensure that hydrogen and fuel cell solutions can realise the many benefits offered across economic growth, energy security, carbon reduction and beyond. Through the breadth, expertise and diversity of our membership, we work to trigger the policy changes necessary for the UK to fully deliver the opportunities offered by emerging clean energy solutions and their associated supply chain requirements. We promote and represent our members' interests across the hydrogen and fuel cells space, and work to make the UK the best possible place for hydrogen and fuel cells across the full range of applications and opportunities.

Our members include the leading UK hydrogen and fuel cell players, as well as companies with wider energy interests, supply chain businesses, and materials and components suppliers, as well as service providers and universities.

# Our members

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| ITM POWER Energy Storage \| Clean Fuel | Ingersoll Rand | JM Johnson Matthey | AngloAmerican | AIR PRODUCTS |
| Burges Salmon | ceres | BOC Member of The Linde Group | AVL | BAKER BOTTS |
| CPH2 Clean Power Hydrogen | conrad energy | | FUEL CELL SYSTEMS | HiiROC |
| AMES GOLDSMITH CEIMIG | HYDROGEN LONDON | Imperial College London | HYDAC | CLEAN ENERGY TECHNOLOGY |
| DCA | JREPrecision | kiwa | Logan Energy | LOW DEE |
| LUXFER GAS CYLINDERS | SAFI Thermoplastic Valve Solutions | FAUN ZOELLER | Marubeni Europower | NanoSUN |
| NET ZERO ENERGY DEVELOPMENTS LIMITED | Northern Gas Networks | NVFCL | Petrofac | POWERHOUSE ENERGY GROUP |
| PRESSURE TECH | PROTIUM | AURIGA energy | tfp H2 | Rolls-Royce |
| SCOTTISH Hydrogen & Fuel Cell ASSOCIATION | SIEMENS Ingenuity for life | Gen2 Energy | Swagelok Swagelok Manchester | Sustainable Working And Living Environments Ltd |
| T:E BUSINESS DEVELOPMENT | CMB.TECH | Thornton Tomasetti | ALCAZAR | tpgroup |
| UCL | ULEMCo | UNIVERSITY OF BIRMINGHAM FUEL CELLS GROUP | The University of Nottingham | Ulster University |
| Reynolds Logistics | BayoTech On-Site Hydrogen | PhotoVolt Development Partners | creo | bp |
| COFTEC | STAHL | water to water | Statkraft | Diffusion Alloys |

# Annex B: Why hydrogen and why now?

The recent announcement by UK Government that it will enshrine the recommendations of the Climate Change Committee for Carbon Budget 6 increases the ambition for emission reductions and the need for low carbon hydrogen technologies[9]:

- UK Government to set in law world's most ambitious climate change target, cutting emissions by 78% by 2035 compared to 1990 levels.
- For the first time, UK's sixth Carbon Budget will incorporate the UK's share of international aviation and shipping emissions.
- This would bring the UK more than three-quarters of the way to net zero by 2050.

BEIS has published an impact statement which makes it clear that hydrogen is a central theme throughout the assessment[10]:

The targets are very challenging and technically stretching. They require at least doubling current electricity generation by 2050 and rely on substantial hydrogen production and biomass use, although the final energy mix is highly sensitive to modelling assumptions. If the UK is to keep options open on the path to net zero by 2050, then by 2035 any option for the sixth carbon budget will entail:

- significant electrification of sectors such as transport, heating and industry, and continued decarbonisation of the power grid;
- substantially improved energy efficiency in all sectors;
- deployment of low-carbon hydrogen, Carbon Capture and Storage (CCS) and GHG removal technologies at scale;
- increased switching to low-carbon fuels (e.g., hydrogen, biomass) in hard to electrify areas such as industry, heavy transport, aviation and shipping; and
- implementation of available abatement options across all natural resources sectors (e.g. afforestation, low carbon farming practices).

The case for hydrogen is clear; the UK requires a zero emission fuel that is well understood, has extensive regulations and standards in place, is readily scalable and which can be used across multiple energy vectors. Hydrogen is that fuel.

There are major technical and economic hurdles to meeting the UK's Net Zero goals without hydrogen, particularly for heating and transport applications. The country's gas grid supplies 3x more energy than the electricity grid today[11], and the transport sector accounted for over a third of final energy consumption in 2019[12]. While there is significant renewable power generation potential in the UK, notably from offshore wind, electrifying all heating and transport is likely to be an unsurmountable challenge by 2050. Mass electrification would require a major overhaul of the current energy system, and massive scale up of batteries,

9 https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035
10 Impact Assessment for the sixth carbon budget: legislation.gov.uk
11 ARUP, 2019 speech at the World Energy Council
12 DUKES, 2019, page 5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820277/DUKES_2019_Press_Notice_GOV.UK.pdf

improved transmission systems and smart metering. Alternatively, hydrogen can be integrated into current energy distribution and end-use systems and utilize high renewables potential in the UK by converting green electrons into green molecules, that can be widely transported and stored seasonally. Mechanisms to store significant volumes of energy are important for coping with extreme environmental events like the infamous “Beast from the East”.

Lastly, hydrogen offers a pathway to revitalise manufacturing capabilities in the UK and improve the skill base for workers. The UK was a leader in discovering hydrogen and creating fuel cells, and today has several world leading manufacturers and supply chain businesses that with the right support could become global leaders and engines of economic growth for the UK economy. Using hydrogen, the UK could also become a global Centre of Excellence for hydrogen mobility and transport across land, maritime and aviation sectors.

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*Cover image credits*

*Image 1 and 3: Johnson Matthey*