GREATER BRIGHTON HYDROGEN STRATEGY

Targeting opportunities for inward investment

Report for: Hydrogen Sussex

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Ricardo Energy & Environment, Gemini Building, Fermi Avenue, Harwell, Oxfordshire, OX11 0QR, UK | +44(0)1235 75 3000 | ee.ricardo.com
Registered company no. 08229264 | VAT no. GB 212 8365 24

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Contact:
Graeme MacLean, Gemini Building, Fermi Avenue, Harwell, Didcot, OX11 0QR, UK

T: +44 7515 787490
E: graeme.maclean@ricardo.com

Author:
Graeme MacLean, Alec Davies, Sandra Fischer, Maggie Adams

Approved by:
Graeme MacLean

Signed

Date:
30 January 2022

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1. EXECUTIVE SUMMARY

Introduction

This strategy was commissioned by Hydrogen Sussex, with funding from Greater Brighton and Coast to Capital Local Enterprise Partnership. The objective is to provide a strategy that helps the region to decarbonise energy, improve resilience, support and promote a hydrogen economy and attract investment to the area.

Low-carbon hydrogen will play a key role in reaching global and national decarbonisation targets over the coming years, particularly in hard-to-decarbonise sectors such as high-heat industry, heavy transport, aviation, and shipping. Hydrogen adoption can simultaneously improve air quality, support national energy security, and create a green growth opportunity. With $500 billion global hydrogen investment expected by 2030, there are significant possibilities in this fledgling sector. The UK government recognise this opportunity and are actively investing to foster a domestic hydrogen economy that has the potential to grow to be able to realise global export opportunities.

Regional profile

Sussex has the chance to become a key component of the UK's developing hydrogen landscape. This study found that the region has a long-standing history of engineering excellence that is continuing to evolve with new technologies and a shift to sustainable energy. Home to several high-profile hydrogen technology companies, this region has the potential to take advantage of the growing UK hydrogen landscape. The private sector and academia have been building on their success from government funding opportunities, particularly in maritime decarbonisation.

The strong local academic sector is increasingly aligned with the needs of energy transition. Until recently, there were no specific courses for decarbonisation. However, a recent win of government funding has allowed the development of a unique course covering hydrogen, emerging fuels, and practical skills at Chichester College. With two well renowned universities supplying relevant and evolving courses to support the energy transition, the region is well equipped to push forward this momentum and provide a solid green skills landscape to support the scale-up of the local hydrogen industry.

It was found that large-scale hydrogen production potential in the region is challenging due to already fully utilised renewable energy as well as land development constraints. However, there is still an opportunity at a more local scale that could further catalyse growth. Shoreham Port has the most advanced project that could become the flagship hydrogen hub for the region. Newhaven port and Gatwick airport also have strong potential to develop into hydrogen hubs due to the enabling infrastructure and variety of local offtakers. Unlike much of the UK, the region already has some active hydrogen consumers.

Highlights of progress in the Greater Brighton region	
Ceres – are a leading developer in high efficiency Solid Oxide Fuel Cell technologies	**H2Green** – are developing a hydrogen production plant located in Shoreham Port
Bramble – are a fuel cell technology disrupter with a unique approach to scalable manufacture	**Metrobus** – due to receive 20 Wrightbus hydrogen fuel cell single decker buses for their operations
Brighton University – have worked with a number of companies in the region to develop their innovations	**Ricardo** – have built a state-of-the-art test and development centre for hydrogen propulsion technologies

Table 1 – Examples of hydrogen economy progress in the Greater Brighton region

It was found that local councils share the ambition to develop a local hydrogen economy and that the political landscape is broadly conducive to support this. Hydrogen has the potential to contribute toward the 10 pledges to help tackle the climate crisis developed by the Greater Brighton Economic Board.

Barriers, and how to overcome them

The conversations held as part of this study found that the region is forward thinking in its decarbonisation plans. Most local authorities have already outlined opportunities and proposals within energy plans, with some making mention of the need for hydrogen. Local authorities have a seemingly harmonious relationship with one another and recognise their strengths in certain areas, laying a good foundation for creating an enabling environment for a hydrogen economy.

Through literature reviews of the national and regional policies, alongside extensive engagements with local stakeholders, this study identified the three most prominent barriers for hydrogen roll out in the area to be infrastructure, demand visibility, and policy and regulation at a local level. Infrastructure regularly dominated conversations with stakeholders, the most prominent issue expressed being the lack of existing infrastructure to support new developments, mainly pertaining to the availability of renewable energy, connection to the electricity grid, and connection to water supply. This barrier subsequently causes increased capital expenditure (CAPEX), delayed deployment, and in some cases, the complete abandonment of plans. This in turn links to the barrier of demand visibility. Securing hydrogen off-taker commitment is a new area for most developers in the UK, particularly for green hydrogen. Developing a multi-million-pound project with minimal knowledge of potential local off-takers increases the investment risk, and with higher CAPEX as a result of lacking infrastructure, this risk raises further. Stakeholders, including those with direct interest in developing on-site production, expressed that they have too little clarity of current and potential local demand to warrant high risk investment at this stage. The main reasoning behind policy and regulation at a local level being a barrier for stakeholders consistently related to planning. The lack of existing infrastructure, implications of deploying renewables, and overall uncertainty over planning requirements amongst stakeholders was found to be a considerable issue for the region.

The impact chart below shows the drivers that were communicated that would aid local stakeholders in overcoming the immediate barriers and are placed in order of highest impactful to lowest, as well as easiest to overcome and hardest to. The results are based on the stakeholder analysis conducted throughout this study, particularly regarding the feasibility of overcoming regional barriers.

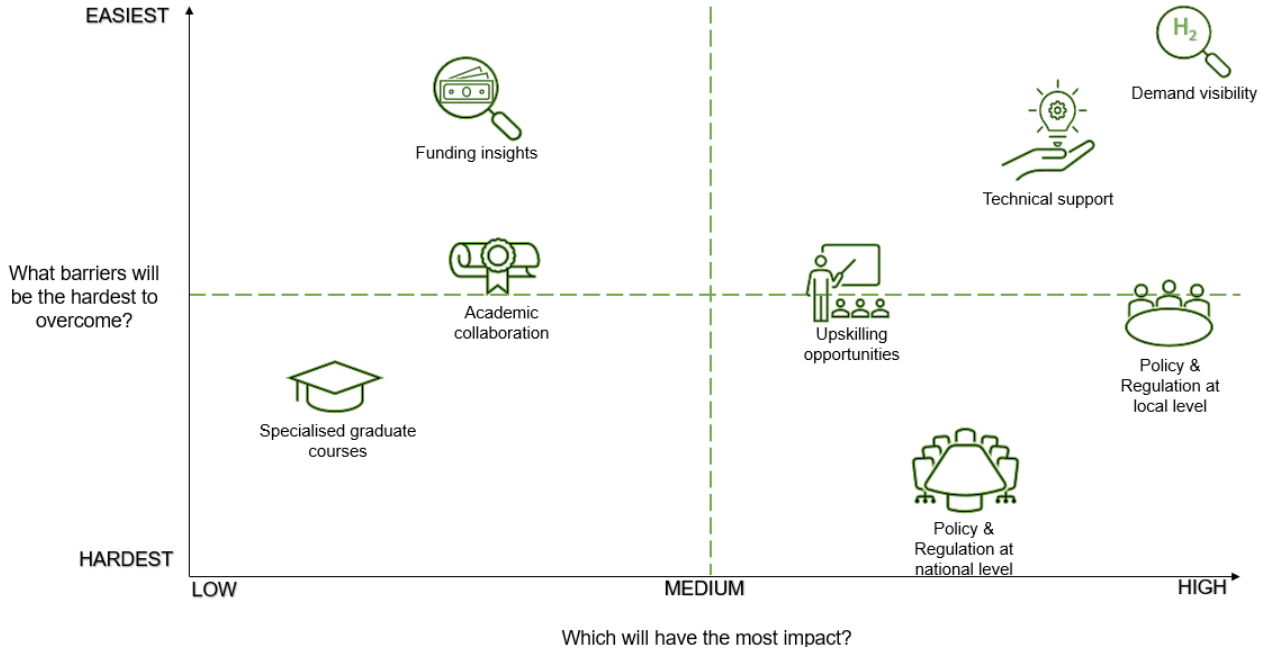

Figure 1 - Impact of the most impactful, and hardest barriers to overcome according to stakeholders

From these findings, paired with additional analysis, 42 actions were identified that from near-term to long-term. These actions should be undertaken to accelerate economic growth in the region by unlocking the local hydrogen economy. Many of these actions will require cross-sector collaboration to ensure success. Combining literature reviews, Hydrogen Sussex's experience, and Ricardo's expertise, the actions take a

forward-looking approach and span from 2023-2030 with the ultimate goal of generating economic growth in the region. Eight example actions are shown in the table below, with colour-coding to represent the responsility for implementation.

Hydrogen Sussex Public Sector Private Sector Academia Utilities All

POLICY & REGULATION	SKILLS	INFRASTRUCTURE	FUTURE SUPPLY & DEMAND GROWTH
Review planning policies to give clear hydrogen-specific guidelines for planning applications	Promote and develop the research and innovation capabilities of the region to increase collaboration capacity	Feasibility study to identify the most crucial infrastructure required for initial scale up	Identify opportunities for local authorities to stimulate the local hydrogen economy by becoming an anchor demand
Encourage and support the creation of incentives to alleviate the socio-economic impact of the energy transition	Support the development of engineering-specific upskilling opportunities, programmes, and internships to encourage uptake and develop more skilled workers	Initial investment in supply to build capacities and deploy planned hydrogen projects	Communications - Publish case studies and news items on successful projects to raise awareness locally and nationally of action in Sussex

Table 2 – Ten examples of actions from the action plan

In addition to the action plan, this study includes a route map of goals identifying key milestones to be achieved up to 2030. This route map separates the goals into four strategic themes: Policy and Regulation, Skills, Infrastructure, and Future Supply and Demand Growth. These themes encapsulate the key barriers identified throughout stakeholder engagements and represent the key milestones that would be achieved if each action is completed successfully.

This strategy, its goals, and its roadmap, will support the decarbonisation of the region, attract the crucial investment required to achieve this, and aid the progression of the local hydrogen economy.

Summary

With the correct focus, collaboration and action, the region has real potential to stand out within the UK hydrogen landscape and gain economic and environmental benefits from hydrogen.

2. INTRODUCTION

On 26th February 2021, the energy group Hydrogen Sussex (HS) was launched to promote and support a hydrogen economy across the region by pooling regional expertise and lobbying power. The group grew out of Greater Brighton Economic Board's (GBEB) Energy Plan to drive Greater Brighton's (GB) transition to become a zero-carbon economy and bring inward investment to the region from the public and private sector.

Hydrogen Sussex commissioned Ricardo Energy & Environment, a sub-division of the Ricardo group, to develop the Greater Brighton Hydrogen Strategy. This report is a study developing a foundation of knowledge to inform a strategy tailored to the opportunities presented in the region. It accompanies an activity baseline conducted by Net Zero Associates, and a review of hydrogen strategies from around the world conducted by the University of Sussex.

2.1 OBJECTIVES

The strategy aims to help the region to decarbonise energy, improve resilience, support and promote a hydrogen economy and attract investment to the area. The focus of the strategy is on 'green' hydrogen, produced by electrolysis with renewable electricity. The overarching objectives are to:

1. Encourage and support development of a strong hydrogen sector in the Greater Brighton and wider Sussex region.
2. Secure broad economic benefit from public sector and private sector support for development of regional hydrogen production and use.

The investment proposition will give a clear focus for the priorities for action next 5 years and the pathway to scale up ambition into the future. It will establish a place-based perspective, help key stakeholders understand the opportunities in the region, and prepare the ground for significant funding applications.

Greater Brighton and the wider Sussex area has opportunity to become a leader in the hydrogen economy thanks to access to:

- Key infrastructure including Gatwick airport, Newhaven Port and Shoreham Port
- Engineering leadership with private companies innovating in the hydrogen field
- Research excellence of two universities supporting research and innovation
- Environmentally passionate citizens with forward thinking local authorities

Progress towards a local hydrogen economy has begun. For example: a multi-megawatt hydrogen production electrolysis plant has been announced at Shoreham Port; Brighton & Hove buses are due to receive fuel cell buses; Michelmersh bricks have assessed the feasibility of replacing natural gas with hydrogen in the brick making process; multiple companies are innovating with hydrogen technology as their core proposition.

The heart of this strategy is based on engagement with numerous stakeholders that built an understanding of the landscape as it is now, what is in the way of the development of a hydrogen economy and what Hydrogen Sussex and its members can do to support it to drive economic growth.

This report presents the landscape for hydrogen, focussing on the region, discussion of stakeholder engagement, regional analysis, initial hydrogen strategy including a roadmap and short-term action plan and with it, outlining the role of Hydrogen Sussex.

3. ANALYSIS OF THE REGION

3.1 GEOGRAPHY

For green (low carbon) hydrogen production, location is an important factor. Access to strong renewable energy resource keeps power generation costs lower, which is the key cost component when producing green hydrogen. Solar and wind resource for the region is good but is stronger in other parts of the UK.

The offshore wind farm Rampion is large enough to be considered nationally significant infrastructure. There is a second development for this wind farm planned for 2025-6, which will connect into Bolney substation as per the existing wind farm. The GBEB energy plan suggested that an electrolyser could be sited there, although

there are no identified demand locations nearby other than potential refuelling of passing traffic on the A23. However, considering the relative distance to Gatwick airport, which is expected to be a significant future demand, there may be an opportunity for a direct pipeline. This would be further into the future and requires further analysis and bilateral engagement between Rampion and Gatwick. Engagement with Rampion found that, given the large population supplied by the Rampion wind farms, and the relative lack of other large-scale renewables locally, these wind farms are unlikely to face significant curtailment and will fully contribute to decarbonising the local electricity grid. Therefore, using Rampion to produce hydrogen by electrolysis is not seen as the best use case in the near term.

The region has a large land area of natural capital including the South Downs National Park and High Weald Area of Outstanding Natural Beauty. This is a weakness when it comes to implementation of renewables to co-locate with electrolysers (which is an economically attractive option to keep hydrogen production costs down). Renewables that are within view of the park are likely to encounter resistance for planning permission. It can be bypassed by locating out of view, but this restriction could cause developers to consider other regions. The rich biodiversity often found within protected parks can also cause issues for environmental permitting. The hilly topography adds further barriers to the development of renewables that ultimately raise costs to the project and therefore reduces the competitiveness of hydrogen production.

Water is critically scarce within the region and hydrogen production through water electrolysis could provide further stress. Best practice is to encourage hydrogen production to target sustainable water sources to protect future water sources and to win public support. The coastal location of much of the region presents an opportunity as any plant located on the coast could install desalination plants and draw on sea water. A study by IRENA showed that using desalination technologies are expected to increase the cost of hydrogen by 4% (IRENA, 2022).

3.2 INDUSTRY, TECHNOLOGY AND RESEARCH & INNOVATION

Advanced engineering and research in the hydrogen space is very well represented in Wider Sussex compared to other regions in the UK. The hydrogen solutions being developed at local companies Ricardo, Bramble, Ceres, NVH Global, Engas, AFC Energy, Flowserve and Cox are ahead of the wider market. The two universities have PhD studies on innovations in the sector. Brighton University has also partnered with companies to win government research funding.

The region has key infrastructure at Gatwick airport, Shoreham Port and Newhaven Port. These locations act as demand clusters that could be attractive for siting a production plant that can minimise costs associated with distribution. In these clusters, heavy transport is the key early opportunity for decarbonisation by hydrogen. The benefit of the three small demand clusters, compared to the UK major industrial hubs such as South Wales or Teeside, is that investment risks can be taken in a smaller and more gradual approach that can be scaled as technologies develop and costs come down. There may also be less reliance on a single large offtaker.

There are few heavy industry opportunities in Sussex, and those that do exist are dispersed across the region. The issue with dispersed industry is that hydrogen will be more expensive for the off taker who may choose to invest in costly dedicated hydrogen production. An alternative could be to receive road deliveries of hydrogen from a regional production facility. However, road deliveries that could be subject to local traffic issues that could prevent fulfilling the need or inhibiting future growth.

3.3 HUMAN RESOURCES

The hydrogen engineering workforce of the wider Sussex region is advanced compared to other regions. The hydrogen solutions being developed at the engineering businesses and universities, are ahead of the wider market and have drawn in expertise from around the UK and the world. This variety of leading companies can attract talent to the region and make it possible for them to stay within the region when switching roles between companies.

When it comes to practical hydrogen skills, the region is at a disadvantage compared to other UK regions, with only those skills associated with the natural gas network. This contrasts with regions with chemicals, oil & gas industries. The workforce from these sectors is seen by stakeholders as relatively easy to retrain into the hydrogen sector.

There are many colleges offering further education across the region. Until recently, there were no specific courses for decarbonisation. However, a recent win of government funding is enabling a unique course

including hydrogen and emerging fuels and practical skills working with electric vehicles. Electric vehicles have the same powertrain technology as vehicles powered by hydrogen fuel cells, so skills in this area will be useful for the future. There are also two universities supplying graduates with specialist skills. Courses from these education centres do not have a focus on hydrogen yet. However, University of Brighton has a strong engineering school and research engineering through its collaborations with industry.

3.4 POLITICAL AND INSTITUTIONAL LANDSCAPE

The political landscape of the region is broadly conducive to supporting a hydrogen economy. The Greater Brighton Economic Board developed their 10 pledges on the environment to help tackle the climate crisis. A hydrogen economy could potentially contribute to four of the ten pledges (in order of relevance to the region):

- Pledge 9: Innovation
- Pledge 3: Zero emission fleets
- Pledge 7: Low carbon heating
- Pledge 2: Water recycling[1]

The 2020 Greater Brighton Energy Plan also highlights the potential of hydrogen infrastructure development in the region as part of its energy decarbonisation measures. Hydrogen transport is a key strategic theme, and the development of a hydrogen hub is recommended. A hydrogen hub is a cluster of production and use of hydrogen in a defined area to share infrastructure and minimise transport costs.

At a regional level, West Sussex County Council and five of the seven local authorities in the region have declared a net zero by 2030 target. The commitments show concern for climate change and with it an imperative to act decisively on decarbonisation ahead of the government 2050 target. This is often in their own operations but also in supporting constituents and businesses to do the same.

Many of the economic development and COVID recovery plans released by councils show an initiative to support the development of clean technologies and building back greener. Alongside decarbonisation trends such as behind the meter renewable energy and electric vehicle charging infrastructure, hydrogen could be seen as a solution to support these objectives.

[1] Water for electrolysis can be purified from wastewater sources. Waste nutrients can be captured, contributing to nutrient neutrality regulation

3.5 SWOT ANALYSIS ON REGIONAL POTENTIAL ECONOMIC GROWTH WITH REGARDS TO HYDROGEN

Strengths

- Advanced engineering excellence
- Strides in maritime decarbonisation research
- Engaged local government stakeholders
- Multimodal transport ecosystem: ports, airports, road, and rail
- Active projects and companies already consuming hydrogen
- Further education skills aligning with needs of energy transition

Weaknesses

- Fewer practical skills compared to some other regions
- Constraints around deploying renewables inhibits local hydrogen production
- Limited industrial activity
- Disjointed progress
- Weak knowledge in public sector
- Constrained power grid
- Severe water stress

Opportunities

- Potential for commercialising research into new business ventures
- Key infrastructure could become low risk hydrogen demand clusters
- Environmentally minded and supportive public with a track record of investing in energy infrastructure
- Well-developed supply project at Shoreham Port
- Openly prospective hydrogen demands in the region

Threats

- Manufacturing companies relocating to Solent freeport
- Industry relocating to Southampton to leverage cheaper hydrogen from the proposed UK hydrogen network
- High competition for limited experienced hydrogen engineering labour force
- General risk of hydrogen economy being a bubble
- Private sector averse to take risk on emerging technology without stronger drivers

Figure 2 – SWOT analysis for development of a hydrogen economy in the Greater Brighton region

4. STAKEHOLDER ENGAGEMENT

A key part of this project has been to conduct interviews stakeholder both within the region and with regional interest. In total, 44 stakeholder engagements were held. To synthesise the information gathered during stakeholder interviews, each interview was set a structure best suited to the type of stakeholder and the information required. Though each interview held a unique conversation, the core topics remained constant to ensure the conversation remained relevant and the interviews could be analysed as a whole. In addition to the core topics, stakeholder specific questions were asked to gain a deeper understanding of the barriers faced and drivers required between the different organisation types. Throughout stakeholder interviews, Ricardo remained unbiased and ensured that the structure and manner in which questions were asked had no influence on the response.

During each interview, information was gathered in note form and then transferred into a tailored data collection spreadsheet for further analysis.

Categories of stakeholders include:

- Hydrogen supply project developers
- Hydrogen demand project managers
- Hydrogen economy service/equipment providers
- Key infrastructure managers
- Regional organisations
- Academia
- Local authorities
- Utilities

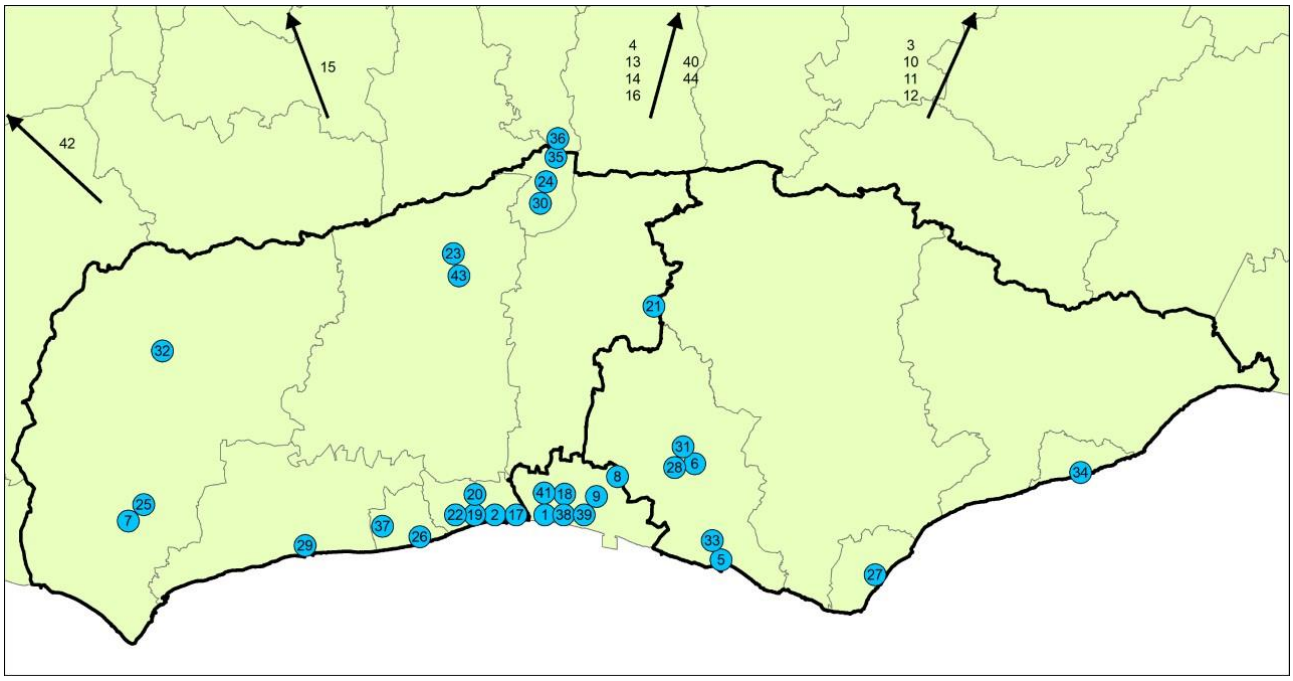

Figure 3 - Map of stakeholders consulted

Name	#	Name	#	Name	#
Utilities & energy generation		**Academia**		**Local and national authorities & public services**	
UKPN	4	Chichester College Group	7	West Sussex County Council	25
SGN	36	University of Sussex	8	East Sussex County Council	28
Rampion	5	University of Brighton	9	Brighton and Hove Council	38
Southern Water	37	**Ports & Airports**		Crawley Borough Council	30
Associations & LEPs		Shoreham Port	17	Lewes & Eastbourne Councils	27
Hydrogen UK	13	Newhaven Port	33	Adur & Worthing Council	26
UK Hydrogen Fuel Cell Association	12	Brighton City Airport	19	Arun District Council	29
Hydrogen Sussex	39	Gatwick Airport	35	**Developers**	
Greater Brighton Economic Board	1	**Mobility providers**		H2Green	17
Thames Estuary	6	Brighton & Hove buses	41	Marubeni	3
Hydrogen East	11	East Sussex Fire & Rescue	31	Scottish Power	15
Coast 2 Capital LEP	2	RWE maritime division	42	Octopus Hydrogen	44
Locate East Sussex	34	**Hydrogen engineering**		**Industry**	
Greater South-East Net Zero Hub	16	Ricardo	20	Michelmersh Bricks	21
Land development		Ceres Power	23		
South Downs National Park	32	Cox Powertrain	22		
Savills	40	Bramble Energy	24		
		Engas	43		

Figure 4 - List of stakeholders interviewed

The findings from these discussions were noted and analysed to develop the context of the region, the level of existing activity, and grasp the barriers that are inhibiting progress. In some cases, the discussions with stakeholders included confidential commercial information, details of which are not included in this report, although they informed the analysis.

4.1 KEY OUTCOMES

Barriers experienced by stakeholders

Throughout the stakeholder interviews held as part of this study, it was apparent that stakeholders face varying barriers to progress effectively or in some circumstances, even at all. Some recurring themes developed across the conversations. The nine most prominent barriers raised are listed in the table below with a description of each.

Barrier	Description
Policy & Regulation at national level	Barriers as a result of national level policies and regulations
Policy & Regulation at local level	Barriers as a result of local level policies and regulations (including the planning procedure)
Technical support	Absence of support during funding application as well as the lack of knowledge of available funding
Funding support	Lack of available funding and subsidies to accelerate deployment
Graduate Level skills	Lack of graduate level workers, particularly with practical skills
Senior Management	Lack of senior level workers with specific hydrogen expertise
Demand visibility	The uncertainty of local demand for hydrogen, both current and forecasted
Infrastructure	Lack of physical infrastructure and the related challenges of its absence
Hydrogen supply	Difficultly in accessing local hydrogen supply due to availability or cost

Table 3 - List of barriers to hydrogen in the region

During stakeholder interviews, each stakeholder was asked to discuss the major barriers their organisation face when considering or implementing hydrogen into their business plan. The number of barriers a stakeholder could raise was not limited or set by Ricardo. In some cases, stakeholders expressed their experience of several barriers. As shown in Table 3, nine barriers were consistently raised. The conversations held with stakeholders as part of this study were predominantly near-term oriented and this should be noted when considering the results. The figure below displays the three barriers that were most frequently raised by stakeholders of the region.

Figure 5 - Most regularly mentioned barriers to hydrogen in the region

Infrastructure, the most frequently experienced barrier among local stakeholders, relates to the lack of already constructed infrastructure, particularly water and electricity grid connections to proposed development sites. Many stakeholders expressed concerns regarding the investment risk of constructing required connections and the additional planning sensitivities that come with it. For policy and regulation at local level, challenges surrounding planning permission were strongly highlighted throughout stakeholder interviews, particularly in relation to environmental objections and understanding the requirements of planning applications for hydrogen

technologies. Demand visibility was the third most frequently experienced barrier by stakeholders and mainly pertained to the lack of visibility of demand potential both locally and nationally. Some stakeholders even noted feeling well aware of the potential for export, but less versed on local demand. When considering all three barriers, it is clear they are interconnected. A lack of infrastructure increases CAPEX , and therefore raises additional hurdles for planning, increasing the investment risk. Stakeholders, particularly those with direct interest in developing on site production, expressed that they have too little clarity of the current and potential local demand to warrant high risk investment at this stage.

4.2 IMPACT OF BARRIERS TO DEVELOPING A HYDROGEN ECONOMY

The impact chart below shows the drivers that would aid local stakeholder in overcoming the immediate barriers and are placed in order of highest impactful to lowest, as well as easiest to overcome and hardest to. The results are based on the stakeholder analysis conducted throughout this study and draws on the knowledge and insight gained throughout interviews regarding the feasibility of overcoming regional barriers. This chart does not reflect any views of Ricardo or Hydrogen Sussex, it is a pure reflection of engagement outcomes.

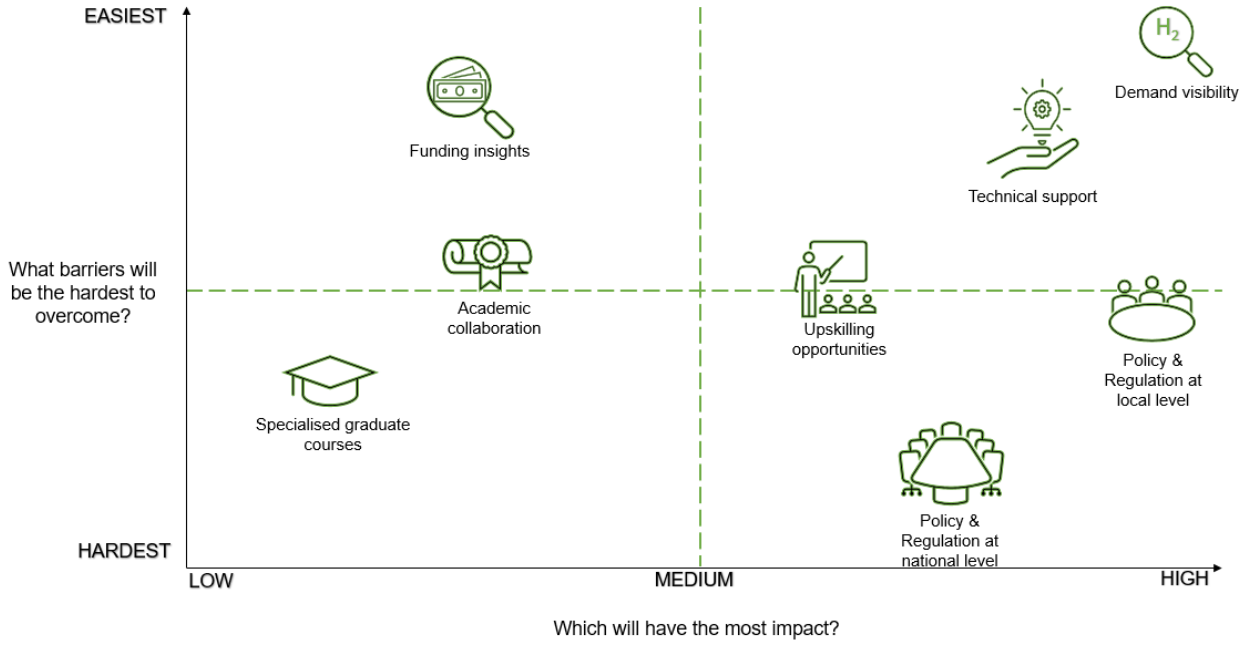

Figure 5 – Impact of the most impactful, and hardest barriers to overcome according to stakeholders

4.3 KEY FINDINGS BY CATEGORY

Hydrogen supply

Shoreham Port has the most advanced hydrogen supply project in the region. The key issue faced there is one being faced nationally. Off-takers are unclear and unwilling to commit to take or pay contracts that remove financial risk and stabilise the price of hydrogen to the price of directly procured electricity as opposed to being bought at market price from the grid. We class this as a **demand visibility** issue. The root cause of the issue is due to **national policy** not providing funding to bring down the capital cost of hydrogen transport and incentivise uptake. Opportunities exist in the forming of innovation funding competitions but the outcome of these are uncertain and there is no opportunity for other demand cases to follow on once the competitions have gone by. Demand needs further stimulation beyond what the government can offer.

Newhaven port also has good potential to develop a hydrogen hub that can both produce and use hydrogen. It serves a ferry route and offshore wind service vessels that have fixed routes and patterns of usage that are simpler to design a refuelling and storage system compared to that needed for other deep-sea vessels. There is a bus depot, a refuse collection fleet and up to 150 heavy goods vehicles visiting the site for the industries that operate there. The key issue for this site is the cost of improving power **infrastructure** to provide power supply to an electrolyser.

Brighton City Airport is investigating the potential to become a hydrogen hub. A key issue they are encountering is the cost of power supply **infrastructure**. They discussed seeking **local government support** to assess the feasibility of installing on-site solar for low-cost self-supply.

A prospective hydrogen producer revealed the depth of research they have to undertake to understand where off-taker opportunities are which a **demand visibility** issue. Co-location with renewable electricity is a key part of their strategy to lower the cost of hydrogen, therefore **local government** consenting more renewable energy infrastructure in the region supports the potential for hydrogen production.

A global investment and development business that is progressing its portfolio of hydrogen projects, revealed that infrastructure and demand visibility are key to attract investors. When asked what would attract the investors to the region, it was stated that the sourcing of renewable energy is a deterrent, and that additionality implications are a cause for concern, however, a strong business case with the added security of off-taker commitments would significantly improve a projects competitiveness and spark interest.

Hydrogen demand

Key hydrogen demand stakeholders are often aligned with the location of the proposed hydrogen supply locations. In these key locations the main need was to convert demand from speculative to committed by providing **technical support**, stronger **national** and **local policy** drivers to develop a near term need for transition, and **funding availability** to invest into the required **infrastructure and equipment**.

One stakeholder in the public transport business will be operating hydrogen vehicles within the region next year. They had difficulties in **sourcing green hydrogen** but have since overcome that issue. They would benefit from more **funding availability** in the future to continue decarbonising their fleet.

One stakeholder had hydrogen vehicles within the region but had to move them out to a neighbouring county due to the closure of hydrogen fuel stations, an **infrastructure** issue. Another niche vehicle type was finding it difficult to be sure about the role of hydrogen for their sector and is waiting to see a market form first.

One industry stakeholder fed back that they experienced difficulty **sourcing green hydrogen** and the infrastructure to become self-sufficient was very costly and far beyond their own resources. They felt they would benefit from **financial support** or **technical support** to develop a feasibility study to provide more substance on what would be required and what other long-term options they might have.

Worthing council crematorium recognised the opportunity they had for hydrogen but needed **technical and funding support** to take the next steps.

One demand type was actively procuring **technical support** to understand the feasibility of utilisation. They felt they need more guidance from **national level** policy.

Local and regional authorities

Local and regional authorities in the region are highly supportive of decarbonisation and address it in their policies. Interviews found there was a more general understanding around the potential that hydrogen has to replace fossil fuels in their own operations and that of businesses within their region but have varied thoughts on the role it has to play – something that may be supported with **demand visibility**. Most recognise that this new technology is an opportunity to grow the local economy in an emerging market.

Most recognised that power **infrastructure** and water availability are critical barriers for electrolysis that may make hydrogen production more difficult in the region.

Some recognised there are risks involved with the new technologies that meant for them that it may be better to follow a hydrogen transition rather than lead on one. Others said they are more interested in taking the leading role but need clear **funding support** and/or the **technical support** to make effective decisions. A few questioned how to attract **infrastructure** that their assets could access.

Stakeholders that identified policy and regulation at local level as an important driver consistently raised planning as the primary reason. These organisations tended to have a direct interest in developing on site hydrogen production and felt the clarification of planning requirements would be hugely beneficial.

Some councils were open about their weak knowledge on the hydrogen topic and could benefit from **upskilling opportunities** to better understand the role hydrogen could play, the infrastructure needed to facilitate it and how they can support it. At present, the lack of knowledge and the emerging stage of hydrogen technologies makes it difficult to make decisions that integrate it into policy. Examples included determining the role it should

play in a local transport plan and how to implement hydrogen into future procurement plans. Local councils have not yet undertaken independent studies to investigate how hydrogen might benefit their area.

Academia

Chichester College recently won government funding to develop capacity in emerging skills with an emphasis on decarbonisation. The alternative energy and hydrogen technologies project will develop a course to build essential skills for the hydrogen economy[2]. Discussions found that initial studies by Net Zero Associates helped to identify the training needs but due to how nascent the sector is, it has been difficult to find technical professionals to deliver the courses. The staff would benefit from **upskilling opportunities** to increase the impact of the course. A key topic is hydrogen safety within the lab environment. This difficult subject reflects the complexity of **national regulation** around working with hydrogen.

Higher Education (HE) institutions have a track record of working on projects in the hydrogen economy. University of Brighton, in particular, has a history of collaborating with local business to conduct innovative research in the sector. In part this has been enabled by **funding availability** from the government that is concluding. Some funding access requires a company lead, so **supporting collaboration** can unlock that to benefit the university and its partners. The opportunities from this are not exclusive to hydrogen technology research but speciality skills such as mapping or data science can add value to a hydrogen economy. Therefore, other funding streams should be assessed as to if or how they might be able to interplay to **support further collaboration**.

Graduate level skills were frequently highlighted as a barrier in the region, predominantly felt by innovation and manufacturing companies. This is generally due to the need for specific expertise such as design and innovation that is not widely included in graduate level courses. Junior level workers that come straight from education to the hydrogen workplace are said to have a good understanding of broad topics but lack deeper knowledge of specialised technologies or practices.

University of Brighton currently has a module on one course that addresses the hydrogen economy but intends to expand on **specialised renewable energy courses** that will provide more **graduate level skills**.

Engineering industry

The engineering industry has varying needs based on the current business objectives they were aiming to achieve. One topic was consistent across them and that was the need for **senior expertise** level skills in the sector. The growth of the businesses meant that competition has risen for the slower growing number of professionals in the region. The attractiveness of well-paying roles may attract expertise into the region but not at a rate fast enough to meet the demand.

Some engineering companies remarked on the need for more supportive **government policy**. Current efforts by the government are too slow and unambitious compared to what is being seen in other countries. There is also the need for more **funding support** to grow at a pace to scale to meet the current activity in the hydrogen sector which is getting bolder and more ambitious with every new announcement.

One barrier seen by at least one company was the difficulty to **procure green hydrogen** at a reasonable cost and grade of purity needed for fuel cells. The government Renewable Transport Fuel Certificates (RTFCs) do not extend as far as company research and therefore they are paying unsubsidised prices.

One company remarked that they were unaware of the full picture of hydrogen activity in the region and would therefore benefit from **demand visibility**. They felt that this visibility may help them potentially partner and support one another or develop innovative new products.

5. ECONOMIC GROWTH

5.1 THE PATHWAY TO LOCAL ECONOMIC GROWTH

Greater Brighton and the wider Sussex area has the engineering excellence to stand out in the UK hydrogen economy and be known as a research and innovation hotbed. It is already advantaged by being home to multiple world-class hydrogen technology businesses and academia with a track-record of winning national

[2] There is value in pointing out that the success of an electric vehicle training centre project is of importance to a hydrogen economy as fuel cell vehicles will be based on electric powertrains.

and international funding for hydrogen related research. Supporting this industry could provide the region with clean growth, attracting private investment into the region and creating high value, skilled jobs.

The UK government recognises that the UK is very well placed to be an international leader in hydrogen research. Wider Sussex has an opportunity to play a leading role in the UK's plans to achieve this. Two of the three firms (Ceres and Bramble) that the UK hydrogen strategy hails as being "at the forefront of the global shift to hydrogen" are within Sussex. Supporting these existing companies and nurturing hydrogen technology start-ups will provide organic economic growth whilst simultaneously contributing towards decarbonising the region. Ricardo estimates that getting this right could add over £261m of gross value added and 2,000 jobs to the regional economy by 2050[3].

Sussex's academic institutions have a track record of winning and contributing to UK innovation. Winning public sector funding may provide around three times the amount of private sector investment (depending on the fund and the organisation). The government has committed to increasing public funding for national research and innovation to £22bn per year by 2024. As hydrogen is in an early stage of development, its role, and the associated technologies to enable it will continue to need to be explored. Research funding is likely to continue to play a central role in the government's hydrogen strategy. The target sectors for investment are clearly identified in the government's hydrogen investor 2021 roadmap (UK Department for International Trade, 2022) . Universities and businesses alike should be prepared to seize this opportunity and further their technologies. Cultivating research from academia into pioneering businesses will provide a more diversified and resilient hydrogen economy.

The global hydrogen investment is expected to reach $500 billion by 2030. Sussex's home-grown hydrogen sector could be well positioned to take advantage of this global growth by exporting its technologies and services. Analysis suggests that around a quarter of UK jobs in the hydrogen sector, and around 30 per cent of economic opportunity, could be driven by exports by 2030, with these growing in relative importance by 2050. The UK government have earmarked £2bn to finance clean growth projects overseas and support export opportunities that will further the UK hydrogen opportunity.

New economic opportunities will arise through developing energy infrastructure and encouraging a local hydrogen supply chain from production through to point of consumption. The UK Infrastructure Bank has £12bn of capital available to support local governments and the private sector in developing projects with hydrogen infrastructure assigned as a priority. Beyond economic growth, Wider Sussex can make strides towards decarbonisation targets by providing low-carbon hydrogen to its hard-to-decarbonise industries. This agenda is aligned with the regional strategies of public bodies and their environmentally conscious citizens. Growing hydrogen hubs in areas of dense infrastructure enables the decarbonisation of multiple energy users as well as allowing them to share infrastructure, avoid distribution costs and benefit from improved local air quality.

The pathway to unlocking this clean economic growth is to support the sector to flourish by removing or mitigating the barriers that are currently restricting it, and by creating an enabling environment that has the potential to drive it beyond current limits.

5.2 SKILLS NEEDS

Achieving the Net Zero ambition will require a transformation of workers' skills across many areas of the economy, particularly those working in buildings, transport, maintenance, and energy. With hydrogen an embryonic industry, the skills required to achieve hydrogen related goals is a widely discussed topic. Released in 2021, the UK Hydrogen Strategy recognises the development of skills as a key component in creating a secure hydrogen economy, highlighting it as a 'challenge to overcome'. Its importance is cemented with analysis included in the UK Hydrogen Sector Development Action Plan that suggests that the UK hydrogen sector could be worth £900 million and support 12,000 jobs by 2030. These jobs will span across production, transport, storage and use technologies for both domestic and export markets and require a diverse range of worker skills. Many of these skills already exist in the UK, although mainly concentrated within the chemicals and oil and gas sectors, and these skills should be utilised through upskilling and retraining in the first instance. Figure 6 - shows the timeline of skills development plans set out in the UK Hydrogen Strategy.

[3] Based on applying regional GDP to UK hydrogen strategy projections

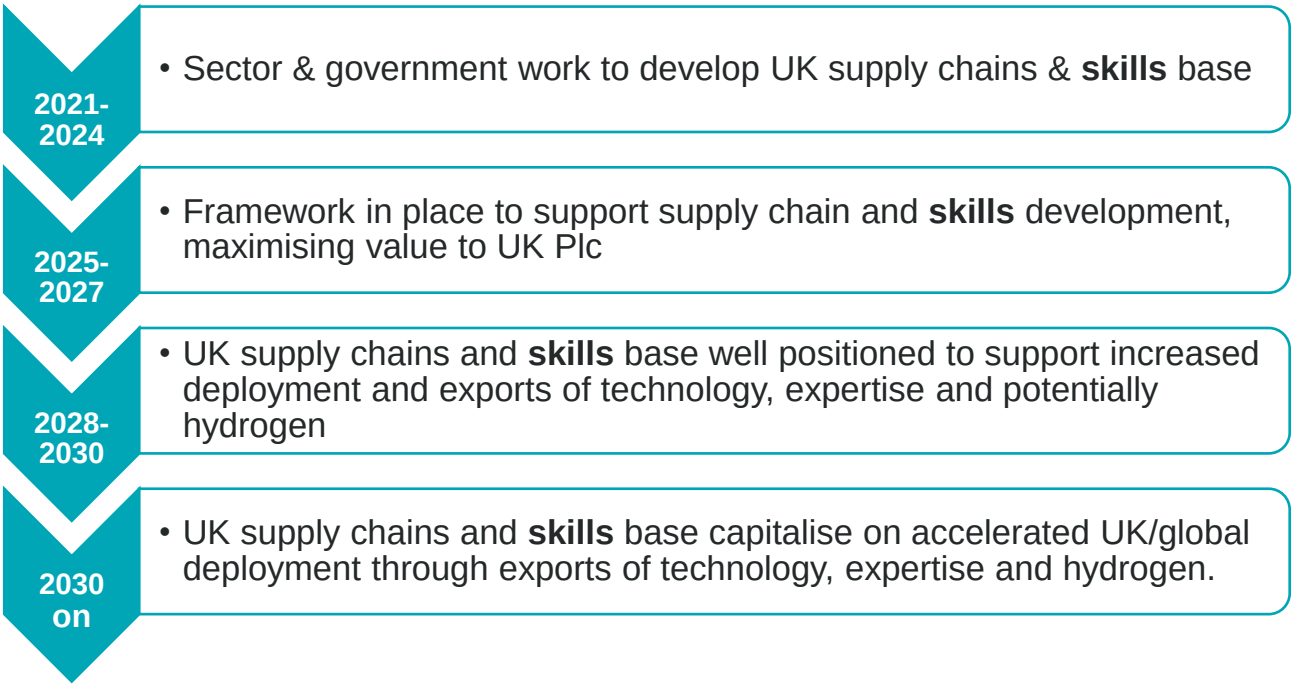

Figure 6 - Skills timeline from the UK hydrogen strategy

Experience with hydrogen across the supply chain remains a niche area, particularly when produced through renewable resources. Grey (high-carbon) hydrogen has been produced and transported in the UK as an industrial gas for decades, meaning there are already experienced professionals with the skills required for the transition. However, these professionals remain in high demand and are mainly located in other regions of the UK. There are examples of such topics beginning to be addressed in the North West of England, such as the Net Zero North West announcement of the UK's first regional skills plan, known as the North West Net Zero Skills Charter. The new pan-regional group made up of businesses and universities will create plans and measures to support those wishing to transition to green jobs in the North West of England. The group will develop an action plan which will identify barriers and suggest solutions to accelerate the green economy and reach the goal of creating a 660,000 strong workforce in the region, some of which will be in the hydrogen industry. Figure 7 showcases the interrelationship between the skills required for the hydrogen economy and other key energy skills.

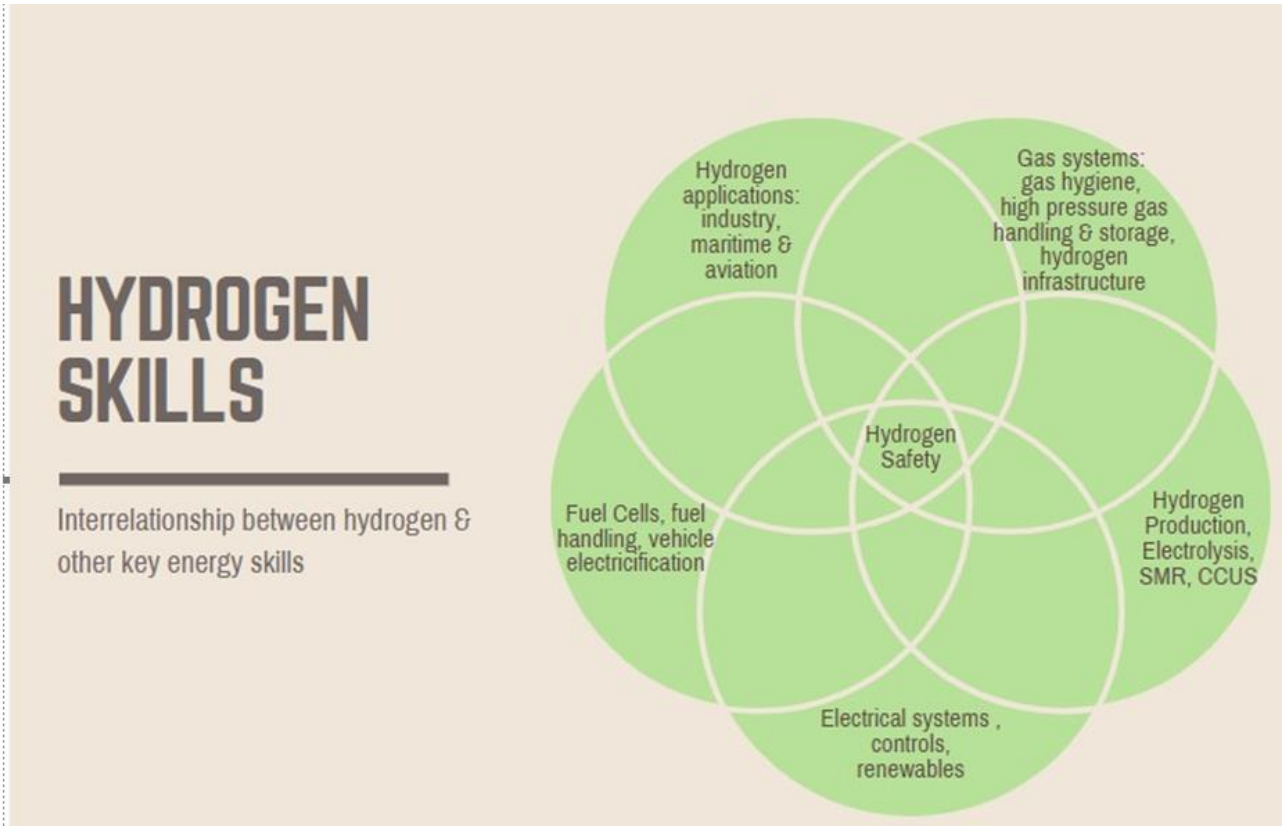

Figure 7 - Interrelationship between hydrogen and energy skills. Imaged credited to Net Zero Associates

Though the region does not have the industrial history of other comparable regions in the UK, it is home to several innovative hydrogen companies, along with two well renowned universities that boast green skills curriculum. The academic collaborations for hydrogen research between local universities and the private sector to date show the region's forward thinking and flair for innovation. This strength in engineering excellence will need to continue to develop with the evolving hydrogen economy to ensure that local employment is achievable, and opportunities are not missed. Through stakeholder engagements, it was found that for the current level of hydrogen related employment, the skills currently in the region are sufficient for engineering and mid-level roles. The main discrepancy between employer needs and worker availability sits at the entry and senior management level, whereby graduate level workers do not have the hydrogen specific expertise required for technical roles, and management level workers with proven experience in hydrogen technologies are scarce. Companies working in the hydrogen space report that they need to ensure their workforce are highly skilled and experienced before they are comfortable releasing them to work on the new and expensive pieces of equipment. The equipment developed and installed for hydrogen refuelling stations, hydrogen delivery, hydrogen buses and refuse collection vehicles is currently hugely expensive, often still bespoke, and any damage or down time will very likely be hugely costly (potentially not only financially, but also reputationally). Hence skilled professionals are generally preferred over those with junior level expertise and practical experience. For this reason, senior level workers have become a commodity and the market is hugely competitive.

However, graduate level skills were frequently highlighted as a barrier in the region. From conversations with stakeholders, this is generally due to the need for specific expertise such as design and innovation that is not widely included in graduate level courses. Further education employees who come straight from education to the hydrogen industry have a understanding of broader hydrogen related topics but lack the necessary depth of technical knowledge. It was also noted that practical skills within graduate level workers were lacking, and, in some cases, graduate level roles have been deemed unsuitable due to commercial risk of unexperienced hands working on new and expensive technology, as well as finding that Small to Medium Enterprise (SME) companies struggle to dedicate the necessary time to train graduates.

Being a region with SME-size hydrogen companies, it is important that these issues are addressed and resolved to allow the local hydrogen economy to scale-up. In the first instance, aligning hydrogen related courses between higher and further education institutions will tackle any mismatch between course modules

and practical elements. Chichester College has recently developed a hydrogen specific course and attained hydrogen equipment to bring a practical element to the learning. Brighton University have introduced hydrogen modules to pre-existing courses and are looking to develop a dedicated hydrogen course in the coming years. Alignment of these courses would provide a 'skills ladder' that would allow those looking to pursue hydrogen as a career a clear path of qualification. This would require an open communication process between the two institutions to ensure the courses meet the needs of local hydrogen employers and supply a continuous flow of new workers to the local economy that accounts for the retirement rate of workers in the sector and transfer of workers in line with Just Transition. The provision of individual training modules for rapid upskilling of the existing workforce with hydrogen skills may prove preferable to multi-year courses for employers.

The development and roll out of upskilling opportunities should be encouraged, revised, and well-advertised in the coming years to ensure they are well utilised and suit the workers that require it most in the early years.

In addition to the skills required for the hydrogen value chain, councils can be critical to the success of hydrogen installations. Hence of key importance are the skills and strengths that a council possess to support the initial stages of the hydrogen economy in the region. Council planning departments typically do not have good familiarity with hydrogen projects due to the scarcity of such projects and may raise concerns regarding safety elements. Councils could be more proactive, as indeed some are being (such as Aberdeen) by ensuring that all the relevant people from within the planning team are educated about the opportunities identified, safety risks and mitigations, and how such a project might fit into the wider context of the local economy and plans, along with recognising the benefits. There will also be the requirement to ensure the emergency responders, particularly the fire service, are adequately trained for the technology change that will be introduced into the region.

5.3 REQUIREMENTS FOR RESEARCH & INNOVATION INSTITUTIONS

Discussions with research and innovation stakeholders found that they do not require added physical space for their activities or planned activities. However, as the region seeks to encourage more research and innovation organisations, extra commercial space will be required to facilitate them. A research park, along with the improvement of links between academia and local hydrogen businesses would help to provide an affordable, high-quality space and stimulate a culture of knowledge sharing and collaboration. It is expected that there would be insufficient needs for a dedicated hydrogen park, but including provision for safe storage and use of hydrogen when planning any new parks would make them attractive for businesses looking to relocate. Studies have shown that science park companies are able to attract a greater proportion of qualified scientists and engineers and grow faster than similar companies at different locations.

5.4 COUNCIL LEVEL FUNDING OPTIONS

Local authorities and regional Local Enterprise Partnerships have shown interest in COVID recovery and long-term growth through supporting decarbonisation investments. The support rarely explicitly suggests hydrogen as a potential solution. Given how nascent the sector is and the high costs associated with new technology, it is a challenge to attract investors to develop the related infrastructure. Local authorities may be able to facilitate seed investment that would ultimately attract larger private investment. An example could be to commit to investing in transitioning their refuse collection fleet to hydrogen, attracting private developers to invest in supply chain infrastructure to serve the demand. Ensuring this infrastructure is capable of serving other customers will give private sector vehicle owners the option of following such a transition.

Local authorities currently face financial challenges. However, should they wish to invest to support the growth in the hydrogen economy, public sector funding to support developments includes:

- Public Works Loan Board
    - UK government loans to local authorities for capital projects – good rate at the gilt yield plus 0.6%
- UK Infrastructure Bank (Less than £5m)
    - Offers financing to local authorities for economic infrastructure projects across clean energy, waste, water, digital and transport
- Local Climate Bonds

    - They are regulated investment products launched by Councils to access cost-effective funding for specific decarbonisation projects, offering local people an opportunity to invest in their area in a way similar to crowdfunding and to make a return from doing so
- Innovate UK
    - Hosts a variety of project calls, many of which centre on decarbonisation and hydrogen, often requiring a commercial and public partner

Monitoring the funding landscape and directing local authorities and private partners to appropriate sources of funding could be a key role for Hydrogen Sussex in future.

As part of this study, a full literature review of the national and regional policies was completed to inform the wider analysis, this review can be found in appendix 1.

6. ROADMAP

For a region to strategically plan toward accelerating economic growth, there must be a clear pathway and direction of focus. By setting goals, a region can implement actions that aid the completion of milestones and better track progress. In turn, a regional roadmap can be compared against nationally set goals and highlight additional areas of opportunity. The strengths and opportunities of the region have informed the goals that the region could strive towards. As part of this study, ten goals are recommended for the region. The goals are realistic, ambitious, and have the potential to unlock economic growth from the hydrogen economy.

Be recognised as a region of engineering excellence

As previously mentioned, the region is already a region of strong engineering excellence. However, while the individual businesses and institutions may be recognised within the industry, their connection to the region may not be. To achieve this goal, the region should direct focus to ensuring university courses remain relevant in the progressive hydrogen market as well as interconnected disciplines such as renewable energies. The promotion of this strength through interregional collaborations (both private and public sector) would contribute to the region being recognised nationally as a region of engineering excellence. Promotion of the region by curation of seminars or events featuring local hydrogen companies and institutions could further this aim.

Be a hydrogen research and innovation hub

The region has the ambition to become a hydrogen research and innovation hub to further cement its place in the national hydrogen economy. Being a nationally recognised research and innovation hub for hydrogen would attract new players to the region and present wider opportunities for interregional collaborations that would stimulate the economy. The ultimate goal should be to have the resources to provide support to external companies where possible and hold unique expertise, such as engineering, that would encourage hydrogen companies to re-locate or set up in the region. As a whole, this would see the region have a wide portfolio of research and innovation activities, projects and organisations.

Increased hydrogen research capabilities

As previously mentioned, the region already has a strong presence of engineering excellence and building on this would create additional opportunities. The uniqueness of innovative hydrogen businesses in the region should be strategically optimised by encouraging and facilitating collaboration between the private sector and academia as much as possible. One example of this could a joint venture development of a hydrogen testing facility, to enable early supply and safe use of hydrogen, perhaps including the maritime case. These collaborations are mutually beneficial to all parties and would bring additional expertise to the region that would:

- Allow academic institutions to extend their research offering
- Generate additional funds for equipment procurement or upgrade
- Advance in-house hydrogen expertise of the region
- Create cross-sector relationships and encourage additional knowledge sharing
- Attract new players to the region, or encourage interregional collaborations, bringing additional income to the region contributing to economic growth
- Create new high skill job opportunities

In addition, the region could seek to fill a niche gap in the innovative space by creating designated test facilities for innovation, particularly for the marine sector. Test facilities, particularly those for marine technologies (not limited to hydrogen), are scarce across the UK, with many companies forced to travel to test their technologies, increasing costs and timeframes for local technology developers. The presence of such facilities would eliminate this barrier locally, attract new players to the region and generate additional income to the region, and present the region as a strong player in the national hydrogen economy context. The near-term aim should be to support the prominent marine sector in the region by creating designated marine testing facilities to develop a landscape where companies can develop, manufacture, test, and roll out their technology locally. By creating designated test facilities for innovation, the region would host a regional commodity.

Support the first regional hydrogen hub

The region is already working toward this goal due to the ongoing development of Shoreham Port, though planning is still underway for its ambitious hydrogen production plans. Achieving this goal would be a significant milestone for the region and encourage additional off-taker agreements as a result of supply security and potentially, the further growth and cost reduction of local hydrogen production. Councils and Hydrogen Sussex should do everything within their powers to support this project (respecting the boundaries of support to private enterprise), as failure of this early achievable project would be a blow to the hydrogen ambitions of the region. Support could include planning (including the required renewable generation), support identifying offtakers and councils potentially acting as anchor customers, for example for refuse collection vehicles.

Advance more hydrogen hubs

This milestone should see the development of additional hydrogen hubs across the region. The ideal location for such hubs should be determined in the near-term and take lessons learned from the establishment of the first hydrogen hub to accelerate development and maximise success. At this stage, clarity of potential off-takers and confidence in businesses with potential for hydrogen applications should be achieved to ensure off-taker security.

Become a hub for green skills

Green skills are skills that are required to support a sustainable society. These skills are diverse and non-exhaustive, ranging from research to implementation. For a region to become a green hub, it must have the required skills to attain such a reputation. By drawing on the experience of innovative businesses and the education sector, the region has the ambition to become a nationally recognised green skills hub and should aim to develop the required skill sets in the near term. For hydrogen, many of these skills will be present but require an element of upskilling or retraining for those already in an interconnected industry such as engineering. Presently a region of engineering excellence, a key focus should be toward the facilitation, utilisation, and roll out of hydrogen specific courses, upskilling opportunities and academic collaborations between academia and the private sector. In the near-term, the region should aim to be self-sustaining for internal employment of hydrogen jobs and further develop to become a region that others are attracted to for its unique employment opportunities within the hydrogen economy. Whether that be to attract high skills workers to the region for its unique opportunities or attract students from all over the UK to study at a local university, this strength will stimulate not only the local hydrogen economy but also the wider economy.

Developed hydrogen skills ladder

A symbiotic relationship within the education sector is a crucial element to ensure the skills landscape of a region is well suited to the needs of the industry. For the region, developing a strong communication base between higher education and further education institutions will ensure the alignment of course relevance. The ultimate goal will be to develop a hydrogen skills ladder that creates a clear pathway for those wishing to pursue a career in hydrogen and create a sufficient flow of skilled workers into the local industry.

The region has a particular strength in engineering excellence, however, further developing and showcasing this strength will emphasise the region as a valuable player within the national hydrogen economy and unlock additional opportunities at a local and national scale.

Have defined planning policies

Defining hydrogen specific policies will be a key aspect to unlocking the region's potential for hydrogen roll out. For this reason, the region should clearly define hydrogen-specific planning policies, including linking them to the enabling renewable generation, and ensure they are clear to stakeholders. This could include identifying areas for wind and solar to support hydrogen development in the Local Plan. These policies should be

separated from other fuels where possible, and where overlaps are present should be clearly explained to avoid confusion and consequent delays.

Capacity building for planning officers

This goal will play an essential role in accelerating the hydrogen economy in the near-term by educating planning officers in not only how to frictionlessly review and process hydrogen project applications, but also inform the staff of the wider economic benefits that hydrogen could bring to the region. These workshops should inform planning officers of best practices, ensure adequate knowledge of the technologies, and ways in which the development application can improved and made more efficient to expedite project development across the region.

Eliminate barriers in enabling infrastructure, to enable an attractive environment for investment in hydrogen production and use

The production and use of hydrogen is dependent on infrastructure owned and operated by a number of different utilities, such as the electricity grid, water and potentially gas. Hydrogen Sussex and the regional local authorities should identify likely local sites for hydrogen and work with the relevant utilities and planning authorities to identify and minimise constraints and connection costs. This will enable investors to rapidly develop hydrogen projects on these sites.

6.1 ROUTE MAP OF GOALS

Based on the preceding sections, the route map below displays each goal in its targeted timeframe and have been categorised into relevant strategic areas.

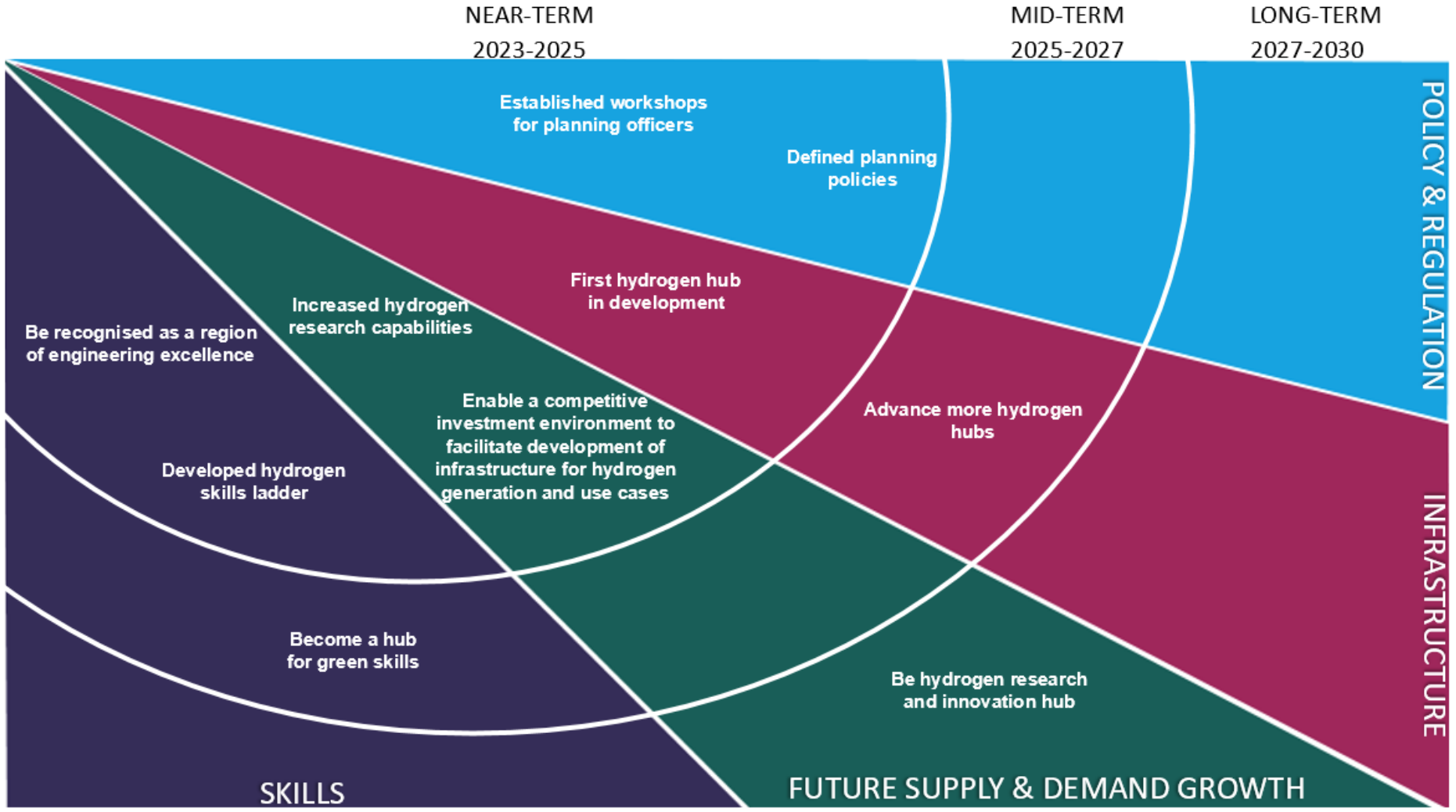

Figure 8 – Route map of goals associated with strategic themes

6.2 ACTION PLAN

In order to accelerate economic growth and aid the success of the local hydrogen economy, 42 actions have been recommended. These actions, though some more substantial than others, will each positively impact the local hydrogen industry and create a pathway for economic growth. These actions were informed by the impact chart along with additional analysis of the region itself and potential opportunities.

6.3 NEAR-TERM 2023-2025 ACTIONS

The table below displays the actions to be undertaken in the near-term. The suggested owners are as follows.

Hydrogen Sussex | Public Sector | Private Sector | Academia | Utilities | All

POLICY & REGULATION	SKILLS	INFRASTRUCTURE	FUTURE SUPPLY & DEMAND GROWTH
Review planning policies to give clear hydrogen-specific guidelines for planning applications	Facilitate industrial and commercial sector & academic sector collaboration	Feasibility study to identify the most crucial infrastructure required for initial scale up	Assessment of the individual business case for local manufacturing of hydrogen technology
Understand and prepare for potential public opposition to and concerns about hydrogen developments	Promote and develop the research and innovation capabilities of the region to increase collaboration capacity and create more jobs	Undertake study to identify where enabling infrastructure is required, for Hydrogen generation, distribution, storage, and enabling. For example, brownfield / industrial zone land, land close to electrical infrastructure, port access, grid capacity	Map potential local off-takers
Upskill public authority employees to recognise the wider hydrogen opportunity to cut carbon emissions as part of energy transition	Create a support knowledge sharing environment	Initial investment in supply to build capacities and deploy planned hydrogen projects	Explore opportunities for inter-regional off-taker agreements, including near hydrogen clusters, ports, export options, supply chain
Provide public information and consultation sessions on hydrogen safety to alleviate protest around planning applications for hydrogen projects	Secure technical support to regional SMEs to gain funding to extend their hydrogen services/utilisation, creating more jobs and upskilling opportunities	Dialogue between HS and LAs to alleviate conflict between planning and infrastructure requirements	Identify opportunities for local authorities to stimulate the local hydrogen economy by becoming an anchor demand
Encourage and support the creation of incentives to alleviate the socio-economic impact of the energy transition	Support the development of engineering-specific upskilling opportunities, programmes and internships to encourage uptake and attract more skilled workers to the area	Host educational sessions to inform stakeholders of infrastructure requirements for hydrogen uptake in business plans	Investigate potential for import of hydrogen or derivatives to Sussex region, particularly via seaports and from neighbouring areas such as Kent, Portsmouth etc, to increase availability of H2 in medium term.
Local authorities to lobby national governments to encourage the required policy introduction and amendments for hydrogen economy growth transition, especially on vulnerable and disenfranchised citizens	Host educational sessions to inform local businesses of assets that can be converted to hydrogen using existing infrastructure and supply chain opportunities	Knowledge sharing of best practices	Communications - Publish case studies + news items on successful projects to raise awareness locally and nationally of action in Sussex
Map potential test sites, with particular focus on marine testing facilities	Identify and map the skills gaps of the region*	Ongoing engagement with water utilities to address demand for water for hydrogen production, including costs and alternative solutions such as desalination, non-potable water, etc*	Develop strong links between H2 development and industrial decarbonisation, especially high-emitting manufacturing sites, to identify and progress decarbonisation opportunities, including low-carbon H2

Information sharing regarding amendments to hydrogen regulation*	Regular forecasting of future skills demand and review educational opportunities accordingly* Encourage open and continuous communication between FE and HE institutions to ensure alignment of hydrogen related courses, addressing regional skills gaps* Assist universities in attracting research funding, especially in partnership with industry. For example: Setting up H2 innovation challenges and research groups across local research institutions; mission-oriented partnerships for developing specific local capabilities; H2 innovation asset catalogues and showcases; establishing interdisciplinary and international research projects and partnerships*	Ongoing engagement with gas suppliers and infrastructure owners on potential for blending, storage, and future investment needs* Ongoing engagement with electricity suppliers to address electricity supply constraints (including renewable electricity), costs, and investment forecasts. Evidence areas where additional electrical capacity is needed to facilitate hydrogen projects*	Secure low-cost support with funding applications to enhance competitiveness* Support with funding insights, including niche funding opportunities for innovation, research and place-based* Facilitate open communication between producers, suppliers, and potential demand* Incorporation of hydrogen into commercial and industrial business ESG strategies* Forecast near-term production volumes to assess the suitability to individual demand requirements* Knowledge sharing of best practices, business models, innovative equipment, etc* Commission a study into the costs associated with the key actions in this plan

Table 4 - Recommended short-term actions

6.4 LONG-TERM ACTIONS

The table below displays the actions to be undertaken in the long-term. The suggested owners are as follows:

Hydrogen Sussex Public Sector Private Sector Academia Utilities All

POLICY & REGULATION	SKILLS	INFRASTRUCTURE	FUTURE SUPPLY & DEMAND GROWTH
Information sharing regarding amendments to hydrogen regulation* Implement designated research sites for shared use for those in the region and further afield to attract new players to the region	Identify and map the skills gaps of the region* Regular forecasting of future skills demand and review educational opportunities accordingly*	Ongoing engagement with electricity suppliers to address electricity supply constraints (including renewable electricity), costs, and investment forecasts. Evidence areas where additional electrical capacity is needed to facilitate hydrogen projects*	Secure low-cost support with funding applications to enhance competitiveness* Support with funding insights, including niche funding opportunities for innovation, research and place-based* Knowledge sharing of best practices, business models, innovative equipment, etc*

	Assist universities in attracting research funding, especially in partnership with industry. For example: Setting up H2 innovation challenges and research groups across local research institutions; mission-oriented partnerships for developing specific local capabilities; H2 innovation asset catalogues and showcases; establishing interdisciplinary and international research projects and partnerships* Encourage open and continuous communication between FE and HE institutions to ensure alignment of hydrogen related courses, addressing regional skills gaps*	Ongoing engagement with gas suppliers and infrastructure owners on potential for blending, storage, and future investment needs* Ongoing engagement with water utilities to address demand for water for hydrogen production, including costs and alternative solutions such as desalination, non-potable water, etc*	Facilitate open communication between producers, suppliers, and potential demand* Incorporation of hydrogen into commercial and industrial business ESG strategies* Forecast near-term production volumes to assess the suitability to individual demand requirements* Continue to progress hydrogen innovation and related engineering and research capabilities to demonstrate the region as a national player Create resources and support schemes to turn research and novel ideas into commercial projects

*Actions that span across near-term and longer-term

Table 5 – Recommended long-term actions

7. SUPPORTING STRUCTURES & NETWORKS

7.1 HYDROGEN SUSSEX'S POTENTIAL ROLE

Hydrogen Sussex's role as defined by GBEB is to support the development of a low carbon hydrogen economy across Sussex. Conversations with stakeholders have formed suggestions on Hydrogen Sussex' activity that would forward that objective. The activity follows four distinct themes: Informing, convening, technical support, and monitoring.

Informing

Hydrogen supply stakeholders have revealed that finding committed off takers is one of their most significant challenges. Furthermore, the Hydrogen Council's "Hydrogen Insights 2022" report states that policy makers need to enable demand visibility to forward implementation projects (Hydrogen Council, 2022).

Hydrogen Sussex is uniquely placed with the right contacts and knowledge to inform regional demand visibility. Supply stakeholders informed Ricardo that keeping track of UK activity through their own mapping has been a part of their prospecting process. By Hydrogen Sussex taking ownership of that process, they will be providing value to suppliers, reducing their burden and giving them confidence in the information they have in the region.

Demand visibility is not the only way to add value through signposting. Other valuable points of interest to signpost could include:

- Relevant research activity;
- Large scale renewable energy plants;
- Energy distribution infrastructure;

- Sustainable water sources; and
- Hydrogen-related service providers.

University of Sussex have expressed that they can support this activity through their internal expertise for complex mapping.

Education

Hydrogen is an emerging sector in energy decarbonisation. Hydrogen Sussex can help to educate others and build capacity amongst policymakers and potential demand users. Well-informed people can be empowered to make decisions with confidence. The education could aim to:

- Share the basics around hydrogen and how it differs to fossil fuels
- Share where it is best placed as a solution and promote other green energy alternatives
- Break misconceptions around hydrogen safety but be clear about the risks
- Share experience on lessons learnt from member experiences

Activity sharing

Stakeholders have seemingly low visibility of hydrogen activities in the region. Sharing hydrogen activity by inviting guest speakers to talk about their experiences and capability could help develop business partnerships or a collaborative take on solutions to problems.

Not everyone will be able to attend Hydrogen Sussex meetings and so a quarterly (or more regular) newsletter would allow people to stay up to date and track activity.

Fund tracking

Some stakeholders reported that they find the UK government funding landscape difficult to keep track of. Flagging funds before and when they are open will give stakeholders sight of the opportunity and time to prepare. For more broad reaching funds, the flagging should also be clear about how the fund could used to benefit a local hydrogen economy.

Convening & Lobbying

Hydrogen Sussex can help to create a stakeholder network conducive to business collaboration or advancing local projects from development to implementation. Hydrogen Sussex could be a touch point into the region for new entrants to the local hydrogen market who might be seeking to establish new contacts who they can do business with. Examples of ways Hydrogen Sussex could add value through ad-hoc convening:

- Introducing prospective supply and demand stakeholders to one another to establish supply agreements
- Guiding demand stakeholders to infrastructure and equipment providers that can enable their transition. Hydrogen Sussex could prioritise introducing stakeholders to local providers that contribute to the economic growth of the region before recommending providers further afield.
    - Introducing engineering technology companies who may be seeking to collaborate

Hydrogen Sussex can influence government for the benefit of stakeholders in need of support. Hydrogen Sussex could act as an agent for the local hydrogen economy bringing attention to the success and opportunities and lobbying to remove barriers at the national level to enable further growth.

Technical Support

Hydrogen suppliers are seeking to aggregate customers that will allow them to meet their minimum commercial viability threshold. Potential customers are unsure of their path to decarbonisation, and this is making it difficult for suppliers to find customers that are committed. Developing business cases for potential end users would inform them of their options, provide confidence in their solution and potentially commit them to become a future hydrogen demand.

There will be a cost associated with developing a flexible model that can calculate a robust business case. The model could be reused with updated data at the time of applications so there is just one larger upfront cost and smaller costs thereafter.

University of Sussex expressed interest in being able to support the development of business cases.

HS could provide technical support to demand users prospecting hydrogen as a decarbonisation option. This would be particularly relevant to supporting users without an energy background. An example could be supporting a potential hydrogen user through a funding application or conducting a market assessment of hydrogen technologies.

Monitoring

The UK government will be setting a framework to monitor and evaluate the development of the hydrogen economy in line with its targets. Hydrogen Sussex could copy the same framework where feasible. This would allow Hydrogen Sussex to report their success in a familiar manner to the government which may aid in lobbying efforts. Metrics to be tracked could include:

Theme	Example metrics
Overall benefits	• Deployment of hydrogen in capacity • GVA added to local economy • CO_2 reductions from hydrogen • Public awareness statistics
Supply chains	• Number and turnover of companies active • Number and turnover of companies engaged by initiatives
Jobs & skills	• Number of different types of jobs in sector • Number of people trained in sector • Funding provided for skills development
Exports & investment	• Exports value • % of companies exporting • Inward investment figures
Research & Innovation	• Funding won for research & innovation • Patents secured

Table 6 – Example key performance indicators that could track regional progress

7.2 FUNDING MODELS

Hydrogen Sussex aims to be a self-sustaining organisation focussed on supporting the growth of hydrogen in the region by various means. This is not expected to include owning or operating any facilities, but as shown below, there are some public and commercial approaches to achieving that remit.

We have conducted analysis of the business models of other successful organisations to assess which Hydrogen Sussex could replicate. Four models were identified. Interestingly most organisations were driven by the private sector. Organisations that started from public sector funding remain on it which presents a risk to their longevity. A private sector approach bears risks of not accruing enough revenue to remain self-sustaining and may require aligning objectives with customers rather than the greater good of the region.

We reviewed several organisations and their business models including the Carbon Trust, the Energy Savings Trust, Hydrogen UK, Solent Cluster, UK Hydrogen Fuel Cell Association, Hydrogen East and Thames Estuary.

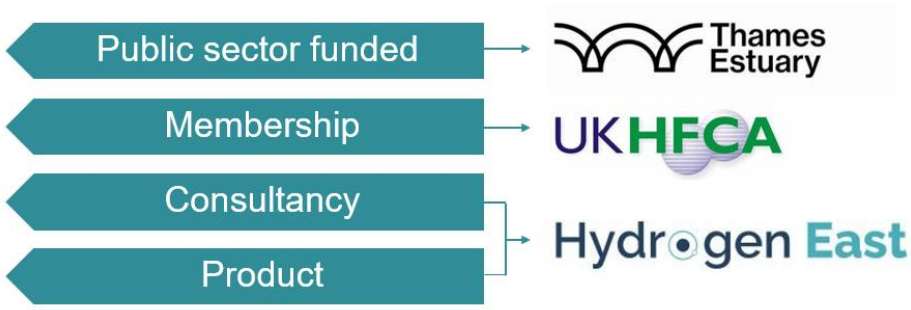

Figure 9: Example organisations in the hydrogen sector and their funding models

Public funding

Thames Estuary are an organisation who received central government funding as a result of the positive action they are having in their region. Their funding is for a certain number of years and therefore is not self-sustaining. However, it is a low initial risk funding model that organisations like Thames Estuary have shown is achievable. They are expected to support a wide variety of hydrogen economy interactions within the region. The main purpose of the funding is to provide an informing and convening role in the region to develop conducive partnerships

Membership

The UK Hydrogen Fuel Cell Association is an example of an organisation that are funded by their members' subscriptions. Under this model the organisation is expected to find a way to consistently maintain a programme of value to all its users who will have diverse needs. The price point needs to be correct to attract members whilst maintaining income.

Consultancy

Hydrogen East are an example of a hydrogen entity who utilise the consultancy private funding model. They contract public sector and private sector concept and feasibility work to operate as a profit-making business. Their expertise is in their regional insight that is important for new entrants into the area.

Carbon Trust and the Energy Savings Trust are also consultancy models, but the former is a not-for-profit specialising in public sector carbon savings. Being a not-for-profit allows them to charge lower prices than for-profit competitors. The latter is a "profit for purpose" organisation which grows to serve its mission in addressing the climate emergency.

Product

Hydrogen East have an online GIS mapping product that contains over 100 layers of data showing information such as: where energy infrastructure exists; where energy consumption centres are; where the largest carbon emitters exist and where environmental factors could present project risks. Hydrogen East have understood the importance of the geographical factor behind hydrogen and the opportunity for their region to become a hydrogen exporter. They have crafted a solution that makes it easy for new entrants to quickly discover suitable locations for projects.

Analysis

The suitability of the funding models have been assessed against the recommended role of Hydrogen Sussex in the table below.

Services	Consultancy	Membership	Product	Public funding
Signposting		X	X	
Education	X	X		X
Activity sharing		X		X
Fund tracking		X		X
Convening		X		X
Business cases	X		X	
Technical support	X			

Table 7 – Services provided to the industry by supporting players against income models

All potential services do not fit under any one business model due to their level of effort or breadth of beneficiary. The public sector funding model has significant benefits in removing start-up risks and provides time for the organisation to grow into its role and demonstrate its value. This could be useful for a base income before a transition into the membership model once a user-base is established.

A membership model would be able to fund a lasting role for Hydrogen Sussex. Unlike public funding, Hydrogen Sussex would be expected to publicly demonstrate its value to its members on an ongoing basis whether this is through communicating to them through activity sharing, fund tracking or updated signposting.

Considering their overlap in services, a split between the two income methods may be appropriate. Part fulfilling with incomes needs with membership fees may assist in evidencing to central government the value Hydrogen Sussex is providing to its members.

There may be value in developing products around signposting or calculating replicable business cases that users pay a one-off charge or a subscription fee for access. However, the need must be sufficient enough to warrant the capital investment into the product and ensure it is recovered.

Ad-hoc support for business cases and technical support are unlikely to facilitate the needs of all members, therefore, they should be provided under bilateral consultancy terms.

8. CONCLUSIONS

The region has already broken ground in the hydrogen industry. The plans for a multi-MW electrolysis plant at Shoreham Port could act as a catalyst for growth in hydrogen across the region. Home to several hydrogen technology companies, the region has a strong capacity for innovation, that if supported, could be developed to expand its engineering excellence and allow the region to stand out within the UK hydrogen landscape. As an environmentally conscious area, it was found that local public authorities share the ambition to become a key hydrogen player and are actively participating in activities that will aid this ambition. In the near-term, this focus will be crucial to ensure the region does not miss its opportunity.

The cross-sector collaboration required to successfully complete various actions listed with the action plan will be key to the region's success. There are already strong existing relationships between sectors, evidenced by the extensive membership portfolio of Hydrogen Sussex, in turn showcasing the regions ambition to accelerate the local hydrogen economy.

In the early years, prioritising actions that contribute to alleviating the three main barriers experienced by stakeholders will ensure that resources are utilised in the most impactful way. These barriers are infrastructure, policy and regulation at local level, and demand visibility. Focus should be placed on building the region's current strengths, continuing to develop its engineering excellence, being proactive and ambitious in the innovation space, and ensuring that the current academic excellence evolves with the hydrogen economy.

By tracking progress against the route map of goals, the region will ensure it stays on track to reach each milestone. Ricardo recommends this route map be regularly revised to reflect progress and future ambitions that arise from success.

In summary, with the correct focus and collaboration, the region has real potential to stand out within the UK hydrogen landscape and gain economic benefits from hydrogen.

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10. APPENDICES

Appendix 1 National funding analysis

1.1 Net Zero Hydrogen Fund

The Net Zero Innovation Portfolio (NZIP) includes the £240m Net Zero Hydrogen Fund (NZHF) which was designed to provide grant funding and a hydrogen business model (HBM) to encourage private sector investment out to 2025. The HBM includes a revenue support mechanism with a twin track approach to provide individual attention to the needs of green hydrogen against blue hydrogen. There are four funding strands

- Strand 1: DEVEX support for FEED studies to grow the pipeline of hydrogen projects with up to 50% co-funding support. Access to this support closed on 23rd of June 2022.
- Strand 2: to provide up to 30% CAPEX co-funding support for projects that do not require revenue support. These are more likely to be smaller electrolytic projects that interact with the Renewable Transport Fuel Obligation. Access to this support closed on 13th of June 2022.
- Strand 3: for HBM projects electrolytic allocation windows. These projects can access up to 20% CAPEX support and the revenue support mechanism. Access to this support is available at the time of writing:
    - The first window recently closed on the 12th of October 2022. It aims to support at least 250MW of production capacity. The first contracts are expected to be in place early 2023
    - The second window will open in 2023 and aims to support further production capacity to stimulate a total of 1GW of electrolytic hydrogen in construction or operation by the end of 2025.
- Strand 4: for HBM projects that are CCUS enabled and are part of the phase 2 cluster sequencing process. These projects can access CAPEX support and the revenue support mechanism. Access windows for this support have yet to be announced but are not expected to be relevant to the region.

Projects taking advantage of the HBM need to meet the Low Carbon Hydrogen Standard to be eligible. Adhering to the standard requires producing hydrogen below a threshold of 20 $gCO2e/MJ_{lhv}$.

Other completed supply funds (which could indicate potential future funds) included:

- The £33m low-carbon hydrogen supply competition which funded 5 projects providing low carbon bulk hydrogen supply solutions.
- The £60m low-carbon hydrogen supply 2 competition which funding to 28 projects. £6m went towards 23 projects to conduct feasibility studies on innovative hydrogen supply solutions. 5 projects went on to receive £38m of funding to support physical demonstration of the solutions.

1.2 Renewable Transport Fuel Obligation

The Department for Transport (DfT) have their own subsidy scheme called the Renewable Transport Fuel Obligation (RTFO). The RTFO requires any suppliers of 450,000 litres or above to provide a volume of sustainable renewable fuel, calculated as a proportion of the total fuel they supply. The RTFO was initially designed to incentivise the uptake of biofuels but has since evolved to incorporate new fuels such as renewable hydrogen. The RTFO covers fuel supplied for use in:

- Road vehicles
- Non-road vehicles, including inland waterway vessels that do not operate at sea
- Tractors
- Recreational craft that do not operate at sea

Suppliers can meet their obligation under the RTFO in two ways; by paying an annual fixed sum for each litre of fuel they wish to 'buy out', or through selling qualifying fuel that RTFCs. RTFCs are certificates that can be exchanged, traded and sold. Any company that supplies development fuel is eligible to claim RTFCs and sell them on the open market to companies who need them to meet their obligation.

Under the policy, hydrogen is classified as a 'development fuel'. As a development fuel, hydrogen is rewarded with RTFCs equivalent to double its relevant multiplier (4.58), meaning for each kilogram of hydrogen, at the current RTFC value, the supplier would be awarded 9.16 RTFCs. Suppliers may trade RTFCs on the open market, the value of these RTFCs fluctuates. Between 2020 and 2021 development fuel RTFCs were traded

between 70-73 pence per certificate, comparative to a buyout value of 80 pence. These certificates act as an incentive for businesses to produce clean fuels and act as a subsidy for production costs.

This represents an ongoing opportunity for hydrogen for transport suppliers that can be utilised at any time. However, the RTFC price may fluctuate and decrease in the longer term as more renewable fuels are brought to market.

1.3 Industry

The government is focussing on decarbonisation of industrial clusters in the UK that together have the largest amount of greenhouse gas emissions. The government believes that these should be the test beds for industrial decarbonisation with hydrogen. All other locations are considered "dispersed" industrial sites, which includes industry based in Sussex. The government's plan shows that widespread fuel switching across dispersed sites is not expected to begin until 2029. Near term access to hydrogen for dispersed sites is expected to come from dedicated pipelines connected to large scale hydrogen production hubs or from local electrolytic production, either on-site or transported by road from relatively local production. The government has been providing funding to support with this transition:

- £315m Industrial Energy Transformation Fund was supporting the uptake of energy efficiency and low-carbon technologies, including hydrogen technologies. Support was provided for feasibility, engineering studies and the capital support for first movers upgrading their equipment. Phase 1 was in 2020 and allocated £70m in funding. Opportunities to apply for the remaining funding in phase 2 which closed in April 2022.
- As part of the 2017 Clean Growth Strategy, a £20m Industrial Fuel Switching Competition was launched. It was a 3-phase competition, initially beginning with research and then competitions for demonstrator projects. The funding aimed to stimulate early investment in fuel switching processes and technologies.
- As part of the NZIP, a new £55m Industrial Fuel Switching 2 Competition was launched, aiming to support the development of fuel switching and fuel switch enabling technologies for UK industry.
- The £26m NZIP Industrial Hydrogen Accelerator Programme aimed to identify, support and then develop credible integrated hydrogen production and fuel switching systems to bring about a step change in understanding and the rate of future deployment to support the achievement of Net Zero by 2050.
- The £10m Green Distilleries Fund provides funding to distilleries across a range of solutions including hydrogen.
- The £40m Red Diesel Replacement Competition provided funding to the development and demonstration of innovative technologies in the Non-Road Mobile Machinery sector used for quarrying, mining and construction.

Throughout the early 2020s, the government will also be supporting the engineering and technical design elements of decarbonisation projects across the UK's industrial clusters through UKRI's Industrial Decarbonisation Challenge.

1.4 Heating

Domestic heating

The government recognises that heat electrification is the most efficient decarbonisation solution and aims to encourage the installation 600k heat pumps per year by 2028. However, they have left open the option of whether or not to pursue hydrogen for heating and plan to make a major decision on their approach to it by 2026. In the meantime, they are generating further evidence on the costs, benefits, safety, feasibility, air quality impacts and consumer experience of using low carbon hydrogen for heating relative to more established heating decarbonisation technologies. The following are key milestones leading to the decision:

- Conduct a hydrogen for heating neighbourhood trial by 2023. The development of this activity is already underway in Levenmouth in Fife and aims to provide hydrogen to 300 homes for heating and cooking.
- Conduct a hydrogen for heating village scale trial by 2025.

- By 2025, develop plans for a possible hydrogen heated town that would be implemented by the end of the decade.
- By 2026, make a major strategic decision on the role hydrogen has to play on decarbonising heat in buildings in the UK.

Blending

In parallel to the above the government is assessing the use case of blending up to 20% volume of hydrogen into the existing gas network by late 2022 and aim to make a final policy decision by late 2023. Blending 20% hydrogen only decarbonises the gas network by 7% due to the low energy density of hydrogen compared to natural gas. However, the key strategic benefit could be the facilitation of an early use case for hydrogen providing a "offtaker of last resort" to suppliers that would reduce the project risk and help get projects to a final investment decision. Blending projects HyDeploy and FutureGrid are providing safety demonstrations on blending and are expected to conclude in 2023. A comprehensive value for money assessment is required to assess the costs and benefits.

1.5 Road transport

Since 2017 the government has been supporting hydrogen use in transport with a £23m Hydrogen for Transport programme. This project led to the design and development of refuelling sites in the UK, one of which was based on Crawley, however the site was not developed further.

Bus

On the 15th of March 2021, the Department for Transport released the national bus strategy for England which discussed the Zero Emission Bus Regional Areas (ZEBRA) scheme. Since then, it has provided funding of £198 million this year and £70 million last year to enable the acquisition of 1,278 new zero-emission buses. The fund is committed to delivering 4,000 new zero emission buses so future rounds are expected.

Road freight

In 2021-22, UK government has invested about £20 million for trials for electric road system and hydrogen fuel cell based heavy goods vehicle.

1.6 Shipping

The NZIP included a £20m Clean Maritime Demonstration Competition to develop maritime technology. The fund ended up allocating £23m to 55 feasibility studies and technology trials. This was followed by a short-notice second round that awarded a further £15m to 31 projects. The third and final round allocates £60m of funding for technology and system demonstrations.

1.7 Non-road mobile machinery

The red diesel replacement programme funded under NZIP aims to increase the technology readiness level of alternatives to red diesel for the off road, mining and construction industries. Many of the projects underway include hydrogen supply and use.

1.8 Aviation

The government has established various funding mechanisms with the aim to decarbonize the aviation sector and deliver zero emission flights. They released their Jet Zero Strategy in 2022 to deliver net zero aviation by 2050. In it they pledge £685m over three years for UK aerospace research and development through the Aerospace Technology Institute programme.

In 2021 the government launch a Green Fuels Green Skies competition providing £15m to support the development of the emerging Sustainable Aviation Fuels (SAF) sector. In the Jet Zero Strategy they offered a further £180m of new funding over three years until 2025. Lastly, £1m is going to support the delivery of the first net zero transatlantic flight.

1.9 Energy Storage

The NZIP funded, £68m Longer Duration Energy Storage Demonstration Competition (LODES) was designed to find ways to store low carbon power generation for longer periods of time to help in managing the natural variation in output of renewable energy. The funding excludes widely deployed technologies including lithium-ion batteries and water storage. The fund was in two streams. The first was for actual demonstration in operational environments. The second was for prototype demonstration to develop first-of-a-kind energy storage prototypes. Both streams have awarded their funding to successful applicants.

Appendix 2 National policy

The government has been developing policy and funds at a national level to support the hydrogen economy. The UK hydrogen strategy, published in August 2021. Describes the ambition for the country and the actions taken to support it. It interlinks and adds upon other national strategies to focus on hydrogen as an energy vector for a wide variety of sectors. The most significant support has been funding targeted at supporting industrial decarbonisation and growing the hydrogen supply market.

The largest funding package was announced in the Prime Minister's 10 point plan for a green industrial revolution in November 2020. It provides ongoing revenue support for hydrogen producers to bring down the cost of hydrogen to make it competitive with oil fuels and thereby more accessible for users. The second most significant funding measures are to help industry to decarbonise through new technologies with hydrogen being a leading solution. Other funding is based around innovation competitions that give one-off opportunities to further decarbonisation amongst end users. These are often open to a mix of solutions.

The £1 billion Net Zero Innovation Portfolio (NZIP) which was announced in late 2020 in the Prime Minister's 10-point plan for a green industrial revolution. The funding allocation aims to accelerate the commercialisation of low-carbon technologies, systems and business models in power, buildings, and industry. One of the priority areas was Driving the Growth of Low Carbon Hydrogen by targeting 5GW of production capacity by 2030 (updated to 10GW in the energy security strategy).

Alongside supply, the NZIP references exploring hydrogen solutions in energy storage, transport and heat. It is also interlinked with investments in Carbon Capture, Usage and Storage which would enable blue hydrogen production.

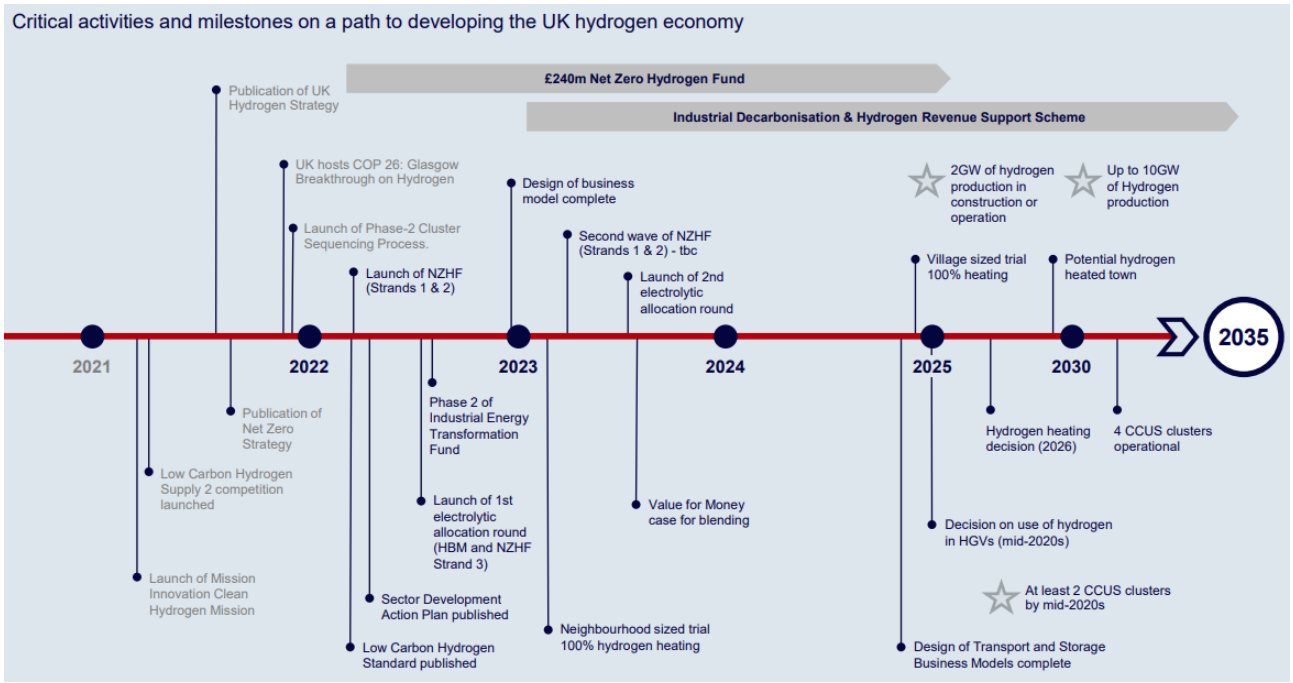

Figure 10: Critical activities and milestones in the UK's roadmap for a hydrogen economy (UK Department for International Trade, 2022)

Appendix 3 Regional policy

2.1 Energy South2East

In 2017 BEIS funded all Local Enterprise Partnerships to develop local energy strategies (LES). Coast to Capital, Enterprise M3 and Southeast worked together to set a vision for energy provision across the regions. They produced their strategy in 2019 that gave 18 project models across five priority themes: low carbon heating; energy savings and efficiency; renewable generation; smart energy system; and transport revolution. We identify that hydrogen can interrelate with 7 of the 18 project models described by the LES:

- District heat networks
- Hydrogen injection into the natural gas grid
- New-build homes on hydrogen grid
- Offshore wind development
- Solar on landfill sites
- EV charging and hydrogen refuelling infrastructure
- Ports – modernisation of energy infrastructure

The study identified the following key opportunities and challenges associated with the assessed regions.

Opportunities	Challenges
Significant renewable potential	Electrical grid constraint prevents growth and development
Rich in natural assets	Waste heat not utilised efficiently
Large amount of development taking place	20% of homes are not connected to the gas grid
Key sectors are already engaging	There are real concerns around air quality and emissions

A disadvantage to the South2East study is its breadth. The study reviews a wider region than GBEB, including as far as Hampshire the west and Essex to the east. The GBEB energy plan builds upon the themes and findings from the South2East study to provide an updated plan more relevant to the region.

2.2 Greater Brighton Economic Board (GBEB)

In October 2020, GBEB declared 10 pledges in tackling climate change. A hydrogen economy could potentially contribute to four of the pledges:

- Zero emission fleets – where battery electric vehicles are insufficient, fuel cell electric vehicles are slated as the alternative solution.
- Innovation – hydrogen is a very nascent technology, therefore developing a hydrogen economy will provide opportunities for knowledge sharing and technology innovation
- Low carbon heating – hydrogen is needed for high-temperature heat processes and can be used as a reserve fuel source for hybrid heating systems
- Water recycling – electrolysis requires very pure water that must be purified beforehand. Water can be purified from wastewater sources with the appropriate purification technology.

To deliver on the pledges GBEB are developing a Green Blue[4] investment plan and a Climate Action Plan. A hydrogen strategy would form part of that plan by providing a direction for investment into stimulating a hydrogen economy.

[4] Energy and water

Greater Brighton Energy Plan

In 2020 GBEB commissioned BuroHappold Engineering to provide a regional Energy plan. The plan was funded by the European Union organisation Interreg Solarise. The energy plan provides a list of key energy projects.

- include an Energy Investment Company to attract grant funding and external investment, and to reinvest profits from projects, with the aim of realising pipeline energy projects, expanding the successful partnerships with community energy companies which are such a notable feature of our City Region. This could potentially be led by the Greater Brighton infrastructure panel. The EIC could run the Power pool
- Brighton Energy Coop and OVESCo are looking into solar farms in region (including landfill sites)
- Ground source heat pump (community heating) with BHCC
- Net Zero Firle Village Microgrid in rural community BHESCo + Firle village heat network (Investment plan underway 2020[5])
- Food waste gas to grid (or gas to hydrogen with CCS research) BHESCo
- Newhaven has a cluster of opportunities around landfill site, waste to energy plant, enterprise zone (H2 could be produced with new solar developments to service the rampion service vessels, bus depot, pilot ignite WTE plant and for hydrogen training hub).
- Newhaven Port, Shoreham Port
- Shoreham heat network, Adur district council
- Landfill solar sites including Beddingham and Lidsey

The 2021 Greater Brighton Annual report[6] suggests the following actions:

- Position Greater Brighton as a region that champions and leads on sustainable growth
- Support the University of Brighton's leading role in the national Clean Growth UK Programme
- Create a Greater Brighton hydrogen hub to accelerate private sector production of green hydrogen
- Support C2C's efforts with partners in the public and private sector to create a world-class innovation centre within Crawley

2.3 Coast to Capital Local Enterprise Partnership

Coast to Capital is an LEP working to enable the region to build back stronger, smarter and greener following the COVID-19 pandemic. To achieve this, the group has three set goals:

- Support Crawley with a plan to grow and evolve by developing new housing, commercial space and enhancement of skills and innovation to match the ambition of Global Britain and of a model for sustainable living.
- Build upon the pre-existing knowledge and innovation community of Brighton to expedite investment in knowledge. This is to include supporting the development of an internationally significant hub for Quantum Technologies alongside digital and clean growth sectors.
- To draw on the regions talented workforce and local business specialisms to lead green recovery and work toward UK net zero targets with a twin-track approach by decarbonising the energy supply chain whilst securing and coordinating investment in natural capital as a way to offset emissions.

In addition, a set of investment 'asks' have been identified in the way of transformational projects to accelerate economic growth, which includes the creation of a Greater Brighton hydrogen hub. This 'ask' comes from the groups particular focus to utilise hydrogen as an alternative transport fuel source, with hopes a hydrogen hub will accelerate public and private investment in hydrogen.

[5] https://democracy.brighton-hove.gov.uk/documents/s155840/Greater%20Brighton%20Energy%20Plan%20Projects.pdf
[6] https://greaterbrighton.com/wp-content/uploads/2022/07/Greater-Brighton-Economic-Board-2020-21-Annual-Report-PDF.pdf

2.4 East Sussex County Council

East Sussex County Council declared a climate emergency in 2019 and subsequently committed to become carbon neutral from its own activities by 2050 at the latest. Within the Climate Emergency Plan document, hydrogen is recognised as a method to reduce emissions from buildings when switching from gas.

East Sussex County Council Recovery Plan 2022

The East Sussex Recovery Plan, created in 2021, presents six 'Missions' that include a number of actions that will drive the county council toward its set goals. The main aim of this document is to set actions aimed to allow the area to 'bounce back' from any setbacks resulting from the COVID-19 pandemic but touches on elements that could also aid acceleration of the hydrogen sector, such as:

- Re-focus Talent Accelerator to support young people into work post-Covid-19. Talent Accelerator is a new framework through which education settings and creative/cultural industry employers can co-design new learning and real-world skills programmes.
- Develop bus infrastructure proposals to also help increase public transport usage.
- Develop a programme to work with low carbon businesses and the energy sectors to support the development/delivery of clean energy technologies and the decarbonisation of the economy, linking with the current LoCase initiative.
- Improve local and international connectivity to support Newhaven Clean Green and Maritime Growth Corridor

2.5 West Sussex County Council

West Sussex County Council (WSCC) has several plans and strategies which may support growth in the hydrogen economy:

WSCC Economic Reset Plan

Two of the 10 'headline actions' in the COVID recovery-focussed plan have direct relation to hydrogen:

- Continued engagement with Gatwick airport (action 8) on climate change through solar, renewable heat and hydrogen economy activities.
- To progress strategic partnerships and potential projects (action 10), this action pairs with projects that would support the economy reset, including projects in line with the Coast to Capital Strategy. This highlights the creation of a Greater Brighton hydrogen hub as a transformational project, potentially linking West Sussex County council plans to the LEP's.

WSCC Climate Plan

The Climate Plan states that £25 million will be set aside for new schemes that support economic developments and £21.2 million set aside for new schemes that come forward as capital improvements. This funding could potentially support hydrogen developments.

WSCC Economy Plan

The Economy Reset Plan 2020-2023 was adopted by West Sussex council in 2020. Some of the 'headline actions' adopted since its creation could link to the development of the regional hydrogen economy:

- Capitalise on Government funding awarded to WSCC for heat decarbonisation studies, considering the best options for the heat decarbonisation of the 50 buildings with highest heat use in the corporate estate. Use the studies as an evidence base for attracting additional funding for project delivery.
- Progress economy activities in support of the Climate Change Strategy, initially focussing on `green skills and jobs` as part of the employment and skills theme, growing the low carbon and environmental goods and services sector through LoCASE, and progressing the SME low carbon programme

WSCC 2030 Energy Strategy

The West Sussex 2030 Energy Strategy follows on direction set by the Climate Change Strategy (2020). Actions which present opportunities for hydrogen include:

- We will develop, and support our partners to develop, more sustainable energy generation and (heat) networks in West Sussex which will contribute to the decarbonisation of energy (heat and power) in the county.

- We will use mature technologies such as solar, battery, wind and heat pumps as well as new and emerging technologies over the course of the strategy.
- Opportunities for decarbonisation in sectors over which the county council has greatest influence (e.g. transport) will be prioritised. This may include supply, facilitation of project development or other contributions towards progress in this important area.

The strategy states the actions they intend to complete to ensure delivery, which includes hydrogen-related skills:

- The council will develop partnerships with local training providers to support the development of green energy skills provision
- The council will use its investment activity and existing assets to leverage learning opportunities for green energy skills.

Appendix 4 Hydrogen economy actors

3.1 National government

National government plays a pivotal role in the development of the UK hydrogen industry. Considered a nascent industry, hydrogen has and will continue to require the introduction and adaptation of regulations and incentives. With limited specific regulation, elements of low-carbon hydrogen fall within other regulations, leaving uncertainty for producers, manufacturers, and developers. This is particularly pertinent when considering the different methods of hydrogen production where relevant policies and regulation differ. National government can enable the hydrogen economy through the creation of dedicated policy and regulation across the entire value chain, including health and safety, qualification and certification standards, and infrastructure. In addition, the release of roadmaps and strategies at national government level can steer the wider industry by highlighting gaps through analysis as well as outline government plans over a particular period. These documents act as a guide and allow industry to align in closing gaps, encourage investment, and increase confidence.

Government funding has and will continue to be a major driver for success in this space. The introduction of dedicated funding, namely the Net Zero Hydrogen Fund (NZHF), Hydrogen Business Model (HBM) and the Industrial Energy Transformation Fund (IETF), has aided a significant number of hydrogen projects to commence.

National government will also play a major role in shaping the skills profile through strategies and training/qualification requirements that will affect each region of the UK. The roll out of nationally recognised accreditations and standards will accelerate dedicated courses for new workers and those requiring upskilling to work with hydrogen, helping close those skills gaps in the region today.

3.2 Local government

Local government can contribute to shaping a local hydrogen economy in several ways, dependent on the knowledge of the organisation itself, its size, financial ability, and its overall influence in its region. One of the main ways that local governments can contribute is by providing support. Support provided at local government level can be in several forms:

- The development of local hydrogen strategies to encourage alignment of the private and public sector in common goals across the supply chain
- The development of local energy communities exploring various energies including hydrogen
- Exploration of the possibility to become a baseload demand for producers
- Incorporation of hydrogen into council owned residential and/or commercial developments
- The development of local renewable energy plans and sites
- Aiding those applying for planning permission e.g., a new hydrogen plant
- Conversion of council owned fleets to hydrogen to act as anchor customer
- Collaboration with other local authorities at a local and national level to share best practices and lessons
- Recognition of hydrogen within purchasing procurement frameworks and alignment between councils
- Testing support for demonstrations through designated test sites

Through local stakeholder interviews, it was made apparent that planning and demand visibility are causing issues for those in the local supply chain. Planning complications and delays have occurred due to unfamiliarity of hydrogen with planning officers, as well as strict criteria – particularly related to sound limits and environmental protection. . The upskilling of planning officers to increase familiarity and recognition of the benefits of hydrogen could allow the impact of this barrier to be significantly decreased. Lack of demand visibility for this emerging technology, particularly for producers, was highlighted as another major hurdle, as off taker agreements are difficult to achieve within the region. To support this, local governments could look to procure both technology and hydrogen locally to stimulate the economy and allow the growth required to distil confidence for wider roll out.

3.3 Electricity and gas utilities

Electrolysis is an electricity intensive process therefore large grid connections are required. Even hydrogen producers co-located with renewable energy providers have indicated that they would not connect without a grid connection to ensure security of supply. They also would purchase renewable power from the grid when local renewable generation is low, or could choose to purchase cheap constrained renewables.

Sussex is a power grid constrained region and the costs associated with grid extension can be very significant. The electricity utility plays a role in designing, costing and implementing grid extensions. The lead times on these extensions and any upstream reinforcement can take many years.

Distribution utilities can also be end customers to companies partaking in power-to-hydrogen. Utilities flag locations of constraint where they may be able to defer investment if decentralised generation can meet their needs. In return they establish contracts that pay a cost for having the security and a secondary cost for every time that system is called upon. Battery energy storage systems often fulfil this function today but for longer durations, batteries are not suitable. In this circumstance power through stored hydrogen may be better placed to provide a service.

3.4 Water utility

Green hydrogen production requires approximately 40-60 litres of water per kilogram of hydrogen (though a proportion of this can be returned, often warmer and with concentrated impurities). The electrolytic process alone requires 9 litres but there are losses at the point of cooling, purification and deionisation. In addition to large volumes, electrolysis requires the use of clean water, and for this reason, water utilities are a key actor within a successful hydrogen economy. Much of the region is considered to be a high water-deficit zone and could therefore present a barrier for large scale hydrogen roll out. To minimise this, water utilities could play a part in collaborating with hydrogen producers to investigate alternative source options to potable water, reducing the risk of further water scarcity whilst allowing local hydrogen production to develop. Alternatives suggested by Southern Water include:

- Water recycling
- Use of non-potable water
- Rainwater harvesting
- Desalination

Each option mentioned above comes with its own expenditure and practical challenges, therefore knowledge sharing between water utilities and hydrogen producers could find a viable solution and minimise conflicts between these two actors. Co-investment for alternative solutions to potable water such as desalination plants could reduce costs for both parties and encourage inward investment that could further improve the water grid.

3.5 Industrial scale Hydrogen production developers

For any region to be a significant player within a national hydrogen industry, local industrial scale hydrogen production will be a key driver. The presence of production at scale secures confidence for inward investment and attracts both private and public projects and off takers to set up business within the region. Hydrogen is notorious for its distribution challenges that often prove costly. From speaking with local stakeholders, it was highlighted that up to two thirds of the cost to purchase hydrogen in the current market is a result of its delivery to site. Some producers will set boundaries of ~100km for its transport to minimise cost for offtakers.

Development of hydrogen production is already underway within the region, with more producers expressing interest. For the entire value to chain to develop, confidence in supply will need to be nurtured through larger production volumes. Investment into the construction of new hydrogen plants would not only attract local off takers and newcomers to the region, but create more jobs, develop the overall skills profile, and encourage wider infrastructure developments.

With companies such as Michelmersh Bricks conducting hydrogen trials to produce bricks, potential demand for energy intensive uses is growing.

In these early stages, producers can play a key role alongside other actors by promoting open communication between themselves and potential off takers. It may be the case that many companies are not fully aware of hydrogen or the potential benefits of its applications in a commercial perspective, therefore the communication

and an element of self-promotion between producers and these businesses could spark interest and build a case for larger scale production.

3.6 Hydrogen distributors

The distribution and logistical solutions for hydrogen are key factors in developing a strong regional hydrogen industry. Hydrogen distributors will play an important role through the distribution of hydrogen itself as well as the skill developments required to achieve this.

Given the density of heavy goods vehicle movements in the region, especially around Shoreham Port, hydrogen distributors could explore the possibility of local logistics hubs to create viable options for companies looking to incorporate hydrogen into their operations. In turn, this could aid the creation of a regional hydrogen network and increase the possibility of cost competitive hydrogen. To achieve this, investments would need to be made in distribution methods such as tube trailers and upskilling of vehicle technicians and drivers.

3.7 Renewable energy producers

Renewable energy production is the key to making low-carbon hydrogen through electrolysis. Without it, the upstream fossil fuel generation is normally higher than simply using fossil fuels. Hydrogen producers must enter into commercial power purchase agreements to officially procure the energy. Government revenue support mechanisms also require evidence that the power was generated at the same time as it was consumed.

Encouraging renewable energy generation into the region is a secondary opportunity in attracting inward investment and creating green jobs. It is an essential part of achieving net zero and can reduce the need for grid infrastructure transmitting power into the region. The major challenges for renewable generation are the issues of space and planning, some of which can be ameliorated by the actions of local authorities

For many hydrogen producers, having renewable energy co-located with their plant is essential in reducing their levelised cost of hydrogen and remaining competitive. A private wire bypasses the need to utilise the grid and therefore avoids the associated fees charged on each unit on electricity.

3.8 Supporting infrastructure providers

Supporting infrastructure providers enable the transport and application of hydrogen to its end user. This includes refuellers, storage units, pipelines and tube trailers. Some hydrogen producers are offering end to end solutions whereby they source the implementation of infrastructure through their partners and cost it into a longer-term offtake contract.

3.9 Offtakers

Though other actors seemingly have the largest impact when developing a regional hydrogen industry, offtakers have a very important role to play. For production to increase, distributors to begin operating and supporting infrastructure to be developed, the realisation and visibility of current and potential demand is critical to ensure confidence in investment. Through stakeholder discussions, it was highlighted that the visibility of demand is currently a major barrier within the region. Hydrogen companies currently operating are unsure if any capital-intensive developments would be commercially wise, as if there is no or limited demand, any developments made would be redundant. Potential off-takers can express interest and open discussions with local authorities and local hydrogen related companies, which would help clarify potential demand as well as educate suitable off-takers of the best way hydrogen could benefit their operations.

Those with operations well suited to hydrogen e.g. heavy duty vehicles, could consider converting their fleets. Incorporating hydrogen into investment plans and sustainability goals, whether short term or long term, would aid the acceleration of the local hydrogen industry.

T: +44 (0) 1235 75 3000
E: enquiry@ricardo.com
W: ee.ricardo.com