HI-ACT

Hydrogen Integration for Accelerated Energy Transitions

Engineering and Physical Sciences Research Council

Review of UK Hydrogen Policy Landscape

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Executive Summary

Meeting the net zero target in the UK will require decarbonisation of difficult to decarbonise sectors such as residential heating, industry and transportation. Electrification of these sectors is one option another possibility is the development of a hydrogen economy. These pathways are not mutually exclusive and are likely to be complementary such as hydrogen for storage and power generation providing flexibility to the whole energy system.

This paper reviews the hydrogen policy landscape in the UK. Focus is given to the UK demand outlook for hydrogen, key policy interventions are summarised alongside forward-looking decisions that enhance the development of a hydrogen economy.

Numerous policy initiatives and financial incentives have been introduced by the UK government to promote the development of a hydrogen economy. A key target is the push for 10GW of low carbon hydrogen production capacity by 2030. To support this the Net Zero Hydrogen Fund was introduced to provide upfront capital cost funding, and the Hydrogen Business Model was announced to provide revenue support. Additionally, revenue support for hydrogen storage & distribution has recently been made available and consultations are well underway to support hydrogen power stations.

Looking forward, and specifically to end of this decade the paper highlights several policies and initiatives that will help make a hydrogen economy a reality:

Carbon Capture, Utilisation and Storage (CCUS) cluster support: The UK government has committed on the deployment of four CCUS clusters by 2030. This is clearly a way in which to increase hydrogen demand therefore support for additional clusters should be considered.

Hydrogen production: Capital and revenue support are provided by the Net Zero Hydrogen Fund and Hydrogen Business Model. Currently, both these financial schemes are initially limited to green hydrogen producers and should now be offered at scale to blue hydrogen producers as the overall aim should be to support all low carbon hydrogen production projects.

Regional decisions: Local and regional plans for hydrogen are mainly manifesting through the need to decarbonise industries with connection to wider regional businesses, power generation and possibly residential heat. One of these manifestations was the competition for CCUS industrial clusters. This was mainly localities/regions, local governments, businesses, and industries combining resources and developing proposals for national funding. Now that this process has mainly concluded, an impasse must be avoided and further government support either through additional funding or by other means such as subsidised loans etc could drive the momentum for development of regional hydrogen economies.

National decisions: The decision on hydrogen heating must be made in good time. Given the ambition to develop clusters, additional demand for heating would give producers of hydrogen the impetus to push through investments which will improve learning rates, lead to economies of scale and potential lower costs.

A timely final decision on 20% hydrogen injection into the gas grid needs to be made by the UK government. This will help companies assess the requirement for production capacity and potentially outline forward looking plans to support 100% hydrogen flows.

Supply chain and end use technologies: It is important that supply chain systems are well understood and geared up to meet targets set by the UK government by 2030 which includes hydrogen production capacity, storage facilities and pipelines. Governments and trade associations can play a critical role to improve awareness of forthcoming market opportunities and support mechanisms and to address issues such as the skills gaps through training and grants, enhanced funding for research and development, enable industry best practice and support for export opportunities. Additionally, the hydrogen boiler industry must do more with regards to information on safety of their products and showcase the benefits of keeping the heating infrastructure within homes largely intact such as radiators and majority of the pipework.

In summary the development of a hydrogen economy could provide the means to get to net zero in a timely and cost-effective manner. To achieve this, support is required from the UK government to encourage nascent technologies and make critical decisions especially with regards to further support for industrial clusters and on hydrogen residential heating.

1. Introduction

To meet climate change targets, many countries are grappling with pathways to decarbonise key sectors such as transport, residential heating, and industry. Electrification has been cited as a panacea for the decarbonisation of these sectors (HM Government, 2023; CCC, 2020). Many concerns exist with electrifying hard to decarbonise industries which was demonstrated by the decision by Tata Steel in South Wales to decommission the blast furnaces for steel production and replace them with electric arc alternatives. This will result in the loss of virgin steel production and lead to many job losses and impact supply chain businesses and local communities (TIME, 2024).

A possible alternative is the development of a 'hydrogen economy'. Currently hydrogen is mainly used in the chemical and oil industries (IEA, 2023). In the UK industrial clusters have been proposed to kickstart the hydrogen economy, linking key industries such a steel, cement and glass production with the wider community through residential and commercial heating and transportation.

The transition to a hydrogen economy needs clarity across several uncertainties such as the size and growth potential of hydrogen industrial demand, roll-out of residential heating where a comprehensive safety case and consumer perceptions need to be confronted and hydrogen production technologies which could be developed economically and to scale.

The development of a hydrogen system will be challenging from an investment perspective due to the scale required and therefore governments must look at various schemes such as grants and revenue business models to build impetus and competition. The investment requirements include the deployment of large-scale production of hydrogen through Steam Methane Reforming (SMR) and capturing emissions through expensive carbon capture, utilisation, and storage (CCUS) systems and high-cost electrolysis equipment.

This report outlines the outlook for UK hydrogen demand and supply infrastructure, the policy landscape, and a way forward as the UK navigates the development of a hydrogen economy.

2. UK hydrogen outlook

Scenarios have been produced to showcase the development and rollout of a 'hydrogen economy'. National Grid Future Energy Scenarios (FES) and Climate Change Committee (CCC) Headwinds scenarios (National Grid, 2023 CCC, 2020) are used to explore the level of the ambition. The development of a hydrogen economy is likely to come down to key decisions that will be made in the mid-2020s which will start making an impact by the end of this decade to mid-2030s.

2.1 Hydrogen demand

Hydrogen demand in the UK is currently (2023) very low, and mainly from the chemical and refining industries.

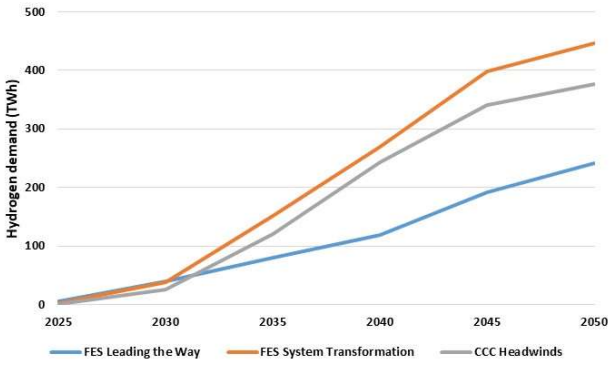

Figure 1: UK hydrogen demand scenarios (National Grid, 2023; CCC, 2020)

The hydrogen demand scenarios that depict high hydrogen penetration in residential and industrial sectors and hybrid solutions (electrification and hydrogen) from National Grid FES and CCC are shown in Figure 1. These show an increase in demand in the late 2020s led mainly by the industrial sector. By the 2030s the FES System transformation and CCC Headwinds scenarios illustrate the impact of a transition to hydrogen for residential heating. By late 2030s hydrogen could reach 200TWh and with further decarbonisation of industry, road transport and shipping, demand could be as high as ~450Twh by 2050.

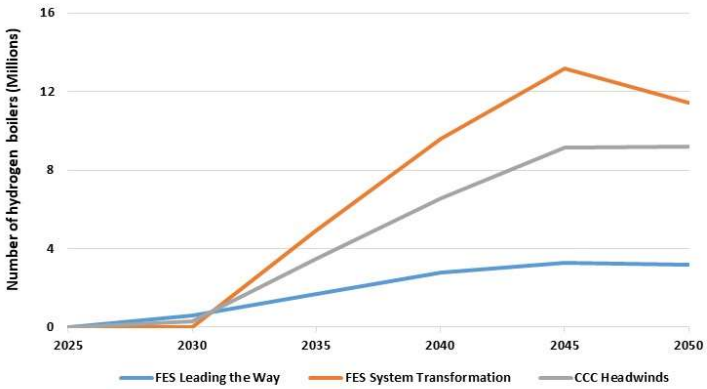

Figure 2: UK hydrogen boiler (only), total installations (National Grid, 2023; CCC, 2020)

Currently there are approximately 23 million gas boilers, accounting for nearly 80% of the residential heating market in the UK. In 2023 1.75 million new gas boilers were installed. Figure 2 shows total hydrogen boiler installations out to year 2050 across the scenarios. In the hydrogen scenarios, there is a step change increase required for hydrogen boiler installations in the 2030s, at a rate reaching around 900,000 on a yearly basis leading up to ~12 million hydrogen boilers installed by 2050.

A summary of the existing energy system and the FES 'System Transformation' scenario in 2035 are shown in Table 1 (National Grid, 2023). This illustrates the changes that are required across the energy system to enable the development of a hydrogen economy.

Table 1: Summary of UK 'System Transformation' scenario (existing and 2035)

	2023	2035
Electricity		
Annual demand (TWh)	286	400
Electricity demand for heat (TWh)	20	21
Total install capacity (GW)	112	225
Wind and solar capacity (GW)	42.7	134
Gas CCGT (GW)	37	27
Gas CCUS (GW)	0	5.1
Hydrogen (GW)	0	7.2
Natural Gas		
Annual demand (TWh)	986	581
Residential demand (TWh)	311	204
Hydrogen		
Annual demand (TWh)	~0	151
Residential hydrogen demand for heat (TWh)	0	49
Industrial hydrogen demand (TWh)	~0	48
Power hydrogen demand (TWh)	0	12
CCUS enabled hydrogen production (TWh)	0	104
Electrolytic hydrogen production (TWh)	0	26

The 'System Transformation' scenario sees growth in industrial hydrogen demand from mid 2020s with initial growth in areas of industrial clusters (e.g. Hynet and East-coast clusters) before spreading beyond these hubs. Industrial demand is expected to reach 48TWh by 2035.

2.2 Hydrogen supply infrastructure

Hydrogen can be produced from a diverse range of resources such as natural gas, coal and biomass and through electrical electrolysis.

2.2.1 Hydrogen production technologies

The main pathways to produce hydrogen are:

Fossil fuel Steam Methane Reforming (SMR) is the currently the dominant form of hydrogen production. In terms of the technological process, it involves input feedstock which in most cases is natural gas reacting with steam (water) at high temperatures to produce hydrogen and carbon monoxide. Carbon dioxide is formed during this process and therefore the hydrogen produced is termed "grey hydrogen". If the carbon dioxide is captured through either pre or post combustion processes the hydrogen produced is called 'blue hydrogen' (see Table 2).

Electrolysis is a process of using electricity to split water into hydrogen and oxygen. Electrolysers mainly consist of an anode and a cathode separated by an electrolyte. The main technologies are Alkaline, Polymer Electrolyte Membrane (PEM) and Solid Oxide electrolysers, the latter of which is showing promising results in potentially decreasing the amount of electrical energy needed to produce hydrogen from water (El-Shafie, 2023).

SMR with CCUS is projected in the System Transformation scenario (Table 1) to contribute ~68% of total hydrogen production by 2035. The scenario also assumes around 22GW of low carbon hydrogen production capacity with SMR CCUS contributing ~12GW and electrolysis at ~8GW by 2035.

The UK government target is 10GW of hydrogen capacity by 2030 (HM Government, 2021b). To achieve either the capacities as depicted in the scenario in 2035 or the UK government target, subsidies and financial support mechanisms (capital and ongoing revenue) will play a crucial role.

The industry accepted colour palette to describe hydrogen production is shown in Table 2.

Table 2: Hydrogen production colour palette (RAEng, 2022)

Colour palette	Process	Source/feedstock
Black	Gasification	Coal
Grey	Steam Reforming	Natural Gas
Blue	Steam Reforming with Carbon Capture and storage	Natural Gas
Green	Electrolysis	Renewable energy
Pink	Electrolysis	Nuclear energy
Turquoise	Pyrolysis	Natural Gas

2.2.2 Distribution and storage

Most hydrogen is currently produced where it can be consumed such as in chemical, steel, and other types of industrial sites. But depending on the end use for hydrogen it can be distributed through pipelines and/or stored and transported through other means (road, ship, train).

Pipelines are often the most appropriate way in which hydrogen can transported. This could be new hydrogen or repurposed natural gas pipelines to carry 100% or a percentage mix of hydrogen. In the GB context there is approximately 7,660 km of steel gas transmission pipes and 276,000 km of low pressure mainly polyethylene gas pipes (by 2030 all low-pressure iron mains within 30 metres of an occupied building will be replaced by polyethylene pipes). Polyethylene gas pipes are suitable for 100% hydrogen flows (National Gas, 2023).

There are many instances where storage of hydrogen would improve the operability of a future energy system. Storage can be used to address the intermittency of renewables, stored energy can then be used later when required. Also, storage could be used to balance varying heat and power demand, especially during winter periods. Lastly, storage could improve energy security and resilience and mitigate shocks on the energy system.

3. UK hydrogen policy landscape

Understanding the outlook for hydrogen in the UK requires insights into the policy direction of government. Key UK government policies over time and the financial support programmes are summarised.

3.1 Policy timelines

The UK government's policies, strategies and delivery plans in recent years and the decisions that are pending are illustrated in Figure 3.

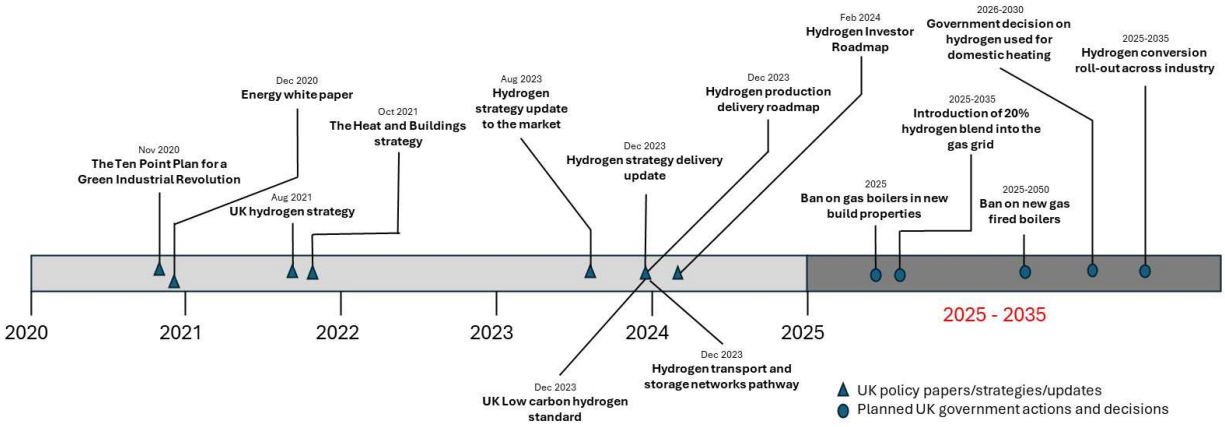

Figure 3: Timeline of UK energy policies, strategies and forward-looking decisions with relevance to hydrogen.

The 'Ten-Point Plan for Green Industrial Revolution' was published in late 2020 and set out the government's vision for boosting industry in the UK with hydrogen taking a central role (HM Government, 2020b). The plan laid out supporting an increase in hydrogen production capacity and proposals for hydrogen villages, towns, cities, and eventually wholescale transition to hydrogen. Following this, the Energy White paper (HM Government, 2020a) was published which set in stone the potential of hydrogen and specific steps to take to cut carbon emissions and support jobs in industry.

The UK hydrogen strategy paper put 'flesh on the bones' and highlighted the government's intentions for hydrogen and its potential contribution in achieving net zero in 2050 (HM Government, 2021b). The government launched the Heat and Buildings strategy, which builds on the Ten-point plan by setting ambitious targets to cut emission from heat and hot water and outlined the role that hydrogen could contribute (HM Government, 2021a). Following this, updates to the Hydrogen strategy were published, mainly to communicate and reassure investors (DESNZ, 2023h; 2023i).

A series of policy roadmaps were published on hydrogen production (Hydrogen production delivery roadmap), transportation and storage (Hydrogen transport and storage networks roadmap) (DESNZ, 2023f; 2023g). These roadmaps focused on the potential technologies (e.g. SMR CCUS etc), the 'where' (locations or stipulation with regards to being connected to industrial sites etc), when these technologies are required and the target capacities (near and medium term). Some of these

technologies (CCUS) will have to meet stringent emissions capture standards to be considered low carbon, this is encapsulated in the UK Low carbon hydrogen standards paper published in late 2023 (DESNZ, 2023e). The hydrogen investor roadmap was published in early 2024 and summarises the up-to-date government policies designed to support the development of a thriving UK low-carbon hydrogen economy (HM Government, 2024).

The UK government has several key policy areas to address in the next 5 years from 2024 onwards. Firstly, to outline support, capital and revenue, to Hydrogen to Power plants (H2P). Government analysis has shown that H2P plants could provide low carbon flexible electricity generating capacity to complement variable renewable generation, reduce wind curtailments and achieve emission reductions at lower cost than scenarios without hydrogen (DESNZ, 2023d). The UK government took the strategic and economic decision to support 20% hydrogen blend into the gas distribution networks, and a final decision is expected in 2025-26 (DESNZ, 2023c). Finally, a decision on the role of hydrogen in residential heat decarbonisation is expected to be made sometime in 2026.

3.2 Targets for hydrogen technologies

To enable the hydrogen economy the UK has specific hydrogen technology targets which are summarised in Table 3.

Table 3: UK targets for hydrogen by 2035

Hydrogen sector	Targets
Hydrogen production	**Electrolytic hydrogen production** • The near-term aim is to have up to 1GW of electrolytic hydrogen in construction or operation by 2025 (HM Government, 2021b). • By 2030, the aim is to have least 6GW of electrolytic hydrogen capacity.
	CCUS enabled hydrogen production • By 2025, the aim is to have to 1GW of carbon capture, utilisation and storage (CCUS) enabled hydrogen in construction or operation (HM Government 2021b). • To have 4GW of CCUS enabled hydrogen capacity by 2030.
Hydrogen transportation pipelines	• Regional pipeline infrastructure to support hydrogen storage, production, and power generation sites to be in operation or in construction by 2030 (DSNZ, 2023a).
Hydrogen storage	• Support up to two geological hydrogen storage projects to be in operation or construction by 2030 (DESNZ, 2023b).
Hydrogen power	• No specific target, but low carbon hydrogen to produce low carbon electricity is seen as a key technology in supporting a decarbonised, flexible, and secure power system.

The UK government hydrogen targets are ambitious. For hydrogen production (green and blue) this means going from zero (2023) to 10GW in only seven years.

For pipeline infrastructure, regional projects are encouraged especially if they connect production and storage to demand centres with a focus on industrial clusters.

The realisation of a core pipeline network (high pressure) for the transmission of hydrogen could also be a significant step in meeting the UK strategic objectives. Such a network could provide transmission of hydrogen to regional networks and allow connection to additional production and storage sites and serve more dispersed users directly.

No targets have been set for H2P plants, but the UK government aims to encourage investment in these plants as they are seen as being able to provide flexible low carbon generation.

3.3 Financial support schemes

Table 4 provides a summary of the financial support schemes introduced to promote low carbon hydrogen projects.

Table 4: Financial support schemes for promoting low carbon hydrogen infrastructure.

Category	Financial support scheme	Notes
Hydrogen production capacity and infrastructure	Net Zero Hydrogen Fund (NZHF), (DESNZ, 2023g)	Up to £240 million of funding is provided to low carbon hydrogen projects across four strands with the aim of driving UK hydrogen production closer to goals set by the UK government. The NZHF is separated into four strands: • **Strand 1**: DEVEX support for early projects • **Strand 2**: CAPEX for projects that do not need a Hydrogen Business Model (HBM) • **Strand 3**: CAPEX for projects requiring an HBM. • **Strand 4**: CAPEX for carbon capture, utilisation and storage (CCUS) projects requiring an HBM.
	Hydrogen Production Business Model (HPBM), (DESNZ, 2023g)	The Hydrogen Production Business Model (HPBM) provides 15 years' worth of revenue support contracts to hydrogen producers. The HPBM provides a subsidy representing "the difference between a 'strike price' reflecting the cost of producing hydrogen and a 'reference price' reflecting the market value of grey hydrogen".
	CCUS Cluster Sequencing Process (DESNZ, 2021)	Included in the Ten Point Plan was a commitment to deploy Carbon Capture, Utilisation and Storage (CCUS) in two industrial clusters by the mid-2020s, and a further two clusters by 2030. To support this aim, £1bn CCUS Infrastructure Fund (CIF) was created, which supports capital expenditure on transportation and storage networks and industrial carbon capture projects.
Hydrogen transportation pipelines	Hydrogen Transport Business Model (HTBM) (DESNZ, 2023a)	The Government's position is that a Regulated Asset Base (**"**RAB**"**) model will form the basis of the transport business model. The RAB model allows a private company owner of an infrastructure asset to receive revenue from charges paid by users of the infrastructure. The regulator ensures that charges to users are fair and

		not excessive and manages efficiency incentives for the provider. Currently the eligibility criteria for HTBM are, that the project must: • consist of an onshore pipeline transporting hydrogen as a gas. • involve large scale regional, shared (multiple producers and users) infrastructure. • include planned interface with at least one large scale (i.e. geological) storage facility.
Hydrogen storage	Hydrogen Storage Business Model (HSBM) (DESNZ, 2023b)	Hydrogen storage is vital to ensuring that the balance between hydrogen demand and production levels can be properly managed. In line with other similar schemes, the business model will provide support in the early growth phase and be reduced over time as a competitive market develops. The UK government is pushing ahead with the implementation of a 'revenue floor' business model. This will give a minimum revenue amount to the facility provider, regardless of how the facility is used (must be available for use). The floor would be equal to the total capital costs of creating the storage facility, plus fixed operational costs, plus some return on capital investment. Currently the eligibility criteria for HSBM are, that the project must: • be a new build or converted mothballed geological gas storage facility. • have a minimum energy value of 50GWh of working gas (geological storage facility).

There are multiple hydrogen financial support schemes in operation with several that are due to start from 2024/25 onwards. With regards to hydrogen production, electrolysis and SMR with CCUS are supported through these schemes. Current industry reports show that blue hydrogen accounts for more than 80% of the hydrogen production pipeline (Edie, 2023). The capital support provided by the NZHF is currently focussed on electrolysis projects, later rounds may open to blue hydrogen projects. Similarly, the early rounds for the HPBM are initially targeting green hydrogen projects.

To support the large investment needed for CCUS infrastructure, blue hydrogen projects can get support through the CCUS Infrastructure Fund (CIF) but will have to show linkages to industrial clusters, which are assessed through the Cluster Sequencing for CCUS process (DESNZ, 2021).

Specific funding for transportation and storage are provided by the HTBM and HSBM (see Table 4). Both funding schemes are due to start in 2025. Hydrogen storage will be vital to ensure that the balance between hydrogen demand and production levels can be properly managed.

The UK government is consulting (2024) on a potential Hydrogen to Power (H2P) financial package. But even with the current schemes the UK has demonstrated strong policy framework for growing and kick starting the hydrogen economy.

4. A way forward

Hydrogen has been identified as a potential solution for the decarbonisation of several sectors by the UK government.

The UK Government's investment in hydrogen to de-risk early projects could unlock private sector co-investment in key hydrogen infrastructure and bypass the classical 'chicken and egg' problem and support the formation of stable hydrogen demand be that for industry, aviation, shipping or indeed heating. A UK hydrogen economy could potentially contribute 20-35% of overall energy demand with a GVA of ~£48 billion annually with the creation of up to 600k+ jobs cumulatively by 2050 (PWC, 2023).

Hydrogen demand

Historically, before the transition to natural gas in the UK, coal and town gas were the main sources of energy for domestic and industrial processes. Town gas itself consists of hydrogen, carbon dioxide, methane, and nitrogen. This experience of large-scale transition to natural gas and the technical learnings from the limited hydrogen trails could be used to good effect if the UK decides to pursue a roll-out of a comprehensive hydrogen system.

With the UK governments first hydrogen strategy (2021), the timeline for events from a residential heating perspective were to firstly establish a neighbourhood trail, which took place in Fife Scotland where 300 homes used hydrogen for heating and cooking and the production of hydrogen was via electrolysis powered by offshore wind turbines. Following this, a decision was made not to go ahead with planned hydrogen village trails in 2025. The UK will decide on the suitability of hydrogen for residential heating in 2026.

One way to create demand for hydrogen is to allow up to 20% hydrogen blend into the existing gas grid. Another way is to create clusters or hubs. These clusters have at their core a concentration of potentially high hydrogen demand industries such cement and steel making.

As electricity generation decarbonises, and centralised and flexible power plants such as Gas CCGTs are replaced by generally inflexible plants such as wind, PV and nuclear, there is concern about the operational security of the power system. Hydrogen power plants have the potential to offer this flexibility.

Hydrogen production

One of the most recurring critiques of a hydrogen economy is where will the hydrogen come from and how to de-risk production technologies with high upfront capital and operating costs. To partially address these issues, the UK introduced policies such as revenue support business models and funds to support mainly green hydrogen production technologies. It is hoped over time that accelerated learning will help reduce costs and reliance on government schemes.

Distribution -Transmission infrastructure

As part of the clustering approach, local and regional networks are planned to connect hydrogen production with demand. With the ongoing UK iron mains

replacement programme, gas distribution pipes are being converted from steel to polyethylene pipes, and these pipes enable the transport of 100% hydrogen flows.

Forward looking issues and policies

- **CCUS cluster support**

The UK government committed £1 billion for the deployment of four CCUS clusters[1] by 2030. Government funding is vital, the support for four cluster is commendable, but if further growth of hydrogen demand and the development of a hydrogen economy are the goals, then support for additional clusters should be considered. This could include the support for the South Wales Industrial cluster, leading to the creation of 10,000 jobs, the capture of 1,641 million tonnes of CO2 (2029-2048), and reinvigoration of the South Wales economy with important industries such as steel production, power generation and the wider supply chain benefiting (SWIC, 2023).

- **Hydrogen production, blue and green**

Blue hydrogen production through SMR with CCUS is likely to have the lowest levelised costs among the low carbon alternatives (Al-Qahtani, 2021). Most analyses do not include the costs associated with CCUS as this is most likely to be shared amongst many uses and industries across the supply chain. The costs surrounding CCUS infrastructure should be further supported by the government for production of low carbon hydrogen from natural gas which would encourage the development of regional backbone CCUS pipelines.

The HBM is initially being provided to green hydrogen producers, and this should now be offered at scale to blue hydrogen producers as the overall aim should be to support the reduction of overall costs of low carbon hydrogen production.

- **Local, regional, and national decisions**

Local and regional plans for hydrogen are mainly manifesting through the need to decarbonise industries with connection to wider regional businesses, power generation and possibly residential heat. One of these manifestations was the competition for CCUS industrial clusters. This was mainly localities/regions, local governments, businesses, and industries working collectively to develop proposals for national funding. Now that this process has mostly concluded, an impasse must be avoided and further government support either through additional funding or by other means such as subsidised loans etc could drive the momentum for development of regional hydrogen economies.

The decision on hydrogen heating must be made in good time. Given the ambition to develop clusters, additional demand for heating would give producers of hydrogen the impetus to push through investments which will improve learning rates, lead to potential economies of scale and lower costs.

The hydrogen boiler industry must do more with regards to information on safety of their products and showcase the benefits keeping the heating infrastructure within homes largely intact such as radiators and majority of the pipework. The potential of reduced ‘nuisance’ in the deployment of new residential heating technologies should

[1] The East Coast, Hynet, Viking and Acorn CCUS clusters (Global CCUS Institute, 2023)

be marketed as benefit of hydrogen heating.

- **Hydrogen blending**

A timely final decision on 20% hydrogen injection into the gas grid needs to be made by the UK government. This will help companies assess the requirement for production capacity and potentially outline forward looking plans to support 100% hydrogen pipeline flows.

- **Supply chain support**

It is important that supply chain systems are well understood and geared up to meet targets set by the UK government by 2030 which include 10GW hydrogen production capacity. This will require access to raw materials and the equipment to enable manufacture of hydrogen production technologies, storage facilities and pipelines.

Government backing is crucial to ensure a supportive environment for innovation to thrive. Together with the formation of trade associations, governments can help to improve awareness of forthcoming market opportunities and support mechanisms and to address issues such as the skills gaps through improved training and grants, provide further funding for research and development, enable industry best practice and support export opportunities (Wood, 2022).

In summary the development of a hydrogen economy and system will have the ability to provide integration with other energy vectors, such as gas and electricity and could provide the means to get to net zero in a timely and cost-effective manner. To achieve this, support is required from the UK government with the help of regions to encourage nascent technologies and timely and critical decisions are needed on further support for industrial clusters and hydrogen residential heating.

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