# HYDROGEN INSIGHT 2025


Opportunities and challenges in
the UK's emerging hydrogen market

# Contents

## List of Abbreviations

| Abbreviations | Definitions |
|---|---|
| ATR | Auto Thermal Reforming |
| Capex | Capital Expenditure |
| CCS | Carbon Capture and Storage |
| CfD | Contracts for Difference |
| Devex | Development Expenditure |
| EHB | European Hydrogen Bank |
| ETS | Emissions Trading Scheme |
| EU ETS | European Emissions Trading Scheme |
| FID | Final Investment Decision |
| GW | Gigawatts |
| HAR | Hydrogen Allocation Round |
| HPBM | Hydrogen Production Business Model |
| HSBM | Hydrogen Storage Business Model |
| HTBM | Hydrogen Transport Business Model |
| LCCC | Low Carbon Contract Company |
| LCHA | Low Carbon Hydrogen Agreement |
| LCHS | Low Carbon Hydrogen Standard |
| Mt CO2e | Million tonnes of carbon dioxide equivalent |
| Mtpa | Million tonnes per annum |
| NESO | National Energy System Operator |
| R&D | Research and Development |
| SAF | Sustainable Aviation Fuel |
| SMR | Steam Methane Reformation |
| SSEP | Strategic Spatial Energy Plan |
| T&S | Transportation & Storage |
| TRL | Technology Readiness Level |

# 1 Executive Summary

Hydrogen will over time become an important component in the energy mix. Its specific contribution by 2050 will be dependent on factors such as pace of deployment, enabling policies and cost reductions. In the Climate Change Committee's Seventh Carbon Budget report, the Balanced Pathway sees hydrogen playing a small yet important role by 2040, especially in hard-to-electrify industries like ceramics and chemical production. Additionally, hydrogen is seen to have an important role in electricity supply by providing long-term storage that can be dispatched when needed and serving as a feedstock for synthetic fuels.

The UK is seeking to make the most of the opportunities this presents to create a successful low-carbon hydrogen sector. It is rightly seeking to leverage the expertise of its industrial and oil and gas sectors to accelerate the growth of this new industry which is still at the early stages of its development.

We recognise the pace of development has been slower than anticipated which means that the early targets for deployment set for the UK's hydrogen ambition are likely to be missed. For electrolytic hydrogen, the roll out of the Hydrogen Allocation Rounds has been slower than expected and lower capacity than expected was awarded in the first round. Electrolytic hydrogen in the UK is comparatively more costly than EU counterparts reflecting the cost of electricity; these issues will have to be addressed if the UK wishes to be a significant player in the emerging hydrogen industry.

We need to think big to succeed. CCS-enabled hydrogen offers the opportunity to achieve low carbon hydrogen production at scale and can pave the way for electrolytic hydrogen. However, to date, the CCS-enabled hydrogen production projects in the UK are yet to take Financial Investment Decision (FID). Without the scale of CCS-enabled hydrogen, it is not possible for the UK to reach its ambitious targets.

Developing a strong hydrogen sector remains critical to our industrial future. Hydrogen has the potential to decarbonise specific sectors, including power generation and transportation and offering industrial fuel switching and energy storage. However, hydrogen remains fundamentally more expensive than conventional fuels because of a combination of technology and electricity costs. For it to be competitive there needs to be cost reductions which will only be achieved if we initiate early investments and learn from them.

Growth in the hydrogen market should ultimately be driven by demand, but currently, there is a noticeable lack of it, partly due to fragmented policies across the value chain that create uncertainty. For example, the absence of business models for transportation and storage must be swiftly addressed to enable sector-wide development. Wider energy policy levers can support a more competitive market over time, while ongoing innovation and supply chain advancements will help reduce deployment costs. Establishing robust transportation and storage networks will enhance flexibility and provide the necessary options for both producers and offtakers.

Hydrogen is essential for decarbonising some of the hardest-to-abate industries, where few viable alternatives exist. Therefore, large-scale deployment is urgently needed to meet our climate goals. The case studies in this report demonstrate how OEUK members are already laying the groundwork for the hydrogen sector. The recommendations provided outline a clear path for the UK to leverage its strengths and take a leading role in this emerging market.

## 1.1 Key recommendations

1) **Prioritise early hydrogen end-uses:** There needs to be a clear prioritisation of sectors where hydrogen can be most competitive and impactful, rather than viewing it as a universal solution. Without decisive action, the UK risks falling behind other countries in the hydrogen economy. Hydrogen production costs are typically 3-9 times the costs of natural gas, even taking carbon pricing into account. Whilst costs will come down as production efficiencies grow, it will still be an expensive resource. Thus, its use is most suited to activities which are hardest to decarbonise such as high-temperature industrial manufacturing and dispatchable low carbon power generation and should be recognised as such.

2) **Confirm hydrogen ambition by committing to deliverable deployment targets:** The UK has the potential to be a major player in hydrogen, given the size of its market and the capabilities of its supply chain. However, the landscape that the hydrogen sector is set against has changed significantly in recent years and setting this government's ambition for the UK hydrogen sector is essential. It is crucial that project developers and supply chains have visibility of the size and scope of the sector they are developing and deploying.

3) **The funding mechanism for business models, such as the proposed GSO, must be designed to support the long-term nature of the market. It should be both robust and sustainable, with the flexibility to allow for adjustments over time as the market evolves:** Affordable long-term funding mechanisms for hydrogen business models are essential to provide certainty for investors. OEUK is working with members to respond to the Gas Shippers Obligation consultation, ensuring that long-term hydrogen funding is fair, proportionate, and balancing the need to preserve energy security and delivering net zero objectives. Carbon pricing should support projects in the long term but other potential markets such as hydrogen exports to Europe must be accelerated to maximise competitiveness and reduce reliance on taxpayer's funding.

4) **Policies must recognise the essential role of gas in achieving the necessary levels of low carbon hydrogen deployment:** Gas is a critical input for producing CCS-enabled hydrogen, also known as blue hydrogen, which is currently more cost-competitive than electrolytic (green) hydrogen. While both CCS and electrolytic hydrogen will be needed, CCS-enabled hydrogen can be a bridge, and CCS-enabled hydrogen projects in the pipeline need prioritising, especially the pipeline of projects totalling 9.5-14 GW of capacity which currently lack a route to market.

5) **Government and NESO should work closely to ensure strategic planning activities are aligned for the future energy system including electricity, hydrogen and its derivatives. It is also important to ensure that NESO has adequate resources and capacity:** Strategic planning for hydrogen within the energy system will be handed over to NESO in 2026 and in the interim government will be responsible. The complementary and competing nature of electricity generation and hydrogen highlights the needs for a systems approach to planning and deployment. This is reiterated when the links between hydrogen and electricity are considered with regard to the deployment of CCS infrastructure.

6) **Enable transmission-level blending:** Government has committed to consulting in 2025 about enabling hydrogen blending at the transmission level within Great Britain. This move has the potential to provide a (flexible) baseload for hydrogen demand and will also avoid the costs associated with importing blended gas from Europe, where blending is already enabled.

7) **Integrate hydrogen and wind:** The UK has a unique opportunity to lead in the hydrogen economy by leveraging its abundant renewable resources, specifically offshore wind, and existing infrastructure. By strategically designing and optimising hydrogen production, storage, and transportation systems, the UK can maximise its renewable resources, reduce energy wastage, and create a robust hydrogen market. Hydrogen production systems should be designed to utilise excess wind energy, which is often curtailed, and this issue is expected to grow significantly in future. By converting this excess energy into hydrogen, the UK can store it for later use, effectively balancing supply and demand. Therefore, government should take hydrogen into consideration for ongoing electricity market reforms (Contracts for Difference, Review of Electricity Market Arrangements (REMA) and grid connection reforms).

8) **Maximise the opportunity of repurposing existing energy infrastructure to hydrogen:** The UK's existing infrastructure for natural gas transportation and storage offers a valuable foundation for hydrogen. A significant portion of this infrastructure can be repurposed for hydrogen, reducing the need for new investments and speeding up the deployment. To capitalise on this, it is essential to avoid overregulating the hydrogen pipeline infrastructure and to learn lessons from the early design of CCS transportation networks.

9) **Simplify and evolve business models to remain investible:** Early business models are essential to make early hydrogen production and end-use economically viable, but they need simplifying and evolving to remain investable (see business model recommendations section).

10) **Standards regarding the definition of low carbon hydrogen should be harmonised between the UK and EU:** The ability to access other markets would be made easier should the UK and EU harmonise or recognise the slight differences in approach to qualifying hydrogen volumes.

# 2 Introduction

Low carbon hydrogen[1] presents a potential solution to several decarbonisation challenges across different sectors of the economy. Its versatility makes it an option for replacing high carbon fuels for industrial uses (industrial fuel switching), power generation, energy storage, transportation and potentially heat. The shift to hydrogen may be less challenging and disruptive for some consumers, given the current extensive use of gaseous and liquid fuels in the UK for energy. The UK, alongside many other countries, have recognised that hydrogen must be part of their energy mix. When the UK Hydrogen Standard was developed, government anticipated that hydrogen could have made up between 20-35% of the UK's final energy consumption by 2050. This range is uncertain due to the nascent nature of the sector but regardless of the precise level of hydrogen in the energy system, it is expected to play an important role in reaching net zero objectives.

The sector's development has been limited so far, partly due to high costs, low demand, and delays in several key areas. These include allocation rounds for electrolytic production, financial investment decisions (FIDs) for CCS-enabled production, transport and storage (T&S) business models, and the finalisation of policies related to T&S and end-use. It is essential to provide clarity on the sector and maintain consistency to drive the demand market and address cost barriers across the value chain. In turn, this will give supply chains the signals needed to develop the capacity and capabilities to support a robust hydrogen sector in the UK and beyond.

While hydrogen production and deployment are currently limited, there is significant interest to expand its role, as evidenced by the national hydrogen strategies put forth by multiple governments, including the UK. The new "hydrogen economy" aims to leverage hydrogen in innovative applications that align with climate targets. The specific role of hydrogen in the global energy system and in the UK remains unclear and will depend heavily on how quickly production scales up alongside the creation of demand-side market signals.

Low carbon hydrogen also has a role to play in replacing traditional hydrogen demand. This demand has historically been from refining, fertilisers and industrial uses. At the time of the publication of the UK Hydrogen Strategy, global demand was around 90 million tonnes per annum (Mtpa), and was met mainly by production without emissions capture (grey hydrogen). These industries will still require hydrogen for their processes, so global low carbon hydrogen production must address both the existing demand and the innovative future use cases. Therefore, it is crucial to prioritise early hydrogen end-uses where hydrogen can be most competitive and impactful for decarbonisation. This recommendation is also relevant when considering that some decarbonisation opportunities will prioritise electrification. If electrification is possible, then it will likely be prioritised in the current environment, given it may be more cost effective to do so, there will be reduced energy losses and there is likely to be electricity infrastructure.

The challenge of stimulating both supply and demand in tandem, combined with nascent policy frameworks and supply chain constraints, has prevented projects from materialising as the industry had

[1] Unless otherwise specified, when "hydrogen" is mentioned in this report it is in the context of low carbon hydrogen regardless of its production method.

anticipated a few years ago. Nevertheless, the low carbon hydrogen sector is expected to grow, with a global capacity pipeline of over 110 Mt by 2050.

To achieve the necessary scale up of hydrogen production, gas will play an essential role. Gas is a critical input for producing CCS-enabled hydrogen, which is currently more cost-competitive than electrolytic hydrogen. While both CCS-enabled and electrolytic hydrogen will be needed, CCS-enabled hydrogen can be a bridge, enabling the early development of a low-carbon hydrogen market while electrolytic hydrogen technologies continue to evolve and become more commercially viable, and ultimately scaling up. The “twin-track approach” of developing CCS-enabled and electrolytic production methods in parallel will allow the UK to scale up hydrogen production in a cost-effective way, building the foundations of the hydrogen economy.

The UK has made progress in developing the policy foundations for the emerging hydrogen sector since the publication of its Hydrogen Strategy in 2021, including the design of the low carbon hydrogen standard and hydrogen production business models. The development of the sector represents a significant economic and exporting opportunity for the UK as average global hydrogen expenditure is set to reach approximately £93 billion between 2035 and 2040.

# 3 Hydrogen market overview

## 3.1 Global outlook and the UK's place in it

The current hydrogen production capacity equals 121 Mtpa: 97.2% grey, 2.4% CCS-enabled (or blue), 0.4% electrolytic (or green). The global production in 2050 is forecast to be 215 Mtpa of this, 43% of the low carbon hydrogen pipeline is based on electrolytic hydrogen, while 11% comes from CCS-enabled projects.

There is a global variation in the hydrogen production mix based on the strengths of different countries that shape their competitive edge. For instance, over 60% of the cost of producing hydrogen through electrolysis is attributed to electricity costs. Therefore, countries with access to low-cost renewable electricity have a competitive advantage. On the other hand, CCS-enabled hydrogen is seen as a highly scalable option that can be more competitive in some regions due to the ability to leverage existing infrastructure and a lower reliance on components with limited supply chain capacity like electrolysers. Both electrolytic and CCS-enabled hydrogen production routes are important tools to meet net zero targets. This should not be viewed as a competition but rather as an opportunity to scale up both production methods, ensuring that supply aligns with demand.

National hydrogen strategies have been developed in many countries, signifying the intent to create an international hydrogen production market. Further, international cooperation is beginning to develop. For example, the UK have partnered with Germany, Chile and Australia, aiming to increase the share of hydrogen in the energy mix, unlock financing for hydrogen exports and drive innovation into the sector. Agreements are also taking place with nations that will have a surplus of hydrogen supply, coordinating with other nations that can benefit from surpluses.

In the UK there is a pipeline of over 100 projects with a cumulative potential of over 15 GW by 2030. Currently, the UK industrial electricity prices are some of the highest globally and to support electrolytic hydrogen, there needs to be continued work in building out the grid. In tandem with this, the UK can leverage an oil and gas heritage that has the skills and capabilities that are highly transferable to hydrogen production and infrastructure. UK companies and professionals have decades of experience in operating energy infrastructure safely and efficiently. A significant portion of the UK's existing energy infrastructure can be repurposed for hydrogen. The UK has the world's second largest pipeline of CCS-enabled hydrogen projects at 3 Mtpa following the US which leads with 10 Mtpa.

Figure 1

Hydrogen production capacity additions

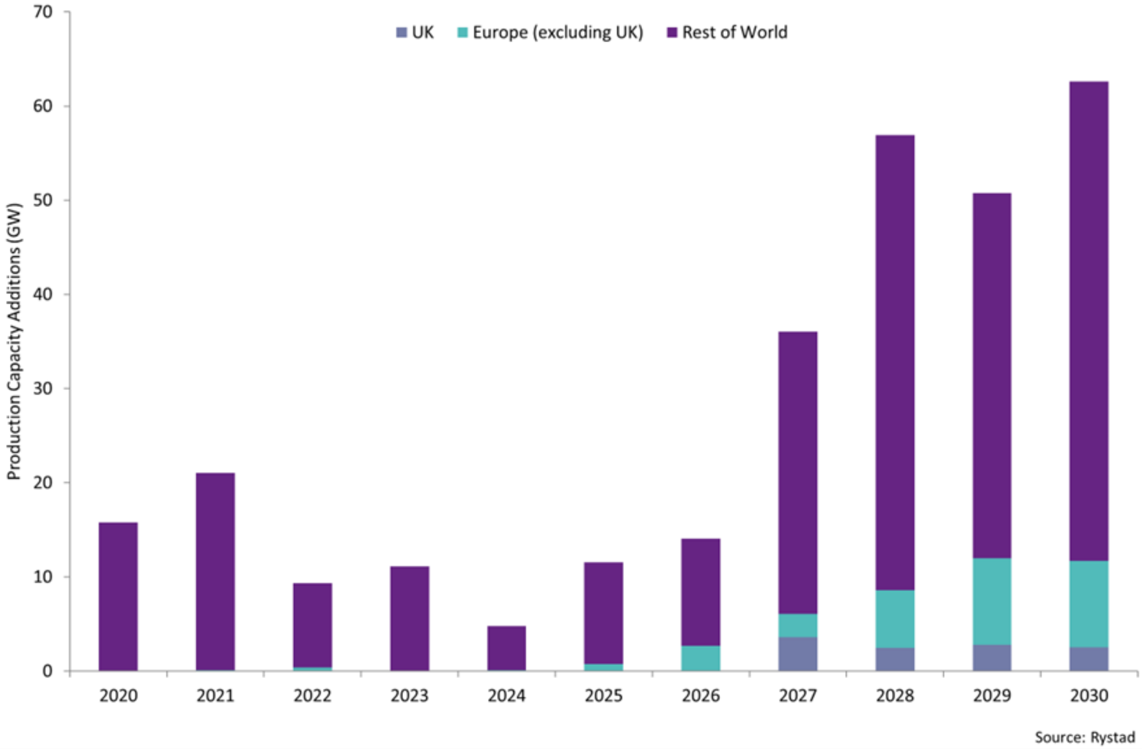
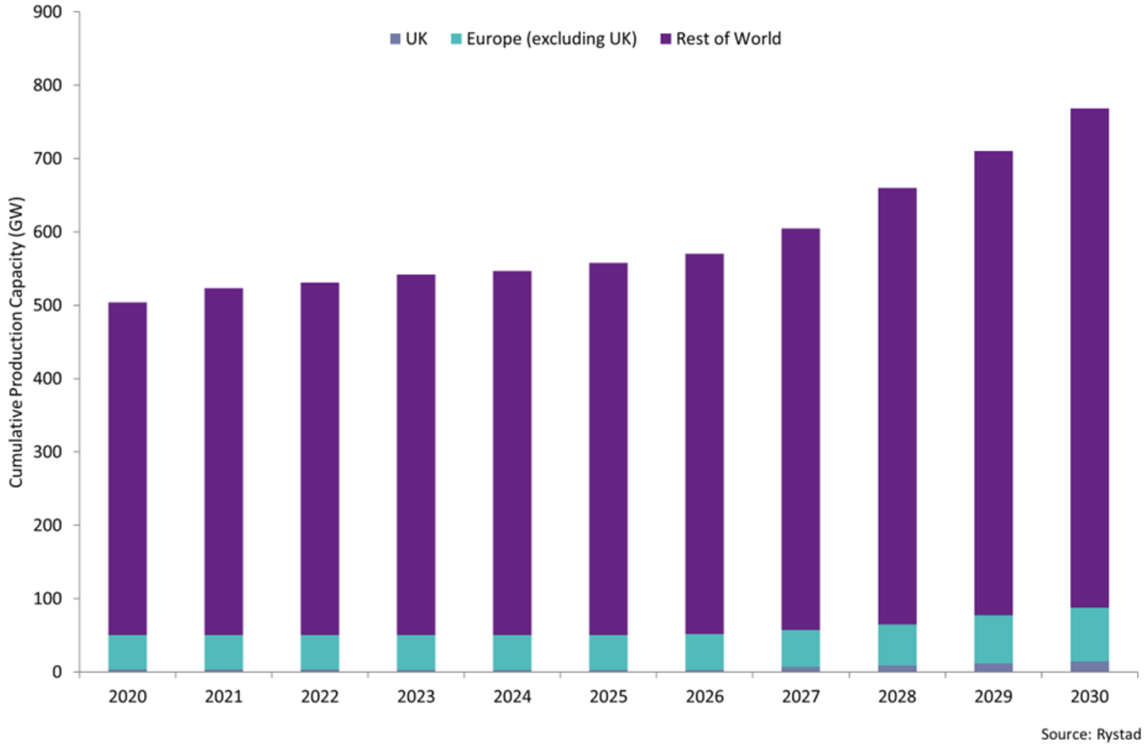



Figure 2

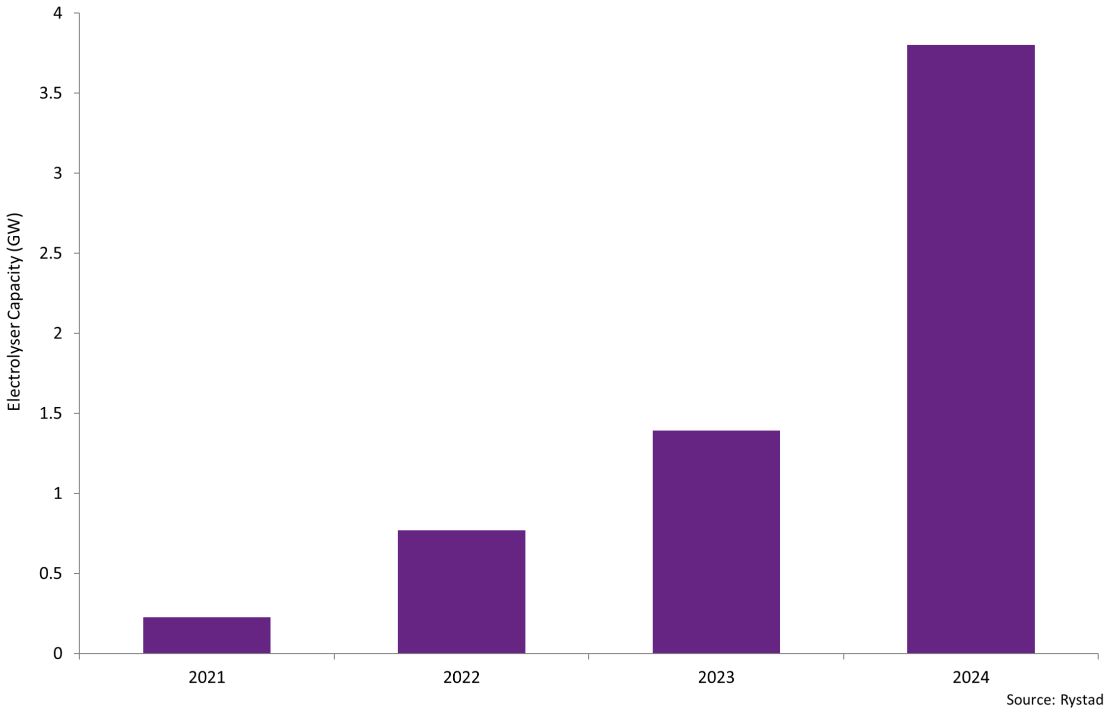
Hydrogen production capacity



Hydrogen has been widely used for decades, and existing supply chains already meet many challenges associated with its production, transportation, storage, and end use. However, there remain significant opportunities for innovation to reduce costs and enhance efficiency. There has been significant growth in the global electrolyser installed capacity and further growth will be needed to meet production targets. This expansion shows the need for substantial scaling efforts and infrastructure development, especially for electrolytic hydrogen.

Figure 3

Electrolyser installed capacity (GW)




## 3.2 European hydrogen market

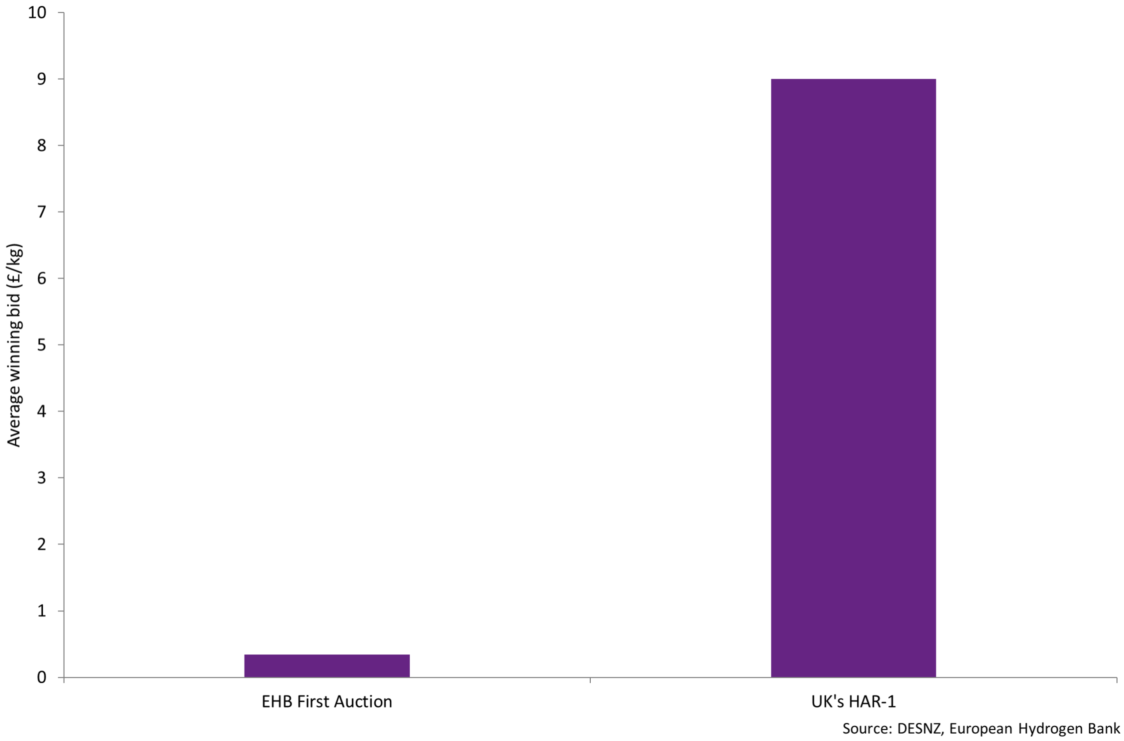
Hydrogen is a key part of the European Union's drive for net zero. The European Hydrogen Bank (EHB) is aimed at establishing a new market for hydrogen. The EHB uses an auction mechanism funded through revenues of the European Union Emissions Trading System (EU ETS) where potential hydrogen producers compete for a fixed subsidy per kilogram of renewable hydrogen produced. The first auction, in April 2024, attracted significant interest with 132 bids. The round allocated €720 million to seven projects from the Iberian Peninsula and the Nordics, which are regions with abundant renewable energy priced competitively. The initial auction revealed winning bids averaged €0.40/kg, well below the price ceiling of €4.50/kg. For context, the Hydrogen Allocation Round (HAR) 1 auction in the UK saw winning bids at around £9.00/kg. A second auction, commencing in December 2024, has a budget of €1.2 billion.

The cost differential between the two regions reflects the ability to finance a project and source cost effective electricity options rather than the technology costs, given the supply chains in the two regions will be very similar. The risk of the UK market is perceived to be higher and the electricity prices in the

UK are more expensive than those specific to the chosen projects in areas with low costs due to high renewables in Europe.

Figure 4

Cost comparison between the first electrolytic hydrogen auctions in the UK and Europe




Alongside EU-wide initiatives member states are developing their hydrogen plans and providing additional support. For example, Germany is leading the way in the development of a national hydrogen transportation network. Its hydrogen core network is being developed to create a nationwide hydrogen infrastructure to support its National Hydrogen Strategy. The network will connect major hydrogen consumption and production centres, including industrial hubs, storage facilities, power plants, import corridors, and hydrogen clusters. The proposed network is 9,040km, with approximately 60% of this being existing natural gas pipelines repurposed for hydrogen. The German government approved the proposed network with an expected investment cost of €18.9 billion in October 2024. The project is set to be operational in phases by 2032.

## 4 The role of hydrogen in achieving net zero in the UK

Hydrogen can be considered versatile due to the range of decarbonisation applications, as well as its ability to be transported and stored. Despite this, its precise role in the UK energy system by 2050 remains uncertain. A critical factor influencing the uptake of hydrogen will be the availability of transportation and storage infrastructure as well as the extent of electrification across energy users.

The disparity between potential production locations and points of demand is well understood. From a strategic planning perspective, options for regional and national hydrogen transportation pipelines are being evaluated, aiming to connect supply and demand. Technically, this work is being supported by a range of projects that are assessing the viability of these networks. While financially, the government has acknowledged there is a need to provide support for transportation and storage infrastructure to bolster the synchronisation between production and use.

### 4.1 Industrial decarbonisation

Low carbon hydrogen has the potential to contribute to the decarbonisation of industrial processes and should also be used to replace existing hydrogen production. In industry, hydrogen can be used as a feedstock for processes that require high temperatures and where electrification is not possible. It can also be used as an alternative input into industrial processes that normally incorporate emissions intensive materials.

Industry in the UK will need to decarbonisation their activities to meet emissions reduction targets, meet governance requirements and to avoid potential cost increases that may arise from various market mechanisms. The UK has witnessed dramatic deindustrialisation in recent decades, with further losses if industries are unable to decarbonise their activities at pace.

Decarbonising industrial activities is both expensive and burdensome, therefore, to kickstart the process of industrial decarbonisation government has developed a suite of support mechanisms. This support has enabled industrial users to develop, innovate, trial and implement decarbonisation technologies. There is a variety of support that addresses different barriers that industrial users may come across in the process of decarbonisation.

For example, the Industrial Energy Transformation Fund provides capital expenditure (capex) and development expenditure (devex) support for the development and deployment of technologies that enable businesses with high energy use to improve energy efficiency and invest in low carbon technologies. Another example is the Industrial Fuel Switching Competition that provides funding for the development and demonstration of fuel switching and relevant enabling technologies.

### 4.2 Transport

UK Emissions from surface transport, aviation and shipping were equal to 103 Mt $CO_2e$, 35 Mt $CO_2e$ and 11 Mt $CO_2e$ respectively in 2024. There is an expectation that electrification will remain the main method of decarbonisation for cars, vans and buses, however, decarbonisation of heavy goods vehicles, aviation and shipping has been identified as more challenging due to their difficulty electrifying.

Therefore, hydrogen, derivatives and technologies have been identified as potential decarbonisation methods.

Heavy vehicles, aviation and shipping are examples of where it may be more appropriate to use hydrogen due to the lack of alternatives. Market conditions that could drive investment in decarbonising these transport types have not fully materialised. Therefore, to simulate demand, government has developed the Sustainable Aviation Fuel (SAF) Mandate which obligates the supply of an increasing amount of SAF in the overall UK aviation fuel mix.

## 4.3 Power

Combustion of low carbon hydrogen to produce electricity is known as hydrogen to power. It has been identified as one of several potential methods that may need to be deployed in the long-term displacement of unabated gas and could be implemented through the use of new or retrofitted stations. Use of hydrogen in this way can complement the UK's expanding renewable fleet by generating electricity when there is low renewable generation. This process is similar in principle to pumped hydropower, where excess electricity in the system is used to 'top up' the system in preparation for when it needs to be deployed.

The role of hydrogen to power in the electricity system would be as a flexible generation source as it can be stored for long durations. The ambitions for the UK electricity system are being driven in the short term by Clean Power 2030. Hydrogen to power will play an increasing role in the electricity system but it is likely to come online after 2030. This is reiterated in NESO's Clean Power 2030 capacity outlook based on technology which assumes 0.3-2.7 GW of dispatchable power (gas CCS or hydrogen) by 2030.

In order for hydrogen to power to make an impact in the displacement of unabated gas in the flexible generation market, there needs to be large-scale hydrogen storage available, large-scale production and relevant pipeline networks to connect the elements of the process. There also needs to be updated market structures that deploy this technology above more emission intensive methods, should it be cost effective to do so. Lastly, the coordinating mechanism for grid balancing needs to develop and build resilience such that the increasingly complex system does not undermine the way in which generation methods are deployed.

## 4.4 Domestic heating

Emissions from commercial and residential building in the UK equated to approximately 81 Mt $CO_2e$ in 2024. In order to address the emissions associated with the heating element of the UK building stock, hydrogen has been identified as a potential decarbonisation mechanism. The case for hydrogen for residential heating has proven to not be as robust as other alternatives, when considering feasibility, infrastructure, costs and availability of hydrogen.

The public perception and willingness to use hydrogen in homes has not been positive and as such, it is anticipated that there will be little to no role for hydrogen for domestic heating. A key aspect of the public view is the safety of using hydrogen, there is a role for industry and government to show how hydrogen will safely become a larger part of the UK's energy mix. A notable outcome of the studies and investigatory period around hydrogen for heating has shown the ability and pace at which government and industry are able to deploy initiatives to establish safety cases.

The official government decision on hydrogen for heating is still outstanding and as such, is creating uncertainty on the size and scope of the UK hydrogen sector. There is a general consensus that there is unlikely to be any significant role for hydrogen for domestic heating, but the uncertainty still shapes the sector. Government must outline their ambitions and targets for the sector.

# 5 Boosting the UK's hydrogen sector

The UK government has taken a considered approach to developing the foundations of the UK hydrogen sector. The UK Hydrogen Strategy, the Hydrogen Production Business Model, the Low Carbon Hydrogen Standard and the Low Carbon Hydrogen Agreement all contribute to the UK being considered a forerunner in developing a low carbon hydrogen sector.

To move from these positive foundations to a functioning sector, the current government need to **confirm hydrogen ambition by committing to deliverable deployment targets**. Investment signals are still not strong enough to catalyse UK supply chains. It is essential to provide clarity and consistency to drive the demand market and address cost barriers across the value chain. In turn, this will give supply chains the signals needed to develop the capacity and capabilities to support a robust hydrogen sector in the UK and internationally.

Cost is a barrier to its widespread deployment. Cost profiles experienced during early stages of a sector, the cost of alternatives and wider economic forces (for example carbon prices), all undermine the competitiveness of hydrogen as a decarbonisation option. Short-term funding of hydrogen will be needed to grow production capabilities and support demand, however over the longer-term carbon pricing will be the primary mechanism for pricing support.

## 5.1 Production – a twin track approach

The UK has opted to develop a 'twin track' approach to hydrogen production, where both electrolytic and CCS-enabled production methods are simultaneously supported. The ambition of government is to have 10 GW of low carbon hydrogen production by 2030, with 6 GW from electrolytic hydrogen production and 4 GW of CCS-enabled hydrogen production.

Government developed the Hydrogen Allocation Rounds which are auction rounds to compete for government support from the Hydrogen Production Business Model (HPBM) for electrolytic projects. Table 1 shows the proposed frequency and targeted capacity that government have proposed to date for the rounds. Whilst setting a timeline for these allocation rounds is a positive signal, they need to be appropriately funded. The long-term funding mechanism for the HPBM is proposed to be through the Gas Shipper Obligation, it is welcome to see a mechanism in place, but the longevity and sustainability of this levy must be considered.

**Table 1**

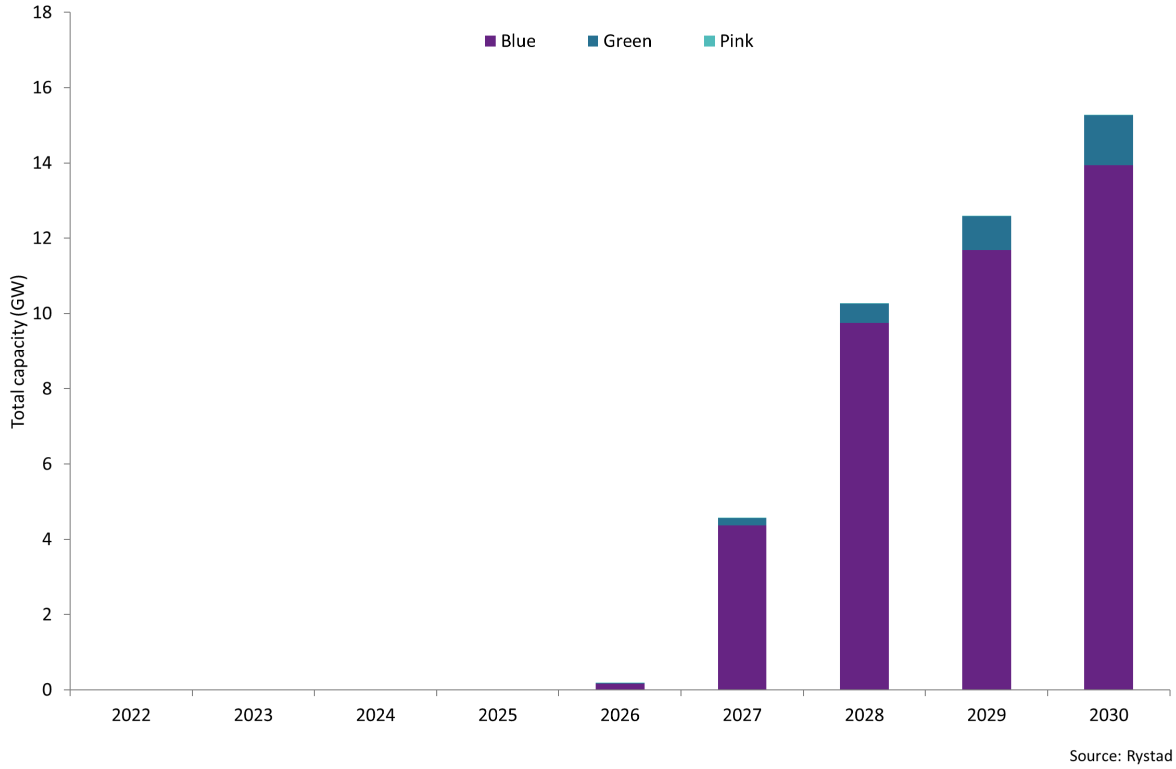
**Hydrogen Allocation Round Capacity and Timelines**

| Allocation Round | Production Capacity (MW) | HAR Launch Year *Proposed* | Contract Award |
|---|---|---|---|
| HAR1 | 125 (originally 250) | 2023 | 2024/2025 |
| HAR2 | 875 | 2023 | 2025 |
| HAR3 | 750 | 2025 | 2026 |
| HAR4 | 750 | 2026 | 2027 |

CCS-enabled hydrogen projects are supported through the cluster sequencing process. In October 2024, Track-1 clusters (East Coast Cluster and Hynet) received confirmation of £22bn of funding over 25 years. CCS-enabled hydrogen projects in clusters, which are yet to receive confirmation of support, will be crucial to deploying hydrogen production at scale, as can be seen in Figure 5, therefore **policies must recognise the essential role of gas in achieving the necessary levels of low carbon hydrogen deployment.** This will require continued progression of the sector through delivery of Track-1 and Track-2 clusters and a route to market for those outside the cluster sequencing process.

Figure 5

UK Pipeline of projects



# Case Study:
# UK Project H2NorthEast

H2NorthEast is a partnership between Kellas Midstream and SSE Thermal to build a 1GW CCS-enabled (carbon capture and storage) hydrogen production facility on Teesside, in one of the UK's most energy-intensive industrial heartlands. The project will support large-scale industrial decarbonisation across the region, through the supply of affordable low carbon hydrogen.

H2NorthEast is vital for Teesside and the UK. It can unlock over £2 billion of investment and support thousands of jobs locally, and will be vital to the UK's clean power plan by making a very significant contribution towards the government's 10GW hydrogen capacity target.

At the end of 2024, H2NorthEast completed front end engineering design (FEED) for Phase 1 and commenced preparations for the planning application process required for nationally significant infrastructure projects. H2NorthEast now awaits further policy decisions from government that will enable its continued progress, including clarity on timing of the Track 1 expansion process.

The facility will be co-located with Kellas' CATS (Central Area Transmission System) gas terminal which has been operating safely and reliably on Teesside for over 30 years. Today, CATS handles around a quarter of all UK-produced gas coming ashore from the North Sea.

H2NorthEast will be unique in using UK-produced gas via CATS to produce low carbon 'blue' hydrogen, with the CO2 created in the production process captured at source and securely sequestered in the Northern Endurance Partnership's (NEP) CO2 storage facility being developed under the North Sea.

Integrating UK-produced gas into the hydrogen production process in projects like H2NorthEast is pivotal for scaling up the availability of low carbon hydrogen. The required technology can be implemented now, and at the scale needed to accelerate the UK's transition to clean energy.

Gas serves as a crucial feedstock and energy source which enables efficient and scalable hydrogen production. Utilising gas in conjunction with advanced technologies like CCS can significantly reduce emissions, and position hydrogen as a key player in the transition to clean energy. This synergy enhances the feasibility of large-scale hydrogen deployment and underscores its critical role in helping the UK meet its clean power targets by providing a reliable low carbon energy source to complement intermittent renewable power production.

## 5.2 Transport and storage infrastructure

The development of hydrogen transport and storage infrastructure is essential to kickstart the sector. These T&S networks will link producers with offtakers, and with storage built-in, it will help to balance supply and demand. The government is creating business models to support the rollout of T&S infrastructure. This includes designing the Hydrogen Transport Business Model (HTBM) and the Hydrogen Storage Business Model (HSBM), both of which aim to offer certainty for investors and de-risk early-stage projects. These business models should underpin the government ambition of developing two hydrogen storage sites supported by regional transportation infrastructure in construction or operation by 2030.

Responsibility for strategic planning for hydrogen within the energy system will be transferred over to the National Energy Systems Operator (NESO) in 2026. In the interim, **government and NESO should work closely to ensure strategic planning activities are aligned for the future energy system including electricity, hydrogen and its derivatives. It is also important to ensure that NESO has adequate resources and capacity.** Considering hydrogen as part of the system allows for system optimisation, minimisation of costs and strategic deployment of assets that support emission reductions across the UK. Hydrogen will be a key component of the Strategic Spatial Energy Plan (SSEP) to be developed by NESO. The SSEP is focused on the generation and storage of electricity and hydrogen, and this will also enable better planning of the power grid. The SSEP will act as a blueprint from which future plans will flow.

Bulk transmission and local distribution infrastructure may be required for hydrogen akin to that currently used for natural gas. It is envisaged that transmission level infrastructure will be developed as a combination of new and existing pipelines gradually serving regional hubs before potentially connection hubs on a wider basis to form national infrastructure.

Distribution level infrastructure will also be a mix of new and existing infrastructure, but it is expected there will be a significant number of new pipelines. In order to support the deployment of these pipelines the HTBM is required to reduce barriers to entry and de-risk investments for developers in this emerging part of a nascent sector.

Energy storage in the short term has the ability to deliver stability to the energy system as a whole and in the long term can provide energy security. Hydrogen storage will address short term variability in supply and demand and provide reserves for both hydrogen and electricity. In order to have an effective energy system, small- and large-scale storage will be required.

Large scale storage, in the form of salt caverns or depleted gas reservoirs capitalise the UK's natural geographical features. The development of large-scale storage facilities will be expensive and as such, the government has developed a support mechanism that addresses this. The HSBM is being developed to provide support to developers to derisk their projects.

## 5.3 Repurposing existing infrastructure

As the UK sees a fundamental change in its energy landscape, there are significant opportunities to repurpose existing assets and infrastructure that allows integration into the system. The role of gas in the UK energy mix will change, therefore, the existing infrastructure and networks may present an opportunity for the evolving hydrogen sector. Repurposing some of the transmission and distribution level pipelines have been identified as an opportunity to develop a hydrogen transportation system.

Transmission level transportation would be needed to link hydrogen production sites with demand and storage across the UK. There are cost benefits associated with using pipelines to transport gases across the UK, and repurposing parts of an existing system could reap even more cost savings. Project Union, led by National Gas is aiming to both repurpose existing gas transmission pipelines and build new sections to create a hydrogen backbone for the UK.

The UK hydrogen sector will see geographical misalignment between key production sites and large-scale users, especially in early phases of development. Production sites will be near locations of excess renewables (for electrolytic-enabled production) or CCS-clusters (for CCS-enabled production). Large-scale demand will initially focus on industrial clusters but later on it can potentially grow to dispersed sites, and transportation hubs that will need hydrogen for their operations or power and storage sites that are fixed due to natural or existing infrastructure. This reflects some of the geographical misalignment that is mediated by the existing gas transmission and distribution networks and therefore highlights the opportunity in repurposing some of these existing networks.

# Case Study: FutureGrid leads the UK's switch from natural gas to hydrogen

Research must overcome various technical issues to repurpose pipelines on a large scale. National Gas's FutureGrid programme is analysing how to integrate hydrogen into the National Transmission System for hard to decarbonise sectors. The project involves the design, build and operation of a high-pressure hydrogen test facility using decommissioned NTS assets to test hydrogen mixtures and eventually pure hydrogen as well as conducting intensive lab tests on material behaviour and examinations of how hydrogen affects pipeline maintenance activities like corrosion control and repairs. The primary objective is to evaluate the feasibility and safety of transporting hydrogen through existing pipelines.

Phase 1 of the project, which commenced in 2021, concentrated on repurposing transmission assets for hydrogen. Phase 2 involves the development of a compression and 1km long pipeline test facility, along with the addition of infrastructure for de-blending, purification, and refuelling to secure a safe and cost-efficient hydrogen network.

FutureGrid Phase 1 repurposed assets were subjected to testing at different blends of natural gas with hydrogen (2%, 5%, 20%) and 100% hydrogen; this was achieved with no major findings in differences in terms of how the assets interact with hydrogen.

The Lord Cullen Training Centre is not just another classroom—it is a place to experience hydrogen hazards up close, to feel the gravity of the lesson. Watching fires ignite and hearing explosions for the first time is both humbling and eye-opening. Experiencing these dangers firsthand makes it clear why understanding hydrogen risks isn't optional—it's essential. The practical approach here doesn't just teach us about the hazards; it shows us why every risk management measure matters. This isn't something you can fully grasp from a book—it's something you have to live through to truly understand.

DNV's Research and Development Facility at Spadeadam, Cumbria was established in 1977 and has performed comprehensive research to evaluate the impacts of major and minor hazards on life, property and the environment. These findings have been instrumental in pioneering risk management for entire industries. In parallel; this understanding of hazard and risk has allowed for new control measures, shaping of industry standards, and safeguarding against unintentional and intentional threats.

FutureGrid (and the wider Hydrogen Research Facility), and the Lord Cullen Training Centre – form a unique hydrogen hub that drives advancements in safety and innovation. The combined hub ensures that DNV's Facility at Spadeadam is a world-class hydrogen test and demonstration site, that is providing key evidence to transition the UK gas network. The previous, ongoing and future projects being undertaken are a critical element for the energy transition in the UK as it looks to reach its legally binding Net-Zero goals by 2050.

The FutureGrid facility (Phase 1 shown here) aids the UK's transition from natural gas to hydrogen

## 5.4 Supply chains and innovation

To meet the anticipated scale up of the hydrogen sector, the supply chain needs to innovate and scale in tandem to support cost reduction and standardisation activities that have benefited fixed offshore wind and solar sectors for example. Additionally, the existing supply chain needs to expand its capacity as many aspects of the existing energy supply chain translate into the hydrogen sector. Therefore, it will be expanding to meet the needs of many areas of the energy sector. as there will be demand from

One of the main challenges comes when scaling up from laboratory to industry as there is less funding available. In the UK there is some funding available for early Technology Readiness Level (TRL) innovations, but the supply chain still faces high upfront Research and Development (R&D) costs and a lack of appetite from investors due to high risks. Partnerships with Research Institutes and Academic facilities can help to scale up to prove an innovation and help it move from development to commercialisation.

It is also crucial that industry play a role in innovation and scale up, Industry Joint Projects with funding from industry and potential government can help to embed innovation in supply chain activities.

# Case Study: Hy-One - Scotland's Hydrogen Storage Testing Facility

HY-ONE
SCOTLAND'S HYDROGEN STORAGE TESTING FACILITY

Hy-One is a comprehensive hydrogen storage test facility designed for plug-and-play testing and demonstrations of hydrogen storage systems, prototypes and accessories. It is funded by the Scottish Government as part of the Hydrogen Innovation Scheme, a £7m capital funding stream of the Emerging Energy Technologies Fund (EETF).

Through a partnership between Robert Gordon University and the Scottish Government, the facility will support the development, demonstration and implementation of compressed hydrogen storage vessels and accessories, from small to large scale. The overall goal of Hy-One is to support increased renewable hydrogen production across the UK. The facility is also poised to contribute to the government's target of achieving 5GW of installed hydrogen production capacity by 2030.

## Key Capabilities

Prototype & Concept Development

Hy-One will support prototypes and concepts across TRL 1 to TRL 9, focusing on early-stage concept evaluations. The team will offer advice to businesses on prototype development and guide storage vessel developers on best practices for testing, improving and evaluating new technologies.

### Hydrogen Vessel & Component Testing

Hy-One will produce technical reports on current and future understandings of hydrogen storage technology and inform government standards for the development of compressed hydrogen vessels. It will also conduct various testing on hydrogen storage technologies and associated accessories using sensors, measurement equipment and data acquisition systems.

### Certification

Hy-One will offer certifications and compliance qualifications in line with national standards, supporting the development of compressed storage vessels and advancing renewable energy production and integration into energy systems.

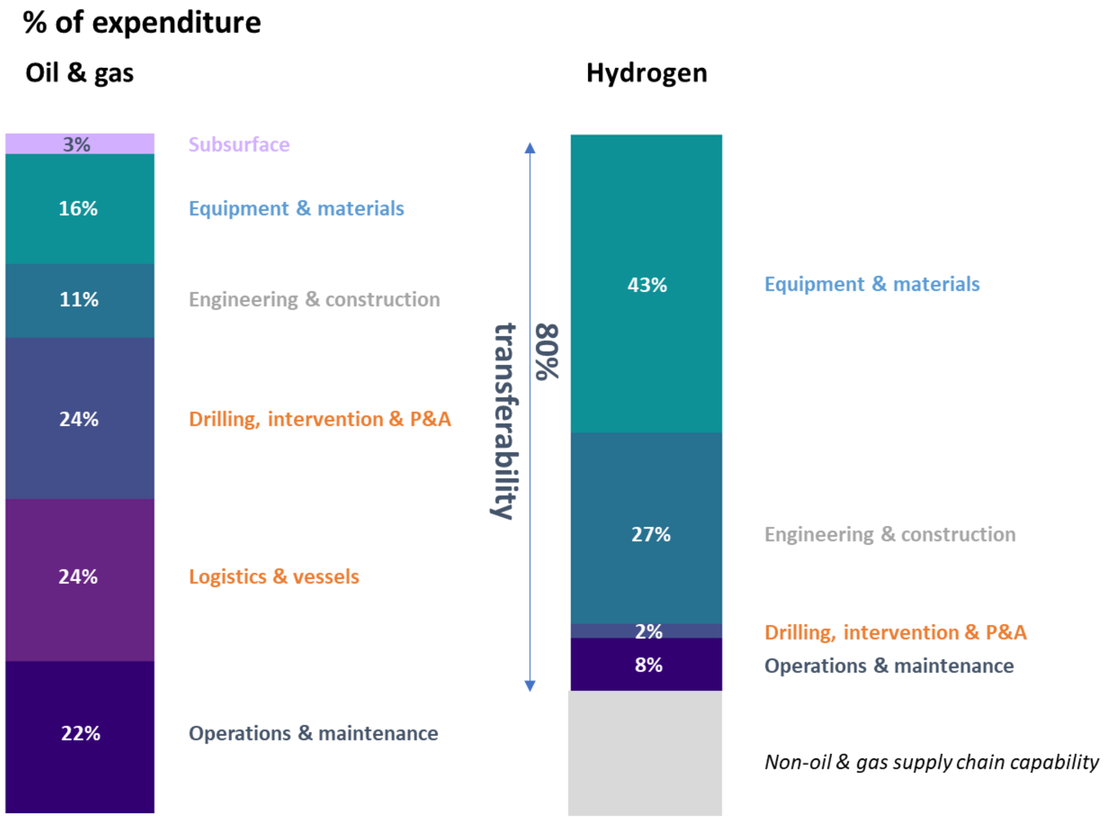

### Collaboration

As Hy-One advances, it aims to leverage the growing range of hydrogen innovation assets to develop a hydrogen cluster, providing training and development for the national supply chain and supporting job creation. Hy-One also offers collaboration opportunities in the fields of certification and compliance qualification services, facilities for developing proof-of-concept prototype stage and support for prototypes and concepts in the hydrogen sector through research facilities and business advice.

Alongside innovation, it is crucial that the existing supply chain is used to its full potential. In an independent supply chain study commissioned by OEUK and carried out by Rystad Energy, it showed that most of the UK oil and gas supply chain's capabilities align with the capabilities required for building hydrogen supply chains. About 80% of the hydrogen market can be targeted by the oil and gas supply chain, driven mainly by the onshore construction supply chain and equipment and materials.

Figure 6

Supply chain capabilities in the hydrogen sector




Source: Rystad, OEUK

## 5.5 Hydrogen demand and use

Signals that often force consumers to change their processes have been too weak to drive demand for hydrogen. A low carbon price, lack of hydrogen transportation and storage infrastructure and concerns about security of supply have all militated against conversion to hydrogen.

There are energy policy levers that can be pulled to begin to generate the moving forces that warrant change of users that may be inclined to invest in hydrogen. These have not been effectively mobilised to date, but support has been developed. The external environment that will drive demand in hydrogen needs to change so that producers can have - and demonstrate - sufficient certainty that the demand will be there for the hydrogen they produce.

Hydrogen users have highlighted that sometimes the expectation of them to have offtaker commitments of at least 15 years has meant they are not able to commit.

# 6 Economic drivers and policy foundations

In the early stages of developing the low-carbon hydrogen sector in the UK, funding support will be essential for both producers and offtakers to de-risk early projects and bridge the gap between hydrogen production costs and their counterfactuals.

Funding for the UK hydrogen sector to date has been through the exchequer. The Energy Act 2023 set powers to establish a hydrogen levy that would provide a funding mechanism for hydrogen business models. The Act specifies that the "relevant market participants", Great British and Northern Irish gas shippers, will make payments to the Hydrogen Levy Administrator (should the mechanism be brought into force). These payments would aim to fund the payments of the counterparty of the business models, the LCCC, cover the cost of the administrator, build up reserves and cover losses in the case of insolvency. The Gas Shipper Obligation (GSO) is the planned mechanism and government have consulted on the details of it in early 2025.

It is likely that the levy imposed will increase the unit cost of gas shipped in order to cover the costs of the HPBM payment, the administration of the obligation mechanism and contingencies. This will have the impact of increased costs to users of gas, including consumers.

It is envisaged that the GSO will be operational and collecting by 2027, in the short term it is likely that the impact on the GSO on bills will likely be limited, however in the mid to long-term there could be a more pronounced change in associated costs for consumers and a risk of de-industrialisation for intensive users. Therefore, **the funding mechanism for business models, such as the proposed GSO, must be designed to support the long-term nature of the market. It should be both robust and sustainable, with the flexibility to allow for adjustments over time as the market evolves.** The funding mechanism needs to be flexible if gas volumes in the UK are to reduce, as those who still use gas will pay for the levy, but split over a smaller proportion of users. This may require an assessment in the mid to long-term about the operability of the mechanism.

There is the opportunity to learn from other markets outside the UK, such as the European Hydrogen Bank model will be important. Further, competition and emissions reduction requirements should continue to be encouraged in end use markets.

## 6.1 Hydrogen Production Business Model

The Hydrogen Production Business Model is a government mechanism to support the production of low carbon hydrogen. This is underpinned by the Low Carbon Hydrogen Agreement (LCHA), which is a private law contract between producers and the Low Carbon Contracts Company (LCCC), the government-appointed counterparty. The business model provides financial support through the CfD mechanism, similar to the one used in the offshore wind sector.

**Main components of the HPBM:**

**Strike Price:** A key aspect of the LCHA is the negotiation of a fixed strike price for each project. This strike price reflects the level at which a producer can cover production costs and secure a predefined return on investment. This is aimed at providing revenue stability.

**Reference Price:** To calculate the financial support required, the LCHA uses a reference price, aiming to set the market value of hydrogen. However, the hydrogen market is still nascent, there is no price benchmark. As a proxy, the reference price is determined as the higher of:

- The producer's achieved sales price for their hydrogen, which is the total sales price less specified cost exclusions.
- A floor price set at the lower of the current natural gas price or the strike price. The rationale for linking the reference price to natural gas is that it is the most likely fuel from which users would switch to hydrogen, and because of carbon pricing, users would likely be willing to pay at least the gas price for hydrogen

**Difference Payments:** Based on the strike price and reference price, the LCHA provides difference payments between the LCCC and the producer.

- If the strike price is higher than the reference price, the LCCC pays the difference to the producer. This ensures producers receive sufficient revenue to cover their costs and achieve their expected returns.
- If the reference price exceeds the strike price, the producer pays the difference to the LCCC. This helps protect the taxpayer.

Note: there are also two further ways that producers can receive payments: through price discovery and a top up mechanism that is triggered if sales in a billing period fall below 50% of that forecast.

Early business models are essential to make early hydrogen production and end-use economically viable, the HPBM is a welcome method of de-risking projects for producers by ensuring they will have a guaranteed revenue. However, it is crucial to simplify and evolve business models to remain investible. Key recommendations to improve the business model include:

- Simplify the HPBM. The Low Carbon Hydrogen Agreement is too complex and a barrier for small/medium sized projects.
- Reduce/make flexible the current 15-year offtake commitment with regular contract price re-openers as the market develops unpredictably.
- Review allocation rules for future HARs, including geographical proximity of electrolysers to renewables.
- Develop flexible matching rules (power to electrolysers) within the Low Carbon Hydrogen Standard (LCHS). The UK has stricter half-hour matching vs Europe’s 1 hr.
- Learn lessons from RAB model for CCS T&S as government is planning a RAB model for hydrogen transportation networks.

Further, it is important to consider that project developers estimate that 50% to 70% of a project spend occurs before production, so although the HPBM de-risks the uncertainty regarding the revenue stream, there is still a large financial commitment and risk to put in place ahead of receiving revenue and revenue support. This reiterates the importance of transparent and long-term plans for the sector by **confirming hydrogen ambition by committing to deployment targets.** It also highlights that support mechanisms that help cover upfront costs in projects are supportive to developing the sector.

## 6.2 Low Carbon Hydrogen Standard

The Low Carbon Hydrogen Standard (LCHS) has been developed to allow producers to demonstrate the emissions intensity of their production process and enables eligible volumes to access the government support mechanisms.

The standard provides calculations for a range of low carbon hydrogen production methods. It states what aspects of each production method needs to be accounted for in the intensity calculation.

This approach allows for numerous production pathways, reducing the UK's reliance on one specific method. To qualify as low carbon in the UK, the final GHG Emission Intensity has to be below 20g CO2e/MJLHV.

In Europe, renewable hydrogen is promoted, whereby the hydrogen must be produced from renewable sources and achieve at least a 70% saving in greenhouse gas emissions. This was formalised by the adoption of two delegated acts:

- The Delegated Act on a methodology for renewable fuels on non-biological origin. It defines conditions as to when hydrogen, hydrogen-based fuels and other energy carriers can be considered renewable, including additionality and temporal & geographic correlation as two key criteria.
- The Delegated Act establishing a minimum threshold for greenhouse gas (GHG) emissions savings of recycled carbon fuels.

## 6.3 Project economics

In the independent report carried out by Rystad Energy, it shows that capital expenditure makes up 40% to 60% of total lifecycle costs for hydrogen projects. As generation equipment for electrolytic hydrogen is costly, it means that around half of the total expenditure is incurred before production begins. This cost is mainly tied to the design, manufacturing of production equipment, construction, commissioning, and fabrication of the main plant. For electrolytic hydrogen, equipment design and manufacturing account for a significantly larger portion of the total cost—30% to 35%—compared to CCS-enabled hydrogen, where it represents only 10% to 15%. This is due to the higher costs associated with electrolysers for electrolytic hydrogen compared to the production of CCS-enabled hydrogen via steam methane reformation (SMR) or auto thermal reforming (ATR) with carbon capture.

Figure 7

Indicative lifecycle cost of an electrolytic hydrogen project

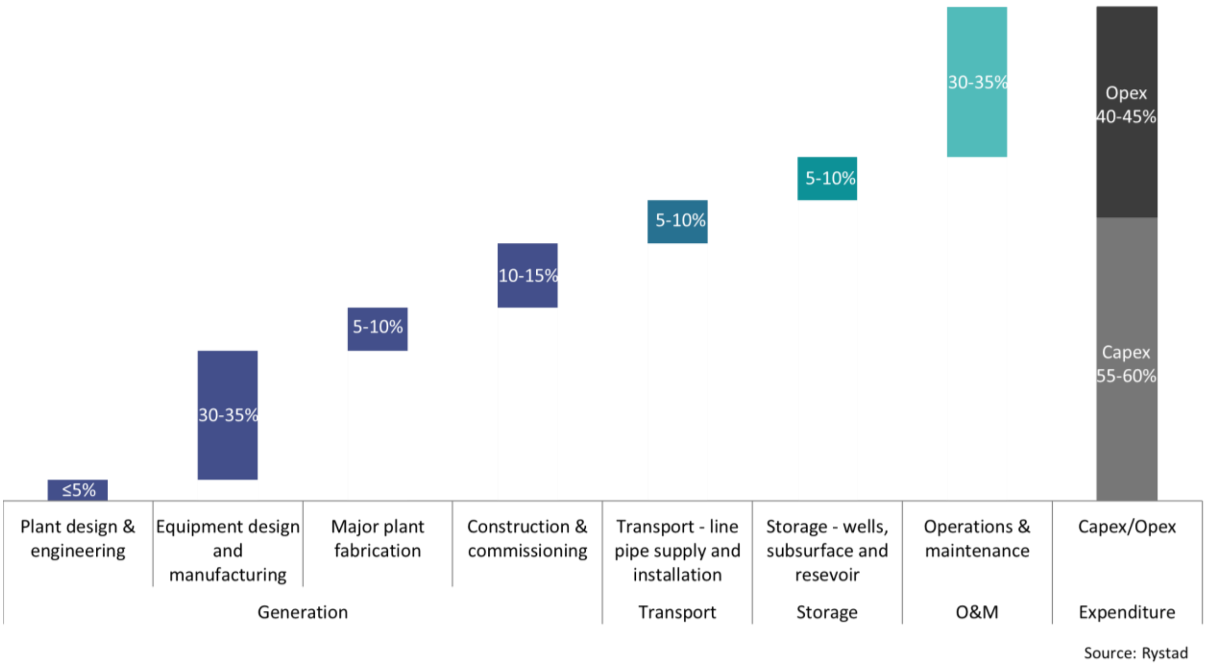
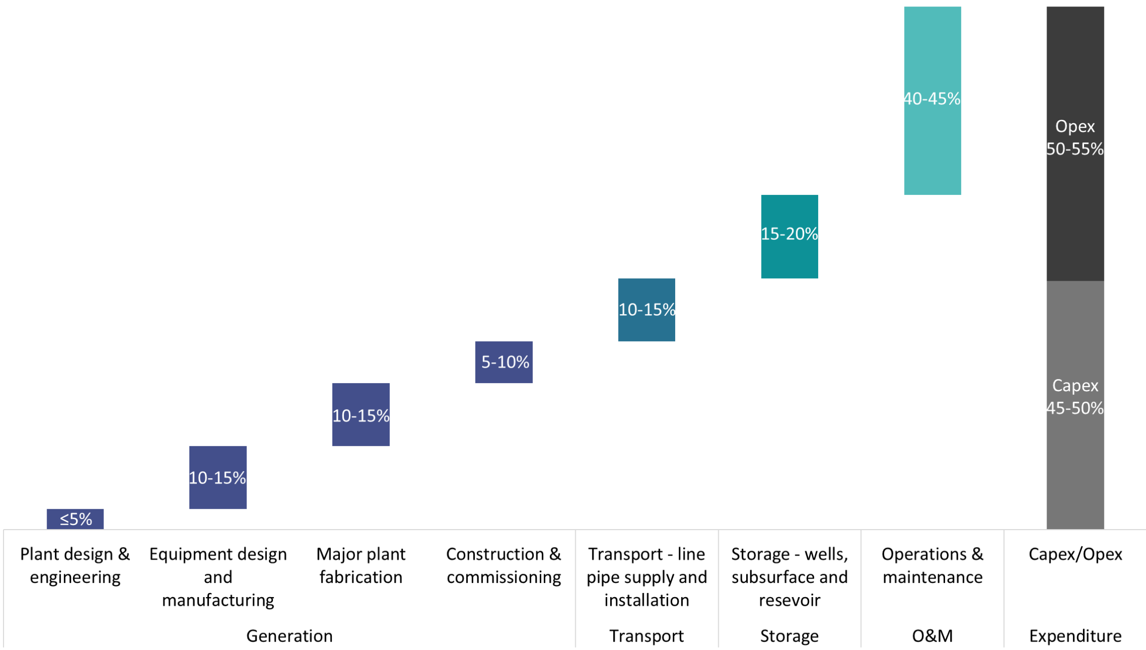



Figure 8

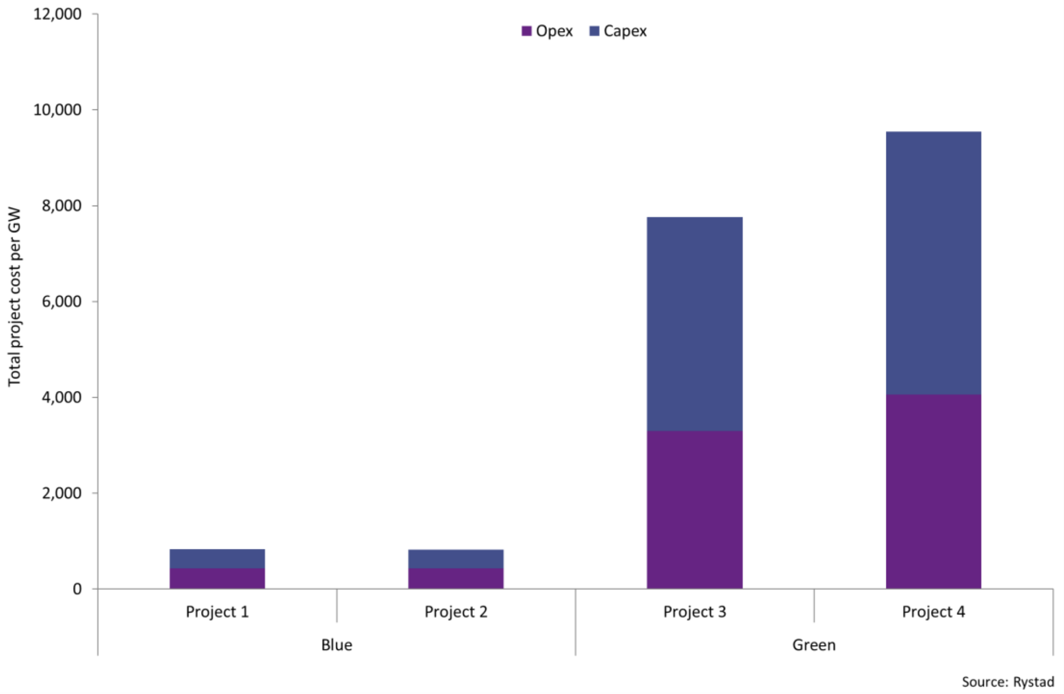
Indicative lifecycle cost of a CCS-enabled hydrogen project



Project costs and breakdown differ greatly between CCS-enabled and electrolytic hydrogen as is shown in Figure 9. This shows that to produce hydrogen at scale, CCS-enabled hydrogen is initially much more cost competitive.

Figure 9

Total cost of hydrogen projects per GW by type




The UK has a unique opportunity to lead in the hydrogen economy by leveraging its abundant renewable resources, specifically offshore wind, and existing infrastructure. To do this, the UK needs to be able to **integrate hydrogen and wind.**

The current structure of the Contracts for Difference (CfD) scheme for offshore wind primarily encourages participation in the day-ahead market, restricting its flexibility for electrolytic hydrogen production. The key challenge is the misalignment with the HPBM, particularly concerning price indexation, which introduces commercial risks and uncertainty.

To improve integration between offshore wind and hydrogen production, policy refinements are needed to address challenges during periods of negative pricing. Allowing electrolysers access to the CfD reference price could help secure affordable renewable electricity, reducing financial risks. As electrolytic hydrogen production depends on a consistent renewable energy supply, offshore wind farms could be incentivised to provide baseload power for the production. However, the current CfD rules discourage long-term trading making direct agreements with hydrogen producers less viable. Achieving better alignment between the CfD and HPBM while managing associated risks will be key to fostering a more efficient market. Allocation Round 6 excluded offshore wind supplying oil and gas facilities from private wire CfD eligibility, increasing the need for clarity on acceptable co-location models. A broader recognition of the system benefits that co-location could provide will be essential in shaping future offshore energy policies.

## 6.4 Role of blending

Blending is a key mechanism to kick start the hydrogen sector that is often a way to address the misalignment of supply and demand, it can help to create a basic market for hydrogen with demand capable of accepting variable supply.

Hydrogen blending offers a location for producers to put their hydrogen, should their offtake not be available or there be no access to storage. Blending of hydrogen is not currently a competitive or likely way of transporting hydrogen but it presents a location for short term de-risking. For it to be able to fully derisk the sector, blending would have to be considered a qualifying offtaker by the business models.

In the UK, the strategic decision to approve blending at the distribution level has been permitted, with the outcome of the safety review still outstanding. The safety of blending hydrogen is paramount to the ability to permit it, but some issues around billing in the system may be a further barrier that needs to be addressed before it can become an option. Government has committed to consulting in 2025 about enabling hydrogen blending at the transmission level within Great Britain. This move is crucial to avoid the costs associated with importing blended gas from Europe, where blending is already enabled.

# 7 Export Opportunities

The UK has export potential for both hydrogen molecules and the products, skills and services that will be needed to deploy the hydrogen economy.

Transportation of hydrogen via shipping or pipelines to other geographies would allow for the UK to contribute to the variable energy landscape that is developing globally. Strategic links with nations are needed so that trading mechanisms can be developed. There are alliances developing for an offshore hydrogen backbone, as well as effective port partnerships to ensure correct infrastructure is in place to enable hydrogen movements.

The UK and EU have a fundamental difference in the qualification of low carbon or renewable hydrogen based on the renewable electricity sources used, the difference in standards could create challenges for cross-border trade of hydrogen between the UK and EU. Therefore, standards regarding the definition of low carbon hydrogen should be harmonised between the UK and EU.

The UK's industrial strategy is aiming to support both growth and the energy transition. There are components and services that are fundamental to the hydrogen sector that would shore up the industrial capability. If the UK can establish supply chains for critical components, then there is an opportunity for an export market.

Additionally, there is the opportunity for the UK to become a leader in engineering design, asset management and risk and certification for some aspects of the hydrogen value chain. In doing so, there is a potential to compliment the export opportunity in the goods market.

The UK hydrogen sector requires policy, strategic and financial support to deploy at the scale and pace required. The uncertainty in the likely trajectory of the sector is proving a significant barrier to entry and stifling investment. Industry requires stable policies with clear direction that are coherent with the strategic vision of the UK energy plan and financial support to de-risk investments.

# Case Study: Hydrogen Backbone Link – Connecting green hydrogen from UK to Europe

Net Zero Technology Centre

Technology Driving Transition

Hydrogen Backbone Link

NZTTP Programme

The Hydrogen Backbone Link (HBL) project aims to create a hydrogen export pipeline to connect Scotland with Europe, representing a significant step towards supporting the UK's economy and Europe's decarbonisation targets.

Scotland aims to become a net exporter of green energy by 2045, enabled by growing renewable resources onshore and offshore. Initiated in 2021 and funded by the Scottish Government and industrial partners, the HBL project aims to design a robust and reliable hydrogen export pipeline to connect supply and demand centres.

- **Phase 1:** Phase 1 involved routing development, technology studies, economic assessment, and safety analysis. It concluded that a new purpose-built pipeline is preferable due to technical complexities in repurposing existing pipelines and estimated a capex investment of £2.7 billion.
- **Phase 2:** Phase 2, ongoing until 2025, focuses on exploring additional connection routes, closing technology gaps, and addressing non-technical aspects of an offshore export pipeline.
- **Progress:** Key achievements include identifying suitable sites for hydrogen production and storage, identifying feasible offshore export routing, establishing cost competitiveness of Scottish green hydrogen, and forming strong industry partnerships.

**Phase 1: Concept and Feasibility Engineering**

Phase 1 focused on routing development, technology studies, economic assessment, and safety analysis. The primary objectives were to identify potential export and import sites, assess the critical transport technologies required, and the economic viability of the pipeline.

**Three key learnings emerged from Phase 1:**

**Repurposing and Routing –** Having reviewed options for existing pipeline repurposing, Phase 1 concluded that whilst feasible, the technical complexities of repurposing and the current utilisation for hydrocarbons means that a new purpose-built pipeline route is preferable.

The new build pipeline would connect Scotland with Germany to deliver a direct link to market at pace to meet anticipated demand growth in the 2030s.

**Economics –** The capex investment needed to realise this new pipeline is estimated at ca £2.7 billion. The resulting transportation tariff of 32p/kg will yield a 6% initial rate of return for investors. Balancing the (albeit higher) production and (predicted lower) transportation costs, Scottish green hydrogen will be cost competitive to other globally sourced hydrogen from countries and regions with lower production costs such as Canada, Chile and the Middle East.

**Enabling Technology –** In general, the technology required to deliver the HBL is available, but there are still technologies to be developed, and there remain several key areas where investment is needed to rapidly develop, reduce cost and scale up solutions to enable the system to function. Emerging compressor technologies, including centrifugal designs, require accelerated development and scale up. In parallel, pipeline inspection, flare and venting systems, hydrogen specific metering testing, and application of the latest specifications for valves in hydrogen service, require further development.

**Phase 2: Further Development and Engineering**

Phase 2 is ongoing and will finalise in 2025. This phase explores additional connection routes, closes key technology gaps, and assesses further non-technical aspects to enable this vital opportunity for Scotland, the

UK, and Europe. Given the innovative nature of the project, safety assessments and risk mitigation strategies are also being developed.

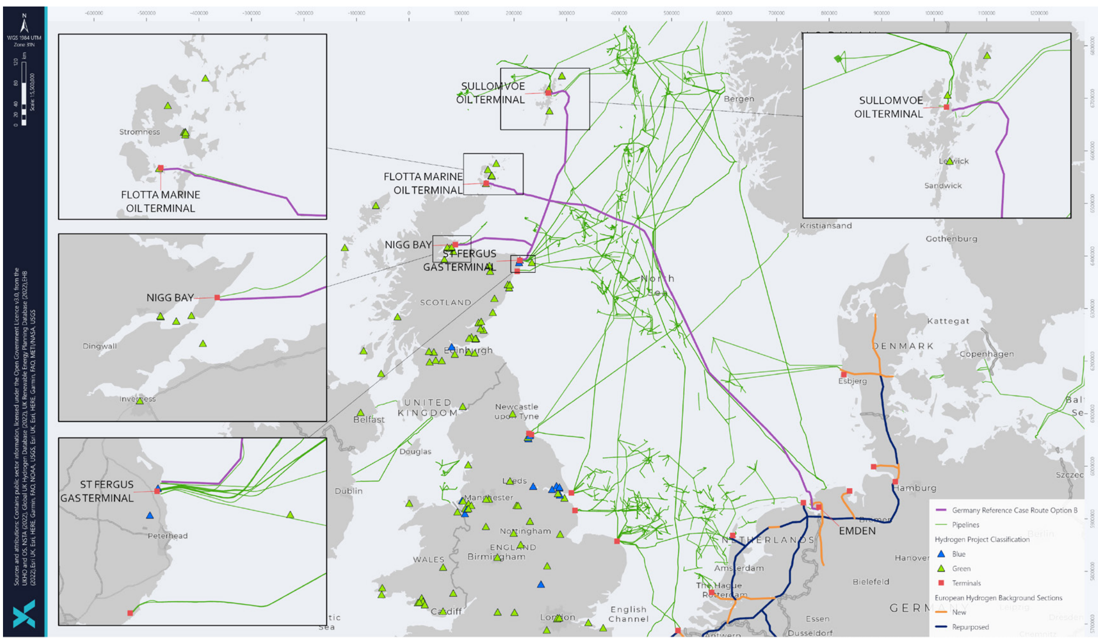
**Three emerging conclusions from work undertaken to date so far in Phase 2 include:**
**Technology development –** Critical technology gaps are explored. Valve studies and testing within Phase 2 addresses leakage limits, material suitability, and a new standard for valve qualification in hydrogen service.
Metering and compression challenges remain and require further large-scale testing and validation. Testing is being undertaken by other industry bodies, the findings of which are expected to apply to the HBL.
Analysis of large-scale storage sites to support the HBL indicates the presence of suitable sites in onshore salt caverns and offshore depleted reservoirs, however, further piloting is required to demonstrate this suitability, and to develop the design of supporting infrastructure.
Supporting systems such as pipeline inspection, hydrogen detection, and flare and vent systems are also assessed.

**Additional connections –** Phase 2 studies show it is technically feasible to connect the West Coast of Scotland, and Ireland, to the main HBL route – collecting additional hydrogen supply and providing wind resources with a route to market.
It is also technically feasible to connect to Gascade's 'AquaDuctus' offshore hydrogen network, at a point ~400km from the German coastline.
Final routing options are still under consideration and will be influenced by both technical and commercial factors.

**Commercial landscape –** Phase 2 involves close collaboration with key stakeholders including UK and European Governments, regulatory bodies, and potential hydrogen producers and off-takers – identifying opportunities and challenges to progressing the HBL. To fully realise this opportunity and capture the mutual benefits of the growing hydrogen market, the development of cross-border policy and standards, the UK's Hydrogen Strategy, and public and private investment is required.

**Progress and Achievements**
**The HBL project has made significant progress in Phases 1 and 2, including:**
- Identification of suitable sites for UK hydrogen production and large-scale storage facilities.
- Identification of an optimal window for connecting UK supply with European demand centres and interconnection with the European Hydrogen Backbone.
- Established that green hydrogen transported via pipeline from Scotland, could be cost comparable to other global sources.
- Identification of critical technologies required for hydrogen transport, and the gaps requiring closure.
- Establishment of strong partnerships with industry partners, and engagement with wider key stakeholders.
- Development of comprehensive safety assessments and risk mitigation strategies.

**Future Outlook**
Looking ahead, the HBL project aims to close-out Phase 2, and in the future, further develop a business case, while optimising technologies, and establishing key stakeholders and partners. Continuous innovation, stakeholder collaboration, and regulatory support will be crucial in ensuring the project's success.




Option 1B, selected as preferred routing option in Phase 1. Phase 2 explores alternative routing options.

Working together, we are a driving force of the UK's energy security and net zero ambitions. Our innovative companies, people and communities add value to the UK economy.

Join us today and help strengthen the UK offshore energy industry and your business.

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