Hydrogen UK

# Driving Demand

July 2025

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# Executive Summary

Hydrogen offers the UK a unique opportunity to deliver decarbonisation for some of the hardest to abate sectors of our economy. Since the publication of the UK Hydrogen Strategy in 2021, there has been much debate surrounding where hydrogen will and won't need to play a role. In 2025, we have greater certainty around the criticality of hydrogen to certain sectors and a greater appreciation of the nuances of its use in other sectors, alongside electrification and other solutions. As the Government looks to refresh its hydrogen strategy, it should look to focus policy support on the high value cases for hydrogen.

**Power** **Industry** **Surface Transport** **Maritime** **Aviation**

| Hard-to-abate Classification | | |
|---|---|---|
| | **No-regret / high-value** | **Case by case** |
| **Surface** | Non-road mobile machinery | Heavy goods vehicles |
| **Industry** | Chemicals<br>Refining<br>Steel<br>Glass & ceramics | Food & Drink<br>Cement & Lime<br>Non-ferrous metals<br>Paper & Pulp<br>'Other industry' |
| **Power** | Seasonal electrical supply<br>Grid balancing | Short-term energy storage |
| **Maritime** | Long-haul shipping | Short-haul shipping |
| **Aviation** | Long-haul aviation | Short-haul aviation |



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Whilst many organisations have attempted to model hydrogen's use on a sector-by-sector basis, Hydrogen UK's research would indicate that, whilst there is significant value in this approach, there are other factors which mean that the outputs from these models are oversimplified and likely underestimate the requirement for hydrogen. Site characteristics, geography, local energy system constraints and operational requirements can all play a role in determining the most cost effective and deliverable decarbonisation pathway. This means that whilst it is important that we prioritise those offtakers that have no alternative to hydrogen, we must recognise that this criteria has to be evaluated on a case-by-case basis for many sectors.

**Process Requirements**

**Site Characteristics**

**Geography**

**Local System Constraints**

**Operational requirements**

The UK policy frameworks have focused primarily but not exclusively on stimulating production of hydrogen which has successfully delivered a strong UK production project pipeline. Less focus has been placed on stimulating demand and supporting offtakers to switch to hydrogen. Whilst there are a range of challenges across different sectors and offtakers, Hydrogen UK's research has identified four common barriers to the adoption of hydrogen.

### Economics

Requirement to commit to long term offtake contracts; lack of strong and stable carbon pricing; access to capital

### Policy Uncertainty

Inconsistencies between policies; delays to funding allocations

### Infrastructure

Lack of hydrogen transport and storage infrastructure

### Technology Demonstration

Customers racing to be second ('seeing is believing')

## Recommendations

There is in excess of £20bn of private sector investment that is ready today to invest in UK hydrogen projects. If the UK Government is going to capitalise on this opportunity it must act swiftly to address the barriers to hydrogen adoption and accelerate deployment. This can be delivered via a combination of a clear vision, market creation, incentives and mandates that are delivered in a targeted and holistic manner.

### Vision

- Publish a refreshed **Hydrogen Strategy** that reflects the role that hydrogen can play in an integrated energy system, one that allows customers to choose the decarbonisation option that best suits their needs
- Employ a fully **unified approach** across all Government departments to accelerate deployment and deliver on the clean energy superpower and economic growth missions
- Provide support for hydrogen **Transport & Storage Infrastructure** as a critical enabler for lowest cost hydrogen production, market development and achieving clean power
- Greater **Knowledge Sharing** to improve awareness and acceptance of hydrogen and its role in decarbonisation
- **Application & Planning Streamlining** to prevent unnecessary delays

### Market Creation

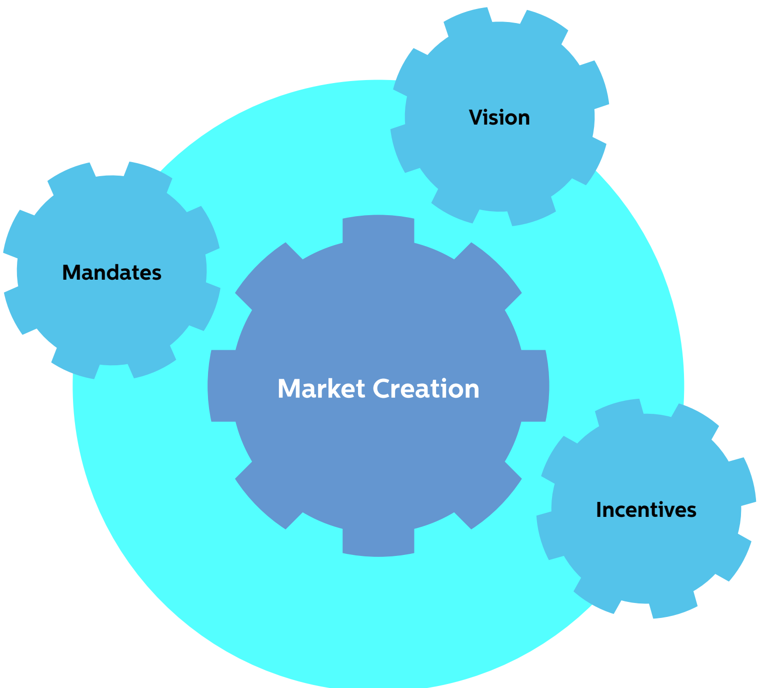
- Create a **Low Carbon Products** market to stimulate demand for products made with hydrogen
- Use the weight of **Public Procurement** to anchor demand for hydrogen or products made with hydrogen
- Allow **Risk Taking Intermediaries** to play a role in the market, helping both producers and offtakers
- Create **Flexibility Markets** that incentivise the lowest cost production of hydrogen
- Stimulate further demand with supportive **Finance** options for smaller potential offtakers

### Incentives

- Offer **DEVEX and CAPEX Grants** to help bridge the full cost of fuel switching for offtakers
- Provide **R&D Grants** to stimulate technology development and innovation
- Utilise **HRS and Vehicles Grants** to kick-start hydrogen mobility

### Mandates

- Consider a **targeted, flexible mandate system**, specific to the UK market and complimented by support for first movers, to stimulate demand
- Align **Low Carbon Fuel** mandates with wider decarbonisation policies and standards
- Facilitate strong and stable **Carbon Pricing** to help offtakers take decarbonisation investment decision while maintaining cost competitiveness



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# Introduction

Low carbon hydrogen has a fundamental role to play in not one but two of the UK Government's core missions. First, it can help grow the economy - with thousands of new jobs and opportunities breathing new life into our industrial heartlands. Second, it can help the UK become a clean energy superpower by using clean, secure energy that we control. Third, it can future-proof the UK's foundational industries, delivering decarbonisation and energy security to the hard-to-abate sectors which underpin the UK economy.

Hydrogen developers across our membership report growing interest from customers in a wide range of sectors. Whilst current government policy has helped start the hydrogen economy, industry wants this to accelerate and become more holistic so that interest is translated into demand, allowing the sector to fully develop and the UK to meet its decarbonisation targets. With growing international competition, the UK Government should prioritise the growth of hydrogen technology implementation, leveraging the nation's natural geological and geographical advantages. Although £20 billion in private capital investment is estimated to be ready to support the UK Government's hydrogen ambitions, persistent delays and market uncertainty risk this funding being lost to other markets.

This report outlines the importance of Driving Demand for offtakers, complementing the strong market foundation built from Government's early hydrogen production focus. For effective policy implementation, industry stakeholders have highlighted the importance of finding balance: retaining low-carbon technology optionality alongside certainty and support for investment, with the adoption of a clear 'vision' and 'market creation' supported by a tailored mix of 'carrots and sticks' to support the market.

From the research conducted by HUK, it is clear that the choice of decarbonisation options is not done on a sector-by-sector basis, that even within companies the decision-making process is site-by-site. This reflects the sensitivity of numerous factors that will ultimately determine the best solution for their site, and re-enforces the view that customers must be allowed the choice of decarbonisation options.

Hydrogen will play a significant role in decarbonising some of the hardest to abate sectors of the UK economy, complimenting the role of electrification, CCUS and other decarbonisation technologies. These sectors represent the hardest, and therefore most expensive to decarbonise. However, hydrogen also provides an opportunity to deliver significant economic growth through a thriving domestic supply chain, and so a holistic approach should be applied.

Hydrogen UK's members urge Government to actively engage with them as they prepare the 'refreshed' UK Hydrogen Strategy.

# Identifying Use Cases and Modelling Demand for Hydrogen

The role that hydrogen will play in the UK's decarbonised energy system is the subject of much analysis and discussion. While direct electrification is often thought to be the best solution where feasible, there are parts of the economy that rely on molecules or flames to deliver their specific energy requirements. The following section delves into the potential use cases for hydrogen, how a sector-by-sector approach to modelling demand misses the more site-by-site considerations that customers are faced with, leading to an underestimation of demand for low-carbon hydrogen.

## Use Cases

Low carbon hydrogen provides similar combustion performances to fossil fuels, and its strongest opportunities lie within decarbonising the hard-to-abate sectors of the UK's foundational industries, many of which are energy intensive but will struggle to fully electrify. In high input energy applications within the power and industry sectors, hydrogen can deliver temperatures of over 1500°C without costly equipment replacement. Hydrogen can also protect industrial users, which require baseload energy, from peak power prices, especially if coupled with on-site storage. This flexible energy vector also supports the stability and security of the energy market, balancing variable renewable sources with its suitability for long-term storage.

In the transport sector, due to hydrogen's high energy density and long-term storage capabilities, it provides unique advantages for payload and refuelling time which can be leveraged in HGVs. Additionally, low carbon hydrogen will be required for the production of fuels for long-haul aviation and shipping.

As hydrogen infrastructure and production scale up, delivering cost reductions through economies of scale and the optimised use of natural resources, hydrogen can also decarbonise other parts of the energy system, complementing direct electrification, and ensuring that the UK achieves a balanced, resilient, and cost-effective pathway to net zero.

| Hard-to-abate Classification | | |
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However, some recent modelling[1] and commentary has suggested that hydrogen's role in the decarbonised energy system of the future will be limited to 'a small but important role', with significantly reduced roles in industry and surface transport compared to previous estimates. The following sections reveal the limitations of such modelling, and presents real-world examples of where sectors that are assumed to electrify are in fact relying on hydrogen as a critical tool to decarbonise.

# Power

Hydrogen's use in the power sector is much more certain, with the Government's Clean Power 2030 Action Plan explicitly recognising the criticality of hydrogen as the primary source of intraseasonal energy storage and hydrogen to power (H2P) a key low carbon dispatchable generation technology alongside Gas-CCS. However, the generation capacity (and total supply) for the two technologies is combined in most models, creating some uncertainty over the actual level of hydrogen demand that will be needed for power generation.

Government has recognised the need for a bespoke support mechanism for the first of a kind H2P projects to enter the market, and has committed to completing the design of a H2P Business Model in 2026 to support the deployment of H2P. Government is also looking to enable H2P to participate in the Capacity Market. Hydrogen T&S infrastructure is critical to H2P, required to bridge the imbalance between supply of low carbon hydrogen during periods of excess renewable generation capacity and steady baseload CCUS-enabled production, and demand, when the sun isn't shining and the wind isn't blowing.

Hydrogen can also be blended with natural gas for use in existing power generation plant with minimal retrofitting required. This can deliver a partial but valuable decarbonisation of the power sector quickly and for very little effort.

Distributed power generation is another area where hydrogen is already playing a role, with hydrogen powered generators helping construction sites, film sets and festivals access clean power.

# Industry

The UK economy is underpinned by a set of foundational industries, which provide the materials, parts, and infrastructure on which the country depends. Many of these foundational industries – such as chemicals, steel, critical minerals, construction, and materials – are energy intensive and often dependent on fossil fuels. Decarbonising these sectors is therefore crucial to the UK's transition to Net Zero, while also future-proofing an integral part of the UK economy.

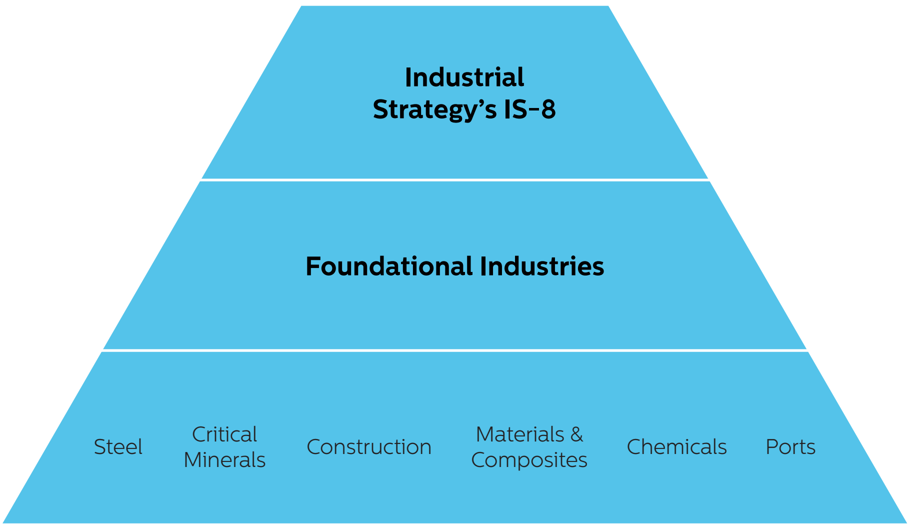


**Figure 1:** The UK Government's Modern Industrial Strategy concentrated on eight sectors which are intended to deliver growth (IS-8), and emphasised that the success of the IS-8 was dependent on the UK's foundational industries[2].

Decarbonising industry is vital, but is a significant challenge due to the heterogeneous range of processes and products involved. This means that industrial decarbonisation options are often not just sector and process specific, but as HUK members have experienced as part of the electrolytic hydrogen allocation rounds (HAR) and carbon capture usage and storage (CCUS) Cluster Sequencing processes, even site specific.

The choice of decarbonisation pathway for industrial emitters is not straight forward and will likely consider the following factors:

**Process Categorisation**

Feedstock/fuel, direct/indirect heat, low/mid/high temp

**Technical readiness of solutions**

**Location**

Access to enabling T&S infrastructure including hydrogen and CO2

**Electricity grid access**

Capacity and timing

These factors, combined with long investment cycles, high energy use, low profit margins, and trade exposure have led to many of these sectors being characterised as 'hard-to-abate.'

| Use-Case | Feedstock | Direct Heat | Indirect Heat |
|---|---|---|---|
| Chemical | | | High Temp |
| Steel | | High Temp | High Temp |
| Refining | | | High Temp |
| Food & Drink | | Medium Temp | Low-Medium Temp |
| Non-ferrous metals | | High Temp | High Temp |
| Glass & Ceramics | | High Temp | |
| Cement & Lime | | High Temp | |
| Paper & Pulp | | | Medium Temp |
| Other industry | | | Low-Medium Temp |

Energy intensive industries that rely on hydrogen as a feedstock or require high temperatures unachievable by electrification should be considered 'no regrets' for the use of low carbon hydrogen to decarbonise. These categories of industrial low carbon hydrogen use should hold true even factoring in local technical feasibility and economics.



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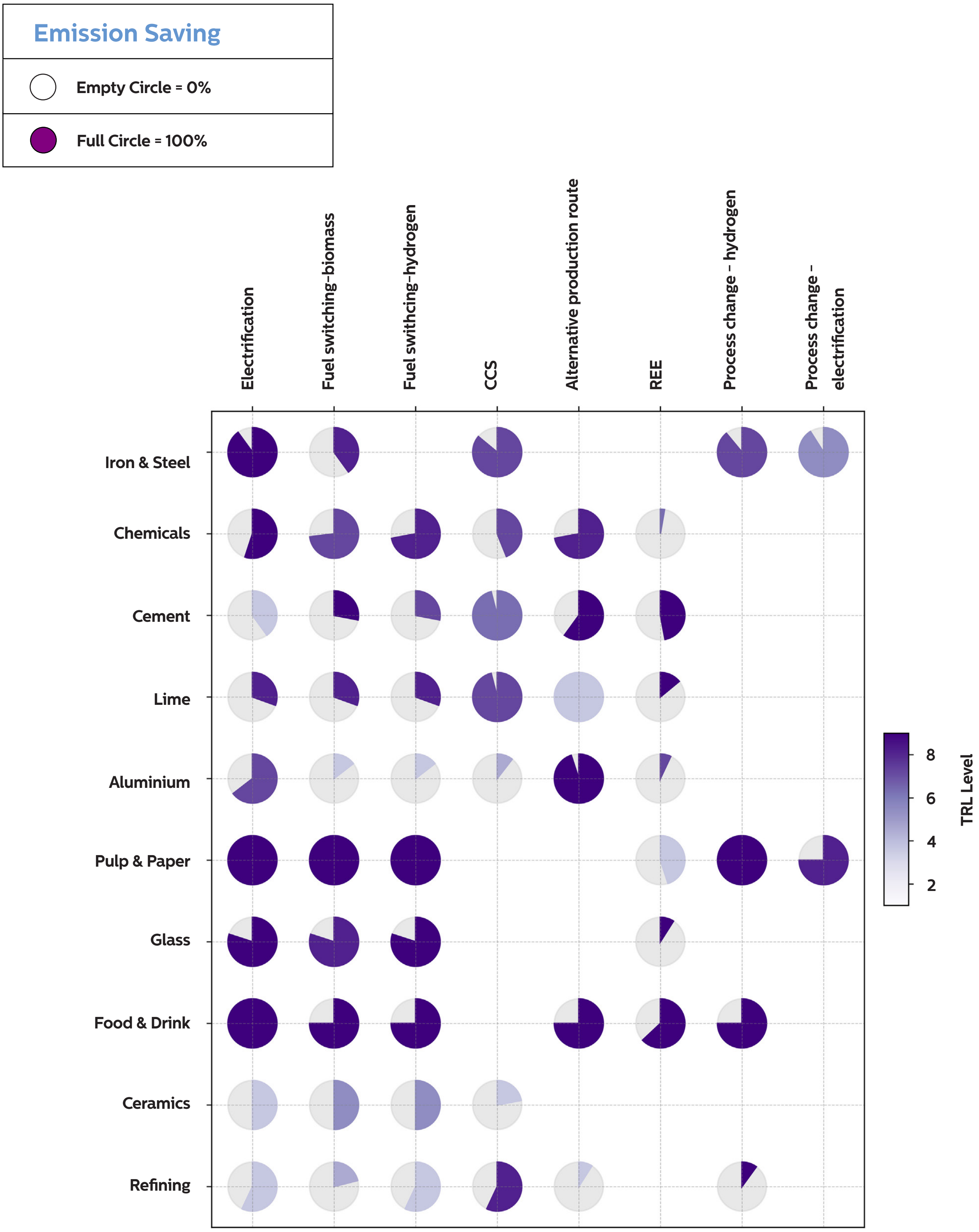


**Figure 2.** Emissions savings potential for industrial sectors by abatement category and TRL[3]



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The government has rightly prioritised these 'hard-to-abate' sectors of the foundational industries – including ceramics, chemicals and brick manufacture – as first movers. These sectors require high energy density, operational flexibility, or high-temperature processes, making hydrogen an indispensable tool for deep decarbonisation.

However, this definition is too narrow, stifling potential growth and failing to recognise the wider value proposition for the UK economy. The opportunity for hydrogen's use in other industrial applications, including off-cluster and low energy intensity emitters, is more influenced by site/company specific factors such as local conditions and access to infrastructure. The availability of reliable and affordable low carbon hydrogen will play a significant role in determining how big the demand will be from this category of industrial use.

Furthermore, an individual site may need to decarbonise multiple applications. The ability of low carbon hydrogen to decarbonise all aspects is attractive to many customers, offering a simpler solution with minimal disruption to operations.

Large sections of the UK economy – many of which are considered to be or to rely on foundational industries and employ millions of British workers – are under pressure through their supply chains to progress decarbonisation plans, and they see hydrogen as the only viable solution. These real and significant demands on companies to decarbonise are not alleviated by a top-down definition of 'hard-to-abate'.

Analysis conducted on decarbonisation technology options for the full range of industrial sectors[3] shows that there are a range of options with very high TRLs for decarbonising low-temperature heat, including electric, biomass and hydrogen boilers, and CHP based on hydrogen and biomass. In contrast, many options for decarbonising high-temperature heat rely on novel uses of electricity or novel process change that are at low levels of technical maturity.

Figure 1 shows that fuel switching to hydrogen, and process changes to incorporate hydrogen-based CHP, are viable decarbonisation options for a significant portion of emissions across the full range of industrial processes.

The following sections focus on those industrial sectors that are assumed to need little to no hydrogen, and discusses why such an assumption is not necessarily valid.

## Cement & Lime

The cement and lime sector is unique in that the majority of carbon emissions are 'process emissions'.  However, a significant proportion of emissions stem from the requirement to fire kilns to temperatures in excess of 1600°C.

***Made with Hydrogen*** campaign member Heidelberg Materials notes in its **Road to net zero – asphalt** paper[4] that fuel switching from fossil fuels to low carbon hydrogen is a key lever in decarbonising cement and asphalt production at its UK sites. A cement kiln at Heidelberg Materials' Ribblesdale works in Lancashire has successfully been operated using a net zero fuel mix which includes hydrogen. It was a world-first demonstration and established a pathway to moving away from using fossil fuels and has the potential to be replicated in other industries, including asphalt production.

In addition, there are opportunities to use hydrogen to power large plant and HGVs to reduce the company's Scope 2 emissions.

Lime production is another industrial process that does not have an electrification option, and in its **Priorities for the Next Government: Decarbonisation, Growth, Delivery** paper[5], the Mineral Products Association noted that hydrogen should be prioritised for firing lime kilns.

Case Study

# Pilkington UK – Offtaker

**Sector/Subsector:** Industry – Flat Glass

**Location of plants:** St Helens, Merseyside: In partnership with Grenian Hydrogen at Greengate Works site.


▲ Steve Rotherham, Mayor of Liverpool City Region, visits the Greengate site in St Helens.

## Reasons for hydrogen requirement

Pilkington United Kingdom Limited is a glass-manufacturing company, part of the NSG Group, supplying glass to the Architectural, Automotive, and Creative Technology sectors. The St Helens project, which is scheduled to start production from 2029, involves using green hydrogen to supply the site furnace, expanding the manufacturing of low carbon architectural glass for buildings.

The float furnace has a baseload energy requirement and operates at high temperatures (over 1500oC). Partial electrification is possible but only for a minority of the energy requirement.  Demonstrations funded under the Industrial Fuel Switching programme have proved that hydrogen is feasible as a decarbonised fuel supply, with liquid biofuels also showing positive results. The glass manufacturing process is also very sensitive to interruptions in energy supply, requiring suitable security of supply and back-up.

## Barriers to hydrogen use

- LCHA provisions require temporal correlation with renewable electricity generation, eroding energy supply resilience. Consequently, a back-up natural gas or alternative fuel supply is required, which entails material additional OPEX.
- The current lack of hydrogen transport and storage infrastructure adds significant logistic complexity and costs.
- Current/forecast UK ETS price results in commercial uncertainty and insufficient incentive for material decarbonisation expenditure.
- Currently not seeing widespread willingness to pay for 'green premium' products.
- While the HAR scheme supports developers, there is minimal aid for the delivery of offtake projects.



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## Food & Drink

Food and drink manufacture is another example of an industrial subsector that it assumed to fully electrify. However, driven by supermarkets and major food outlets aspiring to win the race to decarbonise and meet Scope 3 emission reduction targets, HUK members report that food and drink manufacturers are seeking to improve their competitiveness in both domestic and international markets for their products, and also in the financial markets for both debt and equity, by using hydrogen to decarbonise their processes.

**Electrification**

- Long down-times
- Technical feasability
- Costs of redesign
- Grid capacity

**Hydrogen**

+ Compatible with existing processes
+ Familiar operation
+ Reduced need for redesign

Whilst, from a technical perspective electrification is a possibility, it is often neither realistic nor commercially viable in practice. The length of time a food manufacturer would need to be offline to switch to electrification alone (two years in one manufacturer's estimation), could be catastrophic to a site's business case. Access to mature electrification technology and the availability of capacity in the electricity grid are also areas of concern, while many manufacturers prefer hydrogen due to its compatibility with existing processes which rely on flames or high-temperature heat.

For industries accustomed to using natural gas or liquified fuels, hydrogen offers a more seamless transition. It maintains the familiar operation of gas-fired equipment and reduces the need for costly retrofits or complete process redesign. In some processes, retaining a flame-based heat source is critical to achieving product consistency.

Pioneering work funded through BEIS/DESNZ's Industrial Fuel Switching competition has proven the feasibility of switching baking ovens, oil heaters and steam boilers used in food and drink manufacturing to run on hydrogen, as well as a new hydrogen CHP gas engine[6]. Phase 2 demonstrations[7] have since been carried out at some of the sites to prove the viability of fuel switching, and that product quality is not compromised. This is reflected in the decarbonisation technology assessment in Figure 1 which shows fuel switching to hydrogen as a suitable option for the food and drink sector.

Hydrogen is also an attractive option for whisky distilleries. The key energy requirement for the whisky production process is steam generation, which could be electrified. However, distilleries are located in dispersed sites, many of which simply cannot get access to a grid connection to directly electrify. In their 2020 report[8], the Scotch Whisky Association showed that 19% of emissions from whisky production in Scotland could come from fuel switching to hydrogen. This number may be out of date as more of Scotland's 158 distilleries are able to take advantage of increased electricity generation and transmission in Scotland, however, hydrogen is seen as the only option for the 20-30 most remote distilleries. And given that their whiskies can age in barrels or casks for upwards of 10 years, these distilleries have a motivation to decarbonise quickly.

However, while distilleries are featured in HAR1 via the Cromarty project being co-developed by HUK member Storegga, this use case appeared to be deprioritised in HAR2 with many applications not making it to the shortlist. This apparent change of prioritisation (the majority of funding in DESNZ's Green Distilleries Programme was awarded to hydrogen based projects[9]) is confusing to industry and investors, and must be addressed in order to maintain confidence in the allocation process (see section Measures to Drive Demand below).

## Pulp and Paper

Decarbonisation of the CHPs and boilers used in pulp and paper manufacturing will significantly decarbonise the sector[10]. As part of BEIS/DESNZ's Industrial Fuel Switching (IFS) Phase 2, Essity is running a demonstration at its paper manufacturing plant in Lancashire, with hydrogen replacing natural gas to deliver high-grade heat for the drying process[11].

***Made With Hydrogen*** campaign member Kimberly-Clark has projects in HAR1 and HAR2 to decarbonise three of their manufacturing sites. Due to hydrogen's long-term storage and combustion performance characteristics, its role within KC's strategy focuses on direct heating applications at high and varying heat loads, such as those required for tissue manufacturing. Electrification is not seen as a viable option due to the combination of extensive retrofitting requirements, storage difficulties and insufficient temperature capabilities.

## Refining

Refineries are complex plants that process crude oil into valuable products such as gasoline, diesel and other petrochemicals. Grey hydrogen has various roles and can be switched to low carbon hydrogen for emission reduction, and refinery fuel gas can be switched to low carbon hydrogen for use in fired heaters.

Phillips 66 Limited (P66) intends to abate its Humber Refinery emissions through a combination of carbon capture and storage, energy efficiency measures, and the use of low-carbon fuels (LCFs) such as hydrogen, of which LCFs is planned to abate around 20% of total site CO2 emissions.

P66 conducted a decarbonisation feasibility assessment through DESNZ's Industrial Energy Transformation Fund. Due to the combination of inability to reach the required heating conditions, and grid connection unavailability, it was determined that fuel switching is the only viable option to decarbonise the refinery's geographically remote heaters. The study showed that hydrogen could safely achieve the high temperatures required by the refinery's processes within the existing equipment which cannot currently be achieved by electrification.

This example is repeated in other refineries, where hydrogen's importance for decarbonising refinery operations is reflected in the fact that four of the UK's six refineries have projects shortlisted in HAR2[12], with a fifth also planned to be an offtaker of low carbon hydrogen via the Track-1/Track-1X process.

Case Study

# Kimberly-Clark – Offtaker

**Sector/Subsector:** Industry – Paper & Pulp; Manufacturing

**Location of plants:** Barrow-in-Furness (Off-cluster): Partnership with Carlton Power (HAR1); Northfleet, Kent (Off-cluster)

## Reasons for hydrogen requirement

Kimberly Clark are a global consumer goods and personal care corporation that produces mostly paper-based consumer products. Their decarbonisation strategy utilises different technologies which best suit their broad range of products. Due to hydrogen's long-term storage and combustion performance, its role within KC's strategy focuses on direct heating applications at high and varying heat loads, such as tissue manufacturing. Another adopted vector for decarbonisation is electrification. However, KC is not solely reliant on this pathway due to its extensive retrofitting requirements, storage difficulties and insufficient temperature capabilities. By branching out from total grid connection dependence, hydrogen also provides greater energy security.

▲ Kimberly-Clark will use hydrogen at its Barrow-in-Furness tissue manufacturing facility.

## Barriers to hydrogen use

- Lack of transport and storage infrastructure - requires hydrogen supply and demand synchronisation (Operational risk).
- Temporal correlation (imbalance in treatment between renewable energy and hydrogen supply) - offtaker is having to carry additional risk through operation flexibility with electricity pricing.
- LCHA provisions have enforced a 1-to-1 contract, eroding energy supply resilience.
- Lack of knowledge and skills within the industry is forcing project developers to become renewable sourcing experts.
- Lack of understanding/clarity for hydrogen's role within industry and the wider energy system.
- Mismatch of developments and understanding along value chain which can be mitigated through a hub/cluster model.
- Current/forecast UK ETS price not providing enough incentive for decarbonisation expenditure.
- Currently not seeing willingness to pay with 'green premium' products.

# Transport

## Surface Transport

The role of hydrogen in surface transport has come into question recently, with some models suggesting that it will play only a very niche, if any, role in surface transport in the UK. However, this finding is at odds with both global and local sentiment.

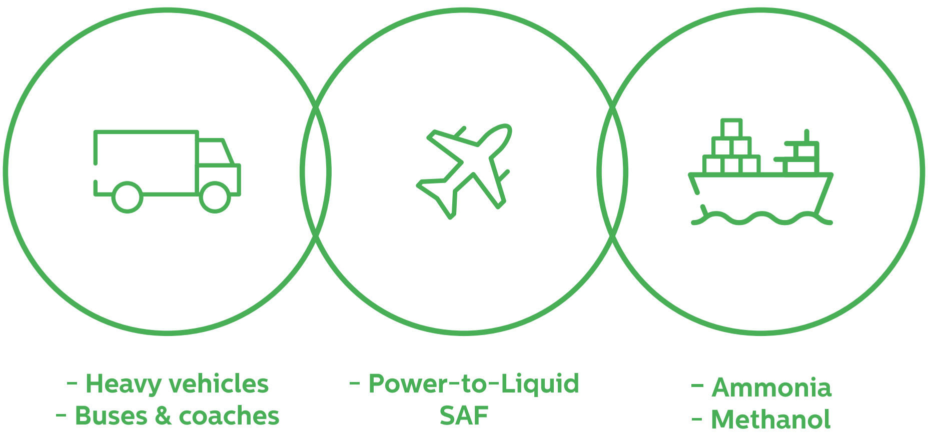
Analysis by Agora, based on IEA data, shows that hydrogen could be used to fuel long-range (>400km) and 'specialist' vehicles[13]. Perhaps more importantly, in a report published in June 2025, the Road Haulage Association (RHA) found that "12% of HGV operators surveyed plan on introducing hydrogen vehicles within the next 5 years."[14] With a fleet of more than 500,000 HGVs, this shows that UK has a significant pool of heavy vehicles that intend to rely on hydrogen to decarbonise and maintain operations.

Zemo Partnership also published a report in June 2025[15], concluding that significant gaps remain in the policy framework for achieving net zero road transport. The report makes explicit reference to hydrogen as a decarbonisation option for heavy goods vehicles (HGVs), buses, and coaches, and provides proposals to drive down road transport emissions with urgency by decarbonising the existing vehicle stock and accelerating the shift to a zero emission fleet.

Another consideration for 'full electrification' of transport is the concept of critical metals efficiency. HUK member Johnson Matthey published a white paper[16] highlighting the much larger requirement for critical metals such as copper, nickel, cobalt and lithium in BEVs and electricity distribution cables, versus FCEVs and hydrogen pipelines. BEVs can be considered 'energy efficient', whereas FCEVs are 'metals efficient', and we will need a mix of both technologies to avoid supply chains constraints and unsustainable extraction activities that risk delaying or derailing the energy transition.

And while BEVs will undoubtably be the dominant option for passenger vehicles, the refuelling infrastructure required to service the HGVs and other 'specialist' vehicles will enable the use of FCEV passenger vehicles for those without access to charging infrastructure.

Developments in hydrogen-powered rail are still progressing, with demonstrations showing promising results in long-haul freight.



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## Aviation

Hydrogen will play a significant role in the production of sustainable aviation fuels (SAF) thanks to the UK's SAF Mandate and associated Revenue Certainty Mechanism. The SAF Mandate contains a sub-mandate for power-to-liquid (PtL) SAF, which are synthetic fuels made using low-carbon hydrogen and captured carbon dioxide. The PtL sub-mandate starts at 0.2% of total UK jet fuel supply in 2025 and increases linearly to 3.5% by 2040. Along with funding for six projects that are looking to produce hydrogen-derived SAF via the Advanced Fuels Fund[17], this provides a significant signal to the market for hydrogen-derived SAF to be produced in the UK.

## Maritime

The International Maritime Organization (IMO) has approved a new global marine fuel standard aimed at achieving net-zero greenhouse gas (GHG) emissions from international shipping by around 2050. The Global Fuel Intensity Standard (GFI) is the first of its kind globally to combine mandatory emissions limits with a pricing mechanism across an entire industry sector. It is designed to accelerate the adoption of scalable zero-emission fuels, including ammonia and methanol. The mandatory fuel standards enter into force in 2027 for ships over 5,000 gross tonnage, and will rise over time.

The Department for Transport (DfT) recently published its Maritime Decarbonisation Strategy. The key policy for driving the shift to zero or near zero GHG emissions fuels is proposed to be domestic fuel regulation from 2026, which is aligned with the IMO's GHG Strategy. Additionally, the UK-ETS expands to include maritime emissions from 2026.

Questions remain over how the standards will account for full well-to-wake (WtW) emissions, capturing the emissions associated with the upstream production of the fuel, and how this will impact the level of domestic fuel production versus being sourced internationally.

# Modelling Demand

In a 'cost optimised' model with only one pathway, there is little room for showing the sensitivity of changes to key input variables (such as hydrogen production costs and electricity costs) which can lead to 'cliff-edge', binary results and conclusions. And while cost is important for those looking to decarbonise, it is certainly not the only consideration, as this paper will show. Other considerations include emissions relative to socio/technoeconomic factors such as GVA, jobs, profit margin, security of supply, strategic importance, etc.

> **Electrification is more than simply a function of specification of the heat. Grid capacity, temperature profile, process response time, etc. are all important factors. For many companies and sites, direct electrification might be the best option 'on paper', however, considering their location and the lack of grid access, and the long waiting times, it is not a viable path.**

## Hydrogen Production Costs

The cost of low carbon hydrogen is often held up as a reason for low future demand.

***"Both the high cost of hydrogen fuel and its limited geographic availability restricted the selection of hydrogen options" – Climate Change Committee, Seventh Carbon Budget***

However, such treatment of low carbon hydrogen risks perpetuating a self-fulfilling prophecy. And similarly, using past sales as an indicator of future deployment for a nascent technology is disingenuous, and ignores the cost reductions achieved by mass deployment of other low carbon technologies such as solar PV and offshore wind.

The cost of electrolytic hydrogen today is high, just as it was for electricity produced from solar PV and offshore wind when they were at early stages of deployment. Some of this is due to an imbalance in the treatment of low carbon hydrogen versus early electrification and renewable energy deployment. Where these low carbon technologies benefited from generous subsidies and flexible enabling policies, low carbon hydrogen is effectively being asked to march orderly before it has learned to crawl. Hydrogen producers are burdened with restrictive, onerous and costly requirements such as temporal correlation, despite grid carbon intensity being both out of the hydrogen producer's control and subject to wider decarbonisation policy.

However, in our recent ***Splitting the Difference*** report[18] with Renewable UK, we show that there is significant opportunity to reduce the average LCOH of electrolytic hydrogen from approximately £9.50/kg to under £5/kg. This cost reduction reflects the opportunities afforded by more favourable policy, increased availability of low cost, low carbon electricity, and hydrogen T&S infrastructure to allow optimal location of production facilities. Such cost reduction potential would likely have a significant impact on the relative deployment level of hydrogen in a 'cost-optimised' model which currently assumes only a minor reduction for hydrogen production costs (approx. 16% between now and 2050) versus a 31% reduction in electricity costs in just five years[19].

CCUS-enabled hydrogen production has a different set of cost contributors to electrolytic hydrogen, and can deliver low carbon hydrogen at scale and pace, complimenting the scale-up (and cost reduction) of electrolytic hydrogen.

## Cost reduction in an integrated energy system

The deployment of hydrogen alongside renewable generation is shown to deliver significant reductions in required infrastructure investment. Analysis by NESO for its Clean Power 2030 Advice shows the addition of 2.4GW of dispatchable low carbon generation (including H2P) and 0.6GW of firm nuclear generation reduces the need for 16.9GW of offshore wind, batteries, demand side flex and long-duration energy storage.

Other studies, such as Guidehouse's Gas and Electricity Transmission Infrastructure Outlook 2050[20] and Centrica's study[21] with FTI highlight the potential cost savings and benefits of a whole-system approach to energy infrastructure planning and rollout.

The NIC's Second National Infrastructure Assessment concluded similar, with a core national network of hydrogen pipelines connecting the clusters to each other and geological storage sites, allowing for the lowest cost production of hydrogen. This would then enable the use of low-cost, low carbon hydrogen in dispersed sites outside of the industrial clusters.

## The importance of optionality and customer preference

HUK members note feedback from their potential customers that there is a strong preference to maintain their existing gas-fired equipment so far as is practical, while also noting that electrification is 'not a drop in fuel'. Whereas direct electrification requires infrastructure to be adjusted on-site and, in many cases, entire process heat installations to be replaced, fuel switching from natural gas to hydrogen may – from the end-user perspective – simply involve the exchange of burners and fuel lines. It is not just the significant difference in the level of investment, but the disruption, associated retraining, etc. that comes with such a significant change to the process equipment.

Industry should be allowed to decide according to their business case and individual situation which solution is most suitable.

## Wider Benefits

Hydrogen UK's most recent Economic Impact Assessment estimates that the hydrogen sector in the UK could support approximately 30,000 direct jobs and contribute more than £7 billion gross value added annually by 2030. On a global scale, the hydrogen market is projected to be worth $2.5 trillion by 2050. The UK has a real opportunity to capitalise on rapid deployment by anchoring a thriving domestic supply chain that can capture a significant share of the global market, an opportunity that was missed for the offshore wind sector.

The use of hydrogen to decarbonise can help prevent de-industrialisation, and even stimulate re-industrialisation as new markets are created particularly in SAF and maritime fuels.

The value of decarbonising now with hydrogen, versus 5 or 10 years' time when a direct electrification option becomes available, should be accurately assessed in terms of achieving carbon budgets and avoiding the cumulative environmental damage over that time.

# Current Barriers

Hydrogen deployment faces key challenges that must be addressed to drive adoption. Despite a well designed and generous subsidy through the HPBM, and a significant level of potential demand as highlighted in this report, producers still face difficulty in securing offtake agreements with customers.

In order to understand the barriers, and suggest measures to overcome these, HUK engaged its members and stakeholders in the Made with Hydrogen campaign via a survey and a series of interviews.

As part of the engagement process, four key barriers were identified:

- **Economics**
- **Policy Uncertainty**
- **Infrastructure**
- **Technology Demonstration**

**Note:** The long-term affordability of the HPBM, and by extension the ability for more low carbon hydrogen to enter the market, is dependent on both reducing production costs and increasing sales price to reduce the total subsidy required. Measures that can help this, and therefore indirectly help drive demand, are not discussed in this report – please see our **Splitting the Difference** report for further discussion on the supply side measures.

# Economic Barriers

## Offtakers required to sign long-term contracts

In a commercially immature market dominated by bespoke, one-to-one contracts, producers require credit-worthy, long-term offtake commitments (typically 10–15 years) to secure financing for their projects. This is a significant extension from the typical natural gas procurement strategies of current 2–3-year natural gas contracts, and as such offtakers can be reluctant to enter into such long-term agreements. Uncertainty in future demand of their products also heightens this, making business cases more challenging.

## Carbon price

Current low levels of UK ETS pricing, and lack of certainty over future UK ETS pricing, results in a relatively small economic benefit for industrial gas users switching to low carbon hydrogen. That small incentive might not be sufficient to justify the required fuel switching CAPEX, even with the opportunity to purchase low carbon hydrogen at (near) the price of natural gas.



Hydrogen UK

Case Study

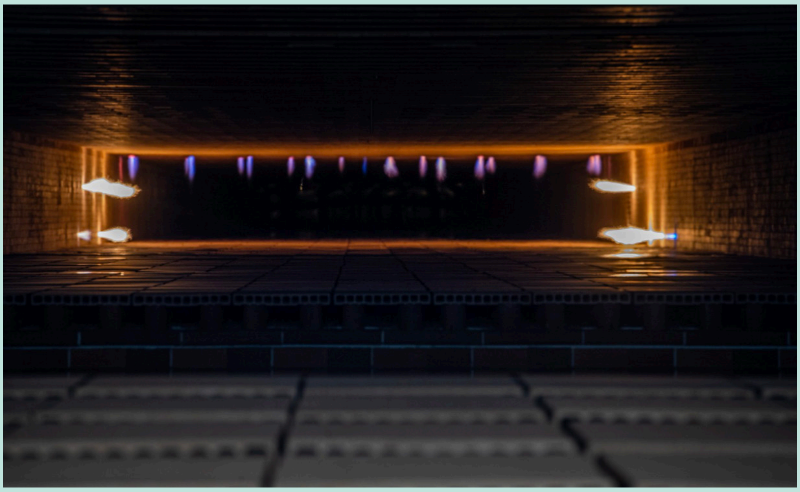
# Forterra – Offtaker

**Sector/Subsector:** Industry - Bricks

**Location of plants:** Measham brickworks, North-West Leicestershire; Desford brickworks, North-West Leicestershire; Kirton, Newark; Whittlesey, Peterborough; Wilnecote, Tamworth; Claughton, Lancashire; Accrington, Lancashire.

## Reasons for hydrogen requirement

Forterra manufactures a range of building products for the UK construction industry including bricks, blocks, pre-cast concrete and paving. As part of Forterra's decarbonisation strategy, kiln emissions are being reduced through fuel switching away from natural gas. Due to the sensitivity of brick quality to temperature fluctuations and environmental conditions within the kiln, hydrogen is being adopted as a kiln fuel because of its high heat capabilities.



▲ Forterra's Desford kiln has been run on a hydrogen blend

While assessing other low emission technology, electrification was not deemed to be feasible as the greatly reduced setting density within the kiln resulted in a far greater process footprint - the kiln would need to be 40% larger to maintain current production levels and support the UK housing ambitions. Additionally, unlike retrofitting for hydrogen, electrification would require a complete system replacement resulting in plants being stood down for at least 2 years, along with extensive grid connection upgrades.

## Barriers to hydrogen use

- Minimal energy supply resilience requires a back-up natural gas fuel supply, which entails substantial OPEX costs.
- Lack of transport and storage infrastructure makes delivery logistics complex and costly, especially since the facilities are not cluster based.
- Mis-match between hydrogen rollout and current/forecast UK ETS price not providing enough incentive for decarbonisation expenditure.
- Limited capital funding builds greater risks with CAPEX investments.
- Requirement for 15-year offtake agreement brings considerable operational risk.
- Currently not seeing a willingness to pay with 'green premium' products. However, some support is expected with the anticipated government housebuilding targets.

Although producers backed by the HPBM are able to sell their hydrogen for the same commodity price as natural gas, this funding doesn't completely bridge the cost gap. Factoring in the CAPEX required for fuel switching, alongside costs associated with transport, storage, and operational costs (such as expanded safety zoning, automatic shutdown systems, staff training, etc.), hydrogen offtake can become economically challenging. These added burdens prevent many industrial users from being able to make long term investment decisions, or erode profitability.

### Access to capital funding

In parallel, access to capital expenditure (CAPEX) and development expenditure (DEVEX) funding remains a challenge. The Industrial Energy Transformation Fund (IETF) being placed on hold in Autumn 2024, and with no clear replacement announced in the recent Industrial Strategy, has complicated potential offtakers' planning for transition to hydrogen.

Some organisations who did secure IETF funding also reported struggling to effectively deploy the grants within narrow annual spending windows, particularly given broader market volatility. This challenge should be addressed in the design of future CAPEX grants.

### Willingness to pay

Beyond the immediate cost challenges, offtakers face significant uncertainty regarding future demand and pricing structures. Final consumer priorities have shifted over recent years, with inflation and cost-of-living pressure pushing industries to prioritise cost reduction over sustainability. This shift has created a low willingness to pay for decarbonisation solutions, particularly in upstream industrial sectors where decarbonisation costs are often highest, and profit margins are thin.

## Policy Uncertainty

The lack of clarity and definition within the current UK Government's approach to hydrogen, given its limited explicit endorsement of previous hydrogen plans, adds another layer of uncertainty for producers and offtakers. Delays to Hydrogen Allocation Rounds (HAR) and Cluster Sequence processes are feeding through to individual projects, and combined with what industry noted as an apparent shift in prioritised sectors for hydrogen's use during the HAR2 shortlisting process, make planning for offtakers looking to use low carbon hydrogen more challenging. Project start times are being pushed back, and compressed timelines force rushed decision-making, increasing the risk of technical and commercial missteps in later project stages.

To prevent hesitation in HAR3 applications, it is vital the upcoming hydrogen strategy update is released at the earliest opportunity; ensuring there is a defined role for all forms of low carbon hydrogen in the energy system which potential subsidy applicants can align to.

Gaps in funding frameworks and slow progress on sector specific regulatory standards have also delayed the launch of pilot projects, particularly for ready-use applications where early deployment could otherwise be achieved. Although the current, production-focused policy framework has built a strong market foundation, the misalignment between hydrogen business models themselves, and with wider net zero policy timelines, combined with challenging aspects for securing offtake, further contributes to uncertainty. This creates pressure for businesses operating close to compliance thresholds who expect stricter future policy.

Inconsistencies in policies between DESNZ and DfT mean that the production of low carbon fuels (LCFs) including hydrogen via the Renewable Transport Fuel Obligation (RTFO) and hydrogen-derived SAF are currently not cost-competitive because they rely on electrolytic hydrogen and double stacking of incentives under the SAF Mandate is not allowed. In the early phases of the hydrogen economy and building up a UK SAF industry, government should address both of these points to ensure competitiveness in a global market. Better alignment between DfT and DESNZ is required, potentially with consideration of allowing CCUS-enabled hydrogen as a feedstock for SAF and hydrogen as a fuel for surface transport.

Similarly, the classification of hydrogen internal combustion engines (H2-ICE) as zero-emissions will help accelerate the deployment of not only hydrogen-fuelled vehicles and machinery, but also refuelling infrastructure.

## Infrastructure

Hydrogen transport and storage infrastructure limitations pose critical operational risks for potential offtakers. Despite progress made through the clusters, the absence of a dedicated hydrogen pipeline network forces reliance on more costly transport methods, such as tube trailers. These logistics drive up prices and increase the risk of supply interruptions, a potentially catastrophic possibility for many industrial applications where continuous operation is critical. As a result, early adopters are likely to maintain dual supply options (retaining natural gas supply alongside hydrogen), preventing the reuse/conversion of existing onsite gas pipelines and adding further CAPEX for new hydrogen connections and. This common complexity is not due to the feasibility of fuel switching, but rather the certainty of supply.

Hydrogen's current geographic dependencies, coupled with the lack of transport and storage (T&S) infrastructure, further restrict scaling efforts, as renewable energy generation sites are often remote and their generation profiles not synchronised with major industrial demand hubs which require steady supply, or H2P plants that are required to operate at high capacity during times of low electricity supply.

The recent announcement of funding for hydrogen T&S infrastructure[22] is welcomed by industry. However, there remains uncertainty over the location and extent of the infrastructure that could be supported. Moreover, there is no clear roadmap for 'off cluster' decarbonisation. Given the uncertainty surrounding hydrogen T&S infrastructure, most industrial players do not know if, when or how they will have access to low carbon hydrogen. With around half of all industrial emissions occurring outside of the clusters, this is particularly concerning to dispersed industrial sites like cement and lime production facilities. As noted in the CCC's Deep Decarbonisation Pathways report, geographic location will be a key constraint, highlighting the role of hydrogen transport and storage business models in providing secure hydrogen supply[23]. Therefore, it is critical to develop a clear and predictable transition plan, one that enables companies to align their replacement cycles with the availability of low-carbon hydrogen.

## Technology Demonstration

Switching equipment to run on hydrogen can be complex, with costs for large industrial operators easily exceeding £5 million. Many offtakers are 'racing to be second', keen to see processes using hydrogen successfully elsewhere for confidence in their own investment. This is made more difficult with not one solution suitable for all applications. Limited funding for pilots and demonstration means that there are few projects to investigate this deployment, slowing down hydrogen adoption. Additionally, lack of R&D funding access has stifled technology development, leaving few proven original equipment manufacturers (OEMs) in key areas like hydrogen-ready turbines.

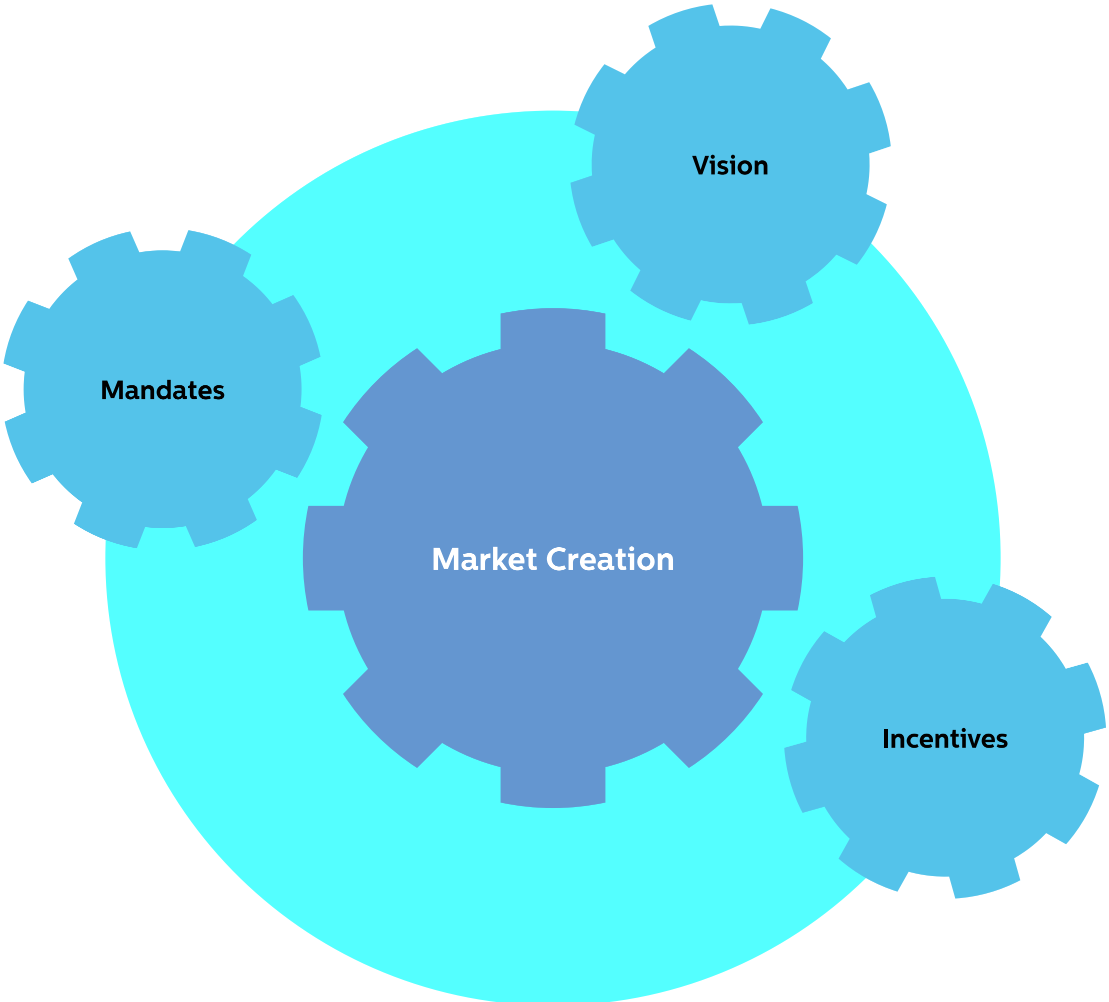
# Measures to Drive Demand

The Second National Infrastructure Assessment[24] (NIA2) published in 2023 made the following recommendation to government for industrial decarbonisation:

**"Government should ensure policy actively encourages industrial decarbonisation at the speed needed to hit its carbon budgets through a mix of carbon pricing, other incentives, regulation and shifting public procurement to low carbon products."**

At present, offtakers are reluctant to commit without guaranteed supply and competitive prices, while producers cannot scale without credible, bankable demand. Breaking this cycle will depend on building a liquid market, with a pool of producers and offtakers connected with the necessary T&S infrastructure that is delivered in time or, preferably (for giving confidence to producers and offtakers) ahead of need. This evolution is achieved by addressing all critical barriers simultaneously, providing strategic planning, clear policy support, and market-wide coordination.

Through significant collaboration with HUK members and other industry stakeholders, many of which have been awarded HAR1 contracts or shortlisted in HAR2, or developing projects in the Track-1 clusters, the following suggestions provide detail on potential measures which will drive demand for offtakers, categorised into vision, market creation, incentives ('carrots'), and mandates ('sticks').



Focusing on offtaker demand, a balance of 'carrots' (incentives for early movers) and 'sticks' (mandates when there is a viable industry) is required to de-risk the market. The timing of these measures is critical, requiring mandates to succeed incentives once there is a functioning market, and have transitional support with sector specific price signals and long-term visibility. The chances of success of the measures will be increased if implemented in a targeted, co-ordinated and properly sequenced manner.

The following is a list of potential measures that should be considered for stimulating demand, particularly while the UK Hydrogen Strategy is undergoing a 'refresh'. It is not a definitive list of 'asks'. Hydrogen UK's members urge Government to actively engage with them during this process, and are ready to work with Government to develop the measures identified.

| Vision | Market Creation | Incentives | Mandates |
|---|---|---|---|
| Hydrogen Strategy | Low Carbon Products | DEVEX and CAPEX Grants | Mandate System |
| Transport & Storage Infrastructure | Public Procurement | R&D Grants | Low Carbon Fuels |
| Knowledge Sharing | Risk Taking Intermediaries | HRS and Vehicles Grants | Carbon Pricing |
| Application & Planning Streamlining | Flexibility Markets | | |
| | Finance | | |

# Vision

## Hydrogen Strategy

At present, offtakers are reluctant to commit without guaranteed supply and competitive prices, while producers The most effective action for market clarity is the development and delivery of a robust hydrogen strategy, which clearly indicates which sub-sectors will be prioritised for support by government. This will directly support developer and offtaker planning, driving investment and partnership agreements. The refreshed strategy should also reflect the identified growth areas of the Industrial Strategy, providing much needed certainty to sectors of industry that they will be supported on their decarbonisation journey while the maintain, or grow, their operations, locking in demand for low carbon hydrogen.

The refreshed strategy must also include timelines for business model allocations, with indicative capacities and cost expectations for project developers and investors to work towards.

An important factor to note here is that this strategy must find the correct balance of technology selection, certainty and optionality. Ensuring the scope isn't too narrow allows greater technology flexibility for businesses, allowing projects to be more robust and adaptable. While the 'correct' low carbon solution depends on circumstances, certainty can be achieved through agnostic support, allowing customers to choose the option that works best for them. Effective prioritisation of 'best use cases' within hard-to-abate sectors is imperative and should be done in consultation with industry. While initial prices are expected to be high across selected use cases, embracing this early market entry will ultimately pave the way for economies of scale and cost reduction for hydrogen's use in further sectors.

Underpinning this vision and strategy should be a joined-up approach between DESNZ, DfT, DBT, DWP and other Government departments to ensure that hydrogen supply, demand, infrastructure, supply chains and technology development are progressed in step, or preferably, ahead of need. Policies, business models and standards must be aligned and consistent, providing certainty to developers and investors.

## Transport & Storage Infrastructure

There is broad industry consensus, reinforced by government-backed publications from the Climate Change Committee (CCC), National Energy System Operator (NESO), and others, that large-scale hydrogen transport and storage infrastructure is critical to achieving the government's legislated decarbonisation targets and maximising the benefits of its Clean Power 2030 Mission. To ensure this infrastructure provides the most effective means of accelerating market development and stimulating sector growth, no-regret hydrogen applications should be prioritised for support.

Direct pipeline connections significantly enhance fuel supply resilience for offtakers in addition to reducing transportation costs. The requirement to co-locate producers and offtakers, which is often not geographically or economically optimal, is also reduced. Moreover, storage availability, along with necessary adjustments to LCHS, as outlined earlier, will enable electrolytic hydrogen producers to better respond to power price fluctuations and demand changes, allowing electrolysers to operate flexibly and balance the grid. Storage also benefits CCUS-enabled production as it enables large-scale anchor offtakers, e.g. H2P, to be viably served by a smaller producer, saving overall system costs. This price stability and risk reduction encourages sector wide offtake commitment to long-term hydrogen adoption, ultimately driving cross-sector demand.

The development of transport networks should commence with early point-to-point value chains that support regional clusters before expanding into a larger transmission network. To facilitate this, the government must increase backing for existing projects, including distribution-level initiatives such as HyNet, the Humber Hydrogen Pipeline and East Coast Hydrogen (which also includes some transmission-level pipelines), and provide a timeline for support for a hydrogen backbone across the UK. The announcement of funding for the first regional network is welcome, however, a role-out timeline for the subsequent regional networks and national backbone will foster growth in existing industrial clusters whilst allowing non-cluster sites to plan connection points to future pipelines.

Hydrogen UK member Exolum has also recently successfully completed a world-first demonstration of the use of liquid organic hydrogen carriers in the UK's existing road and aviation fuel infrastructure, demonstrating the role that such infrastructure could play in providing additional options for hydrogen transportation and storage.

The development of interconnectors and import/export terminals that facilitate trade of hydrogen and hydrogen derivatives should also be supported to ensure the UK is positioned for future international trade when the need/opportunity arises.

Given the complexity of storage development, initial facility designs should align with primary value chain demands, which operate 'no-regret' hydrogen use-cases. This prevents excessive flexibility, which risks underutilisation and inflated development expenditure (DEVEX) costs with little practical benefit. Therefore, it is essential that the government understands the specific needs of primary value chain organisations, particularly at a regional level. This will allow policymakers to provide early strategic direction for the hydrogen value chain.

Contracts for storage delivery must be integrated with broader business model allocation processes, with methodologies clearly communicated to stakeholders as early as possible. The significant costs and resource demands associated with ongoing engagement in these hydrogen allocation processes are placing considerable financial pressure on projects. Further delays could risk high quality projects from falling away due to diverted resources. Additionally, ensuring organisations are sufficiently informed will help justify DEVEX funding within the corresponding geographical areas. The conditions of participation for these tender processes should also be updated to ensure there is an agreed volume of storage which aligns with forecasted demand. The respective target operational dates can then be agreed as part of the negotiation process.

## Blending

With the current nascent market and lack of T&S infrastructure, one-to-one contracts are limiting supply chain resilience, preventing flexibility with supply and demand. While producers are able to sign contracts with multiple offtakers, complexity in applications and management hinders this. Hence, most producers have a primary offtaker, and thus any significant change to their operations can have a material impact on the producer's ability to comply with their LCHA, forcing onerous conditions and costs into offtake agreements to cover the risk. However, enabling producers to blend excess hydrogen into the gas network would provide an offtaker of last resort, mitigating both storage and financial complications. Therefore, producers would be able to scale production capacity, notwithstanding the industrial demand and production mismatch. These larger production plants will subsequently achieve lower levelised costs of hydrogen through economies of scale, whilst spreading the capital cost recovery over greater hydrogen volumes. This low carbon hydrogen could be marketed through a mechanism similar to renewable electricity guarantees of origin for consumers that are not capable of becoming a direct offtaker yet but want decarbonisation to be available to them.

Such support for blending is envisaged to be short-term, while the necessary hydrogen T&S infrastructure is developed. This is especially important for CCUS-enabled hydrogen production which operates at a base load, and electrolytic projects that site in regions to help relieve grid congestion. With early-stage storage development, the use of blending can reduce to a supporting role, taking excess volumes when storage capacity fills.

In 2023, after showing its potential strategic and economic value, the UK Government took a policy decision to support blending of up to 20% hydrogen by volume into GB gas distribution networks[25]. While only distribution level blending has been considered to date, HUK is hopeful that support for transmission level blending shortly follows, subject to user acceptability and cost benefit assessments.

## Knowledge Sharing

The emerging role of hydrogen in the energy sector has led to an uneven distribution of knowledge across the market, often favouring those with greater access to capital. Given the highly interconnected nature of the hydrogen value chain, this imbalance must be addressed to ensure cohesive sector-wide growth. Without this, less experienced businesses, often reliant on producers for guidance, may find delays in business planning, potentially creating bottlenecks. As a result, there is a growing call within the industry to promote both commercial and technical knowledge sharing.

Currently, DESNZ-funded initiatives, such as the IFS and IETF schemes, generate reports that can be valuable resources for smaller projects. These insights could be aggregated, summarised and shared using a technology-agnostic template applicable to all businesses. Focus could be placed on addressing the most complex, cross-cutting challenges in the value chain, as overcoming these could unlock significant market opportunities. Public sector guidance on policy and permitting is also be vital, to ensure consistent decision making without unnecessary delays.

One recommendation is to introduce standardised offtake agreements, built around key principles and considerations. This would particularly benefit smaller teams with limited policy expertise and funding, helping to reduce both legal costs and the risk of delays caused by unexpected commercial disputes, issues that others in the market may have already faced. While a universal solution isn't feasible across all hydrogen applications, a flexible agreement template would allow offtakers to adapt terms while still streamlining negotiations.

Additional avenues for knowledge sharing include events, webinars, and digital learning tools. For instance, inter-cluster events like the Novelis open day within HyNet offer valuable opportunities for targeted networking.

## Streamlining of Funding Allocation and Planning

Streamlining of business model allocation rounds and the planning system is essential to reducing delays and unlocking the full potential of hydrogen offtakers. Previous delays with allocation rounds and the cluster sequence, including misalignment of scope and timing between the various hydrogen business models, have created uncertainty and hindered project delivery. A dedicated permitting taskforce could be established, similar to those for renewables, to act as a central contact point for developers navigating the complex permitting landscape. This body would facilitate coordination between local authorities, regulators, and government entities.

Alternatively, a fast-track planning route could be introduced, designating hydrogen projects as Nationally Significant Infrastructure Projects (NSIPs) following the 2008 Planning Act, thereby accelerating approvals. Standardised permitting templates and harmonised regulations would further simplify the process, ensuring consistency and efficiency.

A clear UK hydrogen roadmap identifying pre-approved zones, supported by technical guidance, would empower regional and cluster-level authorities to independently approve and advance local projects. Co-ordination between DESNZ, NESO, Local Authorities, and regulators could unlock material improvements to project delivery timelines. Additionally, whilst maintaining the integrity of safety standards, streamlining through prioritisation of environmental and safety assessments, particularly for hydrogen blending, is necessary to avoid further delays.

Prioritisation is also required for grid connections, ensuring clean energy projects, especially for electrolysis-based hydrogen, are no longer receiving grid access dates as late as 2038. Addressing these barriers will be vital to ensuring the rapid development of hydrogen infrastructure and fostering long-term demand from industrial offtaker

Case Study

# Heidelberg Materials – Offtaker

**Sector/Subsector:** Industry – Cement, GGBS and Asphalt

**Location of plants:** Heidelberg Materials operates over 300 sites across the UK, of which, three are cement plants (considered highly energy intensive) and 35 are asphalt plants (considered medium energy intensive). Its UK hydrogen projects, to-date, include: Port Talbot, south Wales (Off-cluster): GGBS grinding works; Ribblesdale, Lancashire (Off-cluster): Cement production; Criggion, mid-Wales (Off-cluster): Asphalt production


▲ **Heidelberg Materials used a mix of 100% net zero fuels – including hydrogen – to successfully operate a cement kiln at their Ribblesdale facility.**

## Reasons for hydrogen requirement

Heidelberg Materials UK is a leading supplier of heavy building materials to the construction industry, including aggregates, asphalt, cement and GGBS. Fuel switching from fossil fuels to lower carbon hydrogen is a key lever in decarbonising cement and asphalt production. In addition, there are opportunities to use hydrogen to power large plant and HGVs, which are being investigated in order to reduce the company's scope 2 emissions.

In asphalt production, due to the combination of process heating requirements, facility shift patterns and production scheduling, each site's energy demand varies considerably, with fluctuating high loads to periods of almost zero demand. As a result, the cost and downtime involved in upgrading the grid connection for electrification cannot be economically justified. Additionally, retrofitting equipment for electrifying these processes is found to be significantly more expensive than for hydrogen fuel switching. The variable energy demand further supports the case for adopting hydrogen.

## Barriers to hydrogen use

- For dispersed sites, being a sole offtaker of hydrogen makes it harder to share risk.
- Current/forecast UK ETS price not providing enough incentive for decarbonisation expenditure.
- Currently not seeing willingness from customers to pay for 'green premium' products.

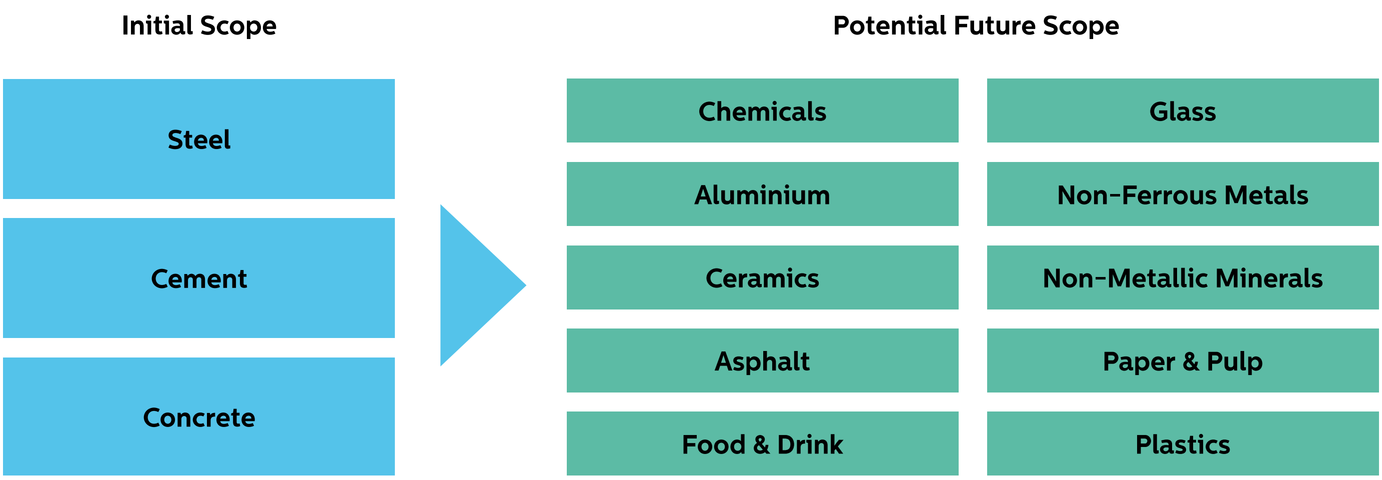
# Market Creation

## Low-Carbon Products

Obligations have long been utilised to support the ramp up of specific market segments, which are deemed to explicitly achieve net societal gain. Combined with product intensity standards they are an effective way to engage the collective efforts of industry and leverage competitive forces to achieve a net societal gain. They establish a level playing field and have a strong precedent – most recently used to successfully and affordably reduce sulfur in marine fuel.

Low-carbon products (LCPs) and their respective certification present a pivotal opportunity to drive demand for low carbon solutions, particularly hydrogen in hard-to-abate industrial sectors. Achieving this potential requires robust frameworks such as voluntary low-carbon product labels, product carbon standards and credible carbon credit systems. To ensure transparency and effectiveness, these systems must use harmonised carbon accounting methodologies based on trusted data such as ETS and CBAM schemes. By helping consumers identify and value low-carbon products, the supply chain can monetise emission reductions through fairer market competition and stronger justification for any green premium.

Following the release of the UK Government's Modern Industrial Strategy, a consultation was published concerning the design of a policy framework to grow the market for low carbon industrial products. The consultation proposes the introduction of an Embodied Emissions Reporting Framework (EERF), which is intended to help producers and consumers of industrial products measure, report, and verify the emissions associated with certain products. The initial scope of the EERF is intended to be limited, with numerous more products listed as candidates for future expansion of the EERF[26]:




The government has proposed that participation in the EERF be voluntary at first, before potentially transitioning towards a mandatory system in the future. Alignment with other schemes, such as the UK ETS and CBAM, is also being explored.

To support LCP market growth, the public sector should introduce a phased, performance-based criteria. This should build on existing methodologies and establish a clear trajectory for carbon intensity reductions, with thresholds that tighten over time. Such a framework would offer predictability and transparency for industry. Public procurement must also play a strategic role, with Government acting as early adopters and anchor buyers. By incorporating non-price criteria and committing to minimum demand thresholds, the public sector can de-risk supply chains and boost stakeholder confidence.

As global momentum builds around corporate net-zero commitments, green public procurement, and consumer sustainability preferences, demand for low-carbon products is growing. The UK now has a strategic opportunity to shape this market by implementing regulatory and pricing mechanisms that send clear, technology-neutral signals. These mechanisms must align seamlessly with existing and emerging policies, covering all scenarios and ensuring compliance. By focusing on affordability in lead markets with minimal green premium, the UK can drive adoption with limited economic disruption. For this LCP strategy to succeed, carbon pricing must also gradually increase in a way that supports economic resilience. This approach avoids market distortion and fosters technology inclusivity by creating real value for low-carbon hydrogen, without relying on direct subsidies. To prevent carbon leakage, this strategy must be reinforced with a strong Carbon Border Adjustment Mechanism (CBAM), maintaining a level playing field for UK industry in the global market.

## Public Procurement

Public procurement refers to any instance of government or state-owned enterprises purchasing goods, services or works. More specifically however, green public procurement is where public bodies use their significant purchasing power to choose environmentally friendly options stimulating the demand and consumption in the low-carbon economy.

The use of green public procurement is not a new concept and in fact the majority OECD nations have some form of green public procurement in place (see below graphic). Around 13% of the GDP of OECD countries is spent on some form of public procurement[27], however only a fraction of that is spent specifically on low carbon goods. Evidently therefore, the purchasing decisions of public bodies has a major impact on the incentives of industrial players within an economy, especially when considering some of the large infrastructure projects undertaken by public bodies.

Large infrastructure projects taken on by public bodies often require large amounts of goods from heavy industries such as steel, cement, glass, and ceramics (bricks), making them perfect candidates for increased green public procurement efforts. Hydrogen, as a viable fuel for decarbonising heavy and hard-to-abate industries could have its development supported through targeted public procurement. Infrastructure projects like these represent significant annual spend, as shown in Figure 3.

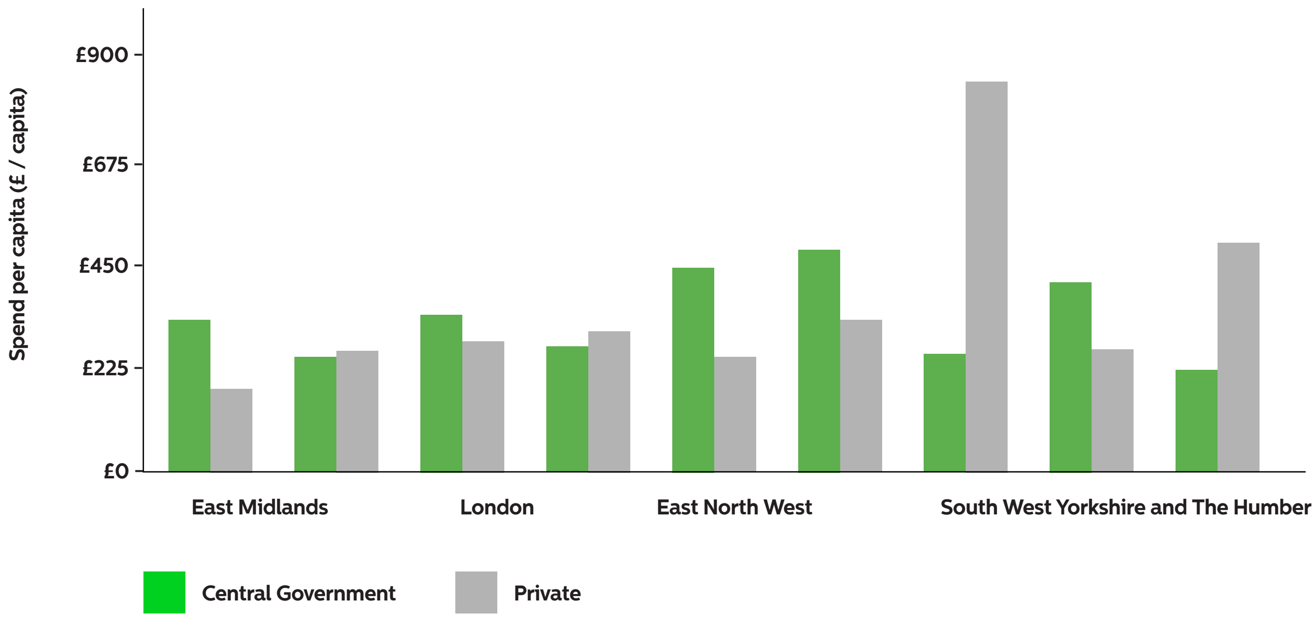



**Figure 5.** Estimated regionalm per capita spend on infrastructure and construction between 2021/22 and 2024/25 (including mega prjects)[28]

Green public procurement offers public authorities a great opportunity to stimulate the low carbon economy, whilst simultaneously reducing carbon emissions, and helping reduce long term costs.

It should be noted that any such public procurement should be reflected within the wider market, to avoid the risk of creating 'parallel markets'.

**National Highways – Lower Thames Crossing**

An example of the power of public procurement is the commitment from National Highways to make their construction sites diesel free by using hydrogen and biofuel to power heavy construction, alongside electric vehicles and equipment. For the Lower Thames Crossing project, National Highways intends to purchase the largest ever volume of hydrogen on a UK transport project, accelerating the construction industry's shift away from diesel by providing its supply chain the confidence to invest in hydrogen-powered machines, as well as develop the new skills required to operate and maintain them[29].

## Risk Taking Intermediaries

Currently, Risk Taking Intermediaries (RTIs), who provide a volume support mechanism between producers and consumers, are not permitted to sign offtaker agreements under the LCHA, and are excluded from funding eligibility. However, by enabling offloading or acquisition of hydrogen when required passes commercial risk away from these entities, encouraging greater market participation. A possible candidate is gas distribution network operators (GDNOs), who can then co-ordinate with hydrogen storage developers/operators, better matching the current gas network system with licensed shippers. HUK members see that the opportunities from such schemes dramatically outweigh the government's concerns about gaming and export of subsidised hydrogen.

The additional commodity avenue within the market builds business cases by providing flexible demand aggregation while also fostering those who can't sign full offtake contracts or commit to direct offtake. To ensure legitimate trading, guardrails should be implemented, including resale preapproval from the LCHA counterparty, the Low Carbon Contracts Company (LCCC), disclosure criteria, and profit-taking limits. Additionally, a material increase in price discovery incentives (PDI) will make market-based transactions with direct sales to end users more financially beneficial, preventing illegitimate or unnecessary RTI trading. This body implementation will drive a shift towards organic trading within a free market and better hydrogen value transparency, further supporting government subsidy valuation.

Another consideration is the potential for Great British Energy to act as a central procurer of hydrogen. Having a central buyer and seller for hydrogen can mitigate some of the risks that exist between producers and offtakers, particularly in the early stage of market development, and help accelerate the transition to stable a market. Similar models are in place, such as H2Global's 'double-auction' mechanism, which provides bankability to producers through long term contracts while also providing ease and flexibility to customers with standardised, short-term offtake agreements[30].

## Flexibility Markets and LCHA & LCHS Adjustments

Enabling hydrogen producers to access increased volumes low-cost low-carbon electricity, as possible in a fully integrated energy system, will close the cost gap between hydrogen and electrification in many applications and locations.  Supply-side measures, such as CAPEX grants and market arrangements that incentivise the flexible use of electrolysers particularly for the avoidance of constraints, and altering the LCHA and LCHS to better reflect the decarbonisation of the grid, will unlock greater volumes of low-cost, low-carbon hydrogen which can be accessed by customers. Further details on these and other supply-side measures can be found in HUK's ***Splitting the Difference*** report, our 2024 Manifesto and other publications[31].

### Finance

Letters of credit and guarantees from parent companies can play a pivotal role in stimulating hydrogen demand, particularly among smaller subsidiary offtakers that may have limited creditworthiness. These financial instruments provide assurance to hydrogen suppliers and infrastructure investors, thereby reducing counterparty risk. By improving the bankability of offtake agreements, letters of credit could help overcome key investment barriers in early-stage hydrogen projects, unlocking participation from a broader range of industrial users.

**Note**: bankability and other investment aspects will the subject of a separate Hydrogen UK report later this year.

## Incentives

Government incentives and grant schemes are critical to accelerating hydrogen adoption, particularly for offtakers who often operate as lean organisations. Many have reduced costs to a minimum, including streamlining their teams to only essential personnel. As a result, these companies may lack the financial and logistical capacity to invest in exploratory projects or fuel-switching initiatives without external support.

### DEVEX and CAPEX Grants

Existing government interventions have already played a key role in narrowing the cost gap between hydrogen and conventional fuels like natural gas. However, recent insights have revealed that the barrier to adoption is no longer solely fuel price, but also the downstream costs associated with development expenditure (DEVEX) and capital expenditure (CAPEX) for the offtaker. These costs are now a major bottleneck for project feasibility.

Members and other industry stakeholders have widely cited the IETF as a catalyst for progress, allowing many to explore and implement fuel-switching projects that would otherwise have been unfeasible. To maintain this momentum, there is strong support for either the continuation of IETF funding rounds or the introduction of an alternative, more inclusive scheme. Ideally, such a scheme would cover a broader set of Standard Industrial Classification (SIC) codes, extending eligibility to sectors currently excluded under the Energy Intensive Industries (EII) classification. This would ensure hydrogen's decarbonisation potential is realised across the wider economy to align with the UK's Net Zero targets.

### Research and Development Grants

In addition to deployment grants, R&D funding and subsidies, such as those provided by the Net Zero Innovation Portfolio (NZIP), are equally essential. These mechanisms enable continued progress in hydrogen technologies by supporting field trials, early commercialisation, and system optimisation. As more projects move from lab-scale to field testing, access to capital will determine the market's ability to validate performance, prove reliability and uptime, and reduce perceived risk for potential adopters. This is especially crucial in direct-fired industrial applications, where fuel composition directly affects product quality, thus requiring thorough feasibility studies.

### Refuelling Infrastructure and Vehicle Funding

While the availability of vehicles and refuelling infrastructure begins to ramp up from its current low base, short-term measures should be introduced to help accelerate the uptake of hydrogen fuelled vehicles and machinery.

A heavy goods vehicle and bus infrastructure strategy should be published, underpinned by a strategic spatial plan, one that ensures that a minimum viable network of hydrogen refuelling stations is deployed by 2035.

Building on the Tees Valley project as a model for deploying heavy goods vehicles alongside hydrogen production and refuelling stations, Government should support the development of regional hydrogen transport hubs across the UK. This should consider additional benefits including cross-modal transport applications, and wider industrial decarbonisation. Support programmes should have sufficient flexibility to manage the risks of scaling hydrogen mobility infrastructure and access to vehicles, and closely align with other business models.

Projects such as HyHAUL and ZEN Freight within the Zero Emission HGV and Infrastructure Demonstrator (ZEHID) programme are vital for deploying hydrogen HGVs on UK roads and proving the complementarity to BEV in decarbonising surface transport.  However, greater alignment between DESNZ and DfT is needed, including adoption of the low carbon hydrogen standard as the single fuel standard, to enable the end-to-end delivery of low carbon fuel, vehicles and refuelling infrastructure.

# Mandates

Mandates play a critical role in shaping early markets and driving adoption by targeting the correct stakeholders requiring market behaviour adjustment. This ensures demand generation across the hydrogen value chain. However, mandates must be carefully implemented, supported by appropriate incentives, and only introduced once there is further development toward a functioning hydrogen market. A poorly designed mandate system can lead to inefficiencies, market distortions, or unintended consequences, particularly for early adopters operating on tight margins. To build a clear, binding framework, the UK requires a structured mandate system.

### A UK Approach to Industrial Mandates

### Lessons for the UK


**1.**

Avoid narrow defenitions of hydrogen types, and remain technology neutral.

**2.**

Implementing tiered mandates, supporting novel applications while pushing mature sectors.

**3.**

Accompany mandates with incentives to mitigate initial cost barriers.

For UK adoption, it should incorporate key lessons from the EU experience. First, the UK should avoid an overly narrow definition of eligible hydrogen types; instead, it should embrace a technology-neutral approach that values emissions performance over production pathway. This would align better with recent shifts in policy tone favouring all low carbon hydrogen forms that meet climate targets.

Second, the UK should design mandates with a tiered structure, applying softer, incentive-driven mandates for early or low-margin sectors to build market confidence. Hard mandates tied to penalties should be reserved for mature segments. This graduated approach will help avoid market distortion and support natural, sustainable growth.

Finally, mandates must be complemented by supportive incentives, such as subsidies, guarantees, or tax relief, to help mitigate initial cost disadvantages and build investor confidence. With these adjustments, the UK can implement a more adaptable and resilient mandate system that accelerates hydrogen deployment without imposing excessive burdens on early market participants.

## Low Carbon Fuels

Low carbon fuel mandates already exist to drive demand, through DfT's RTFO and the SAF Mandate. However, these obligations must be made compatible with the HPBM. This will significantly increase the availability of UK-produced hydrogen, and other fuels manufactured using that hydrogen, for fuel suppliers who need to meet these mandates. Without greater alignment there is a risk that a large part of the demand that government has created with these mandates will not be met by UK-based hydrogen production. Compatibility can be achieved by 1) adopting the UK LCHS and 2) allowing subsidy from the HPBM to be claimed on hydrogen that is a precursor in the manufacture of a fuel supplied under these mandates, with appropriate mechanisms to avoid over-subsidy.

In the maritime sector, the upcoming UK maritime fuel regulation should build in incentive mechanisms for the early adoption of hydrogen-based e-fuels, as seen in the FeulEU Maritime and IMO Fuel Regulations.

## ZEV and Refuelling Infrastructure Mandates

ZEV mandates have proven successful in accelerating the deployment of BEV passenger vehicles, however, as pointed out by the Zemo Partnership, it is too early for such a measure for HGVs. Before this can be implemented, a number of initial demand boosting measures must be put in place, such as a strategy for national refuelling infrastructure, capital grants for FCEVs to help bridge the TCO gap to diesel equivalents, and a more joined-up approach between transport and energy policy making to ensure customers have access to cost-effective, low carbon hydrogen fuel.

The UK should also harmonise regulations with the EU to recognise the role of H2-ICE particularly in re-powering existing the HGV fleet.

Case Study

# N-Gen Energy Solutions Limited – Producer

N-Gen

**Sector/Subsector:** Industry & Transport

**Location of plants:** Bradford, West Yorkshire: in partnership with Hygen Energy

▲ The proposed Bradford Low Carbon Hydrogen site layout

## Reasons for hydrogen requirement

Bradford Low Carbon Hydrogen (BLCH), a joint venture partnership between developers N-Gen Energy Solutions and Hygen Energy, will play a vital role in driving demand for hydrogen by addressing key market barriers. As the UK's largest planned low carbon hydrogen production, storage and refuelling facility to start construction, the plant will significantly boost the volume of electrolytic hydrogen in the UK market, tackling the chicken and egg (supply and demand) conundrum faced by this nascent industry.

With a capacity of 35MWe, BLCH is the largest hydrogen production facility approved in the government's first Hydrogen Allocation Round (HAR1) and has the potential to produce 12.5 tonnes of hydrogen each day. BLCH is unique, as it is a HAR1 project designed to meet the needs of multiple customers, rather than focus on a single industrial offtaker. This maximises the opportunity for hydrogen use in a range of applications. Whilst the hydrogen produced daily is enough to enable 800 buses to switch from fossil fuels to hydrogen, the plant is expected to attract a wide range of offtakers wishing to lead the race to decarbonise ahead of time and gain a competitive advantage. Expected applications include construction and other heavy vehicles, taxis and industrial use. Alongside the government's production subsidy which aims to bridge the cost gap between low carbon hydrogen production costs and conventional fossil fuels, BLCH's refuelling infrastructure tackles the issue of affordability, ensuring hydrogen is a commercially viable future fuel for the first time.

## Carbon Pricing

### ETS and CBAM

The UK's ETS is a cap-and-trade system, whereby government sets limits of the total GHG emissions allowed from specific sectors. While participants must hold allowances equivalent to their emissions, they are able to buy or sell these, creating a carbon market with a fluctuating carbon price depending on supply and demand. Currently, only power generation, heavy industry, and aviation are covered. However, following the recent maritime decarbonisation strategy (March 2025), domestic shipping with also be included from 2026.

The carbon price mechanism is determined through auctions, market forces, cost containment mechanisms (CCM) and free allocations. Currently, power generation receives no free allocations, heavy industry receives some free allocations (to prevent carbon leakage) and within aviation, airlines must purchase UKAs for intra-UK and certain international flights.

ETS reform should incentivise decarbonisation and drive demand for low carbon technologies whilst aligning the ETS with the UK's overall Net Zero goals. The recent announcement to work towards alignment with the EU ETS is welcomed as it would make the UK carbon market larger, more predictable and less volatile. HUK encourages Government to move quickly to agree and implement the link so that UK industries benefit from the larger market as soon as possible.

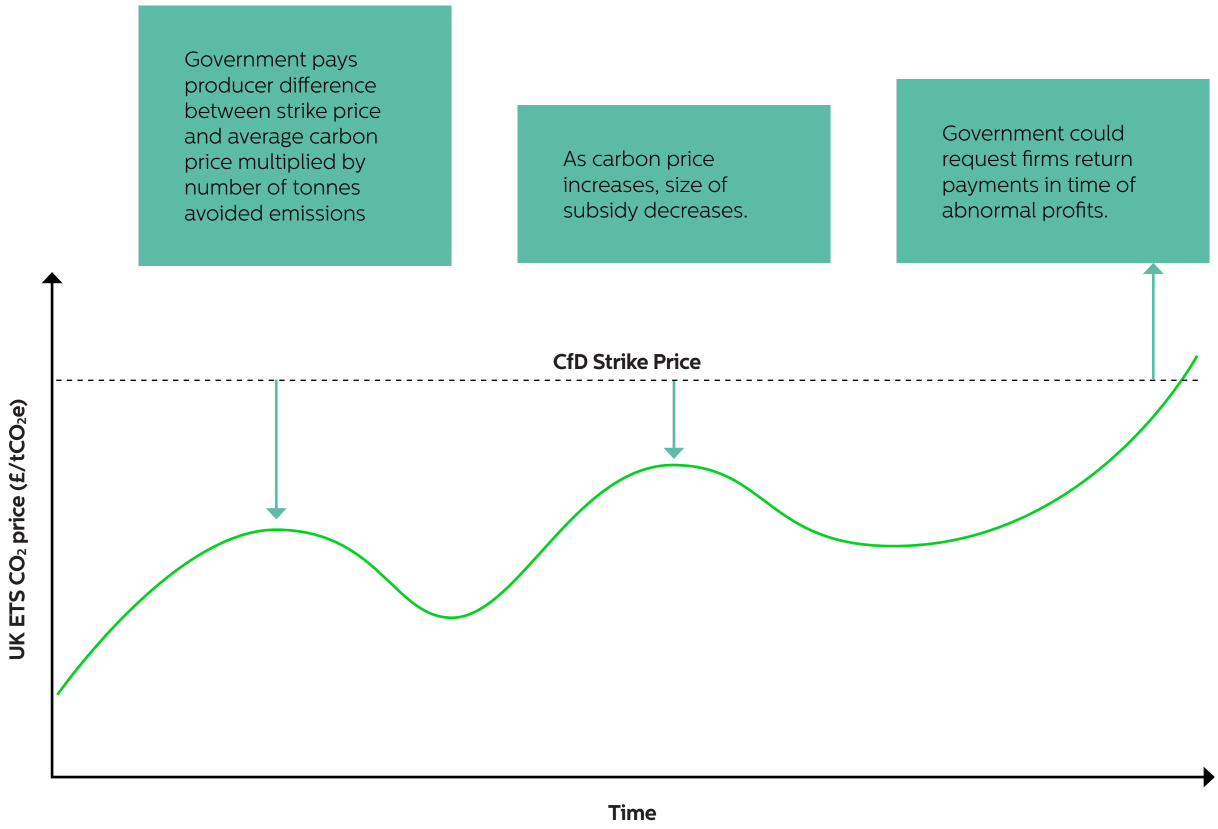
Reducing free allowances must be phased to prevent substantial cost rising for carbon-intensive sectors. These clear pricing signals will help investors make long-term decisions, whilst accelerating innovation. Implementation of this policy must however retain the industrialisation within the UK and therefore be managed holistically. Loss of competitiveness with carbon leakage must be addressed with the implementation of the UK CBAM.

### Carbon Contract for Difference (CCfD)

For some hard-to-abate industrial sectors, the UK ETS is insufficient to provide a long-term profitable route towards decarbonisation. ETS carbon prices are too volatile and too low for investors to have the required confidence needed to commit towards the expensive and risky process of converting industrial equipment and switching to the usage of low carbon fuels.

One suitable proposed policy to boost the incentive for reluctant industries to switch to low carbon production methods is a carbon contracts for difference scheme (CCfD). This policy would set a given carbon strike price for a set period (e.g. 15 years) such that switching to a low carbon fuel would become economically viable. Therefore, low carbon industries can mature and reach cost competitiveness over time.

Under a CCfD, government would pay the difference between a given strike price and the average ETS price over the year on all tonnes of emissions avoided annually. As the total cap of emissions decreases, the ETS price will generally increase, reflecting the fact that production costs should decrease over time. By purely targeting the carbon emissions reductions, a CCfD offers the taxpayer the best value for money in terms of emissions reduced per pound spent.




There is a choice to be made as to whether a carbon CfD works as a one or a two-way system. In a one-way system, when the ETS price is greater than the strike price, no subsidy payment is made. In a two-way system, when the ETS price is greater than the strike price producers will pay back to government a share of their abnormal profits as a compensation for government taking on the ETS price risk. A two-way system would provide the best taxpayer value to money whilst still giving investor confidence over the long-term carbon price stability.

A CCfD is a viable and cost-effective policy to help hard-to-treat industries such as green steel and cement to become cost competitive with higher carbon production methods. By setting a guaranteed carbon price, the social price of carbon is better reflected, giving investors' confidence in the long-term profitability of low carbon projects. There is a clear gap in demand side policy currently surrounding hydrogen making supply side policy less effective in solitude. Giving clear incentive for industry to adopt low carbon measures such as using hydrogen as a fuel, will not only drive down emissions in the industrial sector but stimulate production of low carbon fuels such as hydrogen. This process will encourage the development of carbon capture and incentivise forms of producing low or negative carbon fuels such as through hydrogen BECCS. Action, in the form a CCfD will see that no part of UK industry is left behind as we move towards net zero.

# Conclusion

With current strong focus on low carbon hydrogen production, HUK strongly believe the UK government needs to now incorporate policies to drive demand. To reach the UK's Net Zero 2050 goals, low-emission technology must work together. Finding which technology or technologies is suited to each application is the next hurdle. Evidence within this report has emphasised the importance of hydrogen to decarbonise hard-to-abate sectors and foundational industries, including applications which do not lie within 'average' energy profile demands. Its ability to provide flexibility with long-term energy storage and immediate availability for offtake provides the UK with a vital opportunity within energy system resilience and security, as well as the ability to capitalise on variable renewable energy sources, and an electricity grid that may not be able to provide connection or increased capacity in the timelines needed. In such cases, while often assumed electrification can be the solution, the included case studies provide a few examples of why this is not possible, and where hydrogen should be adopted.

The barriers and respective measures discussed within this report are a recommendation for the UK Government to consider in the upcoming Hydrogen Strategy Refresh, ensuring the nation retains its international competitiveness and reclaims its front-running hydrogen market position. For effective implementation, the government must find the correct balance in retaining low-carbon technology optionality alongside certainty and support for investment, with a 'vision' supported by a tailored mix of 'carrots and sticks'. Driving this offtaker demand is the next step to unlocking full value chain growth for sector wide decarbonisation, while also providing significant economic growth opportunities.

# Appendices

## Appendix A – Use Case Definitions

| | | |
|---|---|---|
| **Surface Transport** | **NRMM** | Non-Road Mobile Machinery (NRMM) includes mobile machines and transportable industrial equipment or vehicles but not made to transport goods or passengers on roads (fitted with internal combustion engines). These remote, grid-limited sites can be decarbonised with hydrogen fuel cells as well as H2-ICEs in some applications, across sectors such as construction, mining, and agriculture. These fast-refuelling technologies ensure uptime remains high. |
| | **HGVs & PSVs** | Hydrogen can decarbonise the surface transport sector through both combustion engines and fuel cell powered vehicles. Through longer ranges, faster refuelling, and greater cargo capacity, FCEVs and H2ICEVs can comply with tight company schedules. This is particularly beneficial for operations requiring around-the-clock use, extremely high payloads, or use far from the grid. Applications include buses, trucks, and construction vehicles |
| **Power** | **Seasonal electrical supply** | The grid will need seasonal to multi-annual energy storage capacity, with the former primarily shifting wind and solar generation from high- to low-output months, and the latter primarily shifting hydro generation from wet to dry years. Electrolysers can use excess (curtailed) clean energy to make hydrogen, which can then be stored at large volumes over long periods of time. Hydrogen can then be used in its pure form or be converted back to electricity using fuel cells. Salt caverns provide the UK with an excellent opportunity for this long-term |
| | **Grid balancing & resilience** | Combined with appropriate storage solutions, hydrogen can counteract the variability of renewable energy sources (incl. solar and wind) – when the wind doesn't blow, and the sun doesn't shine. Re-electrification via hydrogen to power technologies such as fuel cells and turbines to build on the UKs capacity market. This application can utilise shorter-term energy storage such as tanks. |
| **Maritime** | **Maritime Shipping (Long & short haul)** | Combined with appropriate storage solutions, hydrogen can counteract the variability of renewable energy sources (incl. solar and wind) – when the wind doesn't blow, and the sun doesn't shine. Re-electrification via hydrogen to power technologies such as fuel cells and turbines to build on the UKs capacity market. This application can utilise shorter-term energy storage such as tanks. |
| **Aviation** | **Aviation (Long & short haul)** | Combined with appropriate storage solutions, hydrogen can counteract the variability of renewable energy sources (incl. solar and wind) – when the wind doesn't blow, and the sun doesn't shine. Re-electrification via hydrogen to power technologies such as fuel cells and turbines to build on the UKs capacity market. This application can utilise shorter-term energy storage such as tanks. |

# Appendices

## Appendix A – Use Case Definitions

| | | |
|---|---|---|
| **Industry** | **Chemical** | Hydrogen plays a foundational but indirect role in the production of polymers within the chemical industry, primarily by enabling the synthesis of key feedstocks like ammonia, methanol, and olefins, which are then polymerised into plastics and other materials.<br>1. Feedstock for ammonia: Haber-Bosch process with nitrogen. Ammonia uses include:<br>- Fertilisers (80% of global ammonia)<br>- Chemicals for plastics, explosives, dyes, cleaning agents, and refrigeration<br>2. Textiles and pharmaceuticals in synthetic fibres, drugs and dyes<br>3. Hydrogen carrier or direct fuel (see aviation & shipping)<br>4. Feedstock for Methanol - mostly utilised as a chemical building block to create various chemicals, fuels, and additives, in addition to ammonia. This also includes the production of olefins (via MTO process) and polymers.<br>5. Hydrogenation – adds to unsaturated bonds using a metal catalyst for reduction of compounds (e.g. alcohol).<br>6. Reducing agent – electron transfer for metal reduction (e.g. DRI), in fuel cells, reductive amination (e.g. pharma & fine chemicals), in petrochemicals. |
| | **Steel** | Most primary steel today made via BF-BOF (high GHG). Lower carbon options:<br>• H2-DRI-EAF: reducing agent<br>• H2-DRI-SMELT-BOF: reducing agent & direct/indirect heat<br>Transition to clean hydrogen must be soon to avoid long-term BF-BOF lock-in. |
| | **Refining** | Within the processing of crude oil into valuable products such as gasoline, diesel and other petrochemicals, grey hydrogen has various roles and can be switched to low carbon hydrogen for emission reduction:<br>• Hydrotreating: removing sulphur and other impurities from crude oil fractions.<br>• Hydrocracking: breaking down crude oil to smaller molecules with higher value.<br>• Hydrogenation: stabilise certain chemical products.<br>• Alternative fuel for steam generation in heavy oil production<br>• Petrochemicals which use hydrogen as a feedstock include methanol and synthetic hydrocarbons. These are involved in the formation of plastics, fertilises, and solvents (see Chemicals section).<br>• Hydrocracking & hydrotreating in the formation of olefins in steam cracking. |



Hydrogen UK

# Appendices

## Appendix A – Use Case Definitions

| | | |
|---|---|---|
| Industry | **Food & Drink** | Hydrogenation processes which transform liquid vegetable oils into semi-solid fats, which have a longer shelf life and are used in a wide range of food products. Additionally, hydrogen gas is used in some food processing applications & packaging to create a protective atmosphere that helps extend the shelf life of foods such as meat and seafood, by inhibiting bacterial growth.<br>Additionally, significant interest has already been shown by Scottish distilleries to adopt hydrogen, due to its combustion performances in steam in boilers being able to meet sudden variations in steam demand. Estimated demand across the distillery categories is up to 13.8 kt/year. |
| | **Non-ferrous metals** | Hydrogen's application within metal production includes the fuel switching from natural gas for aluminium, copper, nickel and titanium production. It can also act as a low carbon alternative for coal in zinc fuming.<br>Further opportunities include hydrogen plasma technology (high efficiency metal reduction) and metal processing (casting and rolling). |
| | **Glass & Ceramics** | Mined or quarried natural non-fuel minerals are currently transformed into various products in energy-intensive processes which emit significant GHG emissions.<br>Hydrogen can be used as an alternative fuel to natural gas in the high-temperature heating processes, and in indirect heating (steam generators). Applications include:<br>• Glass manufacturing<br>• Ceramics and other mineral processing |
| | **Cement & Lime** | • Fuel switching from natural gas in high-temperature transformation processes of quarried minerals can be used in both cement/clinker and lime production in kilns. |
| | **Paper & Pulp** | Hydrogen can be used as an energy carrier for CHP for process heat and drying of various paper and pulp-based products This includes board & packaging, tissue paper, graphic paper, recovered fibres & chemical pulp. |

## Appendix B – EU Style Mandate System

### EU's Mandate System

The EU has taken a comprehensive approach to mandates through its Fit-for-55 package, with the Renewable Energy Directive (RED III) being central to accelerating the use of renewable energy, including hydrogen. Formally adopted in April 2023, RED III introduces legally binding targets, including consumption-based targets for Renewable Fuels of Non-Biological Origin (RFNBOs), which are key to the EU's hydrogen strategy.

The RFNBO classification aims to ensure that hydrogen used within sectors like industry and transport is renewable and traceable. The EU's overarching target is that at least 42.5% of gross final energy consumption must come from renewable sources by 2030 (with an indicative aim of 45%) and 60% by 2035. RFNBO targets are calculated using a numerator-denominator method, where the numerator is the amount of RFNBO hydrogen meeting sustainability and traceability standards, and the denominator is total hydrogen consumption in a sector. This system ensures the focus remains on decarbonising sectoral hydrogen usage, rather than simply increasing total renewable energy.

The EU's mandate system is structured hierarchically. The European Commission sets overarching directives and targets, which Member States are then responsible for translating into national-level policies. This flexibility allows each country to account for its unique energy system and hydrogen consumption patterns. For instance, Member States can tailor mandates to suit specific sectoral needs and ensure a level playing field among hydrogen consumers, given that the scale and distribution of hydrogen usage varies widely across the EU.

This decentralised but guided approach ensures uniform progress toward collective climate goals while accommodating diverse national circumstances. It also places the responsibility on national governments to design effective, context-sensitive pathways to meet RFNBO targets.

### EU Mandate System Limitations

Despite its structured nature, the EU's mandate system faces challenges. A key issue is the current limited availability and high cost of RFNBOs compared to fossil-based alternatives, which can hinder market growth. The strict classification allows only green hydrogen to be counted in the RFNBO numerator, limiting flexibility and disadvantaging other low-carbon hydrogen types that still contribute to emissions reductions.

Furthermore, industry stakeholders have raised concerns about the rigid requirements and the financial burden placed on sectors already operating on narrow margins, such as industrial offtakers. Mandates, particularly those tied to penalties or operational restrictions, must therefore be designed with care to avoid stifling early market activity. While the EU has seen increased demand for RFNBOs due to these mandates, the cost pressures and compliance complexities remain significant concerns.

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