Hydrogen Skills Alliance

EMPOWERING THE FUTURE:

A Strategic Skills Plan for the UK Hydrogen Economy

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Cogent Skills for science and technology

NATIONAL COMPOSITES CENTRE

Founded by Cogent Skills and the National Composites Centre in 2023, the Hydrogen Skills Alliance (HSA) brings together more than 50 organisations from the four nations of the UK – including industry, academia, government and skills bodies – to address skills gaps and promote innovation.

Hydrogen Skills Alliance

Foreword

Our clean energy mission sits right at the heart of this government's agenda. Our ambition is to rejuvenate our industrial heartlands creating jobs, skills and the provision of clean, secure and cheap power for millions of homes and businesses.

With our Clean Power 2030 target in place, we know there is not a moment to waste and we must deploy the full range of low carbon technologies at our disposal, including hydrogen.

The drive to clean power now represents the biggest economic opportunity in a generation, with the Industrial Strategy green paper 'Invest 2035' highlighting clean energy industries as one of eight growth sectors.

Low carbon hydrogen will be essential for heavy industry and for hard to abate sectors to decarbonise. But we must act now if we're to develop the skills needed to give people access to the good, well-paid jobs hydrogen can offer.

That means having a new workforce to look towards the green jobs of tomorrow and continue the expertise of those already employed in the UK's world leading oil and gas sector.

I'm pleased to say we have already established Skills England and the Office for Clean Energy Jobs to coordinate and guide our Growth and Skills offer, as well as introducing the Employment Rights Bill to Parliament. I look forward to working further with all stakeholders as we develop our full Industrial Strategy and its supporting policies later this year.

I must also thank the Hydrogen Skills Alliance and members of the Hydrogen Delivery Council Jobs, Skills and Supply Chain Working Group for delivering Empowering the Future: A Strategic Skills Plan for the UK Hydrogen Economy.

This strategy provides a clear picture of the roles required across the hydrogen value chain, our current strengths and the skills challenge we face for hydrogen to scale up quickly. It sets out the need for a coordinated and collaborative approach between skills providers, employers and government.

As a minister in both the Departments for Energy and Business, I can see the opportunity we have with hydrogen. Not only can we offer a credible solution to decarbonising heavy industry, but we can also create and develop a world-leading hydrogen ecosystem, creating jobs, skills and long, complex supply chains.

All of this is within our reach, as we have the chance to allow this clean and abundant energy source to make a real difference for decades to come.

Sarah Jones MP
Minister of State at the Department for Energy Security and Net Zero, and the Department for Business and Trade.
Co-Chair of the Hydrogen Delivery Council

Foreword

The UK Hydrogen Delivery Council exists to help realise the potential of the development of hydrogen. It proposed and has supported the production of this report, which has been thoughtfully developed with broad stakeholder input and expertise.

The evolution of an economy where hydrogen plays an important part in the energy transition is nascent today, yet globally it is well understood that it will be one of the essential tools needed to achieve net zero. Hydrogen is, of course, not new.

Across the world, tens of millions of tonnes have been produced and used safely for decades in specific applications, so our knowledge of deployment is not starting from scratch. However, with the growth in hydrogen demand comes opportunities for many more people in the UK to be employed, the potential creation of thousands of jobs across the UK in developing and building this exciting sector.

People and skills are the foundation of our capability to make this happen and already we face challenges. The early plans for skills development have historically been fragmented making it hard to navigate for both individuals wanting to learn and organisations needing consistency and confidence in the skills levels they are recruiting to. It is evident that, even at this early stage, some of the skills required are in short supply in a rapidly changing international context.

There are two overarching aspects of the outcomes of this work which resonate particularly strongly: The first, that it recommends a cohesive UK-wide approach. The input from Hydrogen Skills Alliance has been particularly valuable in supporting this conclusion. Secondly, it is a time-bound recommendation, which can be incorporated into other aspects of the clean energy skills agenda. This is wise as the energy transition is not a siloed activity - hydrogen is part of a wider system solution in a fast moving landscape. What's more, a time-bound outcome will be extremely helpful in moving the process along at pace.

As this sector grows, it will need great people and we should be ready to capture the opportunity for well paid, highly skilled jobs in those parts of the country that will most benefit from these opportunities.

Ultimately this approach is about pragmatism and progress rather than absolute perfection at a moment in time. My thanks to all those across the industry who gave their valuable insights to inform this significant piece of work.

Jane Toogood OBE FRSC
International CEO and Co-Chair of
the UK Hydrogen Delivery Council

A Strategic Skills Plan for the UK Hydrogen Economy

Executive Summary

Hydrogen is the simplest and most abundant chemical element in the universe. When harnessed it offers a clean, safe and versatile replacement for high-carbon fuels, helping bring down emissions and providing net zero energy for power, heat, industry and transport. This adaptable energy source is crucial to the government's goal of establishing the UK as a clean energy superpower.

Realising this ambition will help address the UK's economic and social challenges by opening new international markets, creating thousands of jobs, stimulating economic growth, and revitalising local areas.

Estimated workforce demand across the hydrogen value chain by 2030

	Production	Transmission (e.g. project union)	Transportation & distribution	Storage	Transport (usage)	Industrial processes	Heat	Power	Total
Direct	8,500	6,000	1,500	3,000	3,500	2,500	175	3,500	28,675
Indirect	24,000	13,500	3,000	6,000	7,500	3,500	300	6,000	63,800

(HUK - Hydrogen UK, Hii - Hydrogen Innovation Initiative, Cogent Skills/HSA - Hydrogen Skills Alliance)

Two key challenges

Attracting a workforce in sufficient numbers

It is estimated that hydrogen production needs to grow by 10,000 times to generate the 10GW output by 2030 outlined in The UK's Hydrogen Strategy[1] and British Energy Security Strategy[2]. This burgeoning hydrogen economy will require a significant workforce: forecasts estimate 28,675 direct and 63,800 indirect jobs, using a mix of existing and new skills. This is a substantial increase from the current workforce of just 1,600 in the 'alternative fuels' marketplace (including hydrogen and other fuels)[3]. However, there is already stiff competition from adjacent industries for many of the same skill sets hydrogen will require.

Achieving competency at pace

This workforce will need to apply a wide range of specific competencies quickly to achieve new capabilities across hydrogen production, storage, distribution and use. The skill needs will vary across different technologies, industries and regions - and the workforce will have different starting points and backgrounds. Technological advancement will require swift identification of relevant competencies to inform new training courses or risk the hydrogen economy's ability to scale up.

The case for strategic coordinated action

The hydrogen economy is unlike almost any other, presenting a unique set of challenges to skills development. It is evident there is significant market failure, meaning that if the development of hydrogen skills is left to market forces, critical training will not be available when and where it is most needed. Seven key drivers for strategic coordinated action have been identified.

Lack of workforce and labour market intelligence – There is a need to identify the fragmented hydrogen economy and build a dynamic picture of workforce and skills demand across the evolving hydrogen value chain – regionally and nationally, now and in the future.

Workforce and skills shortages – While employers are investing in hydrogen technologies, they are already reporting a shortage of trained staff which will hinder the expansion of the hydrogen economy for 10GW of production.

Nascency means skills demand signals are lost – The current nascency of the hydrogen economy means a lack of engagement with regional skills planning programmes and employers have limited time available to work with providers to design programmes. SMEs are particularly disadvantaged.

1. UK hydrogen strategy - GOV.UK (www.gov.uk)
2. https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy
3. https://www.ons.gov.uk/releases/lowcarbonandrenewableenergyeconomyuk2022

Lack of provider capacity and capability to deliver training – Training providers need to be prepared in advance so that they have the right capability to deliver at the time those skills are needed. Providers have limited access to hydrogen expertise and limited experience in delivery and as such are poorly placed to develop curriculum themselves. This is similar to the challenges addressed by government intervention for skills for electrification.

Higher level skills are lacking – It is reported that university courses in chemical engineering and chemistry have not sufficiently focussed on hydrogen industry needs to enable design and higher-level engineering.

Lack of a single industry voice on hydrogen competencies – The Hydrogen Skills Alliance is in the early stages of developing a Hydrogen Skills Framework. Until this work is complete, learning materials developed may not be based on verified industry need to inspire confidence and provide rigour and consistency.

Cross-sector collaboration on common skills challenges – Across the clean energy landscape there are common skills challenges which, if unresolved, will affect the UK's ability to decarbonise. Lack of anticipatory investment in skills, combined with a critical shortage of key roles – including engineers, electricians, construction specialists and planners – will extend project timelines, increase costs and reinforce reliance on skilled migration. Cross-cutting issues cannot be resolved by a single sector.

An approach for rapid impact

Decisive intervention is required through a strategic plan of action for hydrogen skills which addresses market failure.

This document outlines such a plan and calls for national leadership from industry, government, skills bodies, trade unions and skills providers. Their collaborative approach must be fast, dynamic and complement the existing skills ecosystem. It must foster the institutional capacity for hydrogen skills development ahead of employer demand signals, so strategic investment in hydrogen is not hindered by skills and workforce shortages.

The Hydrogen Skills Alliance (HSA) has already laid the foundations, providing strategic leadership on hydrogen skills by convening employers and other stakeholders to foresight workforce capability, define future occupations and standards, and forecast workforce demand. However, the HSA faces limitations in curating and creating resources, as well as in building capacity for their delivery.

This plan recommends establishing a Hydrogen Skills Academy to address these limitations. The Academy would work with regional ecosystems to develop open-source curricula and develop capacity within training providers to upskill the workforce.

The HSA and the Academy, working with government, industry and the skills system, would create an ecosystem to deliver this strategic plan for hydrogen skills – ensuring the right skills are available at the right time and in the right places for the UK's hydrogen economy to thrive.

A Strategic Skills Plan for the UK Hydrogen Economy

By working together, we will:

Understand

Improve workforce and skills data gathering, analysis and modelling.

We will do this by:

- Building a centralised data repository and dynamic modelling tool that integrates with national and local skills planning frameworks and supports future workforce strategies.
- Supporting Industry and sector bodies to share project data to improve forecasting through a dynamic modelling tool.
- Engaging with Local Skills Improvement Plans and Regional Plans in key locations.
- Benchmarking sector diversity and agreeing improvement KPIs.
- Championing the Skills Value Chain methodology to convene employers to foresight future skills.
- Developing an opensource Hydrogen Skills Framework for key occupations that articulates the hydrogen-specific knowledge, skills and behaviours.

This will help us to...

- Support future workforce and skills planning at regional and national level.
- Understand training needs as the industry evolves.
- Monitor diversity and evaluate ED&I activity.
- Connect innovation to workforce training to integrate new technologies and processes more effectively.
- Establish an industry standard for hydrogen skills.

Underpinned by Collaboration we will...

Improve workforce and skills data gathering, analysis, and modelling through shared insights and data integration and enable quality training to be developed.

Maximise

Make full use of the existing skills offer, leveraging the sector's expertise to ensure it remains current as the industry evolves.

We will do this by:

- Leveraging existing government-funded skills initiatives in all 4 devolved nations.
- Developing a Hydrogen Talent Pipeline Plan ensuring relevant and appropriate routes for every entry point of career lifecycle.
- Reviewing the current government-funded skills offer and supporting the development of new skills programmes to incorporate hydrogen-specific requirements including in apprenticeship standards, frameworks and university curriculum.

This will help us to...

- Reduce the burden of training costs to employers.
- Minimise time to competency for new recruits across the career lifecycle.
- Ensure government funded training programmes deliver the skills industry needs.

Underpinned by Collaboration we will...

Leverage existing skills and expertise across sectors to keep training relevant and up to date.

Develop

Analyse the gaps in provision and develop new curriculum in a collaborative way.

We will do this by:

- Developing a comprehensive centrally owned skills up/re-skilling programme, utilising evidence provided by the Hydrogen Skills Framework and Workforce Foresighting Hub, developing new National Occupational Standards as appropriate.
- Building capacity and capability among providers and assessors.
- Contributing to the development of safety regulations and aligning training as appropriate.
- Developing new models to enable anticipatory investment in skills.
- Developing new models for industry placements that overcome health and safety barriers.
- Benchmarking against European training standards for greater mobility of skills.

This will help us to...

- Ensure consistent, efficient, and adaptable training aligned with future industry needs through data-driven decisions and updated standards.
- Ensure high-quality, consistent, scalable, and adaptable training programs.
- Design training that contributes to safer, compliant and more efficient workplaces.
- Train critical skills ahead of time.
- Invest in future talent through industry placements.

Underpinned by Collaboration we will...

Identify gaps and collaboratively create new curricula and training investment models that meet evolving industry needs.

Attract

Position hydrogen as an aspirational career destination for anyone at any point in the career lifecycle.

We will do this by:

- Developing/delivering a comprehensive careers offer for pipeline and mid-career changers including training hydrogen skills ambassadors with focus on building diverse talent pipelines.
- Outreach to disadvantaged and under-represented groups e.g. ex-services, under-employed, returners etc.
- Developing a hydrogen sector value proposition.
- Developing an awareness campaign for the sector dispelling public fear on hydrogen usage and demonstrating attractiveness of sector as career destination.
- Developing/delivering an action plan for ED&I in the sector.

This will help us to...

- Position hydrogen jobs as an aspirational career destination.
- Widen the talent pool and improve diversity in the sector.
- Attract recruitment of skilled talent at all stages of the career lifecycle and improve retention.
- Bake in diversity to the future workforce.

Underpinned by Collaboration we will...

Position hydrogen as an attractive career destination for a diverse talent pool by uniting efforts to promote and develop the sector.

Understanding the Current Hydrogen Economy

Delivering the right skills at the right time and in the right places begins with gaining a robust understanding of current and future workforce and skills demand: in other words, the volume of people required (workforce) and the knowledge, skills and behaviours in which they must be competent (skills).

Some forms of hydrogen production have existed for many years, meaning an assessment of skills is relatively simple. The need for further technological advancement to scale up new, greener production methods provides a greater challenge, with storage and distribution also requiring larger scale solutions. The most difficult area in which to adequately forecast skills demand is the 'usage' sectors of hydrogen, which are at varying degrees of maturity.

The strategy draws on a significant amount of work to analyse current and future skills demand across the hydrogen economy, creating a substantial evidence base for activity that will ensure workforce and skills do not become a barrier to the hydrogen economy's continued growth.

A workforce assessment[4] was carried out by Cogent Skills on behalf of the HSA in 2023 to better understand the current and future state of the hydrogen workforce. This assessment fed into the work of the government and industry-led Green Jobs Delivery Group and now provides a significant evidence base to support government planning for hydrogen workforce and skills.

The UK hydrogen industry is in its infancy with a low base of employees: just 1,600 in the 'alternative fuels' marketplace (including hydrogen and other fuels). With only a handful of experienced employers active in some of the more nascent areas of the hydrogen economy, an in-depth workforce analysis was not possible. Therefore, to complete the assessment, a range of research activities were undertaken (including a review of international studies from Australia, Canada, and Europe), an interrogation of data and research undertaken to date by the Industrial Decarbonisation Research and Innovation Centre (IDRIC), alongside a series of workshops and surveys with the UK hydrogen business base.

In Wales, a Pilot Skills Mapping Exercise on Hydrogen[5] was undertaken in March 2022 by Ynni Glân and sponsored by the Welsh Government and Innovate UK. The report recognised the multi-sector potential of hydrogen and, at that point, the overlap with other existing skills and skills-related groups and activities in Wales.

In March 2023, ClimateXChange – Scotland's centre of expertise connecting climate change research to policy – published a study investigating the skills needs for the emerging hydrogen economy in Scotland[6], based on the Scottish Government's Hydrogen Action Plan ambition to establish 5GW of hydrogen production capacity by 2030 and 25GW by 2045[7].

These reports complement the HSA's workforce assessment and provide an additional layer of data and analysis in support of the activity outlined in chapter four.

Recognising the lack of robust workforce and skills evidence, the HSA, is aiming to develop a more robust system of data collection and analysis that supports skills planning at a regional and national level, including through dynamic modelling. A template has been established through the work Cogent Skills has done for the nuclear sector to support workforce planning for different energy production scenarios. The ability to more reliably forecast workforce and skills demand will support local skills systems to better plan their delivery and support a clearer national picture of workforce and skills for net zero.

In the rest of this chapter, we will consider the current and future workforce demand across the hydrogen value chain in relation to the government's 10GW production target and hydrogen's role in decarbonisation.

Production

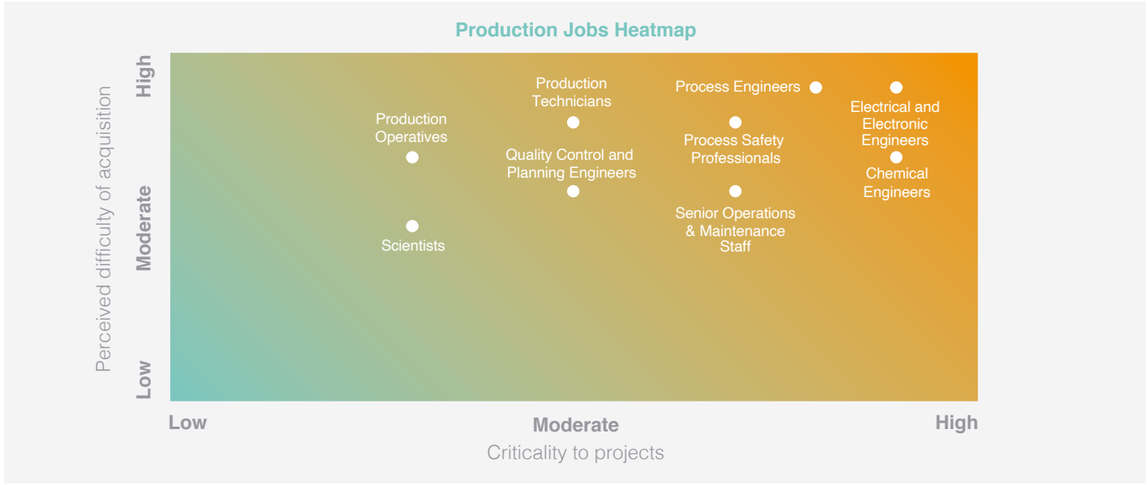
The UK's Hydrogen Strategy and Hydrogen Delivery Roadmap[8] sets the UK's approach of supporting multiple hydrogen production routes including both electrolysed and carbon capture-enabled methods – with ambitions to allocate at least half of the government's 2030 ambition for 10GW production to electrolytic hydrogen.

These approaches mix established and emerging technologies, each offering unique processes, opportunities and challenges and requiring a diverse set of skills which will need updating as new technology develops.

1. CCS-enabled hydrogen

The predominant form of hydrogen production in the UK is steam methane reforming (SMR), in which methane reacts with steam in the presence of a catalyst to generate hydrogen, carbon monoxide and carbon dioxide. While efficient, this method is carbon intensive - to transform this into a low-carbon product, carbon capture and storage (CCS) technology captures the emissions during production. The implementation of CCS not only turns SMR hydrogen

4. https://cogentskills.com/wp-content/uploads/2024/07/Hydrogen-Workforce-Assessment-Executive-Summaryfinal.pdf
5. HyCymru Skills & Training Report Ynni Glan 04 2021 Final LowRes
6. https://www.climatexchange.org.uk/wp-content/uploads/2023/09/cxc-mapping-the-current-and-forecasted-hydrogen-skills-landscape-jun-2023.pdf
7. https://www.gov.scot/publications/hydrogen-action-plan/pages/3/
8. Hydrogen production delivery roadmap - GOV.UK (www.gov.uk)



production into a low-carbon alternative but also exemplifies the UK's commitment to leveraging existing resources and infrastructure towards more sustainable goals.

However, the environmental efficacy of CCS-enabled hydrogen depends on the capture rate and the lifecycle emissions of the utilised natural gas, presenting a complex challenge that requires ongoing technological and regulatory advancements. The Green Jobs Delivery Group Carbon Capture and Storage Findings and Recommendations Report[9] foresees significant workforce challenges if the carbon capture and storage sector is to reach its potential. Although there will be some up- and re-skilling of existing job roles, the bulk of workforce demand will fall in the construction phase, with a workforce already constrained by demand from other parts of the economy.

2. Electrolytic hydrogen

The electrolytic hydrogen production method involves the electrolysis of water, in which an electric current splits water into hydrogen and oxygen. When low carbon electricity is used, hydrogen is considered low or zero carbon because it produces no associated greenhouse gas emissions during its production. The UK's abundant renewable energy resources, especially offshore wind and solar, are uniquely positioned to scale up electrolytic hydrogen production. The appeal of this method is not just in its environmental benefits but also its potential to completely decouple hydrogen production from fossil fuels, offering a truly sustainable pathway toward energy independence. As technological advancements reduce the cost of electrolysers and improve efficiency, electrolysed hydrogen is poised to play a pivotal role in the UK's energy transition, underscoring the critical importance of continued investment in renewable energy infrastructure and innovation.

The expansion of hydrogen production in the UK demands a diverse array of occupations, from engineers and technicians to project managers and regulatory specialists. Jobs range from skilled technicians capable of maintaining and operating hydrogen production facilities to engineers and scientists focused on innovation and efficiency improvements. While certain tasks like system maintenance or electrolysis equipment operation require technical skills acquired through vocational training or on-the-job experience, others – such as engineering design, systems integration, and environmental impact assessment – demand advanced degrees and an understanding of complex scientific principles.

The scalability of electrolytic hydrogen production is currently challenged by high costs and energy requirements for electrolysis, while CCS-enabled hydrogen's reliance on CCS technologies, yet to be deployed at scale, presents its own challenges. Technological advances continue to lower costs and increase hydrogen production efficiency, but the sector's growth also hinges on the development of regulations, safety standards and market frameworks. These challenges underscore the need for a workforce with both practical skills with high-level scientific and managerial expertise.

The assessment of the production workforce shows both technical and graduate-level roles are in shortage and risk the industry's ability to scale up to meet the governments

9. CCSTFG-CCS-Labour-Market-Assessment-Report-FINAL-27.02.pdf (ecitb.org.uk)

CASE STUDY

RWE

RWE, a European utility company, has been actively following a Growing Green Strategy to help the global transition to sustainable energy solutions. In the UK, RWE operates gas-fired power stations and has a significant portfolio in both offshore and onshore wind, as well as solar energy projects. The company employs around 3,000 people across the UK and generates approximately 15 per cent of the nation's electricity. RWE's green hydrogen team, established in 2021, aims to build, own and operate green hydrogen production facilities across the UK, Germany and the Netherlands.

Current Progress in Hydrogen Production

RWE's green hydrogen projects are in various stages of development. The most advanced project, located in Pembrokeshire, is about to start the front-end engineering design (FEED) phase and aims to be operational in the late 2020s. Other projects are at earlier stages, such as a 200 MW project in Grangemouth and collaborations in Teesside and Harwich. These projects involve electrolysis technology powered by renewable energy sources.

The green hydrogen team at RWE has grown from five to approximately 30 members over two years. Recruitment has been relatively successful due to RWE's strong reputation. However, there are concerns about the wider utility sector's ability to meet the growing demand for skilled workers, particularly in the water and gas network sectors. Skills shortages in these areas could impact the successful deployment of hydrogen projects and, ultimately, the net zero transition.

Future Workforce and Skills Requirements

The key to advancing hydrogen production lies in early and consistent government support, including subsidies to make green hydrogen production commercially viable. Uncertainties around funding availability can delay workforce planning and training initiatives.

RWE plans to assess its future workforce needs more accurately once funding and project approvals are secured. This will involve a detailed skills assessment to identify specific training requirements and potential apprenticeship opportunities. However, it is already clear that the journey from project development through to construction and operation necessitates a diverse set of skills across multiple disciplines:

- Commercial and Regulatory Skills: Expertise in contract negotiation, regulatory affairs, and government subsidy applications is essential to secure funding and ensure compliance.
- Environmental and Safety Specialists: These professionals handle planning permissions, environmental assessments, and health and safety protocols specific to hydrogen.
- Engineering and Technical Skills: Engineers with backgrounds in mechanical, process, and electrical engineering are crucial, particularly those familiar with front-end engineering design. Skills at the degree level or higher are typically required.
- Construction Demand: The future construction phase will require a large workforce, including specialised roles such as welders and construction engineers, which might present recruitment challenges due to the scale of simultaneous projects.
- Operational and Maintenance Skills: Although specifics are still under assessment, RWE anticipates transitioning staff from existing gas-fired power stations to operate hydrogen facilities.

Current Training and Development Initiatives

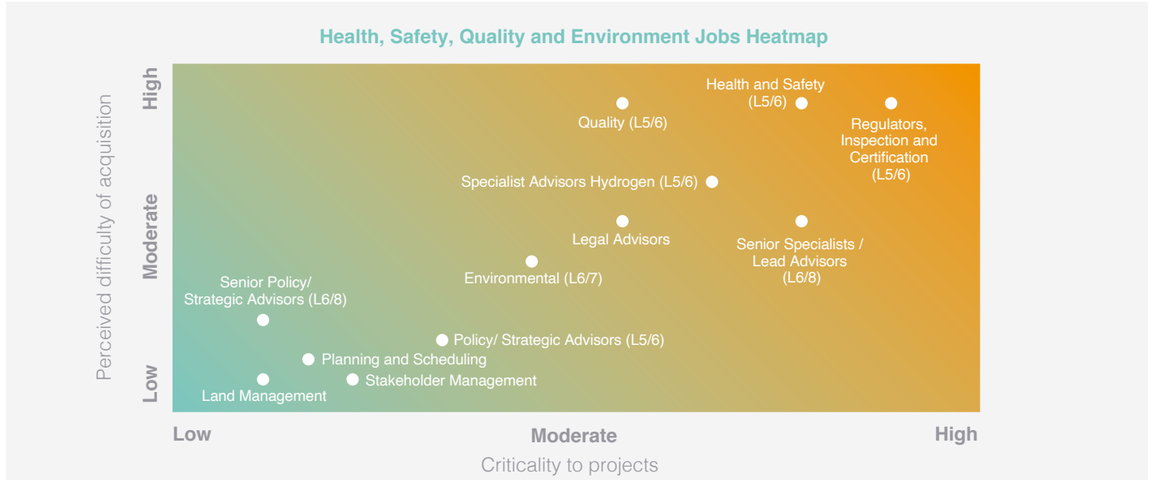
RWE is committed to green hydrogen production and takes a proactive approach to workforce development. Recent initiatives include engagement with local educational institutions and providers to explore the development course content and collaboration and developing educational materials for schools to inspire interest in STEM subjects and hydrogen technology.

10GW ambition. Job roles in critical supply include Process Engineers, Chemical Engineers, Senior Operations and Maintenance staff, Production Technicians and Quality Control & Planning Engineers. Construction skills, already constrained, will be needed to build new production facilities and carbon capture pipelines.

The heatmap above gives an indication of the criticality of the job roles required for hydrogen production and the perceived difficulty of acquiring them (see later for the construction specific heatmap). The occupations closest to the top right of the heatmap are the ones where our focus for mitigating action should lie.

Adherence to national and international safety standards is non-negotiable in all activities related to hydrogen. This responsibility falls on regulatory specialists and safety inspectors, who must have a deep understanding of the legal and technical aspects of hydrogen safety. Their work helps to mitigate risks, ensuring the protection of workers and the public.

Many regulatory skills are in critically short supply. Not only are adjacent industries competing for a limited pool of suitably skilled workers, but the regulator requires similar skills also. A key issue for the regulator is its inability to compete with industry in terms of pay. Increasing the supply of skills is an obvious solution which will require collaboration between industry, the regulator and government.

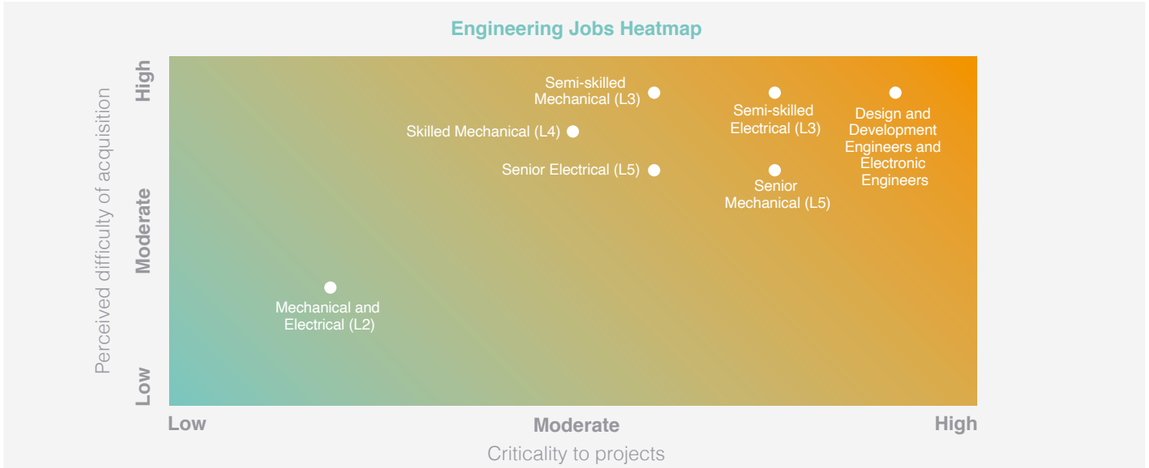


Engineers of almost all types (mechanical, electrical, control and instrumentation, production, process and chemical) are required across much of the hydrogen economy and are in critically short supply. They already feature on the UK government skilled worker visa shortage occupations list due to the demand across renewable industries and beyond.[10] The shortage of higher-level skills is of particular concern due to the length of time it takes to achieve competency. To become a Chartered Engineer, for example, takes eight to 10 years.

If hydrogen's role in the UK economy is to be realised, the number of engineers coming into the hydrogen economy must be maximised. Therefore, it is essential the industry fosters educational partnerships and supports the design of curriculum that caters specifically to hydrogen-based operations. These are science-based engineers operating in potentially high hazard industries and as such require a broader base of multi-disciplinary training than other engineers.

10. UK Government: Skilled Worked visa: Shortage occupations list (date accessed 05/09/2023)

A Strategic Skills Plan for the UK Hydrogen Economy



Transmission and distribution

The hydrogen distribution network, essential for delivering hydrogen across various sectors, must be expanded and adapted to manage hydrogen safely and efficiently. This challenge includes the development of physical infrastructure, such as pipelines and transport fleets, as well as the establishment of a robust regulatory framework to ensure system-wide safety and compatibility. A collaborative approach towards infrastructure enhancement, regulatory reforms and the implementation of stringent safety protocols is vital for the efficient and sustainable distribution of hydrogen to power vehicles, generate electricity and facilitate industrial processes.

The growth and maintenance of the hydrogen distribution network relies on a diverse workforce equipped with varying levels of skills and expertise. On the technical front, skilled tradespeople, such as welders and pipefitters, are essential for building and retrofitting pipelines. These roles often require vocational training rather than a degree, emphasising hands-on experience and specialised skills in working with hydrogen-compatible materials.

Engineers, particularly those specialising in chemical, mechanical and materials engineering, are central to designing the infrastructure that safely transports hydrogen, whether through pipelines or via road and sea. Their work involves intricate knowledge of hydrogen's properties, requiring advanced degrees and a deep understanding of engineering principles.

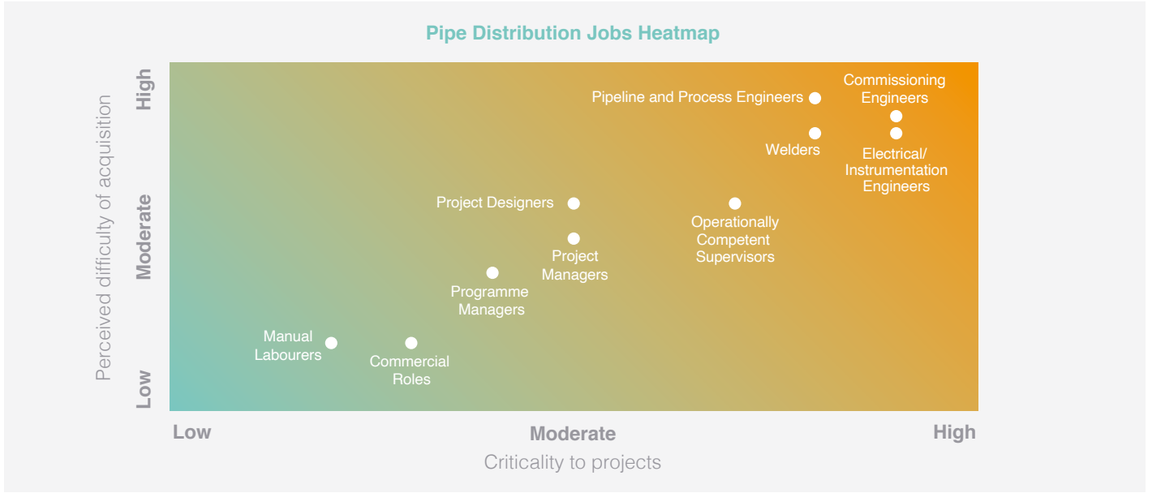
Regulatory specialists and safety inspectors with backgrounds in law, environmental science, or engineering ensure distribution practices meet strict safety and environmental standards. These positions typically require a combination of formal education and specific training in hydrogen technologies and regulations.

1. Pipelines

Regarded as a highly efficient distribution method, pipelines are particularly effective for transporting large volumes of hydrogen over short to medium distances. For example, the HyNet industrial decarbonisation cluster plans to supply nearby industry with locally produced hydrogen transported by an underground hydrogen network being developed by gas supply experts Cadent, the first of its kind in the UK.

Over longer distance, the UK's existing natural gas pipelines could serve as a foundation and are already compatible with transporting a natural gas and hydrogen mix. Significant modifications are needed however, as the proportion of hydrogen in the mix increases above 20 per cent. To distribute higher concentrations of hydrogen, material upgrades will be required to existing pipelines to prevent hydrogen embrittlement. Enhanced leak detection and safety systems will also be required.

Project Union is a pioneering initiative led by National Gas to create a hydrogen backbone capable of transporting 100 per cent hydrogen, connecting hydrogen production and storage facilities with end users in the industrial clusters by the early 2030s. It will also enable connection to a proposed European Hydrogen Backbone, opening international hydrogen markets. This ambitious project will be 2,000km long and



leverage the existing gas network along with additional transmission pipelines. It is estimated that the project will support 3,100 jobs at peak construction with hydrogen specific skills training required to top up traditional skill sets.

Creating new, hydrogen-specific pipelines featuring cutting-edge materials and technologies will be essential for broadening the network's reach and ensuring its safety and durability. Despite the considerable challenges in engineering and investment, transitioning to hydrogen-compatible pipelines offers a promising path to a high-capacity, low-emission distribution method which leverages existing infrastructure.

Skills for pipe distribution are coming into sharp focus given hydrogen's role in industrial decarbonisation and its role in the success of the Industrial Decarbonisation Clusters. Many of the core skills required for hydrogen pipeline distribution already exist within the existing gas network workforce requiring a programme of upskilling to ensure a hydrogen-safe workforce.

A key issue will be ensuring sufficient workforce numbers for both fuels since gas pipeline distribution will continue for many years alongside hydrogen putting additional pressure on skills compounded by an aging workforce.

2. Trucks/boats

For regions not serviced by pipelines or for the purpose of overseas exports, the use of trucks and boats with high-pressure tanks and boats is crucial. Though more resource-intensive, this distribution mode adds crucial flexibility necessary for a global hydrogen market.

Hydrogen is already distributed by road on trucks carrying high pressure storage units. Movement of hydrogen takes place under established carriage of dangerous good regulations. As filling of the high-pressure storage units is the responsibility of the origin site and decoupling the responsibility of the delivery site, there are no hydrogen-specific skills required for truck distribution.

The same technology as truck distribution is used for distribution of hydrogen by boat with pressurised hydrogen storage units. Filling and decoupling remain the responsibility of the origin and delivery site respectively. Again, the transportation of hydrogen by boat is covered under the carriage of dangerous goods regulations and requires no hydrogen-specific skills.

Distribution of hydrogen by truck and boat is expected to increase as the hydrogen economy grows, particularly as the infrastructure investment for pipe distribution may take time to implement. Although no hydrogen-specific skills are required for these methods of distribution, well-documented shortages of HGV drivers in general and strong competition for maritime workers from well-established offshore sectors such as wind and oil and gas, need close monitoring to prevent workforce shortages.

CASE STUDY

Cadent
Your Gas Network

Cadent is actively involved in a variety of hydrogen projects, including HyNet, East Coast Hydrogen, Capital H, and Hydrogen Valley. These projects, which range from feasibility studies to large-scale implementations, aim to support the UK's transition to hydrogen energy and advance industrial decarbonisation.

Challenges and Skills Shortages

The transition from natural gas to hydrogen requires a significant shift in skills, particularly in design and construction. The construction sector already faces a skills shortage, with high demand for project managers, welders, and heavy machinery operators. HyNet alone will require approximately 1,000 construction workers at its peak, making recruitment and retention challenging amid competition from the oil and gas sector. Time is pressing as many of these roles take years to train.

At the same time, current gas distribution operations will continue, adding extra pressure to an already stretched workforce with employers competing for the same talent pool. The sector also has a high number of leavers from operational roles due to an ageing workforce. Ensuring key roles such as programme managers, project designers, process engineers, and operational supervisors are filled will be vital to avoiding labour shortages that could disrupt project progress.

Addressing Workforce Growth

Cadent is addressing the anticipated growth in specialist workforce needs by collaborating with industry bodies. Existing gas competencies are still applicable, with hydrogen-specific skills being added as 'bolt-ons'. However, the volume of training required for hydrogen projects is expected to exceed the number of available trainers.

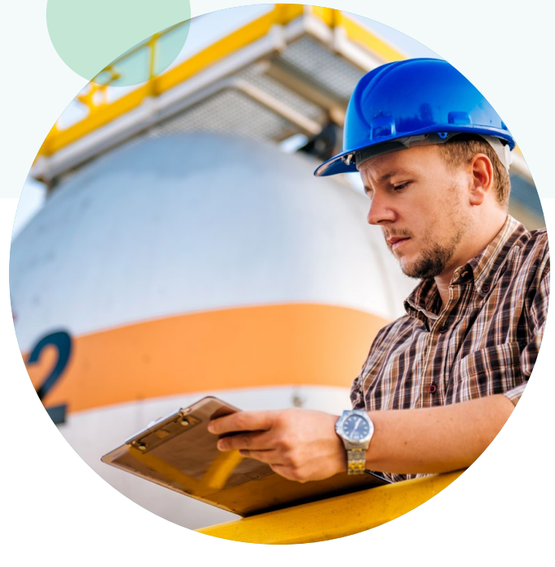
A collaboration task force has been established across the gas distribution network to share limited resources and ensure consistency in training. Cadent is also working with educational institutions to develop hydrogen-specific training content and explore new technologies, such as virtual training environments, to enable personnel to train and gain competence even without hands-on experience.

Recruitment and Diversity Initiatives

Cadent has launched a new talent recruitment initiative aimed at attracting diverse candidates from various backgrounds. This initiative includes:

- Removing Entry Barriers: Eliminating entry barriers for new talent programmes, focusing on potential and capability rather than formal qualifications.
- Modularised Development Packages: Providing tailored development packages based on individual skill levels and experience.
- Diverse Recruitment Channels: Engaging candidates through platforms like LinkedIn, TikTok, YouTube, Facebook, and Instagram, using compelling video content to showcase success stories.

This approach has resulted in a significant increase in applications and diversity, with a notable rise in candidates from ethnic minority backgrounds.



The hydrogen distribution network must be expanded and adapted to manage hydrogen safely and efficiently

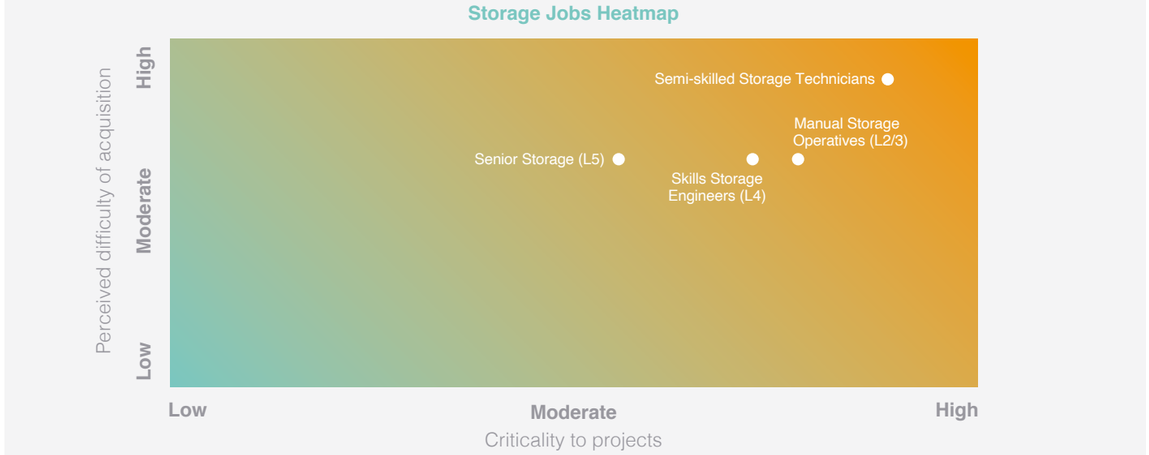
Storage

The ability to store and transport hydrogen decouples its production from its supply and use. Storage is crucial for securing supply for end users and for the creation of a global hydrogen market. Storage also adds flexibility to renewable power generation, providing a constant supply of energy when renewable power generation (e.g. solar and wind) can be intermittent.

Hydrogen has a significantly lower energy density compared to natural gas at standard temperature and pressure.

This introduces distinct storage challenges. For example, hydrogen requires more storage space to achieve the same energy output as natural gas, underscoring the need for innovative storage solutions.

The UK is developing its hydrogen storage infrastructure through various methods designed to meet different needs — from high-pressure tanks and cryogenic storage aiding mobility and transport to salt caverns and solid-state storage for bulk and long-term applications.



1. High-pressure tanks

High-pressure tanks store hydrogen gas at pressures up to 700 bar. This method is particularly suited for small-scale storage applications, such as fuelling stations for hydrogen-powered vehicles and is already used for the transportation of hydrogen by road and sea. The technology behind high-pressure tanks has seen significant advancements in recent years, focusing on materials that can safely and efficiently handle the extreme pressures required for compact hydrogen storage. However, the high costs associated with these tanks and the energy required for compression remain challenges which must be addressed.

While tank storage is the most advanced method of storing hydrogen, its continuing nascency means workforce with the right skills are in short supply and could hamper the expansion of this vital segment of the hydrogen economy. Storage has been a particular focus for the skills foresighting workstream of the HSA.

2. Salt Caverns

With its extensive experience in natural gas storage, the UK is well positioned to leverage salt caverns for large-scale hydrogen storage. Salt caverns offer a cost-effective solution for storing vast quantities of hydrogen underground. The impermeability of salt formations ensures minimal leakage, making this method one of the most promising for the bulk storage of hydrogen, particularly for CCS-enabled hydrogen which is produced in significant volumes. This method is especially beneficial for buffering the supply and demand of hydrogen, providing a significant reserve that can support the energy grid during periods of high demand or when renewable energy sources are insufficient. HyNet partner INOVYN is already repurposing salt caverns in Cheshire, which currently store natural gas, to store 35,000 tonnes hydrogen to be produced by the HYNET industrial cluster. This will provide a secure supply of home-grown energy and enable the management of peaks and troughs in energy demand.

3. Solids

Solid-state hydrogen storage involves the absorption of hydrogen gas into a solid material. This method can potentially offer higher storage densities and lower risks of leaks compared to gaseous storage. Materials such as metal hydrides, which absorb hydrogen and release it when heated, are being investigated. While promising, solid-state storage faces challenges in terms of cost, material degradation over multiple charging and discharging cycles, and the thermal management of the system. Technological advancement will be needed before this type of storage becomes mainstream. As such, skills for solid-state hydrogen storage are yet to be determined.

4. Cryogenics

Cryogenic storage involves cooling hydrogen gas to a liquid state at -253°C (liquefaction), significantly reducing its volume and making it easier to store and transport. This method is especially useful for transporting hydrogen over long distances, where pipeline transport is not feasible. The main challenges are the energy required for liquefaction and the insulation technology needed to maintain extremely low temperatures during storage and transport.

Cryogenic technology is a critical element of hydrogen-enabled air travel. To enable flights of reasonable distance, hydrogen must be stored on the aircraft in a liquified state. Liquified hydrogen requires cryogenic storage. Liquefaction systems may also be required at airports, if hydrogen arrives in gaseous form due to the complexities of transporting liquified hydrogen over long distances by truck or pipeline.

The predominant method of hydrogen storage in the UK is currently tank storage. However, as the UK advances its hydrogen storage capabilities, research and investment are essential to overcoming the current limitations of alternative storage methods. The hydrogen storage economy will require a workforce skilled not only in the technical aspects of hydrogen storage but also in regulatory compliance, safety management and environmental considerations.

Engineers and scientists specialising in mechanical, chemical and materials science are crucial for developing and optimising storage solutions. They typically require a degree in their respective fields, underpinned by a strong foundation in engineering principles and a deep understanding of hydrogen's unique characteristics.

Operational roles, including system operators and maintenance personnel, play a vital role in the day-to-day management of storage facilities. While some positions may require specialized training or certifications, others depend on vocational skills acquired through hands-on experience. This highlights the need for a workforce which combines practical abilities with theoretical knowledge.

A Strategic Skills Plan for the UK Hydrogen Economy

CASE STUDY

The Tank Storage Association (TSA) represents the interests of more than 80 member companies engaged in bulk storage, energy infrastructure, and the provision of products and services to the sector. Terminals and tank farms store and handle a wide variety of products, including transport and heating fuels, renewable energies, chemicals, potable liquids, edible oils and fats, fertilisers, animal feed and molasses.

The bulk storage and energy infrastructure sector is actively engaging in the decarbonisation process, which lies at the centre of the UK's net zero priorities. The fundamental changes ahead will require investment and planning to ensure the import, production, storage, and transport of new energy carriers. With hydrogen set to play an important role in the journey towards carbon neutrality, the TSA is considering the potential for managing the importation and distribution of hydrogen carriers such as ammonia.

Current Progress

Existing infrastructure, designed for the storage of bulk liquids, may require some modifications to handle hydrogen carriers like ammonia, as well as investment in new facilities for hydrogen storage due to temperature and pressure requirements. Regulators have been examining hydrogen storage technologies to ensure the safe management of these inventories in the future. However, progress on physical infrastructure has been limited due to insufficient market certainty, primarily resulting from the lack of clear UK-wide policy mandates for hydrogen usage.

Skills and Workforce Development

Demand for some roles is expected to exceed the capacity of the current workforce, with the sector anticipating the need to recruit individuals with transferable skills from other industries. However, the sector does not foresee extensive new recruitment for hydrogen-specific roles, focusing instead on reskilling and upskilling the existing workforce in the short term. Continuous professional development programmes will be crucial to equip terminal operators with the necessary skills to manage hydrogen carriers safely and efficiently, including specialised training in handling hazardous substances like ammonia.

Sustained efforts are therefore needed to attract new talent, update current training provisions, and develop new standards to create a skilled workforce that can lead innovation and growth in the hydrogen sector. The TSA highlights the need for a skills and apprenticeship system that is more accessible and flexible, especially for SMEs. A more flexible approach has the potential to boost participation and investment in training and development while increasing the sector's attractiveness to emerging talent.

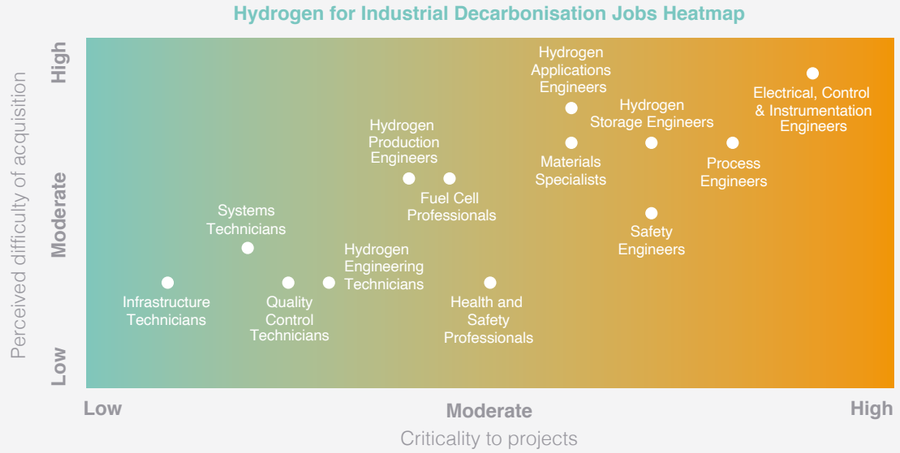
The TSA has been developing a Level 3 Bulk Storage Terminal Technician Apprenticeship standard that includes elements related to future energy carriers. As interest in hydrogen grows, other existing apprenticeship standards will need to be updated to include modules on hydrogen and other future energy carriers.

Government Policy and Support

Greater recognition of bulk storage infrastructure as a key enabler of the net-zero transition is needed to secure the investment and planning necessary for infrastructure developments. Consideration should be given to funding streams, permitting, and procurement procedures that facilitate the participation of storage infrastructure operators, as well as funding for FEED studies to encourage greater certainty and stimulate more speculative investment from the sector. As we anticipate the development of a hydrogen market in the UK, a stable and clear regulatory framework is key to driving long-term visibility for investors and market certainty across the entire hydrogen value chain.

Usage

The emergence of hydrogen as a versatile and clean energy source offers transformative potential for a wide range of end-use applications. Its ability to serve as an alternative to high-carbon fuels presents a viable pathway for sectors traditionally marked by heavy emissions to decarbonise, such as steel, cement and chemical manufacturing. These industries not only consume substantial amounts of energy but also necessitate energy in forms conducive to high-temperature processes and flexible operations. The broad applicability of hydrogen – from industrial processes and transportation to heating and aviation – underlines the need for innovative approaches to harness its full potential. Each sector presents its own set of challenges, from technological advancements to infrastructure development and regulatory compliance, yet the opportunities for reducing carbon emissions and fostering sustainable practices are unparalleled.



1. Hydrogen for power generation and industry

Adopting hydrogen as a decarbonisation fuel in heavy industries like steel, cement and chemicals is a significant departure from conventional carbon-intensive methods. The transition involves retrofitting existing industrial plants with hydrogen-compatible technologies, such as hydrogen furnaces and boilers, to accommodate high-temperature processes. This shift poses challenges, including the need for substantial capital investment and the development of technical expertise among the existing workforce to manage and operate new hydrogen-based equipment. However, the opportunity to significantly reduce industrial carbon footprints and create a sustainable production landscape makes this transition a pivotal move towards a cleaner industrial sector.

Engineering skills are both critical in industrial decarbonisation through hydrogen and perceived, by the sector, as difficult to acquire. This is echoed across the hydrogen economy. Technician roles are easier to fill and hydrogen specific skills at that level can often be embedded through on-the-job training programmes. Whilst much of the technology is still in development, employer/provider collaborations such as those described below are essential.

2. Transport

In the automotive industry, transitioning to hydrogen means moving beyond traditional combustion engines to hydrogen fuel cells, particularly for heavy goods vehicles (HGVs) coaches and construction equipment, where electrification may not be as suitable as it is for cars and light vehicles due to weight and expected travel distances. This shift requires developing a hydrogen refuelling infrastructure and redesigning vehicles to accommodate fuel cells and hydrogen storage systems. The technical challenges include ensuring the durability and efficiency of fuel cells under varied operating conditions. However, this transition offers the opportunity to reduce dependency on fossil fuels, cut emissions and potentially revolutionise vehicle design, emphasising hydrogen's role in powering cleaner transportation solutions.

The current limited availability of hydrogen HGVs or tractor units means purchase costs are high. Greater adoption of the technology is expected to see prices come down as hydrogen enabled transport becomes more mainstream.

Roles critical to the scaling of hydrogen-enabled automotive require hydrogen specific training. Industry reports that providers are beginning to respond to demand signals in regions where this technology is being developed. A number of research roles, however, find themselves on the critical list due to the pull of other developing technologies, including batteries, which are receiving more research funding. This could impede the evolution of technology and delay the mainstreaming of hydrogen-enabled transport.

CASE STUDY

hydrasun

Pioneering Skills and Technology in the Hydrogen Sector.

Hydrasun has been a key player in the UK's hydrogen sector for more than seven years, contributing to more than 40 projects across areas including transport and industrial fuel switching. Their offerings include packaged Hydrogen Refuelling Stations and comprehensive support for engineering, procurement, and construction (EPC) contractors. This extensive experience has positioned Hydrasun as a key contributor to the advancement and operational efficiency of the UK hydrogen market.

Key Projects and Initiatives

One of Hydrasun's significant achievements is the development and deployment of hydrogen refuelling stations, which are essential for the growth of hydrogen-powered transport. These stations are crucial for establishing a robust infrastructure to support hydrogen vehicles. Additionally, Hydrasun has been instrumental in industrial projects aimed at transitioning to hydrogen fuel, demonstrating their versatility and expertise in various hydrogen technology applications.

Hydrasun supported the pneumatic testing for the Toyota Hilux prototype, a newly designed hydrogen vehicle that is being developed and manufactured in the UK. Hydrasun carried out the survey of work required and offered a turnkey solution including the supply of all relevant equipment, scheduling competent manpower resources, and producing appropriate risk assessments and testing procedures. This project aims to highlight the practical applications and benefits of hydrogen technology in reducing industrial carbon emissions.

Hydrogen Skills Academy

To meet the growing demand for skilled professionals in the hydrogen sector, Hydrasun has established the Aberdeen-based Hydrogen Skills Academy. This academy is designed to provide specialised training and upskilling opportunities to support the local industry. It focuses on bridging current skill gaps, particularly in technical and operational roles essential for maintaining and operating hydrogen projects safely. As more projects move from initiation to operational stages, the demand for technically proficient staff is expected to increase significantly.

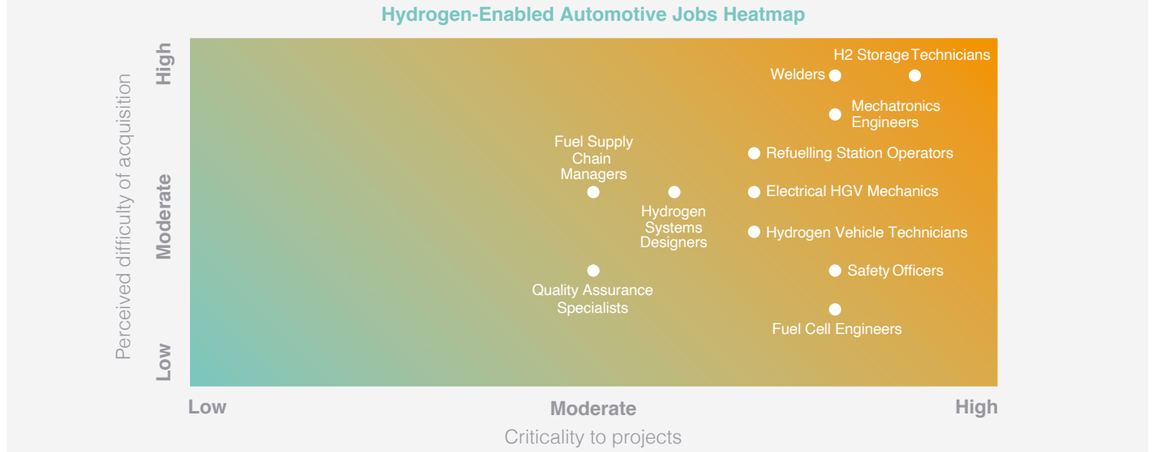
While Hydrasun has not yet faced significant skill shortages, they anticipate an increased demand for technical roles in the near future. To prepare, Hydrasun offers ongoing upskilling opportunities for internal and external engineering and technical staff through the Hydrogen Skills Academy. Current training needs focus on awareness and safety, but as projects evolve, there will be a greater need for advanced technical skills.

Future Outlook and Policy Recommendations

Looking ahead, Hydrasun expects a substantial increase in demand for trained professionals in technical operations and maintenance roles. To support this, they advocate for the establishment of training standards to ensure a skilled and competent hydrogen workforce. Additionally, they stress the importance of funding for upskilling and reskilling initiatives, which are vital for meeting the future requirements of the hydrogen industry.

While Hydrasun's efforts are pivotal for the local hydrogen sector, it is essential to recognise that the pace at which hydrogen skills need to be developed across the UK requires a more connected, national approach. The creation of a national Hydrogen Skills Academy could leverage regional expertise, like that of Hydrasun, within a collaborative framework to minimise repetition of effort and ensure a unified advancement in hydrogen skills across the UK.

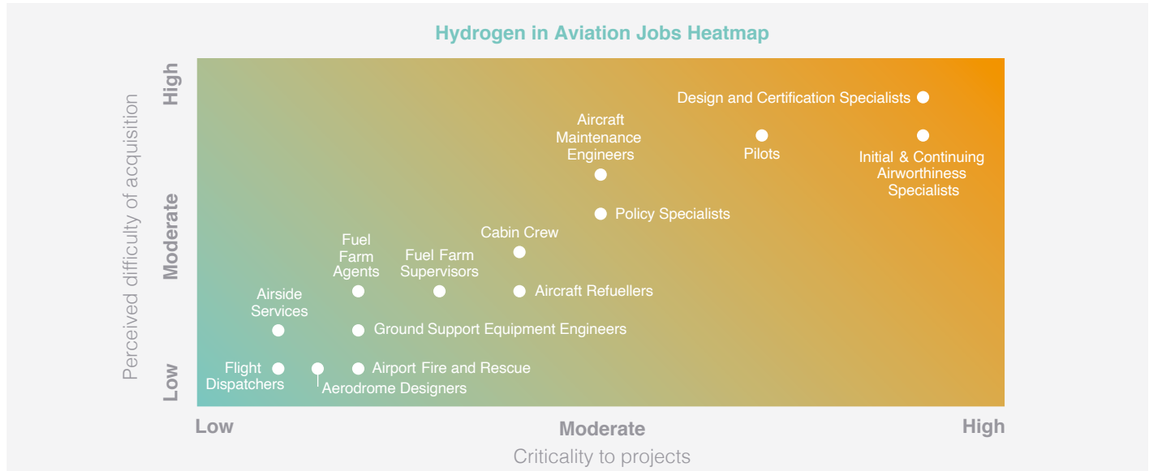
The emergence of hydrogen as a versatile and clean energy source offers transformative potential for a wide range of uses



3. Aviation

Integrating hydrogen into aviation is perhaps the most technically ambitious application, involving the development of new aircraft designs to accommodate hydrogen fuel storage and distribution systems that meet the industry's rigorous safety and performance standards. This shift not only challenges the current fuel supply and distribution paradigms but also promises significant reductions in aviation's environmental footprint. Aerospace engineers, fuel system designers and safety specialists are at the forefront of tackling these challenges, working on innovations in hydrogen fuel storage, propulsion systems and aircraft design to make hydrogen-powered flight a reality. Although experimental flights have been taking place since the late 1980s, the first hydrogen-powered commercial aircraft is not expected to take off until 2035.

Work continues to ensure the right training programmes are available to enable airports to operate hydrogen-fuelled flights. For example, the HSA's work to foresight cryogenic storage and fuel cell manufacture – led by the National Composites Centre – will be crucial to ensuring training providers can deliver the right skills at the right time to support the new technologies as they develop towards manufacture. Many of the roles required for hydrogen flight already exist but will require a programme of up- and reskilling.



CASE STUDY

Encirc 360, a leading glass manufacturer and filler, produces 40 per cent of all bottles in the UK and Republic of Ireland, amounting to about three billion bottles each year. With operations at three sites in Cheshire, Bristol, and Northern Ireland, Encirc is at the forefront of the glass industry's decarbonisation efforts.

Decarbonisation Efforts at the Cheshire Site

The Cheshire site, which houses the world's two largest container glass furnaces, is spearheading this transition. Currently, these furnaces run predominantly on natural gas, supplemented with electricity. However, Encirc is collaborating with the HyNet project to secure a supply of low-carbon hydrogen, starting in 2027.

The plan initially involves blending hydrogen with natural gas in the existing furnaces to reduce carbon emissions. This will continue until the early 2030s when the existing furnaces reach the end of their operational life. At that point, Encirc will build new, ultra-low-carbon furnaces that will run entirely on a blend of sustainable fuels, which could include hydrogen, renewable electricity, and biofuels, among others. This major infrastructure project demonstrates the need for specialised construction skills in hydrogen furnace technology.

Workforce and Training Requirements

The Cheshire site employs approximately 1,000 staff, with key roles in production, glass making, and filling. Transitioning to hydrogen furnaces requires specific expertise in hydrogen safety and operational protocols. Technicians and furnace managers will need comprehensive training to manage and operate hybrid and hydrogen-fuelled furnaces safely and efficiently.

In preparation for this move, Encirc is working with Glass Futures, a company based in St. Helens. Glass Futures is conducting research by building a small-scale furnace to test hydrogen and other sustainable fuels. This partnership is crucial for developing the skills and knowledge required for constructing and operating large-scale hydrogen furnaces.

While the shift to new hydrogen-powered furnaces will significantly reduce the overall carbon emissions from the manufacturing process, Encirc plans to integrate carbon capture technology in the future to bring carbon emissions effectively down to zero.

Recruitment and Retention Challenges

Encirc already faces challenges in recruiting for roles in engineering, mechanics, and fitting, which are crucial for maintaining and upgrading furnace operations. Historically, retaining staff in the demanding conditions of glass production has been challenging. Shift work, combined with the hot and demanding work environment, has contributed to high turnover rates. However, Encirc has recently implemented initiatives to improve working conditions and integrate high-tech solutions. By making roles more appealing, Encirc has significantly reduced employee turnover and attracted new talent, ensuring a skilled and adaptable workforce for the future.

Encirc 360's transition to hydrogen-powered furnaces marks a pivotal step towards sustainability in the glass manufacturing industry. The company's dedication to decarbonising its operations necessitates a skilled and adaptable workforce, with a focus on retraining existing employees and recruiting new talent in technical and analytical roles. By investing in employee training and partnering with research organisations, Encirc 360 is poised to lead the industry in decarbonisation while evolving its workforce to meet future demands.

A Strategic Skills Plan for the UK Hydrogen Economy

CASE STUDY

The Aerospace Technology Institute (ATI) is a pivotal independent not-for-profit organisation in the UK's aerospace and aviation sectors, funded by both industry and government. Their mission includes advancing mid-TRL (Technology Readiness Level) research, with a strong focus on developing technologies that reduce carbon emissions from aviation.

Their 'FlyZero' project, launched in 2021, was an intensive research project investigating zero-carbon emission commercial flight. The independent study brought together experts from across the UK to assess the design challenges, manufacturing demands, operational requirements, and market opportunities of potential zero-carbon emission aircraft concepts. The project concluded that liquid hydrogen presents the most promising solution for significant carbon emission reductions in aviation. Following this breakthrough, major industry players such as Rolls-Royce and Airbus UK have initiated mid-TRL hydrogen research and technology programmes through the ATI Programme. However, the efforts of many companies within the sector are currently constrained by the limited availability of extensive test facilities in the UK, access to a secured liquid hydrogen supply for research and development, a coordinated research approach to the underpinning fundamentals and a lack of suitably qualified staff are hindering large-scale testing and implementation.

Current Progress and Demand

The use of hydrogen as an aircraft fuel is still in the early stages of technology development. From a skills perspective, both industry and academia are struggling to find people with a combined understanding of cryogenics, hydrogen and aerospace engineering. This presents a challenge where the industry must recruit people with cryogenic skills and then upskill them in aerospace, or vice versa. Individuals with a combination of these skills are not just rare in the UK but also globally, which drives wage inflation. This is particularly problematic for SMEs in this space, who can struggle to compete for talent.

There are cryogenic courses within academia, but they tend to be quite broad and do not deliver the specific skills required for application within aerospace. There is an urgent need for aerospace-specific cryogenic courses at the postgraduate level to deliver the understanding necessary for innovation and technology development. However, there is recognition that with the technology still in its infancy, providers may be cautious about developing courses that are deep enough to achieve what is needed but also broad enough to attract sufficient learner numbers to make them viable. Individual modules could be developed as an interim step until there is greater certainty about which direction the technology will take.

At the same time, the research and testing being undertaken require skilled technicians trained in hydrogen safety and handling for practical applications and day-to-day operations. ATI, in conjunction with the Aerospace Growth Partnership (AGP), also recognises a need for more engineering skills in general. Engaging professional institutions to develop dynamic and responsive engineering qualifications that can adapt to technological advances in hydrogen usage is essential.

Conclusion

ATI's support for hydrogen technology development underscores significant progress and substantial challenges in skills and workforce development. There is a need for strategic, long-term government commitment to funding hydrogen skills development to establish robust training programmes to develop the required hydrogen research capability and the future workforce. Government support is essential to overcoming the hesitation of the private sector to invest in early-stage hydrogen technology development due to its high-risk nature, and this is best supported through long-term structured investment in hydrogen low-TRL research, growing UK skills and capability in hydrogen as a result. There is also a need for enhanced collaboration between training providers and industry to ensure that training programmes meet actual demand, not just in terms of numbers but also in content that matches the specific requirements of the aerospace industry.

Addressing these gaps requires coordinated efforts between industry, academia, and government to create a sustainable and skilled workforce capable of advancing hydrogen technologies within the aerospace sector.

4. Maritime

Hydrogen is poised to play a significant role in the maritime industry, offering a cleaner alternative to traditional fossil fuels and a source of clean energy for port operations. Approximately 80 per cent of global trade by volume and more than 70 per cent of global trade by value are carried by sea and are handled by ports worldwide[11].

The UK has a rich maritime heritage, and the sector will have continued importance in the transition to net zero. Maritime vessels represent around 5 per cent of the UK's domestic transport greenhouse gas emissions[12] but our heritage of shipbuilding, advanced technology and maritime service industries provide a skills base that positions us well to lead in the development and adoption of hydrogen fuel propulsion technologies.

Decarbonising the maritime sector is challenging. So far, emerging low-carbon technology solutions consistently carry increased cost, compared to traditional hydrocarbon technologies. However, hydrogen-fuelled propulsion is increasingly being seen to offer significant potential for the maritime sector, alongside other zero and low-carbon technologies.

The report titled "The Regulation of Hydrogen Fuel Propulsion in Maritime Vessels"[13] emphasises the critical need for specialised training programs to equip the maritime workforce with the necessary skills for handling hydrogen technologies safely and efficiently. It highlights the importance of collaboration between the maritime industry and educational institutions to develop relevant curricula, fostering innovation and research skills to drive technological advancements. The report also confirms the need for enhanced regulatory and safety knowledge specific to hydrogen fuel propulsion and suggests leveraging cross-sector skills transfer from industries like automotive and aerospace to accelerate adoption in maritime applications.

5. Heating

Implementing hydrogen for residential and commercial heating involves modifying existing gas networks and boilers to transport and utilise hydrogen safely. This transformation faces technical hurdles, such as ensuring materials used in pipelines and appliances can withstand hydrogen's properties and training technicians to install and maintain hydrogen-specific heating systems. Despite these challenges, hydrogen heating offers a substantial opportunity to decarbonise the building sector, requiring concerted efforts to upgrade infrastructure, develop safety protocols and educate consumers and professionals about hydrogen use.

11. Review of Maritime Transport 2018 | UNCTAD
12. The Regulation of Hydrogen Fuel Propulsion in Maritime Vessels (publishing.service.gov.uk)
13. The Regulation of Hydrogen Fuel Propulsion in Maritime Vessels (publishing.service.gov.uk)

CASE STUDY

SGN is collaborating with other UK gas distribution networks and the UK and Scottish governments to investigate how to repurpose existing gas pipes for hydrogen delivery instead of natural gas. This initiative aims to build a robust evidence base for hydrogen, which, alongside other renewable technologies, could shape the way we heat our homes in the future.

Replacing fossil fuels is crucial to meeting the net-zero targets set by the UK and Scottish Governments. Home heating is one of the biggest challenges to achieving this, as around 30 per cent of national carbon emissions come from heating buildings. As a key player in the UK's gas distribution network, SGN is exploring various solutions, including biomethane projects and several pioneering hydrogen initiatives.

H100 Fife

The H100 Fife project is a pioneering initiative creating a world-first hydrogen heating network powered by offshore wind. This project aims to deliver green hydrogen safely and successfully to customers in Fife. The project, now adopted as the 'Hydrogen Neighbourhood' trial within the UK Government's Ten Point Plan for a Green Industrial Revolution, will offer customers the choice to opt-in and get connected to the new hydrogen gas network until 2027.

LTS Futures

This project is focused on researching, developing, testing, and demonstrating the compatibility of Local Transmission System (LTS) assets, pipelines, and associated fittings with hydrogen. It will conclude with a groundbreaking repurposing trial to provide a blueprint methodology for repurposing the LTS in Great Britain's network for hydrogen. This project is crucial for enabling the large-scale transformation of the UK gas network, driving decarbonisation efforts.

Skills Development and Training

The H100 site involves the production, storage, and distribution of clean hydrogen, requiring a new skill set for SGN staff. A number of activities have begun to address this:

- Skills Mapping: Skills required for hydrogen were mapped against those of staff at similar SGN sites, such as the Scottish Independent Undertaking (SIU), where the network already operates with non-network gases.
- Identification of Impacted Job Roles: Collaborative efforts were undertaken to identify 15 job roles impacted by the transition from natural gas to hydrogen. Action plans are being created to equip staff with the necessary skills.
- New Training Initiatives: A "Future of Energy" team has been established, and specific hydrogen training has been delivered. In-house training teams are developing new materials to ensure the workforce is adequately prepared.
- Skill Gaps: The primary skill gap identified is in production and storage, as SGN does not currently produce or store gas. While front-line skills are expected to remain similar over the next five to 10 years, support skills (e.g. Network Analysts and Planners) will evolve as hydrogen usage becomes more prevalent.

SGN has conducted workshops with key stakeholders to map out the training and development needs of front-line staff involved in the H100 project. These sessions also included scenario mapping for planned and unplanned events, ensuring all necessary competencies are in place for the project's success.

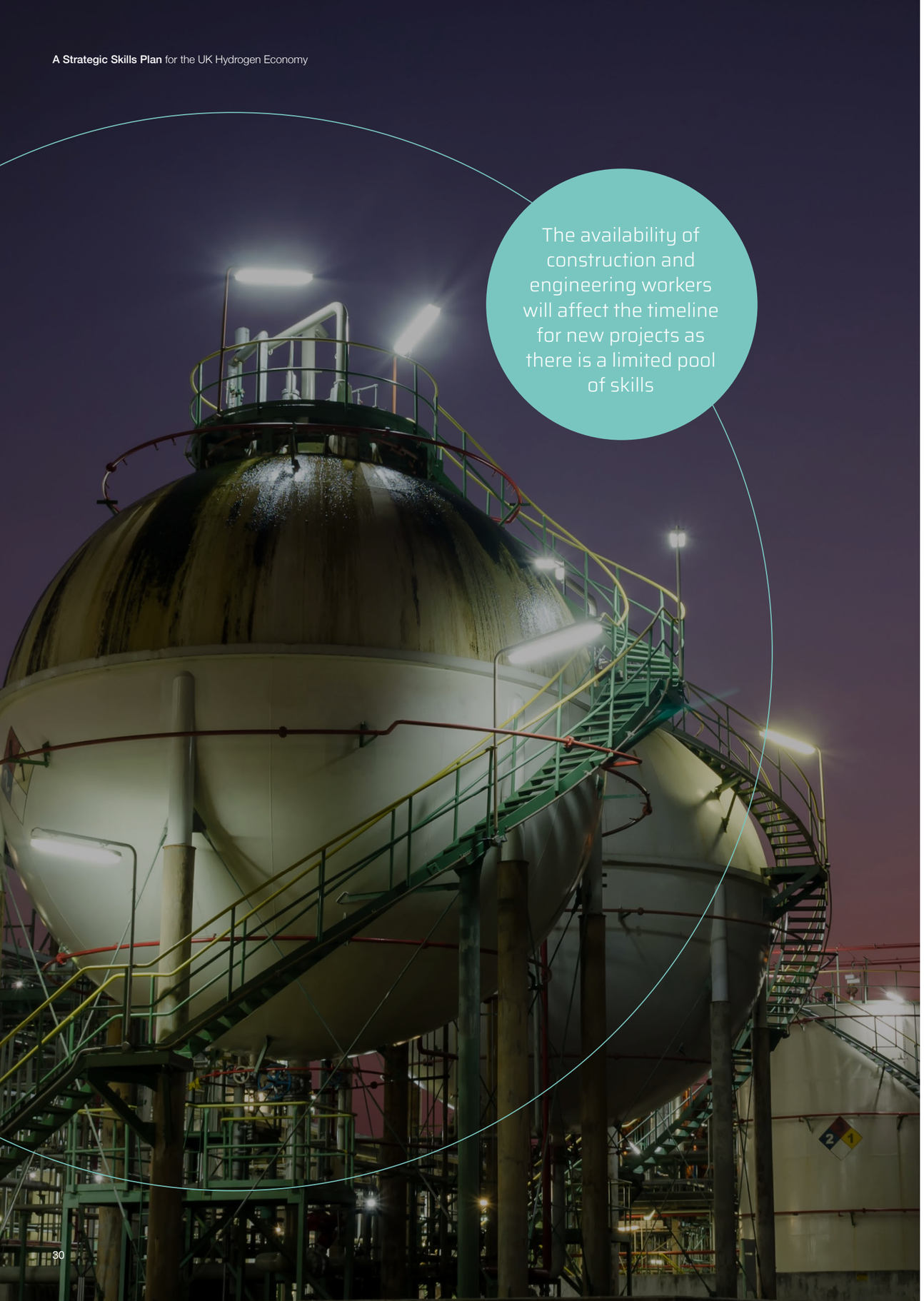
Transitioning to hydrogen involves new tools, equipment, pipe fittings, personal protective equipment, and policies and procedures. These elements are being incorporated into training programmes to ensure they become standard practice as the industry shifts towards hydrogen.

Construction of hydrogen infrastructure

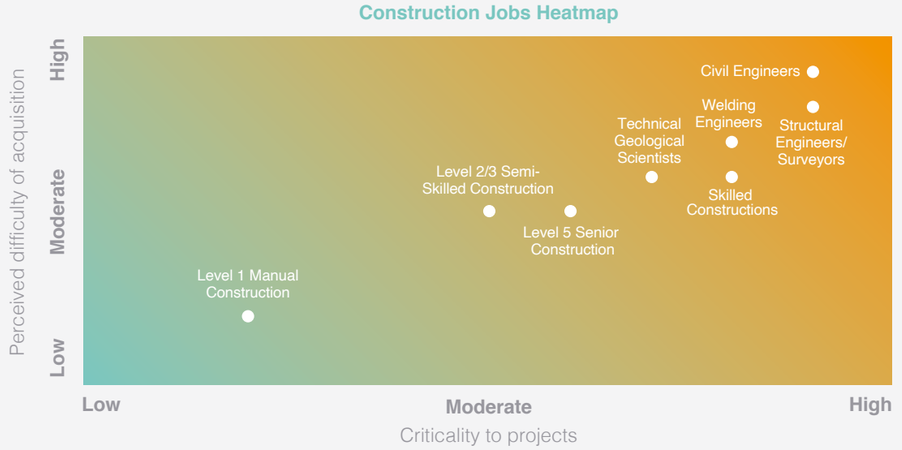
A growing hydrogen sector will inevitably put increasing demand on the construction industry as new facilities are required. The availability of construction and engineering workers is likely to affect the timeline for new projects with competition for a limited pool of skills from other national infrastructure projects such as HS2 and the expansion of Heathrow alongside those directly related to net zero (for example, the construction of carbon capture pipelines, development of offshore wind and the construction of new nuclear power plants). The government's focus on housebuilding will put a further squeeze on the available workforce with CITB highlighting a need for 250,000 additional workers by 2028 to meet growing housebuilding demand[14] alone.

The construction of hydrogen production facilities is a complex endeavour requiring precision and expertise. These facilities involve advanced technologies that can handle the intricate processes of electrolysis and carbon capture, necessitating the expertise of chemical engineers,

14. CSN Industry Outlook - 2024-2028 - CITB



The availability of construction and engineering workers will affect the timeline for new projects as there is a limited pool of skills



civil engineers and architects who specialise in industrial projects, as well as consenting roles and planners. Similarly, the development of storage solutions, such as high-pressure tanks, salt caverns and cryogenic tanks, calls for engineers with specialised knowledge in materials science and cryogenics.

The transition to a hydrogen economy also involves retrofitting existing buildings and infrastructure to use hydrogen for heating or power generation. This demands a broad spectrum of construction professionals, from electricians and plumbers to HVAC technicians, each with knowledge of hydrogen-compatible technologies.

Demand across the whole economy is already outstripping supply of civil engineers, project planning, surveyors, welders and other skilled construction trades. Civil engineers, geologists and pipe welders are among the engineering occupations critical to the hydrogen industry in short supply.

CASE STUDY

STATERA
BALANCING THE GRID

Statera Energy is a leader in the development, operation, and maintenance of assets which provide critical grid balancing support in a renewables-led power system. Statera has more than 1GW of projects in operation or construction, and a pipeline of more than 16GW.

One of its flagship projects is Kintore Hydrogen in Aberdeenshire, which aims to produce green hydrogen using surplus electricity from Scottish offshore wind farms. Kintore Hydrogen could play a substantial role in decarbonising power generation facilities and carbon-intensive industrial clusters across the UK, supporting the energy transition, creating highly skilled jobs, and encouraging investment in the hydrogen supply chain.

Project Overview

The 3GW Kintore Hydrogen project is planned to be executed in phases. When fully operational, the project will contribute a significant share of the UK's total hydrogen production capacity.

The project's front-end engineering design (FEED) commenced in the summer of 2023 and is expected to complete later in 2024. Should the project be successful in securing planning permission, construction is planned to commence from 2025 with the first phase of up to 500 MW operational from 2028 and subsequent phases following into the 2030s.

Construction

The 3GW project could create up to 3,500 jobs across the site and the supply chain. There will be a high demand for skilled roles on site such as electricians, pipe fitters, welders, and instrument technicians. Successful execution of the project will require skilled construction managers to oversee and coordinate large teams, manage safety, and ensure project timelines are met.

The sector faces challenges in securing this labour due to a limited and in-demand pool of workers and managers with experience in handling large-scale energy infrastructure projects in the UK. The sector has an ageing workforce and low entry rates, as attracting and retaining young people for itinerant, project-based roles has become more difficult in recent years. To address these recruitment challenges, Statera Energy is focused on making construction careers more appealing by providing viable long-term career pathways.

Statera Energy is also committed to recruiting from the local workforce, particularly those looking to transition from analogous industries in Aberdeenshire who have skills and expertise which can transfer to new areas. The company is placing great emphasis on providing opportunities for young people by taking on graduate engineers and apprentices, aiming for a market-leading ratio of apprentices for every experienced worker in the supply chain.

Statera is building partnerships with local academic and training institutions, including local universities and Northeast Scotland College, to generate excitement and interest in the project and the broader hydrogen sector. These collaborations aim to foster a skilled workforce ready to tackle the challenges and opportunities presented by the hydrogen sector.

Operation

Once operational, the project could require up to 200 personnel on site. Key roles will include process operators, maintenance technicians, chemical engineers, and production chemists. Many of these positions could be filled by professionals transferring from the gas and chemical industries, with the benefit of additional training on hydrogen-specific safety protocols.

Supply chains

The UK Hydrogen Supply Chain Strategic Assessment[15] identifies priority supply chain areas in which the UK should look to anchor and invest, including through investment in skills. The Assessment highlights that the development of a suitably trained workforce is crucial to deliver hydrogen projects and support the wider supply chain. It prioritises the following value chain areas:

- Electrolytic hydrogen (electrolyser stack, power electronics)
- CCUS-enabled hydrogen (reformer package, air separation unit, CO2 capture package)
- Hydrogen network (pipes)
- Hydrogen storage (compressed storage tanks)
- Hydrogen in industry (burners, kilns, ovens, furnaces etc.)
- Hydrogen for power (gas turbines)
- Cross Cutting Elements such as hydrogen compressors, high voltage transformers, construction, engineering and installation activities

The National Wealth Fund will mobilise billions of pounds of investment in the UK's world-leading clean energy and growth industries. This includes the potential to support companies in the hydrogen supply chain, as well as specific delivery projects, with an expanded suite of financial instruments. At least £5.8 billion of the NWF's capital will focus on the five sectors announced in the manifesto: green hydrogen, carbon capture, ports, gigafactories and green steel. In addition, £8.3bn has been committed for Great British Energy (GBE) over the course of this parliament. GBE is a new, publicly owned energy company designed to drive the deployment of clean energy, boost energy independence, create jobs and ensure UK taxpayers, billpayers and communicates benefit from clean, secure, home-grown energy.

In this section on supply chains, we have identified three pivotal areas not previously covered in our strategy: the enhancement of hydrogen manufacturing equipment, the manufacture of high-pressure hydrogen compressor packages for cavern storage, and the production of hydrogen-fuelled gas turbines. Each of these technologies has been identified by the UK Hydrogen Supply Chain Strategic Assessment as playing a vital role in supporting the hydrogen economy, underpinning the broader efforts to establish a sustainable and versatile energy system.

1. Hydrogen manufacturing equipment

The production chain for hydrogen manufacturing equipment is intricate, involving a plethora of essential components and systems designed for the efficient generation of hydrogen. At its core are electrolysers, used predominantly in the production of green hydrogen through the process of water electrolysis. Similarly, methane reformers play a pivotal role in CCS-enabled hydrogen production. Complementing these primary systems, ancillary equipment (such as compressors for gas movement and purifiers for ensuring hydrogen purity) are indispensable. The manufacturing of these components necessitates not just precision engineering but also continuous innovations in materials science, aiming to boost the systems' efficiency, enhance their longevity and improve overall cost-effectiveness. The evolution of these technologies is critical, demanding ongoing research and development to meet the growing and diversifying needs of the hydrogen market. Again, many of the skills required are already mainstream but require some additional training to embed hydrogen-specific knowledge.

2. High-pressure hydrogen compressor package manufacture

Storing hydrogen in subterranean caverns requires its compression to exceptionally high pressures, making the production of high-pressure hydrogen compressor packages crucial to the supply chain. These specialised packages include advanced safety mechanisms and precise monitoring systems tailored for hydrogen's unique properties. Their design and manufacturing processes must prioritise robustness and reliability, conforming to rigorous safety standards. This level of engineering sophistication ensures that hydrogen can be stored safely and efficiently, ready for distribution and use across several sectors.

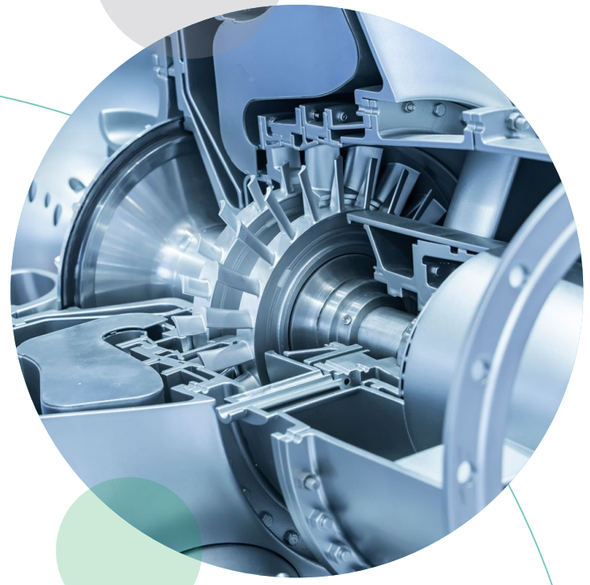
15. FINAL-HUK-Supply-Chain.pdf (hydrogen-uk.org)

3. Gas Turbines

Although gas turbine technology isn't new, hydrogen gas turbines are pivotal in the transition to sustainable energy, offering a cleaner alternative to the use of natural gas. Gas turbines have a range of applications across power generation and propulsion including in power plants, jet engines, marine propulsion and the extraction and processing of oil and gas. The availability of hydrogen-fuelled gas turbines is crucial for the decarbonisation of industrial applications including power generation in steel mills, refineries and petrochemical plants, as well as for grid firming alongside renewable energy sources.

The manufacture of hydrogen-fuelled gas turbines requires a diverse set of skills across various disciplines including mechanical and materials engineering to precision manufacturing and quality control. The UK has a unique opportunity to capitalise on the global rise in demand for this technology if production capability and capacity is not hindered by a lack of skills.

The UK has a unique opportunity to capitalise on the global rise in demand if production capability and capacity is not hindered by a lack of skills



A Strategic Skills Plan for the UK Hydrogen Economy

CASE STUDY

CPH2 is a UK-based manufacturer specialising in membrane-free electrolysis equipment. Unlike traditional electrolysers that use expensive platinum group metals, CPH2 employs a unique approach using cryogenics to separate hydrogen and oxygen. This method eliminates reliance on specific minerals and offers a more sustainable solution.

Current Progress

CPH2 has made significant strides in the hydrogen sector by developing an innovative electrolysis technology that is both cost-effective and environmentally sustainable. Their equipment is designed to be more accessible and sustainable, contributing to the broader adoption of hydrogen technologies.

CPH2 employs a diverse workforce from various engineering backgrounds, often integrating skills from non-hydrogen industries. There is a growing need for technicians and engineers who can adapt their existing skills to the hydrogen industry. The training required to transition someone into hydrogen roles focuses predominantly on hydrogen principles and safety. In many cases, the day-to-day application of skills won't change much from, for example, the oil and gas sector - it's the specifics of handling hydrogen safely that need to be learned.

Challenges Related to Skills and Workforce Development

Specific Skills Required:

- Electrochemistry and Engineering: Understanding of electrochemistry, mechanical, chemical, and safety engineering principles.
- Technical Skills: Skills in handling hazardous materials, maintaining balance of plant systems, and understanding the complete electrolysis process from utilities to gas management.
- Hydrogen Knowledge: Comprehensive knowledge of hydrogen safety and operational principles, including emergency procedures.

Like many employers, CPH2 has noted that recruitment is challenging, particularly when looking for experienced engineers willing to adapt and learn new skills. Work is needed to clarify the scale of opportunity available in the hydrogen sector. Part of the challenge is that the industry is still in its early stages of adoption. There is a belief that once hydrogen starts to be produced and used at scale, it will instil confidence in the longevity of the hydrogen economy. This may stimulate interest in the industry as an attractive place to work and direct people towards pursuing education and training in relevant subject areas.

There is limited availability of external courses specifically tailored to hydrogen technologies. Existing courses are often too general and do not cover the practicalities needed for specific roles at CPH2. Different electrolyser equipment and technologies have varying training requirements for each step in the process, whether that be compression, storage, or dispensing. Because of this, CPH2 conducts comprehensive in-house training programmes on hydrogen principles and safety, supplemented by on-the-job training on their specific technologies.

As the sector grows, structured training programmes and industry standards will need to be developed, particularly for specific roles like electrolysis operators and safety technicians. This calls for collaboration between the government, educational institutions and industry stakeholders to create a coherent strategy for workforce development.

Careers Outreach

CPH2 advocates for integrating hydrogen and renewable energy topics into primary and secondary education to build a future workforce. Its careers outreach in schools around South Yorkshire aims to inspire young people about the opportunities within the hydrogen industry by tapping into their enthusiasm for environmental sustainability. This early engagement not only raises awareness but also encourages students to pursue STEM subjects, which are critical for the future of the hydrogen sector. By fostering interest at a young age, CPH2 hopes to cultivate a new generation of skilled professionals who are passionate about contributing to a sustainable energy future.

Maximising available talent

It is commonly assumed most skills will be recruited with transferable training and experience in the short term, rather than through talent pipelines. These skills may be found, for example, in adjacent or declining traditional industries, in regions with an industrial heritage or in the ex-military community. Effective training programmes must be in place to deliver hydrogen-specific competence at pace while not duplicating more generic skills already embedded.

That said, the sector mustn't neglect early investment in its relationships with schools, colleges and universities if it is to reap the rewards in terms of young talent acquisition in the medium to longer term.

Expected professional and technical skills trends

The skill requirements of the hydrogen industry are expected to evolve over time. Initially, a higher proportion of professional roles will be necessary as technology is developed and matures. As hydrogen usage becomes more mainstream, the demand for hydrogen-specific technical skills is anticipated to increase significantly. Research from the IDRIC report 'Enabling Skills for the Industrial Decarbonisation Supply Chain'[16] anticipates a demand for 28 per cent professional and 72 per cent technical roles.

Graduate recruitment

Given the critical role of graduate and postgraduate skills in the developing hydrogen value chain, it is essential to capitalise on the growing interest young people are showing in STEM subjects. Acceptances to engineering courses are up 21 per cent (from 25,995 in 2011 to 31,545 in 2020[17]). This is driven by an increase in demand from 18-year-olds, suggesting the impact early STEM uptake in schools is now having on higher education. Between 2010 and 2020, the number of women accepted into full-time STEM undergraduate courses increased by 49 per cent. In the same 10-year span, the number of UK 18-year-olds from disadvantaged backgrounds accepted into full time undergraduate STEM courses increased by 79 per cent (from 7,265 in 2010 to 13,040 in 2020[18]). But there is much more to do if we are to achieve the workforce numbers required to maximise the potential of the hydrogen economy.

According to the Institute of Engineering and Technology's report 'Engineering Kid's Futures', it is estimated there is a shortfall of more than 173,000 workers in the STEM sector. That equates to an average of 10 unfilled roles per engineering business in the UK, costing the economy an estimated £1.5 billion per annum. What's more, almost half (49 per cent) of engineering businesses report difficulties recruiting the skills they need[19]. We already know jobs available in the industry are not widely understood and a lack of science capital means young people are less likely to study appropriate subjects if they haven't been exposed to the industry.

A key concern of recruiters of professional skills is the lack of relevant work experience gained by new graduates and the significant time it takes a newly-graduated engineer to become fully competent. Alternative graduate routes such as Degree or Graduate Apprenticeships are gaining favour with both employers seeking to overcome those challenges and learners looking for a lower-cost alternative to university. In England, greater flexibility has increased the attractiveness of higher-level apprenticeships (for example, time to competence can be cut by many months by taking prior learning and experience into account through an accelerated route).

Recruitment of technicians

Apprenticeships are a common and longstanding method of recruitment of technicians in line with other science industries. HSA surveys found 43 per cent of employers, who responded, are planning to expand their apprenticeship recruitment. The well-established nature of apprenticeship programs and the widespread recognition of their value by employers could ensure a steady flow of skilled talent for the hydrogen sector. However, this potential can only be realised if standards are updated to include hydrogen-specific knowledge, skills and behaviours.

Processes for updating existing apprenticeship standards and developing or trailblazing new standards and frameworks are already in place across the UK. Across all renewable sectors, employers are calling for 'top-up' modules and upskilling courses – additional training for specific roles necessary for effective apprenticeship training to be delivered. These courses also have a potential role in delivering hydrogen-specific training for career changers with transferable skills. However, due to the nascent characteristics of the sector there are few employers with the necessary expertise to support curriculum development or trailblazer groups.

16. Research from the IDRIC report conducted by the Northwest Cluster and Chester University titled Enabling Skills for the Industrial Decarbonisation Supply Chain anticipates
17. More young people are taking STEM subjects than ever before - The Education Hub (blog.gov.uk)
18. More young people are taking STEM subjects than ever before - The Education Hub (blog.gov.uk)
19. engineering-kids-futures.pdf (theiet.org)

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To address this, the HSA is actively convening industry and other stakeholders to foresight future workforce capability, define future occupations and standards and forecast workforce demand. This proactive approach is crucial for ensuring that the hydrogen sector can develop a skilled workforce capable of meeting its evolving needs.

Maximising publicly funded initiatives

It is essential that industry understands, engages and maximises the publicly funded skills offer to reduce training costs, address skills gaps and to align national training programmes with evolving industry practices.

Each of the four nations of the United Kingdom offers a variety of publicly funded short courses that can facilitate the rapid and cost-effective upskilling and reskilling of new employees in the hydrogen sector. The sector should prioritise leveraging these existing opportunities before developing new courses.

In England, **Skills Bootcamps**[20] have caught the attention of the hydrogen sector. The flexible framework of these bootcamps permits the creation of bespoke programmes, which aren't always tied to standardised qualifications, thereby catering to unique job roles within the hydrogen sector and allowing for the early testing of curriculum in a rapidly evolving sector before a more formal qualification is settled upon. Uptake by the sector so far has been low. There is undoubtedly a need for further information to stimulate demand coupled with an aggregation of that demand to make course design and delivery cost effective for training providers looking to service a small, dispersed employer base.

Top-ups or additional specialist technical qualifications

build on existing occupational standards at technician level and enable an individual to specialise within an occupation, usually building on prior achievement. They provide a route for the technician level workforce to build on traditional skillsets and the provider market to respond to emerging skills needs. There is a need to review the current range of approved courses and agree a plan to develop and deliver additional specialist qualifications where appropriate.

From 2027 the DfE will provide learners with a loan entitlement to the equivalent of four years of post-18 education – **the Lifelong learning entitlement** – which can be used over the course of their working lives for a more flexible approach to learning. Starting with Higher Technical Qualifications, courses which were once full-time will be modularised, enabling learners to study higher-level skills at their own pace and around other commitments (as well as providing employers with additional skills in demand and learners with an expedited route to acquire skills necessary for career advancement and career change).

In September 2024, the government announced significant reforms to the apprenticeship system in England including a new **Growth and Skills Levy** (replacing the existing Apprenticeship Levy). This will include foundation apprenticeships, providing young people with a pathway into careers in critical sectors while earning a wage and developing essential skills. The new levy will also fund shorter apprenticeships, offering more flexibility for learners and employers. Employers will also be encouraged to invest more in younger workers and fund masters-level apprenticeships outside of the levy. These changes aim to address declining investment in training and the critical demand for skilled roles including those in demand for the growth of the hydrogen economy.

Scotland's **Foundation, Modern and Graduate Apprenticeships** are available from school level to retirement. Foundation Apprenticeships offer valuable work experience for students in the senior phase of school. Modern Apprenticeships are available to study from SCQF Level 4/5 up to SCQF Level 11 (funding contributions vary depending on age/subject). Graduate Apprenticeships enable employees to earn a degree while they are working (eligible employees receive full funding from SAAS). There are more than 100 apprenticeship frameworks, many of which have scope to adapt to include hydrogen modules (e.g. Engineering, Bus and Coach Engineering and Maintenance, Heating, Ventilation, Air Conditioning and Refrigeration).

20. Skills Bootcamps | Skills for Careers (education.gov.uk)

In Wales, **Green Personal Learning Accounts** provide adults in employment in Wales with a fully funded option to study part-time at an FE college or training provider partner to up- and re-skill for the green economy, including in energy, construction, engineering and manufacturing. Courses approved under this scheme are determined by an expert panel including employers to ensure a targeted approach to meeting industry demand for skills.

The Welsh Government has operated a **Flexible Skills Programme (FSP)** since 2016. The FSP is a training grant, available to all employers in Wales, who wish to purchase training courses to meet upskilling objectives and potentially create and fill more green jobs. The Welsh Government contributes 50 per cent towards the training costs. It includes specific programmes to support skills gaps in the Engineering and Manufacturing Sector as well as the development of skills to help address net zero challenges such as hydrogen.

A Northern Ireland initiative – **The Hydrogen Training Academy pilot**, led by Mid and East Antrim Borough Council – was launched in 2021. As part of the pilot, a range of hydrogen courses from Levels 3 to Level 7 have been developed, accredited and delivered to enable people to upskill themselves for Northern Ireland's growing hydrogen industry.

Skill Up, delivered across Northern Ireland, offers training in more than 300 sectors, cutting across all parts of the economy. Specific to hydrogen, 11 courses are provided through further and education providers from Level 2 up to Level 7. Additionally, a broad range of engineering, construction and manufacturing training is available, as well as transversal skills around leadership, project management and sustainable design, which have been of particular interest to the renewables sector as it grows.

Investing in the talent pipeline

The hydrogen economy will need to develop a workforce at pace. Investing in talent pipelines now is crucial for future success and should not be underestimated. To ensure local communities truly feel the benefit of hydrogen project investment, it is essential the sector has a strategic plan for careers outreach to local schools and colleges. This engagement lays the foundation to developing a local workforce that is representative of the community in which each project sits.

Employers who invest in careers education programmes say it helps them develop talent pipelines, close skills gaps, increases diversity and attracts applicants. Across the four nations employers are supported through careers education programmes to engage with schools and colleges in a structured way.

In England, the Careers and Education Company (funded by the Department for Education) has launched a free employer framework to help businesses identify and plan work with schools and colleges and align it with business objectives. The framework allows organisations to assess themselves against nine standards to quantify engagement.

In Welsh schools, the expansion of the Careers and Work Related Experience area of the new curriculum will become increasingly important for learning about green jobs, alongside existing work on programmes such as Eco Schools.

Careers Wales provide a range of support to help employers engage with schools including an education-business partnership to support employers with their school engagement activities, tailoring their support to match the level of involvement to which each employer can commit.

Employment and Enterprise Bureaus provide a range of career and training-related advice to learners in Welsh colleges and are asked to identify opportunities to highlight net zero/green career opportunities such as industry visits, placements and careers fairs.

Scotland's national skills body, Skills Development Scotland, delivers careers advice in every state school in Scotland to enable young people from S1-S6 to develop their Career Management Skills. Developing the Young Workforce (DYW) support young people to prepare for the world of work through linking businesses with education. Hundreds of employers across Scotland have signed up to the Young Person's Guarantee, which aims to connect every 16-to-24-year-old in Scotland with an opportunity.

The Northern Ireland Careers Service offers information, guidance and advice to individuals of all ages, with data driven interventions supported by the Skills Barometer. Careers advisers provide adults with information and advice on current employment trends, future job opportunities, training and post graduate opportunities. It also offers help in applying for jobs including individually tailored guidance to help individuals analyse their personal preferences, strengths, skills, abilities and personality to realise their full potential.

A Strategic Skills Plan for the UK Hydrogen Economy

Investment in relationships with schools, colleges and universities will help the sector acquire young talent

Hydrogen's unique skills supply challenges

Despite the programmes and initiatives in place, hydrogen employers are already reporting difficulties in recruiting the skills they need risking the continuing development of the hydrogen economy.

The hydrogen economy is like no other. Unlike other clean energy sectors, the hydrogen economy faces distinct obstacles that cannot be resolved with generic solutions. By identifying and understanding these specific barriers, we can develop a targeted action plan to effectively align skills supply with industry demand.

Lack of workforce and skills labour market intelligence
Building a robust regional and national picture of current and future workforce and skills demand across an evolving hydrogen value chain is problematic. There are currently only a handful of experienced workers active in some of the more nascent areas of the hydrogen economy, but workforce numbers are expected to rise almost 20 times by 2030. The evolution of the hydrogen economy will also be sporadic, dependent on multiple factors including national and regional policy decisions, private and public investment appetite, technological advancement as well as market demand and public awareness and acceptance. Without a robust understanding of future workforce demand, skills providers cannot prepare to align resource with market needs.

These challenges are exacerbated by a sectoral approach to workforce demand data gathering and the lack of a widely accepted single taxonomy across sectors and regions. This lack of coordination and uniformity can result in overlapping data, making the national picture of demand for key occupations less reliable and unable to truly inform skills planning at a national or regional level.

Lack of a single industry voice on hydrogen competencies
The UK has seen substantial advancements in hydrogen technologies in recent years, particularly in electrolysis and fuel cells. New technologies are also emerging that make these technologies more efficient and cost-effective and open the possibility of new hydrogen applications. The adoption of new technology, however, is dependent on the availability of a suitable skilled workforce.

It is essential the skills system can understand, preferably ahead of time, which occupations will be impacted by new technology and identify the knowledge, skills and behaviours those job roles will need for competency and compliance. The current fragmented nature of hydrogen skills development means there is no single source of truth regarding occupational competency. Providers do not have a clear line of sight to the training required which is leading to varying degrees of quality, duplication and lack of employer confidence.

Competition from adjacent industries and oversees markets
The workforce assessment carried out by the HSA in 2023 found UK hydrogen appears to be facing a pronounced skills shortage. This is replicated across the economy in net zero industries and in other chemical and process industry segments. Assessment carried out by the Green Jobs Delivery Group under the last government identified key occupations in shortage across the net zero landscape including welders, planners and engineers emphasising the need for a cross-sectoral approach to workforce and skills analysis.

For the hydrogen industry, there is evidence competition from adjacent sectors is already impacting the ability to increase production, storage and distribution and will lead to inflated costs as demand for skills outstrips supply.

The UK's hydrogen talent pool is being further squeezed by the European hydrogen market. Europe's policy clarity on the future of hydrogen and availability of funding is giving European projects an advantage in securing scarce talent. The heavy investment in research and development for hydrogen technologies in Europe is creating attractive opportunities for scientists, engineers, and other professionals to engage in cutting-edge projects (and European countries are currently able to offer better career stability and opportunities).

An ageing workforce
In the UK, the average age of an engineer is 54[21]. Adjacent industries, such as oil and gas, have a similar demographic across their technical workforce. The promising rise in STEM subject uptake since 2010 has not yet resulted in the necessary influx of new engineers and technicians. This risks the increasing loss of industry expertise, mentorship and institutional knowledge as a generation of engineers and technicians leave employment. There is a clear need for greater succession planning in the sector to attract and retain new entrants and to ensure vital skills and knowledge are not lost.

Lack of diversity
A data analysis brief produced by the All-Party Parliamentary Group (APPG) on Diversity and Inclusion in STEM estimated that only 27 per cent of the STEM workforce is female, and only nine per cent of the engineering community is female. Ethnic minorities make up 12 per cent of the STEM workforce which is comparable to the rest of the workforce but only seven per cent of engineers are from ethnic minority backgrounds. STEM workers with a disability are also below levels employed in the wider workforce by three percentage points.[22]

The hydrogen workforce will comprise skilled trades, technicians, operatives and engineers - but this talent pool is dominated by men. The common assumption is that the transitioning workforce will meet the growing demand for skills across the hydrogen economy, but the danger is that diversity and age demographic issues are simply imported. With the hydrogen sector in such early stages of development, there is an opportunity to plan for a different outcome. To do this, equality, diversity and inclusion (ED&I) must take centre stage. As competition for skills is so acute, the sector must work hard to appeal to people from all backgrounds and genders, maximising the talent pool from which it can recruit. Early ED&I benchmarking and monitoring would support the formation of a clear action plan to 'bake in' diversity to interventions and make sure local communities truly feel the benefit of the hydrogen projects located in their regions.

Policy uncertainty
The shortage of skills across the hydrogen economy is compounded by a reluctance from employers to invest in skills, particularly in those training to competence like apprentices, due to continuing uncertainty of demand. For example, there is low demand from Gas Safe engineers to train in hydrogen due to continued customer demand for traditional gas installation and servicing, and uncertainty about the future of hydrogen in domestic heating.

Policy shifts and political dynamics create an uncertain foundation both for prospective employees and their eventual employers. This uncertainty extends to the industry's future, making long-term planning challenging particularly when it comes to the adoption of new and innovative technology often requiring skilled immigration to be leveraged to stop up skills gaps. There is a critical need for government to take de-risking measures to unlock anticipatory investment in skills and thereby reduce spiralling wage costs and better manage skilled migration.

Nascency
The employer-led and market-driven skills systems of the UK depend on the presence of identifiable employer demand signals. This demand prompts providers and awarding organisations to respond and develop new curricula. Due to the embryonic nature of hydrogen, there is a lack of visibility of that demand which risks the proactive development of training to meet future need. Additionally, development of training requires a substantial commitment from employers to design and review the frameworks and standards that often underpin other technical qualifications and identify the need for top-ups and other modular training.

There are currently only a handful of active employers in the hydrogen economy with the experience required to support this work. This represents significant market failure and requires intervention to aggregate demand signals that may be lost among more mature sectors in the net zero economy.

Lack of provider capacity and expertise
Lack of capacity and expertise among providers to deliver hydrogen skills is a particular challenge for the industry. This is compounded by a lack of expertise flowing from industry into the further education workforce as is typical for other sectors, simply because much of the hydrogen economy hasn't existed for that long.

Lack of higher-level skills
Higher-level skills are crucial to the evolution of the hydrogen economy but are often absent from the skills conversation which tends to focus on lower-level skills. While there are pockets of excellent practice by universities in preparing a future higher-level hydrogen workforce, ensuring all institutions have the resources to offer comprehensive hydrogen education is crucial. Additionally, increasing awareness and interest among students in hydrogen-related careers is vital to the future workforce.

21. trends-in-the-engineering-workforce_engineeringuk_2022.pdf
22. APPG on Diversity and Inclusion in STEM: The State of the Sector: Diversity and representation in STEM industries in the UK: Data Analysis Brief

Many UK universities are actively involved in hydrogen research and innovation. For example, universities like Teesside, Durham and Birmingham are leading significant projects focussed on hydrogen production, storage and application[23] Historically, the UK has been a major recipient of EU research funding through programmes like Horizon 2020. However, Brexit has introduced uncertainties into future research funding and impacted researcher mobility and collaboration with EU countries.

One key challenge for research institutions considering hydrogen application comes from their requirement for people who are suitably qualified and experienced in multiple disciplines. For example, the Aerospace Technology Institute's Hydrogen Capability Network has identified a challenge recruiting experienced people with experience in both aerospace design and development of liquid hydrogen cryogenics to further its work on hydrogen-enabled aviation. Current solutions are either to recruit from overseas or from alternative sectors, with candidates then needing additional training in aerospace specific requirements. If this is not addressed, the UK's talent pipeline will not develop and the struggle to recruit will become more pronounced which could lead to industry taking this technology development and manufacture overseas.[24]

Regionality and fragmentation

Although hydrogen is often referred to as a 'sector', in reality it has applications across multiple sectors, given it is a source of energy production which can be stored, used as a vehicle fuel and power homes and industry. Each area of the UK has unique strengths and industrial mixes requiring different hydrogen applications. For example, hydrogen production may be the focus in Scotland whereas automotive development may be more prevalent in the Midlands. However, it is essential to recognise that these regional strengths often co-exist with other ancillary hydrogen applications.

The UK government has been focusing on developing hydrogen production clusters as part of its strategy to scale up the hydrogen economy. These clusters, such as the East Coast Cluster and HyNet, are designed to concentrate hydrogen production and usage in specific industrial regions. This approach aims to create hubs of hydrogen demand and supply, leveraging existing infrastructure and expertise to accelerate development and reduce costs. However, this focus on clusters can leave businesses outside these areas at a disadvantage.

For example, businesses not located within clusters may struggle to access the necessary hydrogen infrastructure, such as pipelines and storage facilities, which are being developed primarily within the clusters. Government funding and private investment are often directed towards projects within these clusters, making it harder for businesses outside these areas to secure financial support. Clusters often benefit from tailored policy and regulatory frameworks that facilitate hydrogen production and usage. Businesses outside these clusters may not receive the same level of support, creating an uneven playing field. They may also miss collaborative benefits such as opportunities to work together with other stakeholders, including research institutions, academia and industry partners to develop skills.

There are pockets of excellent practice and skills innovation across the UK. However, the fragmentation instilled in the hydrogen economy by the formation of the industrial clusters, compounded by the lack of coordination between the clusters and wider hydrogen ecosystem, means there is often duplication of effort in the development of training. Most concerning is the lack of consistency in the articulation of occupational competency to act as the foundation for course development. Here there is a risk that training is not widely recognised by other employers or incomplete training results in unsafe environments.

The wider, cross-sectoral challenges

The government's mission to make Britain a 'clean energy superpower' hinges on having the right people with the right skills in the right time and place, yet risks are already materialising. Shortages in skills and workers pose risks to the timely and cost-effective delivery of the UK energy transition and broader industrial decarbonisation.

Employers across clean energy sectors are widely reporting significant shortages in construction, engineering, electrical, fabrication and planning. These skills are crucial to the success of the hydrogen economy, and to many other industries such as wind, solar, nuclear. They are also in high demand by the UK's major infrastructure (projects such as HS2, expansion of Heathrow and the building of new nuclear facilities). Hydrogen, as a single sector, cannot solve the problem alone.

23. The Growing Role of Universities in Supporting the Hydrogen Economy - Hydrogen Industry Leaders
24. Hydrogen Capability Network – the UK skills landscape - Hydrogen Central

Infrastructure to address the barriers to skills supply

The successful development of hydrogen skills hinges on establishing a robust skills infrastructure that fosters an ecosystem for collaboration and innovation. This involves identifying emerging skills needs, developing relevant training programs, and ensuring these programs are accessible to learners across the UK. By fostering collaboration between government, wider clean energy industry and skills stakeholders, the broader cross-sectoral skills challenges that might otherwise impede the scaling up of hydrogen technologies can also be addressed.

The HSA was established in 2023 as a joint venture between Cogent Skills (an employer-led skills charity working with the science and technology sector) and the National Composites Centre, part of the High Value Manufacturing Catapult. Its mission is to develop a skilled workforce for the UK hydrogen economy through convening stakeholders, foresighting future workforce needs, defining occupations and standards, and promoting strategic action. It works across the whole Hydrogen Value Chain, bringing a holistic approach to skills development and ensuring no single area poses a particular skills pinch point to the growth of the hydrogen economy.

A Skills Value Chain Approach

To facilitate the skills system and build a suitably skilled hydrogen workforce, the HSA follows a Skills Value Chain[25] approach which connects workforce development with the wider innovation ecosystem.

The Skills Value Chain

The HSA's focus is on the early stages of the Skills Value Chain (Convene), bridging the gap between skills required for new technologies and the current workforce. These early-stage activities include skills foresighting, and the creation of a Hydrogen Skills Framework that defines occupations and competencies.

Convene

1. Foresighting skills to aid adoption of new technologies

To prevent skills from hindering the adoption of new hydrogen technology and innovation, it is essential for the skills system to anticipate future skill requirements to expedite the development of appropriate training solutions in the future. In 2020 the Workforce Foresighting Hub, initiated and funded by Innovate UK, and built in collaboration with the Catapult Network, was established to enable the sector and skills system to understand and articulate what future skills will be demanded by emerging technology.

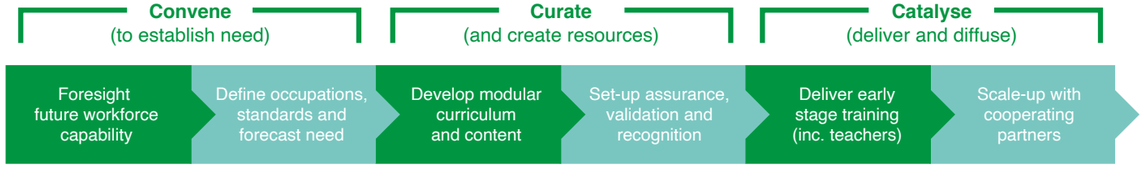
The Workforce Foresighting Hub brings together technologists, employers and educationalists to explore future supply chain capabilities and identify new or modified occupational profiles. This work is informing training provision design and adaptation to enable the adoption of new technologies in the future such as cryogenic storage, pressurised storage tanks, gas turbines and fuel cells.

2. Understanding the hydrogen skills 'delta' for experienced recruits

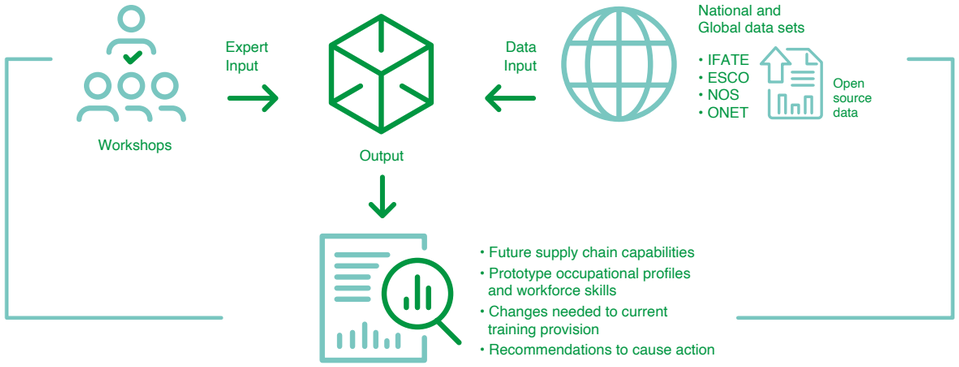
In recruiting people with transferable skills, it is vital to understand what skills, knowledge and behaviours are already embedded and what needs to be taught. This ensures people can reach competency at optimum pace and the unnecessary cost of duplicating skills, knowledge behaviours already embedded is avoided.

The HSA is seeking to better understand and articulate the 'delta' or specific knowledge, skills and behaviours that turn a generic role into something more specific to hydrogen. The resulting Hydrogen Skills Framework will provide a trusted single reference point for the understanding of training needs, the development of new training programmes and will provide evolving evidence to support the modification of existing training programmes, qualifications and university curricula.

The Skills Value Chain consists of three key steps; Convene, Curate, and Diffuse.



25. The Skills Value Chain - HVMC (catapult.org.uk)



The HSA has developed a 'proof of concept' and will collaborate with ECITB and EU Skills, who possess expertise in various segments of the hydrogen value chain, to expand the Framework across the entire hydrogen value chain.

Curate and Diffuse

The HSA has demonstrated strategic leadership in skills development at the initial stages of the Skills Value Chain, however, it faces limitations in curating and creating resources, as well as in building capacity for their delivery and diffusion. Unlike many other low carbon sectors, the evolution of hydrogen is complex, with different parts of the value chain developing at differing paces and at differing stages of maturity. Each region of the UK has a unique mix of hydrogen applications and employers with specific skills needs.

A focused and coordinated approach is essential to overcome these and other issues such as fragmentation, weak demand signals and lack of provider capacity and capability. This approach should build on the convening efforts of the HSA, recognise and leverage the unique regional footprint of hydrogen applications and expertise, and enhance provider capacity to meet future demands.

There are three distinct approaches to be considered:

Approach 1: A sectoral approach

Although hydrogen is often referred to as a 'sector', in reality it has applications across a wide range of industries, potentially touching most, given it is a source of energy production which can be stored and then utilised as a fuel for vehicles, ships and aviation and can power homes and industry.

A sectoral approach would not allow for the holistic approach required as the hydrogen industry innovates and develops its position and offer to the low carbon economy. A sectoral approach risks skills being developed, if at all, in silos with duplication of effort and resource which reinforces the fragmented approach already hampering hydrogen's ability to scale up.

Approach 2: A comprehensive clean energy approach

At face value, this appears to be a strong contender, providing a more holistic approach to the development of skills for the clean energy transition. Hydrogen, however, will require a different approach to skills development than other low carbon industries which are already at a more advanced level of maturity, such as offshore wind, in terms of technology, with occupational knowledge, skills and behaviours already mapped and comprehensive skills solutions in place. An all-low carbon approach risks priority being given to the more readily achievable objectives of other, more developed, sectors and ignoring the specific foundational processes which must be worked through if we are to avoid skills being a barrier to hydrogen's rapid technological development.

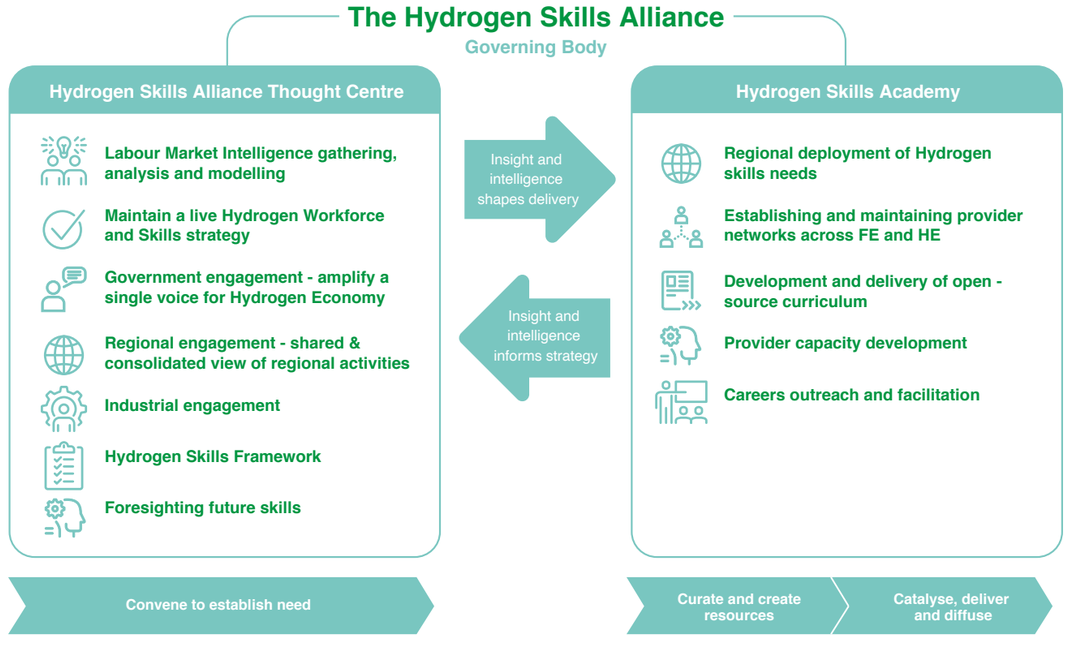
However, there is merit in considering an Academy which encompasses other emerging technologies, particularly those closely related at the molecular level, such as CCUS and biofuels. CCUS will remain integral to hydrogen production for the foreseeable future - but there is a risk that expanding the range of technologies too far could dilute the focus on skills for hydrogen.

Approach 3: A hydrogen-focussed approach

Due to the nascent characteristics of the current hydrogen industry, the need for it to scale up at significant pace and its application across so many sectors, there is an urgent need for market intervention to proactively equip providers to deliver hydrogen skills at the right time and in the right place. Lack of demand visibility is resulting in low levels of siloed curriculum development and patchy provider expertise to deliver training.

Ensuring the seamless alignment between the HSA's convening of employers and establishing of need with the Hydrogen Skills Academy's ability to develop timely training deployed regionally would be the best approach to the curation and diffusion of hydrogen skills. Right skills, right time, right place, thus completing the Hydrogen Skills Value Chain.

The interaction between the HSA and Academy would counteract current market failure. Recognising the need to act before employer demand signals become apparent, it would ensure industry-recognised training programmes are developed and provider capacity is in place to support hydrogen deployment at pace.



A Hydrogen Skills Academy would act as a network of excellence for the delivery of hydrogen skills

A Hydrogen Skills Academy should:

- Act as a network of excellence for the delivery of hydrogen skills ensuring regional hubs are established to marry national and local priorities.
- Aggregate the demand from employers as it emerges on a regional basis to build a greater understanding regionally and nationally of the workforce size and needs and ensure that provision is developing to service identified employer aggregated demand.
- Leverage regional expertise to develop open licence curriculum in the form of modular courses, using the Hydrogen Skills Framework and make it available to training providers across the UK.
- Establish a regional network of excellence to ensure hydrogen skills are delivered at a time and place needed by employers and to a high-quality standard.
- Develop train the trainer programmes to upskill education providers in hydrogen skills, particularly organisations working with sectors where there is a need for up and cross skilling, and with reach across production, storage, distribution, and use of hydrogen.
- Feed in hydrogen specific requirements to regional skills planning, influencing the availability of local provision to meet need.
- Link in with higher education to provide advice on requirements of industry to enable better designed programmes.
- Facilitate the delivery of schools-based STEM learning programmes to increase awareness of the hydrogen industry.

Rather than establishing itself as a single new body with regional teams, the Academy should build on existing regional infrastructures so that it can establish quickly and add to the sustainability of other organisations.

At a regional level	At a national level
Hydrogen employers are identified and engaged. Their skills needs are understood and reported to build a comprehensive picture of development timelines for the hydrogen economy and likely impact on jobs.	Aggregating demand insights to provide a comprehensive view of the evolution of industry jobs across the UK, feeding intelligence into government where appropriate.
Development of curriculum and resources to meet the current and anticipated needs.	A central repository of training curriculum based on the needs of employers across the country ensuring that there is no duplication of development.
Training providers are engaged and upskilled to deliver new training programmes available both within region and through the training module ‘exchange.’	A quality assurance function to ensure that the developed courses map to the central Hydrogen Skills Framework maintained by the HSA.
Employer outreach to disadvantaged groups, schools and other communities to support the talent pipeline.	Development of ‘Train the Trainer’ resources.

The benefits of this initiative include creating a more effective skills landscape to address the emerging needs of the hydrogen industry, establishing a UK-wide training provider infrastructure that is both equipped and upskilled in hydrogen technologies, and ensuring the availability of quality content which meets identified and agreed industry competencies. This positions the UK as a global leader in hydrogen training.

The Academy should build capacity, provide a legacy of programmes and materials, and create options for future skills programmes without setting a requirement for sustainability and ongoing funding.

Collective action

The HSA and Hydrogen Skills Academy will create an eco-system for skills development. However, the successful implementation of this strategic plan for hydrogen skills will require the collaborative efforts of government, industry, trade unions, skills bodies and skills providers.

Given the commonality of skills across clean energy sectors and the challenges in securing them, joint effort is the best solution to facilitate intervention at scale leading to a more seamless flow of skills into and between sectors. Whilst we welcome the establishment Skills England and the Office for Clean Energy Jobs, we propose that a collaborative group be established to include clean energy industries, trade unions, education and government focussed on tackling structural labour market challenges. Key actions should include:

- Connecting Growth with Labour Demand: Implementing a responsive industrial strategy that aligns sectoral councils and provides a unified sectoral perspective.
- Developing a Single Source of Labour Market Information (LMI): Establishing a comprehensive view of shared skills needs across the UK's clean energy economy to enable effective demand-led skills planning and better management of skilled migration and overcoming fragmentation of LMI across devolved nations.
- Unlocking Anticipatory Investment in Skills: De-risking investment to encourage proactive investment in skills development.
- Accelerating and Increasing Flexibility of Apprenticeships: Enhancing apprenticeship programs to be more adaptable and responsive to industry needs.
- Enabling Greater Mobility of Talent: Facilitating talent movement across clean energy sectors and devolved nations through clear articulation of occupational competencies, modular training, and increased access to reskilling funding.

Maximising hydrogen's potential needs a coordinated approach between industry, government, trade unions, skills bodies and providers

A Strategic Skills Plan for the UK Hydrogen Economy

A Strategic Plan of Action

Maximising the potential of the emerging hydrogen economy will require a coordinated and collaborative approach between industry, government, trade unions, skills bodies and skills providers in all four nations of the UK, leveraging the expertise already developing in the regions. While there is much to be proud of, there is still much more that must be done.

Our work must start with getting underneath the real-time workforce demand to understand the workforce make-up, skills shortages and gaps. Identification of occupations impacted by hydrogen and the competencies they will need to acquire will enable the sector to plan effectively and support both regional and national workforce strategy.

Maximising the existing offer provides a low or no-cost opportunity to train incoming workforce while we seek to establish a robust training infrastructure and develop an effective hydrogen training offer for the future. To underpin this work, we must position the hydrogen sector as an aspirational career destination to attract and retain a workforce appropriate for hydrogen's role in a net zero economy.

Understand

By improving workforce data gathering, analysis and modelling we will be able to support future workforce and skills planning more effectively at regional and national level. This is vital to ensure the supply of skills matches the demand from new and growing hydrogen projects and will enable local area skills systems to plan for skills delivery with confidence and efficacy, unlocking investment in skills and mitigating against skills shortages becoming a barrier to project timelines. The foundation for this work has already been laid in the assessment of the hydrogen workforce carried out in 2023 by Cogent Skills as part of the HSA. But there is more to do to ensure workforce analysis is increasingly accurate and effective through coordination and uniformity.

Industries adjacent to hydrogen – such as the wider chemicals, power and networks sectors – have long suffered with a lack of workforce diversity. To meet the demand for jobs we must ensure we are recruiting from the widest possible pool of talent, with jobs that appeal to all and retention policies which ensure diversity is embedded. Whilst the hydrogen economy is in its infancy, there is a unique opportunity to set a course for diversity within the sector that will reap rewards in the future. Understanding the current workforce will enable a focussed action plan to be developed, delivered and monitored.

The hydrogen sector is currently very small but will need to grow exponentially by 2030 if it is to maximise the opportunities afforded by the government's 10GW hydrogen production ambition. The growth of the sector will inevitably see new technologies evolve. It is safe to say while existing skills will form the basis of the hydrogen industry, the competencies of some occupations will need to evolve if new technologies are to be adopted, while other occupations are still to be birthed. These new competencies will need to be embedded through training. Critical to the development of effective training solutions is the ability to articulate the occupations impacted by change and the new competencies they must acquire.

To increase our understanding of the hydrogen workforce and skills needs we will:

- Build a centralised data repository and dynamic modelling tool that integrates with national and local skills planning frameworks and supports future workforce strategies.
- Support industry and sector bodies to share project data to improve forecasting through a dynamic modelling tool.
- Engage with Local Skills Improvement Plans and Regional Plans in key locations.
- Benchmark sector diversity and agree improvement KPIs.
- Champion the Skills Value Chain concept to convene employers to foresight future skills.
- Develop an opensource Hydrogen Skills Framework for key occupations that articulates the hydrogen-specific knowledge skills and behaviours.

Maximise

Although course development is patchy, each devolved nation has a strong framework in place to develop publicly funded courses that support a hydrogen workforce. Government administrations work closely with employers to review and design standards and frameworks which are the foundation for apprenticeships and often required for the development of other qualifications. With employer-led systems in place across all four nations, it is vital that the hydrogen sector continues to be well represented on employer panels tasked with ensuring standards and frameworks are fit for purpose and keep pace with technological advances and revised safety standards.

New flexible government funding for short courses and modular learning is increasingly available to learners wanting to upskill or re-skill and an expedited route to approve low carbon top-up courses for government funding is now in place in England. Wales has also set up Green Personal Learning Accounts (PLAs) to allow for flexible upskilling and retraining for the net zero economy. Although the process for acquiring government funding to deliver courses can be bureaucratic and time-consuming, it removes a barrier, providing low or no-cost training options for smaller companies and for learners needing to fund their own training. Maximising the government funded offer will help ensure routes to competency exist, whatever entry point in the career lifecycle is taken.

To maximise the use of the existing skills offer we will:

- Leverage existing government funded skills initiatives in the devolved nations.
- Develop a Hydrogen Talent Pipeline Plan ensuring relevant and appropriate routes for every entry point of career lifecycle.
- Review the current government funded skills offer and support the development of new skills programmes to incorporate hydrogen-specific requirements including in apprenticeship standards, frameworks and university curriculum.

Develop

Foresighting cycles and the development of an open-source skills framework by the HSA will bring to light new hydrogen-specific competencies that require additional training solutions. However, the nascency of the industry at present is likely to result in a lack of employer demand visibility. Without sight of that demand, providers will not receive signals they require to trigger development of the training.

There is a need for national coordination, through a Hydrogen Skills Academy, to aggregate demand across the UK and to ensure that curriculum development aligns to a national standard framework. Central coordination bridges the disparate parts of the hydrogen skills landscape, reducing duplication of effort and inefficiencies in skills development. A central repository for curricula reduces duplication and ensures public spending achieves greater value for money. By mapping content to a centralised Hydrogen Skills Framework, the overall quality and consistency of provision will be elevated, minimizing the inefficiencies resulting from disjointed public programmes.

Establishing a regional network of excellence will ensure local demand for skills is understood and fed into national priorities so that high-quality hydrogen skills are delivered at a time and place needed by employers. Regional networks will also ensure hydrogen specific requirements are fed into local/regional skills planning thus influencing the availability of local provision to meet need.

Building the necessary capacity and knowledge in the provider and assessor network is key to the effective and timely rollout of hydrogen skills training. 'Train the Trainer' programmes are required to upskill providers in hydrogen skills and overcome the current lack of expertise.

Collaborative development of new models is essential to de-risk anticipatory investment in skills by both employers and skills providers. Without such intervention, there is a significant risk that a sufficient skilled workforce will not be available at the right time and place to initiate projects. This could lead to inefficiencies, escalating wage costs, and an increased reliance on skilled migration.

Industry placements offer employers the opportunity to work alongside the next generation of workers, ensuring they develop the necessary knowledge, attitude, and practical skills to succeed. However, many businesses in the hydrogen economy operate in high-hazard environments, making these placements complex to deliver. Therefore, the hydrogen sector must collaborate to develop new models for high-quality industry placements, which are crucial for building a robust talent pipeline.

To develop effective training solutions that support the evolving hydrogen industry we will:

- Develop a comprehensive centrally owned skills up/re-skilling programme, utilising evidence provided by the skills framework and foresighting hub, developing new national occupational standards as appropriate.
- Build capacity and capability among providers and assessors.
- Contribute to the development of safety regulations and align training as appropriate.
- Develop new models to enable anticipatory investment in skills.
- Develop new models for industry placements that overcome health and safety barriers.
- Benchmark against European training standards for greater mobility of skills.

A Strategic Skills Plan for the UK Hydrogen Economy

Attract

There is a broad lack of understanding of hydrogen's role and its implications for the economy as we move to decarbonise industrial processes and replace our dependence on fossil fuels. A clear and consistent narrative for hydrogen is pivotal in talent attraction but also fosters understanding among the government, the public and potential employees. The Hydrogen Delivery Council are working on a value proposition for hydrogen, emphasising the need for a unified understanding of its importance, role and safety. Once this narrative is developed, it will help raise awareness of the vital role hydrogen will play in the UK's future economy and how effective careers programmes can be built.

Employers, during engagement activity, stressed the urgent need to integrate renewables and hydrogen topics into primary and secondary school education. The adage "if you can't see it, you can't be it" was referenced to stress the importance of showcasing clear career pathways in the hydrogen sector. Opportunities must be created for the industry to collaborate in raising awareness of hydrogen's role in achieving our net zero future and promoting the sector as an aspirational career destination.

Recruiting and developing skills at pace will be crucial for the hydrogen sector, in the face of stiff competition for skills from adjacent industries. We must develop well-defined recruitment and career pathways that position hydrogen careers as aspirational for people from all backgrounds and at all points on the career lifecycle including women returners, engineering career returners, ex-military and the under-employed.

To position hydrogen as an aspirational career destination for everyone at any point in the career lifecycle the HSA will:

- Develop and deliver a comprehensive careers offer for pipeline and mid-career changers including training hydrogen skills ambassadors with focus on building diverse talent pipelines.
- Outreach to disadvantaged and under-represented groups e.g. ex-services, under-employed, returners etc.
- Develop a hydrogen sector value proposition.
- Develop an awareness campaign for the sector dispelling public fear on hydrogen usage and demonstrating attractiveness of sector as career destination.
- Develop and deliver an action plan for ED&I in the sector.

A clear narrative for hydrogen is pivotal in attracting talent and fostering understanding between government, the public and future employees

Looking ahead

This Strategic Skills Plan sets out the rationale for decisive action that will optimise skills for a 2030 10GW hydrogen economy. It outlines the range of impactful activity overseen by the HSA that lays the foundations for a comprehensive skills offer for the hydrogen economy and recognises its limitations. It also proposes a strategic plan of action to build on and super-charge that work, overcoming current market failure and providing the mechanism to address workforce and skills challenges across the UK at pace.

Leadership and collaboration are essential and underpins this strategy. Without collaborative effort between the wider clean energy community, education, academia, trade unions and government we will not overcome the cross-cutting workforce and skills issues that are already impeding the UK's ambition to become a 'clean energy superpower'.

What is clear, is that without immediate market intervention, and centralised coordination, we will miss the opportunity to develop a skills ecosystem for the hydrogen economy that will overcome sector silos, duplication of effort and the fragmented approach already hampering hydrogen's ability to scale up.

The proposed plan should not be seen as the responsibility of the Hydrogen Delivery Council alone, but rather a blueprint for government, industry and skills stakeholders to work collaboratively together to realise UK's vision for hydrogen. Neither is it intended to be a static document, rather it will be regularly monitored, reviewed and adapted as the sector evolves. Its purpose: delivering the workforce and skills needed so the UK hydrogen economy can thrive.

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A Strategic Skills Plan for the UK Hydrogen Economy

About Cogent Skills

Cogent Skills is the skills leader for the UK's science and technology sectors. We are an employer-led skills charity, offering a diverse range of market-leading skills services to help businesses ensure they have a workforce fit for the future. From process safety and competency solutions in high-hazard industries to end to end apprenticeship services for some of the world's leading science companies, the surplus revenue from our commercial activity funds our charitable activity.

Our expertise in employer-led facilitation enables us to support a number of skills groups for employers in industries including life sciences, hydrogen and nuclear. We use the latest evidence and research to identify crucial skills gaps and barriers to the uptake of skills. We reinvest surplus from our individual businesses to deliver a positive impact in our communities and the sectors we serve. For more information, visit: **www.cogentskills.com**

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The NCC is a world leading UK research and development facility that provides access to state-of-the-art engineering capabilities and technology. Collaborating to address the most complex engineering challenges of our time, we accelerate the development of new products across advanced materials, digital engineering, sustainability and hydrogen. Delivering pioneering innovation to drive industrial transformation, NCC works across a diverse range of sectors to deliver benefit to the UK, investing in the talents of our current and future workforce.

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Hydrogen Skills
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