ABERDEEN CITY COUNCIL

bp

An integrated energy partnership

Hydrogen in Scotland

Building the supply chain

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Contents

1 Foreword

This report examines the hydrogen supply chain within the UK – with a focus on Scotland and the North-East of Scotland – and its future challenges.

It aims to identify gaps in supply chain capability and barriers facing suppliers operating in the hydrogen sector or those seeking to enter the market. It suggests how a range of stakeholders including leading corporates, training and skills providers, industry bodies, and government can help to address these gaps.

The Aberdeen Hydrogen Hub (AHH) project is seeking to play a strategic leadership role in the development of the hydrogen sector by its proposal to develop a scalable green hydrogen production, storage and distribution facility in the city, powered by renewable energy. Aberdeen City Council and bp formed a joint venture in March 2022, bp Aberdeen Hydrogen Energy Limited (bpAHEL), to deliver the Aberdeen Hydrogen Hub.

The report provides:

- An overview of the UK and Scottish government targets for transitioning to 'net zero' by 2045 and 2050 respectively, with a focus on renewable and low carbon hydrogen as an enabler. It provides a high-level review of the global context and notable hydrogen-related targets, along with an introduction to the AHH project.
- Discussion of the status of the supply chain and the challenges facing buyers and suppliers of hydrogen-focused good and services.
- Presentation of five key themes affecting the development of the hydrogen supply chain. These themes have been informed by bpAHEL procurement work, discussions with suppliers and other third parties, and research undertaken for this report.
- Recommendations and actions relating to each key theme.
- Signposting of available support and sources of funding to hydrogen supply chain participants in Scotland.

Given the intended phasing of the AHH project, which is outlined in this report, the report extends only to the hydrogen production element of the value chain. It does not address the supply chain challenges and opportunities associated with hydrogen transport and storage.

The report is an integral part of bpAHEL's supply chain development ambitions. The recommendations and actions generated will form the basis of bpAHEL's future supply chain development plan.

We hope you enjoy reading and would encourage you to engage with the AHH project through our website or planned Scottish and National in-person hydrogen focused events.

Dr Oliver Taylor
Chief Executive Officer bp Aberdeen Hydrogen Energy Limited

2 Executive summary

The transition from hydrocarbons to renewable energy sources marks a transformational industrial shift. As such, it presents established and emerging supply chains with a set of strategic challenges and opportunities.

The prospects for the hydrogen industry within the transition can be seen in the context of the Scottish and UK governments' commitments to becoming net zero by 2045 and 2050, respectively. These strategies include Scotland's ambition to achieve 5GW of installed renewable and low-carbon capacity by 2030 and 25GW by 2045, and the UK government's ambition to enable 10GW of installed production capacity by 2030.

Scotland and the wider UK are not alone in setting ambitious targets to establish hydrogen as an integral part of the energy future. The US, India, China, Japan, Australia and other countries and regions including the European Union are also providing incentives to attract supply chain investment and resources. Many investors are keen to invest in renewable and low-carbon market opportunities in the UK, but finding economically viable projects can be challenging.

The current low level of installed renewable and low-carbon capacity in the UK compared to the Scottish and UK Government targets makes the challenge to develop supply chain capability increasingly important. The lack of local manufacturing experience in Scotland, particularly for electrolysers, represents a particular challenge. Analysis by the Energy Industries Council[1] (EIC) indicates that around 2% of the UK companies (>£1m revenue) that currently support the energy industry are working in the hydrogen sector. There are skills and knowledge gaps within hydrogen-related technologies and processes, and industry standards and best practices that might help address these for hydrogen related projects that are not yet fully mature.

Procurement activity undertaken by bpAHEL underlined the scale of the challenge. The Aberdeen Hydrogen hub represents a green hydrogen production storage and distribution initiative that would be facilitated by renewable energy sources. Targeting production from 2026, once operational, the hub will have the potential to deliver up to 300 tonnes of green hydrogen a year through the initial phase of the project. Future phases could see production scaled up to diversify supply and generate large volumes of green hydrogen. This expansion will depend in part on successfully raising the visibility of opportunities for suppliers and rapid supply chain capability development.

Key themes

Five main themes have emerged through our research and supply chain engagements:

No.	Theme	Description
1	**There are specific supply chain bottlenecks**	Supply chain bottlenecks arise in the following areas: • electrolyser availability, with key uncertainties around the best supply routes. • the lead times associated with the procurement of compressors. • the availability of electrical contractors. • the provision of engineering services. All four are vital components in the hydrogen production process and represent significant elements of the project cost and the skills and capabilities required. Information sharing and establishing frameworks for prioritising projects and allocating resources could help to tackle these bottlenecks. This could include regional resource planning, information tools which support cross-training and opportunities, and resource allocation agreements.
2	**Benefit from Aberdeen and the surrounding region's experience and expertise in oil and gas**	While the challenges in making the just transition to a low carbon and ultimately net zero workforce should not be underestimated, there is a wealth of expertise, experience, and infrastructure in Aberdeen and the North-East of Scotland which could enable the region to become a hub for a future hydrogen industry of national and international significance. Transferable expertise exists in disciplines such as project management, health and safety management, engineering, supply chain management, and the provision of specialist manufacturing and maintenance capability. It has been estimated that more than 90% of the UK's oil and gas workforce have medium to high skills transferability and are well-positioned to work in adjacent energy sectors.[2]
3	**Visibility of opportunities and projects**	There is a need to increase opportunity and project visibility so that suppliers can plan and predict for future projects and scopes of work. Tools such as Offshore Energies UK's (OEUK) 'Supply Chain Visibility Tool' and the North Sea Transition Authority's (NSTA) Energy Pathfinder database, could improve supply chain visibility and help resource planning.
4	**Knowledge sharing, and the development of industry standards and best practice**	A framework for industry standards and greater transparency for suppliers and buyers is needed. There are opportunities to extend tools and systems which are well-established in the oil and gas industry to serve the hydrogen industry and other emerging sectors, including floating offshore wind and carbon capture and storage.
5	**Promoting local content**	There is opportunity and need to increase local content, that is, the provision of supply from regions geographically close to the buyer. The provision of local content would mitigate the cost and wider risks associated with importing goods and services and would capture value locally from hydrogen sector projects - supporting a just transition. Experience from the procurement activity associated with AHH has shown that there is scope to enhance local supplier understanding of what is needed to maintain and contribute towards a just transition to net zero.

Resources are already available to support companies looking to enter the hydrogen supply chain. Funding schemes have been launched by the UK and Scottish governments and a range of other organisations provide consultancy services, training, market intelligence, and guidance on bid preparation. An overview of these resources is provided in Appendix A.

Recommendations

We recommend a number of steps are taken to address the challenges. In summary, these are:

Ensure greater visibility of opportunities and upcoming projects: Transparent and timely information about opportunities and projects is needed to encourage market participation and to support investment decisions in supply chain organisations.

Support the development of knowledge sharing, industry standards and best practice: These are vital for fostering collaboration, ensuring safety, and promoting efficiency in the hydrogen industry.

Support, through the inclusion of local content provisions in tendering and procurement, the development of a local hydrogen economy which ensures that hydrogen contributes to local economic development and job creation.

3

The context

The energy transition

The transition from hydrocarbons to renewable and low carbon energy marks a transformational industrial shift, driven by environmental concerns, the need for energy security, and the maintenance of affordable supplies of energy. In this context, we see a long-term need for traditional hydrocarbons, even in a net zero world.

Diversification of energy sources presents established and emerging supply chains with a range of challenges and opportunities – requiring the production, installation, operation and maintenance of new energy technologies, advances in new materials and manufacturing processes, and the development and adaptation of skills and capabilities across the labour market.

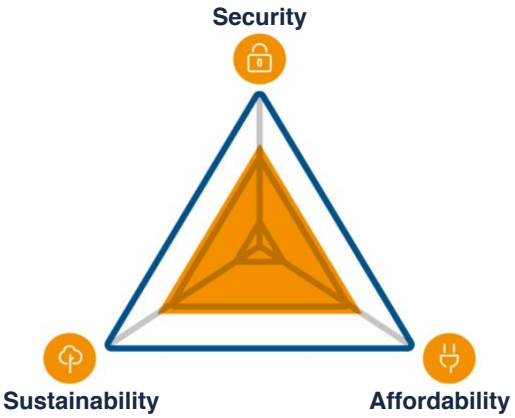
Ambitious government commitments

The Scottish and UK governments have committed to becoming net zero[3] by 2045[4] and 2050[5] respectively. Meeting these targets, while balancing the 'energy trilemma' requires the UK to build a diverse energy mix, including hydrocarbons, renewable power generation, and hydrogen.[6]

Scotland and UK governments each have their own hydrogen strategies,[7] with the UK government, in April 2022,[8] doubling its renewable and low-carbon ambition from 5GW to 10GW installed capacity by 2030.[9] As of 2022, there was less than 1GW installed – on average requiring one 20MW electrolyser per week to be installed to meet UK national 2030 targets.[10]

In December 2022, the Scottish government announced a £90million Green Hydrogen Fund to support pathfinder projects up to 2025-26.[11] In June 2022, it also introduced the Hydrogen Innovation Scheme, offering £10million, 'to support the development and demonstration of renewable hydrogen technologies and products needed to support the Scottish Government's ambition of 5GW installed hydrogen production capacity by 2030'.[12] In April 2022, the UK government committed to a £240million Net Zero Hydrogen Fund to 'fund the development and deployment of new renewable and low-carbon production to de-risk investment and reduce lifetime costs.'[13]

With the award of the ScotWind and Innovation and Targeted Oil and Gas (INTOG) licenses (see box), it is anticipated that offshore wind projects (both fixed and floating) could generate up to 40GW of low carbon intermittent electricity supply, creating an important source of green electrons, but bringing challenges for grid stability .



The '**energy trilemma**' is a framework of three objectives that energy policymakers need to balance, and which is often used as a guide in designing energy policy. The trilemma comprises:

- **Sustainability:** decarbonising energy.
- **Security:** ensuring the security and reliability of energy supplies.
- **Affordability:** minimising the cost of energy to consumers.

In intermittent oversupply circumstances, it may be efficient to use excess electricity in electrolysis and to store energy as green hydrogen, rather than in batteries. Hydrogen can then directly be consumed within those sectors that are hard to electrify, such as heavy transport, cement, and steelmaking.[14]

ScotWind and INTOG

The ScotWind leasing round sought bids for commercial-scale offshore wind projects off the coast of Scotland – resulting in 20 projects with seabed option agreements. The INTOG leasing round sought to enable innovation in offshore wind energy, and supply of wind power to offshore oil and gas platforms in the North Sea.

The context

A competitive global market

Scotland and the wider UK are not the only governments with ambitious renewable and low-carbon targets.

In the US, the Inflation Reduction Act 2022[15] entitles producers of hydrogen between $0.6 to $3 in tax credits for every kilogram of qualified clean hydrogen produced based on a GHG intensity sliding scale (from 4 to 0.45 of CO2e per kilogram of hydrogen).

India's government has announced its intention to grant producers incentives of at least 10% of their green hydrogen production costs.[16]

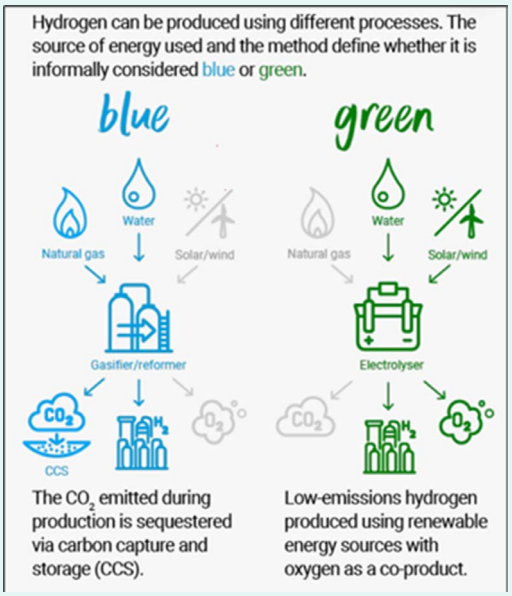
These are just two examples of the kinds of incentives that are being offered around the world to attract supply chain investment in renewables and low-carbon hydrogen. Given the competitive global market, it is arguably more important than ever to ensure that the UK, Scottish and regional supply chain has the capacity, capability and incentive to support hydrogen ambitions and to compete internationally.

The local context: the Aberdeen Hydrogen Hub

The AHH proposes a scalable green hydrogen production, storage and distribution facility in the city powered by renewable energy.

Phase one of the project will involve building a hydrogen re-fuelling facility for buses, cars, vans and trucks, as well as tube trailer export, powered by a solar farm and linked by an underground solar grid connection.

The renewable energy produced by the solar farm would be used to produce green hydrogen via electrolysis, which splits water molecules into hydrogen and oxygen.



Source: bp

The solar farm and hydrogen facility are intended to be located on separate sites linked by an underground solar grid connection. The hydrogen site would have a substation grid connection to power it using a remote onshore wind asset (via a green power purchase agreement (PPA)) during periods of low solar power production, while excess power could be returned to the grid when high solar power is generated.

The aim for phase one is to have the facility producing hydrogen from 2026. Future phases could see production scaled up through further investment to supply larger volumes of green hydrogen for rail, freight and marine, as well as supply of hydrogen for heat and potential export.

Status of supply chain capability

With the ambitious targets for renewable and low-carbon production set by the UK and Scottish governments, and with this market being in its nascency, it is likely that the local supply chain will struggle to meet anticipated demand. A number of specific challenges arise:

Hydrogen specific capability

Hydrogen, offshore wind and oil and gas all have important roles to play in meeting the UK's energy demand and ensuring a just transition to net zero.

Global competition

The hydrogen industry faces competition from other regions with attractive investment incentives, such as the US, Europe and India. This competition highlights both the need to develop a local supply chain that can help meet domestic targets while retaining local economic benefit, and the opportunity for the local supply chain to export its products and services to global markets.

Electrolyser availability

A potentially significant challenge to greater hydrogen production is the need for greater electrolyser capacity – especially considering no domestic capability in Scotland. This challenge could be met by developing domestic manufacturing capacity or enhancing existing manufacturing capability in electrolyser components and packages. Developing domestic supply could limit reliance on international suppliers, but would also entail significant commitment and investment, and is only prudent where the region can demonstrate and retain differentiated competitive advantage.

Skills and knowledge gaps

Building a highly skilled workforce with expertise in hydrogen-related technologies and processes is essential. Bridging the skills and knowledge gap is a challenge in supply chain development. bpAHEL's analysis of the skills and qualifications gap in the hydrogen market has sought to define what skills are needed and what steps should be taken for suitable future skills provision (see box).

Standardisation and best practices

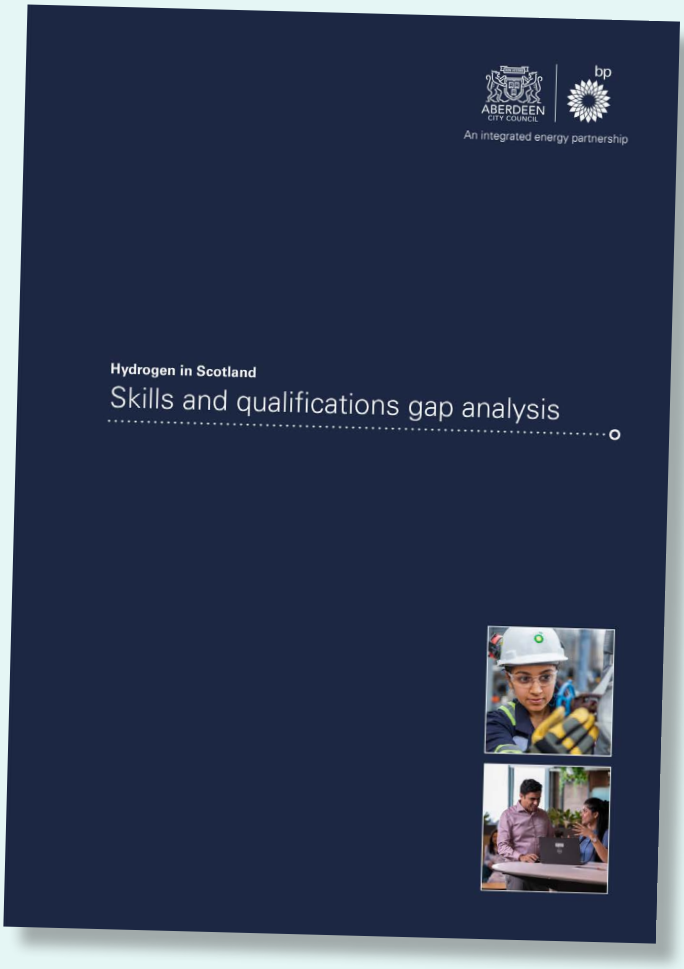
Industry standards and best practices for hydrogen-related projects are crucial for safety, efficiency and promoting a competitive market. They help suppliers by reducing the risk of developing orphan technologies or having to adapt to frequently changing technical requirements. Suppliers also benefit from knowing and being able to state that their products and procedures are in line with industry standards. However, these standards are not yet in place and developing them is proving to be a lengthy and costly process.

'Hydrogen in Scotland: skills and qualifications gap analysis':
A report by bpAHEL

'Investing in skills is critical to deliver the hydrogen opportunity and to help to contribute towards a just transition for North-East Scotland. A developed workforce could create global competitive advantage for Scotland, with potential to access £25billion in Gross Value Added and over 300,000 local jobs.

There is strong potential to transfer talent from oil and gas into renewables. Many technical skills like engineering, project management, and data analysis could be directly transferrable while skills in safety, risk management, and regulatory compliance are essential for both industries.

However, the demand for growth in adjacent sectors is a constraining factor and nurturing new sector-specific capabilities in digital, business and market development, and advocacy/ regulatory model development is vital to help capture integrated value.



Further downstream, the evolution of skills will be required, such as for inspection and maintenance of hydrogen fuel cells and to develop next generation hydrogen vehicles.

Access to a sufficient number of skilled people is likely to be a major challenge. Skills transferability could play a vital role in meeting the challenge, subject to the ability to release talent from oil and gas, and adjacent sectors such as in power, while recognising a significant proportion of the oil and gas workforce is approaching retirement.

Scotland has a vibrant and developed skills ecosystem. Many organisations are building an increasingly detailed view of what the hydrogen sector needs and are developing standards and courses to meet the rising demand'.

To access the full report, click **here**.

Experience on the ground

bpAHEL has engaged with the supply chain to understand the scope of the challenges and obstacles, and to highlight the opportunity presented by the AHH project.

Kenzey Fordyce, Supply Chain Development Lead, bpAHEL, presenting at Supplier Development Programme Meet the Buyer North, September 2023

This engagement included attending and speaking at industry conferences, such as the Energy Transition Zone Green Hydrogen Masterclass[1] and global conference Offshore Europe, as well as presenting at non-industry specific events, targeting small and medium sized enterprises such as the Supplier Development Scotland Programme's Meet the Buyer North event. bpAHEL has also taken membership of industry bodies Hydrogen UK and the Scottish Hydrogen and Fuel Cell Association (SHFCA) to amplify its voice, increase advocacy opportunities and create the opportunity to work collaboratively with other members.

bpAHEL is seeking to contribute to the local hydrogen economy through the AHH project procurement. To that end, it included requirements and expectations in key project tender packages around prospective bidders' commitment and ability to award work to local suppliers, to developing the local supply chain, and to sustainability and the just transition. The submissions received were reviewed, scored and weighted as part of the tender evaluation process. It is intended that both local content and sustainability are reported and measured through contract key performance indicators as part of the main project packages.

Engagements and procurement activity undertaken by bpAHEL in support of phase one of the AHH project confirm key challenges. For example, pre-tender engagement discussions were held with several contractors who expressed interest, but who proved unable to respond to the tender due to a lack of capacity to respond, with a particular issue being the availability of timely quotations further down their supply chain. With the exception of the civils package (which is not in itself a hydrogen-specific scope), there were only, on average, two bids for each package - significantly fewer than would be expected from comparable sized tenders in the oil and gas industry. This experience provides first-hand evidence of the shortage of contractors, particularly to support the hydrogen and electrical packages.

Aberdeen Hydrogen Hub procurement strategy

The procurement strategy included dividing the project scope into four main packages and awarding a single contract within these for design, supply, installation and commissioning. Initially, the packages were identified as:

- Hydrogen equipment
- Electrical integration and grid connection
- Civils package
- Solar PV plant

Following an initial tender phase, market engagement informed an update to the electrical integration and grid connection scope. Typically, the electrical contractors tended to be experienced either in the site integration or grid connection (contestable) works. Bidders indicated they would prefer opportunity to bid on one or both scopes. This feedback was considered, and the package subsequently split, as discussed in more detail within the report.

1 An event, hosted by ETZ and the EIC which sought to provide supply chain companies with "invaluable insights into the latest advancements, ongoing projects, and ingenious solutions that will shape Scotland's future energy landscape." (https://www.the-eic.com/Events/EnergyTransitionZone)

This lack of suppliers reflects the comparatively small scale of the current hydrogen market when compared to other industries, as illustrated in the investment chart (Figure 1) below.[18]

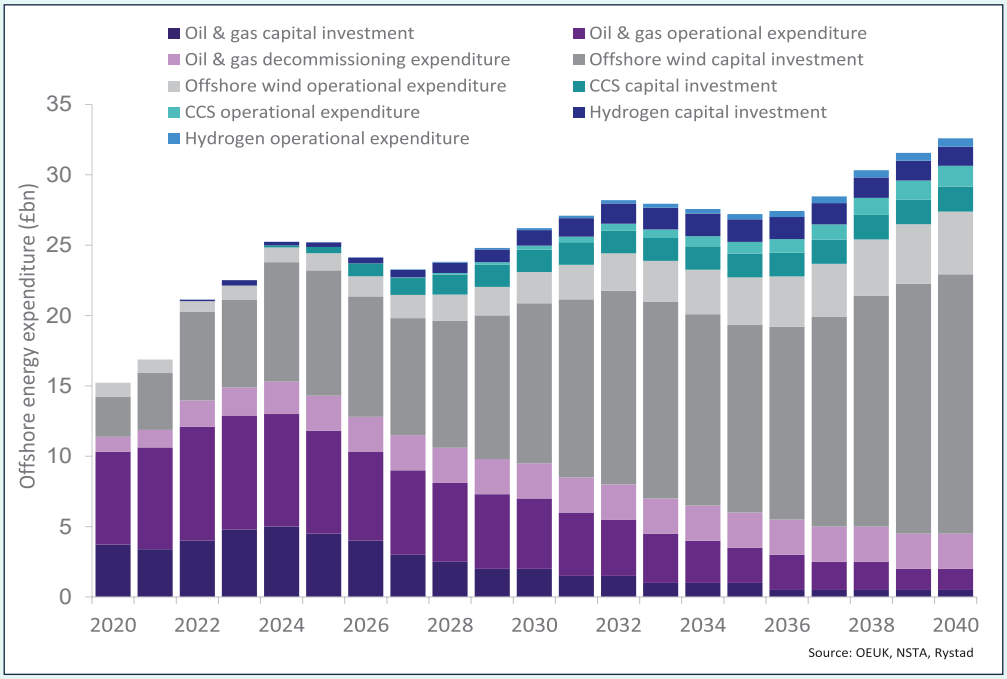


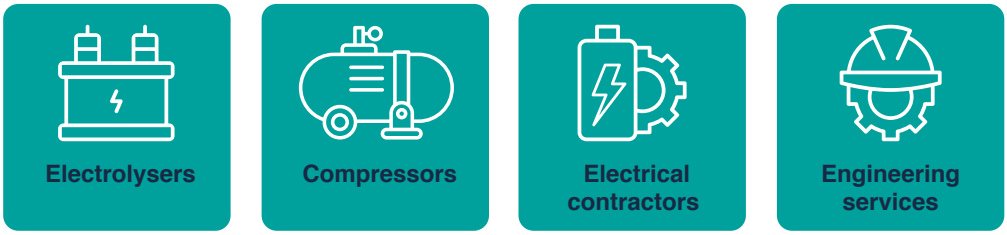
Figure 1:
Offshore energy expenditure 2020-2040 (Source: OEUK)

4

Theme 1: Supply chain bottleneck

As the hydrogen industry gains momentum in Scotland, there is the potential that pressure on certain elements of the supply chain could restrict the wider industry's capability to grow.

High-risk, critical path elements of the supply chain are described as 'bottlenecks'. The bottlenecks discussed here have been identified through desktop research, engagement with suppliers and procurement activity undertaken by bpAHEL in support of the AHH project. They fall into four main categories:



Electrolysers

Electrolysers are a key component for producing green hydrogen through electrolysis. As shown in Figure 2, in typical green hydrogen projects, approximately 82% of project spend is associated with materials. Over half of that can be attributed to the electrolysis package costs and roughly 30% of the package costs can be directly attributed to the electrolyser plant and equipment itself. Figure 3 shows the importance of the electrolyser package within a representative green hydrogen project.

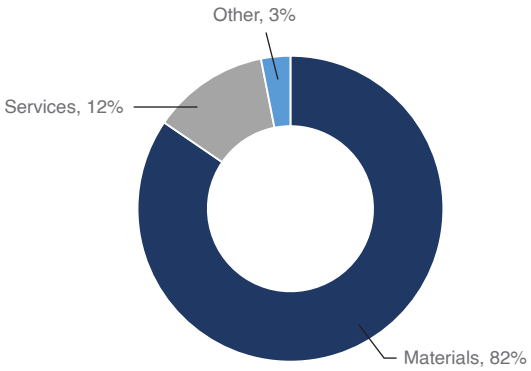


Figure 2:
Breakdown of typical green hydrogen project spend
(Source: OEUK Supply Chain Visualisation Tool)

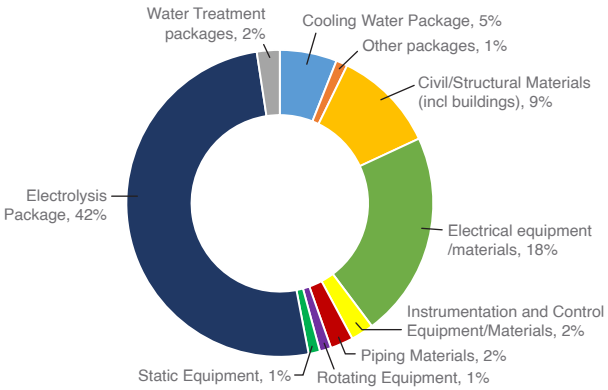


Figure 3:
Representative green hydrogen project
(Source: Source: OEUK Supply Chain Visualisation Tool)

There are no electrolyser manufacturers based in Scotland. Given the Scottish government's 5GW hydrogen target by the end of the decade and longer-term target to 2045 (see Figure 4), coupled with the need and drive to increase local content, and the potential relative value of the electrolyser packages, the potential benefits of developing domestic electrolyser manufacturing capability could be significant. The use of local resources could also offer benefits in repair and maintenance, e.g., where complex operations might require intervention by the original equipment manufacturer.

The Energy Transition Zone (ETZ) Hydrogen Campus, planned to be developed in the Altens area of Aberdeen, is an exciting initiative which aims to address some hydrogen supply chain bottlenecks. ETZ is seeking to encourage an electrolyser manufacturer to establish a facility in the Hydrogen Campus.

Creating local electrolyser manufacturing capability could help ensure a stable supply of these critical assemblies and contribute to job creation and economic growth in Scotland.

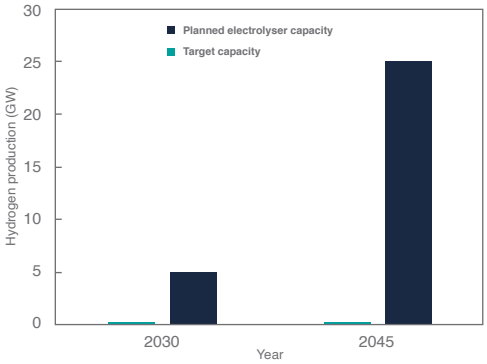


Figure 4:
Targeted hydrogen production 2030 and 2045.
(Source: Scottish Government, Assessment of Electrolysers: Report)

Compressors

Compressors are vital components within green hydrogen projects (see box below). Specifically, the prevalent compressor types used in this context are diaphragm or hydraulic compressors. Hydraulic compressors, which excel in handling intermittent demand patterns, are particularly common in mobility applications, such as the planned AHH refuelling station.

Compressors in green hydrogen projects

Compressors play a crucial role in green hydrogen projects for several reasons:

1. **Hydrogen Storage**: Compressors are essential for storing hydrogen efficiently. As hydrogen is often produced at comparatively low pressure, compressors help increase the pressure for storage, allowing more hydrogen to be stored in a given volume.
2. **Transportation:** In some cases, hydrogen needs to be transported from the production site to where it will be ultimately used or stored. Compressors are required to increase the pressure of hydrogen for transportation through pipelines or in mobile storage, such as tube trailers or tankers. Compressing hydrogen allows for more economical and efficient transportation over longer distances.
3. **Refuelling Stations:** In green hydrogen-powered vehicles or equipment, refuelling stations require compressed hydrogen for dispensing. Compressors are used to increase the pressure of hydrogen to the level needed for fuelling vehicles or machinery.
4. **Optimising Production:** Compressors aid in optimising hydrogen production systems by maintaining the necessary pressure levels for the electrolysis or other production processes, ensuring efficiency and optimal operation of the hydrogen production units.

In green hydrogen projects, compressors are integral to facilitating the entire hydrogen value chain, from production to storage, transportation, and utilisation. They enable the efficient handling, storage, and transportation of hydrogen, ensuring its availability and accessibility for various applications.

In addition to commercial factors, including cost, evaluation of these compressors typically revolves around key technical criteria, including pressure thresholds, maintenance needs, outlet gas purity, and energy consumption. For effective operation in mobility applications, compressors must adhere to specific operational parameters, such as being capable of operating with a flexible supply pressure (potentially down to 30bar), handling discharge pressures up to 1,000 bar, and avoiding introducing contamination.

Procuring compressors presents a challenge due to their significant lead times, averaging around one year, necessitating significant forward planning. Notably, most suppliers maintain their parts and servicing centres predominantly within continental Europe, giving rise to concerns with respect to potential import/export control-related disruptions and cost implications.[19]

To mitigate potential disruptions, strategic measures may involve contractual agreements ensuring suppliers maintain a certain stock of equipment, including the storage of critical spare parts within UK-based warehouses.

Some organisations (including bp) have extensive knowledge of different types of diaphragm compressor. Additionally, reciprocating piston compressors, primarily associated with refilling tube trailers, offer an alternative technology operating at discharge pressures lower than 500 bar, suitable for specific applications within Scotland's hydrogen supply chain.

Navigating the complexities of these compressor types, understanding their supply chain dynamics, and aligning with the post-Brexit commercial and regulatory landscape are critical for ensuring uninterrupted operations and robust supply chain development within Scotland's fast growing hydrogen mobility sector.

Electrical contractors

Electrical works can represent approximately 18% of the representative spend for green hydrogen projects, as shown in figure 3 above.

For hydrogen to be classified as 'green', it must be produced using renewable energy sources. In the case of Aberdeen Hydrogen Hub, the site is intended to be powered by solar energy, produced at a dedicated 8MWp solar facility, and grid supplied renewable power compliant with the renewable and low-carbon standard. The grid connection would also enable bpAHEL to return excess solar energy produced to the grid during times of excess supply. Other renewable energy sources would be proposed for integration during expansion of the AHH, including direct wire offshore floating wind. Experienced electrical contractors are required to build the power grid and connect the hydrogen production package (i.e. electrolyser package).

Relatively few contractors were identified with capability to deliver the full integration and grid connection scope, and the drive to electrification within the context of the wider energy transition has stimulated significant demand for electrical contractors and manufacturers. By disaggregating the scope into two lots, parties could bid on those areas within their skill set. Shifting to a cost reimbursable approach was also chosen to allow better management of risk allocation (e.g., project cost overrun) centrally rather than at the supplier level.

While this approach allowed AHH to progress, an opportunity for electrical contractors to expand their capabilities to offer a full end-to-end service in respect of electrical integration and grid connection services is apparent. Such an offering could be compelling, including to minimise project interfaces, risk transfer and the burden of post-contract administration.

Engineering services

A key facility associated with green hydrogen projects is the provision of engineering services, which account for around one-quarter of the overall project costs associated with services (see Figure 5 below).

The North-East of Scotland is home to a host of engineering companies, from large tier one engineering, procurement and construction firms to smaller specialist providers. While this presents a great opportunity for companies with a local presence in the North-East to become involved in the hydrogen industry as the energy sector transitions, a key arising risk is that the demand for these resources could exceed supply. Many projects could have similar timings (e.g., informed by government and corporate 2050 and interim net zero targets).

Annual spend in the offshore energy industry is set to increase from around £18billion in 2021 to approximately £26billion by 2030, illustrating the scale of the challenge.

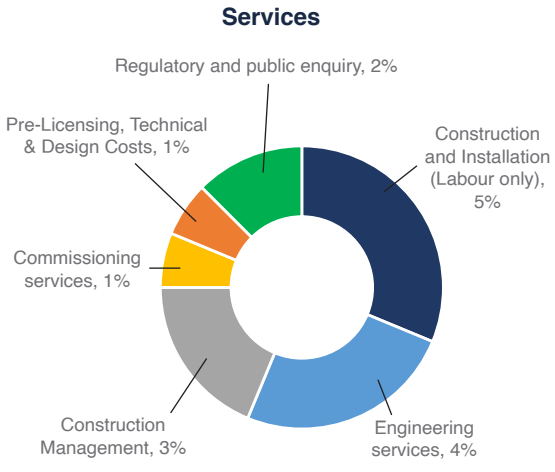


Figure 5:
Representative green hydrogen project
(Source: based on information from OEUK)

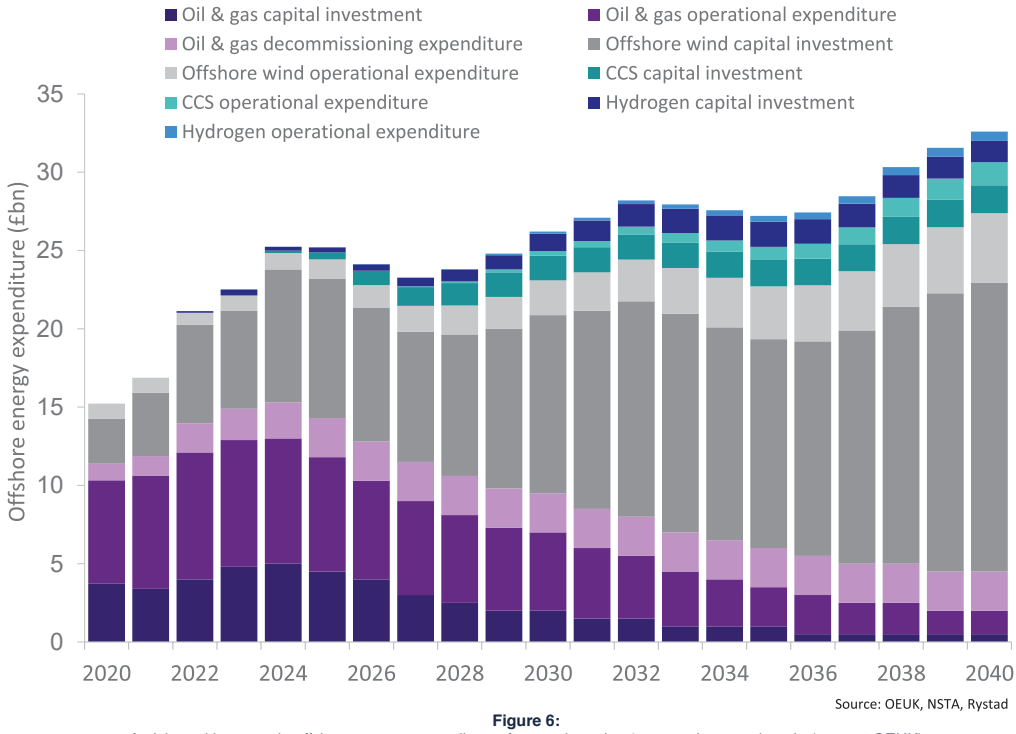


Figure 6:
Anticipated increase in offshore energy expenditure of approximately 50% over the next decade (source: OEUK)

Forward information sharing can mitigate the risk of a bottleneck in the provision of engineering services arising from increased demand. Another possibility is collaboration with local engineering contractors to assess their capabilities and capacity, establish a framework for prioritising projects and allocating resources efficiently, and building capability in activities that deliver most progress towards solutions for increased energy equity, resilience and lower carbon emissions. By putting the right contracting models in place with engineering contractors, risks can be more effectively shared.

The wider energy industry could consider regional resource planning and sharing mechanisms to ensure that engineering contractors are not overwhelmed and can meet the demands of multiple projects concurrently. This could involve creating industry databases, facilitated by the likes of OEUK, detailing available expertise, cross-training opportunities and resource allocation agreements. Steps like these would support smaller organisations who have expressed interest in building their capacity but who currently lack the information and certainty to do so.

5

Theme 2: Opportunity to transfer expertise from the oil and gas sector

The North-East of Scotland boasts a legacy of innovation and expertise in oil and gas. Traditionally celebrated as 'the oil and gas capital of Europe', Aberdeen is evolving to become 'the all-energy region of Europe.'[20] Transformation offers an unparalleled opportunity to capitalise on domestic capabilities, infrastructure and well-established supply chains developed through decades of oil and gas production. By embracing this transition, the region is unlocking potential to become a thriving hub for the emerging hydrogen industry.

Transferability of expertise

Diversifying expertise from the oil and gas industry to the hydrogen industry is a multi-dimensional challenge. Many of the competencies and skills developed in the oil and gas industry are either directly applicable or adaptable to the hydrogen industry, including:

- **Project management:** The oil and gas industry has honed project management practices to ensure efficient operations, meeting stringent safety standards while successfully delivering complex technical projects against tight schedules and budgets. While the hydrogen industry has nuances, particularly for standards and technology, this expertise - refined over many years in oil and gas - is applicable and transferrable to the hydrogen industry.

- **Health and safety management:** Safety is paramount across the whole energy industry. Standards, protocols, and cultures established in oil and gas are transferable to the hydrogen sector but now require development through being applied to producing, storing, and transporting hydrogen - e.g., considering factors such as hydrogen gas/liquid behaviour during release, infrastructure failure rates, and inherently safe operations and maintenance practices.

- **Engineering proficiencies:** Skills in designing and optimising complex systems, including instrumentation and control systems, could be applied to design and deliver hydrogen projects given the similarity in system needs between oil and gas and hydrogen projects.

- **Supply chain management:** The efficient and successful management of a multi-faceted supply chain, which has been crucial for the oil and gas industry, is also vital throughout the lifecycle of hydrogen assets. Contract sourcing, drafting, negotiation and management is required in both sectors, as are capabilities in logistics and material and inventory management.

- **Specialised suppliers:** The oil and gas sector relies upon a network of specialised suppliers that provide essential equipment and services, such as valves, pumps, compressors and inspection and verification services. These suppliers could adjust their focus to support the hydrogen industry, offering expertise in manufacturing and maintaining critical components.

Theme 2

HYDRASUN

An example of transferring technologies and skills from oil and gas into the emerging renewables sector

For five decades, Hydrasun has delivered integrated fluid transfer, power, and control solutions to the global energy market, providing expertise in the design, installation, and inspection services for high pressure, safety critical applications across the oil and gas, renewable, industrial and marine sectors worldwide.

In 2016, Hydrasun entered the hydrogen market as a systems integrator and services provider offering installation and commissioning services for early Hydrogen Refuelling Stations (HRS) and industrial fuel switching projects both in the UK and Europe.

Hydrasun has expanded its offering to include full turnkey Engineering Procurement and Construction (EPC) of HRS solutions and, in September 2022, announced the acquisition of Fuel Cell Systems Limited (FCSL), a market leader in the supply of hydrogen technology including fuel cells, compression and storage packages, and fuel dispensing solutions.

In collaboration with government, academia, and key energy sector stakeholders, Hydrasun opened a Hydrogen Skills Academy, [2023], which builds on its strong track record of delivering 'best in class' training and competency assessment for the Oil and Gas sector. The Hydrogen Skills Academy focuses on providing the practical skills needed for the design, integration, commissioning, operation, maintenance, and on-site testing of hydrogen systems and providing the skills pathways in support of the transition from high carbon industries.

Hydrasun are part of the 'D2Zero' portfolio of five UK companies owned by private equity firm SCF Partners. The 'D2Zero' portfolio combines three companies with a strong oil and gas heritage of Hydrasun, Score Group, Global E&C with the capabilities of two pure play energy transition companies in Fuel Cell System and Powerstar. D2Zero companies are focused on four key areas of emissions reduction, clean hydrogen, power efficiency and management including microgrids, and carbon capture. Each area offers a range of differentiated technologies and capabilities that supports the energy transition and the development of emerging clean energy sources that will accelerate customers' progress towards achieving their decarbonisation and net zero objectives. Together the D2Zero companies create a business of scale with revenues in excess of £500 million and a committed workforce of over 4,000 people.

Knowledge sharing and collaboration

Facilitating the transfer of knowledge and expertise from the oil and gas sector to the hydrogen industry requires a structured approach to information exchange and collaboration. Opportunities to support knowledge sharing and collaboration include:

- **Structured knowledge exchange programmes:** Formal programmes to enable experienced professionals from the oil and gas industry to mentor and share their insights with hydrogen industry counterparts (and vice versa). These programmes could take the form of workshops, webinars or knowledge-sharing sessions. An example of a structured knowledge exchange programme is the 'Knowledge Transfer Partnership' (KTP) programme run by the University of Strathclyde, which is 'a three-way partnership between a business, an academic institution and a KTP Associate… [which] allows for a transfer of knowledge, technology and skills otherwise inaccessible to companies.'[21]

- **Cross-industry collaborative forums:** where energy sector professionals can discuss common challenges, innovative solutions and best practices.

- **Industry associations:** such as OEUK, Hydrogen UK, ETZ, and SHFCA, play a vital role in facilitating knowledge exchange. They host events, conferences and working groups that bring experts from different sectors together to share insights and experiences.

Dr Oliver Taylor, Chief Executive Officer, bpAHEL,
knowledge sharing with hydrogen supply chain at ETZ Green Hydrogen Masterclass

By recognising and understanding the common ground between these industries and promoting collaboration and knowledge transfer, the region could establish itself as a hub for the conventional hydrocarbon sources and a centre for cutting-edge technologies and sustainable energy solutions. This approach would expedite the transition to cleaner energy and bolster the resilience and versatility of the local workforce and supply chain.

6

Theme 3: Enhancing the visibility of opportunities and upcoming projects

In its 2023 'Supply Chain Management Sentiment' survey,[22] OEUK highlighted that across the energy industry, suppliers felt it difficult to 'plan business activity and build accurate demand forecasts'. Twenty percent of respondents stated that their 2021 forecasts were 'less than 25% accurate'.[23] OEUK has highlighted that 'supply chain organisations are moving resources into different markets, which offer greater predictability'[24] as a result of the lack of certainty of projects and workscopes.

A crucial aspect of fostering growth, innovation and investment lies in ensuring the visibility of opportunities and upcoming projects. The supply chain needs to have clear understanding of arising demand to determine how best to align their products and services effectively with industry needs.

Two leading systems have been identified through this research which enhance the visibility of opportunities and future demand:

OEUK's 'Supply Chain Visibility Tool': this provides 'insights on where supply chain capability and capacity are needed, along with supply chain development options and sequencing for timely investments.'[25]

However, it includes comparatively scarce information for hydrogen.

The tool enables buyers and suppliers to extract data concerning supply chain capacity and future demand, based on a number of scenarios.

It could support hydrogen industry suppliers in forecasting potential work and compiling internal business cases for investment in a particular product line or service offering.

For hydrogen developers and the supply chain to enjoy the maximum benefit of this tool, developers need to share project details with each other.

The North Sea Transition Authority (NSTA) Energy Pathfinder database: This provides 'real-time visibility of activity for new oil and gas field developments, decommissioning and projects to support the energy transition, for example, carbon capture and storage, on the United Kingdom Continental Shelf.'[26]

The tool names buyer companies, projects, timelines and provides a point of contact in the buying company. Although NSTA's remit does not currently include the onshore hydrogen industry, the Energy Pathfinder tool is established, known, used by other sectors of the energy industry and already has the capability to be used for hydrogen projects.

The fact that the system is owned and maintained by a government body gives it additional credibility. Further, the tool differs from other supply chain visibility tools in that it is free to use and will therefore be more accessible to smaller companies. It could therefore be pragmatic for the hydrogen industry to adopt the Energy Pathfinder tool as a first point of information, promoting visibility of opportunities and upcoming projects.

In addition to these tools, OEUK, with the support of the NSTA, hosts an annual Share Fair in Aberdeen, an event which 'focuses on giving supply chain companies and technology innovators access to invaluable market intelligence plus opportunities to network with key industry buyers.'[27]

The EIC also makes market intelligence tools available to its members. These have global applicability and could be useful for suppliers looking to understand global demand and export potential for goods and services.

To support supply chain development, and the de-risking of supply chain investments, it is vital to establish a clear and transparent communication channel for upcoming projects and opportunities – potentially including adoption of the two leading tools identified above. Selection, and ongoing support to increase adoption, could be facilitated through industry organisations such as Hydrogen UK, SHFCA or OEUK.

Theme 3

Theme 4: The need for knowledge sharing, industry standards and best practice

As an industry in its infancy, knowledge sharing, the establishment of industry standards and promotion and adherence to best practices are essential for the hydrogen industry's sustainable growth.

As Scotland and the wider UK move from reliance on traditional hydrocarbons to low-carbon alternatives - including renewable and low-carbon - the need for collaboration and information exchange becomes increasingly important. The hydrogen sector is not siloed, but forms part of a wider energy industry ecosystem where expertise from various sub-sectors converge, in which the value of knowledge sharing becomes pronounced. Harnessing the collective wisdom of stakeholders, whether they are new entrants to the hydrogen market, or incumbents from the oil and gas or renewable energy industry, is essential to identify synergies, avoid costly duplication of effort and accelerate the industry's development.

Standards and best practices

'Standards', are prescriptive quality, safety and performance requirements.

'Best Practices' are ways of working, such as the use of common tools, contract forms and sharing information in a standard format, that realise efficiencies both for buyers and suppliers.

Industry standards

Industry standards need to be established to allow suppliers and operators to demonstrate compliance and conformity in an aligned way e.g., from a safety, quality and/or production perspective. Adaptation of existing standards and the development of new ones can ensure that approaches from the oil and gas industry are transferred to hydrogen - embedding appropriate technical standards, test methods for equipment, particular equipment types, and risk-based assessment methods.

By establishing standards in fields such as these, supply chain participants can standardise their own processes and realise efficiencies, ensuring a more secure and reliable supply chain overall.

Likewise, buyers would avoid having to draft bespoke requests with each order to meet safety and production requirements. This could realise cost savings as the supply chain passes on the benefits of its own efficiencies. Leadership in this area could put Scottish and wider UK suppliers in a strong position by enabling them to move more quickly in international markets.

One industry certifying and independent verification body, DNV, has identified that there is an opportunity to increase substantially the development of knowledge sharing, industry standards, and best practice. These are vital for fostering collaboration, ensuring safety and promoting efficiency in the hydrogen industry. As such, it is imperative that work continues to identify the applicability of existing codes and standards to the hydrogen industry, the gaps that exist and where specific standards need to be established and agreed.

bpAHEL engagement with verification bodies also highlights that buyers will need to lead the charge to mandate compliance with specific standards through requests for proposal and contracts. The sense from engagement with suppliers is that they require guidance and leadership from buyers to justify internal investment decisions for developing products to achieve a specific certification.

Best practice

Establishing best practices for adoption sector-wide can create value through setting clear expectations between suppliers and customers, creating a way to apply learnings (particularly relating to safe operations), and minimising risk, and risk transfer to suppliers. Best practices can include adherence to specifications, procedures, and use of common systems/tools. Given the transferability of supply chain capabilities between the hydrogen and oil and gas sectors, it makes sense to modify existing tools rather than create new ones. Such an approach would additionally benefit suppliers who have familiarity (and existing licences) by reducing retraining and incremental investment demands.

Theme 4

There is an opportunity for SEQual, a supplier pre-qualification system[28] currently used in the oil and gas industry, to be modified to serve the hydrogen industry and other emerging industries. Such updates could support several new energy sectors – including offshore wind, and carbon capture and storage. This system benefits supply chain companies and buyers:

- For suppliers, the completion of a standardised comprehensive assessment pre-qualifies them in relation to specific 'product codes' and related activities,[29] eliminating the need for them to provide such information (potentially in slightly differing formats) each time they bid for work. For buyers, there is no need to spend time and resource pre-qualifying bidders with each new market request.
- For customers, SEQual's system offers a list of qualified suppliers for specific product codes, expediting the process of compiling a bid list. This information could be particularly beneficial in a new industry, where suppliers for particular products or services may not yet be well-known. In parallel, for suppliers, the system provides a means to signal their expertise to prospective buyers, who may otherwise be unaware of their capabilities.

Adoption of the OEUK supply chain principles (see Figure 7 below) represents another best practice in the oil and gas industry which could be applied to hydrogen. These best practice procurement guidelines were developed to encourage cooperative and collaborative behaviours between buyers and suppliers and to ensure a fair balance of risk and reward, as well as encouraging good behaviours around specific areas, such as payment terms. By adopting this framework, buyers can highlight their commitment to acting fairly and transparently which may encourage suppliers to enter the market.

Figure 7: OEUK Supply Chain Principles

Theme 5: Opportunity to increase local content

Building a robust local supply chain is critical for the hydrogen economy – to support the mitigation of geo-political risks associated with importing goods and services, to maximise capturing value locally where energy projects are built, and to sustain and create jobs and capture trickle-down benefits for the wider economy.

As part of the North Sea Transition Deal, the UK energy industry has voluntarily committed to achieve 50% local UK content across the lifecycle for all related new energy transition projects by 2030, as well as in oil and gas project decommissioning work.[30]

Benefits of this approach include:

Approach	Description
Supply chain growth:	Local content provisions incentivise the growth and diversification of the local supply chain. This, in turn, enhances the region's capability to meet the demands of hydrogen projects, reducing reliance on imports.
Economic development:	Local content provisions can help stimulate economic development by channelling investments into the region. OEUK has estimated that, across the energy industry, each 1% of additional local content can add up to £210m spend and 1,600 direct/indirect jobs by 2030.[31] Any incremental employment could lead to increased tax revenues and economy diversification, particularly in the North-East of Scotland, thereby reducing dependence on the oil and gas industry.
Skills leadership:	Encouraging local content supports the development of a skilled workforce in the region and builds on the work of several organisations in Scotland such as the Offshore Petroleum Industry Training Organisation, The Energy Skills Alliance, and the National Energy Skills Accelerator. These bodies are already identifying the competencies needed to support the growth of the hydrogen economy. An outline of their work is available in bpAHEL's skills and qualifications gap analysis report. As the workforce builds skills, knowledge and expertise in the production of green hydrogen in a live, functioning production environment, and transfers skills from the oil and gas industry, they become valuable assets, not only for the hydrogen industry, but for future projects in the wider energy sector. This approach also creates the opportunity to export capability internationally.
Community support:	Projects which stimulate positive local economic and social impact can engender greater community support. Building and maintaining social licence to operate is integral to project success and long-term sustainability.

Aberdeen Hydrogen Hub local content

bpAHEL included questions on local content and sustainability as part of its tender process. Responses and supporting evidence provided by bidders was evaluated, scored and given an associated weighting in the evaluation process. Examples of the local content provisions are as follows:

- 'The contractor should develop a local supply chain where possible, to promote local skills and employment, with the objective of supporting a Just Transition to Net Zero'.
- 'Please describe how you will develop a local supply chain where possible, to promote local skills and employment, with the objective of supporting a Just Transition to Net Zero'.

These requests were designed to highlight bpAHEL's commitment to maximising local content, while recognising that setting prescriptive target percentages could prevent some from engaging in the tender process.

Bid responses highlighted that some suppliers had built comprehensive commitment to local content and had high confidence in their ability to deliver significant local beneficial impact. However, others had apparently weaker local content policies, or were inexperienced in responding to procurement requirements in this area.

bpAHEL's experience implies that continuing with local content ambitions is important but should be complemented with supporting suppliers through training and/or knowledge sharing during bid processes.

9

Recommendations and Next Steps

Three priority themes and recommendations arising from this report are shared below, including: **Project opportunity visibility**, **knowledge sharing** and **local content**.

However, suppliers should monitor project pipelines and carefully assess the risks and opportunities of investing in supply chain capacity. Balancing investment decisions against confidence that defined projects will proceed – including understanding the timeline and criteria for reaching Final Investment Decision (FID) – is important to help mitigate risk of stranded investment. Each supplier will have to arrive at their own view considering their risk appetite.

bpAHEL's hope is that by following the recommendations in this report, suppliers could enhance their competitiveness, readiness to deliver, and help build a resilient hydrogen economy in the North-East of Scotland.

Theme	Recommendations
1. Requirement for visibility of opportunities and upcoming projects: Transparent and timely information about opportunities and projects is needed to encourage participation and to support investment decisions in supply chain organisations.	We recommend buyers and third parties expand the use of existing supply chain visibility tools but which need extension into the hydrogen sector. This could take the form of: • Support for the OEUK Supply Chain Visibility Tool, with buyers providing anonymised details for input into the tool (such as information about contracts, future projects, types of spend) to enable suppliers to plan and develop capacity and business cases. • NSTA expanding the scope of the 'Energy Pathfinder' tool to include onshore hydrogen and mandate the use of the tool for hydrogen developers/operators.
2. Need for knowledge sharing, industry standards and best practice: Knowledge sharing, both with and in the supply chain, and the establishment of industry standards and best practices are vital for fostering collaboration, ensuring safety, and promoting efficiency in the hydrogen industry.	We recommend that buyers participate in joint industry projects to help agree industry standards, and that market participants consider adopting well-established pre-qualification tools and principles such as those used in the oil and gas industry. This represents one of many areas where oil and gas industry experience and capacity can support and accelerate the development of the hydrogen market. We recommend: • Widespread adoption of the 'SEQual' supplier pre-qualification tool, currently used by the North Sea oil and gas industry. Its expanded use could be supported by: - Establishing an industry working group to identify and agree the relevant product codes and sector activities to be covered by the tool. - Participating in the development of HSSE and Quality question sets to be used in the SEQual tool for the pre-qualification of suppliers. - Raising awareness and promoting adoption of the tool. • We also recommend that buyers adopt the OEUK 'Supply Chain Principles'.
3. Importance of local content in contracts: Developing a local hydrogen economy will ensure that hydrogen contributes to economic development and job creation. This can be underpinned by including local content provisions in tender documentation and awarded contracts.	We recommend investment and initiatives that target the development of local supplier capability and training, including support that would improve responses to local content and sustainability requirements in future tenders. Specifically, we recommend: • That buyers consider including the North Sea Transition Deal 50% local content target from the inception of new projects, so that it forms part of their thinking and practise. • Buyers focus on targeting those contracts that have the greatest potential to deliver local value. This might involve, for example, breaking contracts into smaller or more discrete packages which enhance the opportunity for local suppliers to tender and supply. • Developing and executing transparent and uncomplicated procurement processes which explicitly include local content requirements and which assess bidders' abilities to meet these requirements. • Facilitating the delivery of 'Local Content' training to improve bidder responses to local content and sustainability requirements in future tender packages.

Next Steps

To take these recommendations forward, bpAHEL intends to:

- provide input to the OEUK Supply Chain Visibility tool and the NSTA Energy Pathfinder tool to ensure greater visibility of opportunities and upcoming projects.
- adopt the OEUK Supply Chain Principles and leverage its membership of industry organisations to promote the adoption of these principles by the wider industry.
- facilitate knowledge sharing, potentially in partnership with others, on local content and sustainability (e.g. through a webinar), The aim would be to give guidance on how to develop targeted plans for tenders. research undertaken for this report.

10

Appendix A: Existing resources and support available to the supply chain

Although there are some gaps in the Scottish hydrogen supply chain and challenges for suppliers, resources and sources of support are available. Finding all available support, and understanding the most applicable for a particular supplier, is potentially a barrier in itself, as the different sources of support can appear fragmented.

Funding support

Several organisations offer funding opportunities for hydrogen projects and the hydrogen supply chain. The UK and Scottish governments have launched funding schemes and have committed to invest £240million and £100million respectively in the hydrogen industry to meet their 10GW and 5GW respective targets.

There is no current database of upcoming funding rounds. A database of this kind could be of benefit to smaller suppliers who lack the resources to be monitoring news announcements and government websites to uncover funding opportunities.

Business / Procurement Support

Scottish Enterprise has offered Scottish businesses 'hydrogen expert support' to 'help Scottish businesses move into the growing hydrogen sector.' The support, intended to help companies understand if they can transfer their existing capabilities into the hydrogen market, understand the potential benefits of entering the hydrogen market or to increase their presence and manufacturing capabilities if they are already working in the hydrogen industry, has been offered at two levels.

- Level one support: two free days of consultancy, learning about the company's operations, capabilities and ambitions and generating a report that describes the company's opportunities in the hydrogen industry.
- Level two support: up to four days of consultancy, 50% of which has been provided by Scottish Enterprise, with the remaining 50% covered by the supplier company. Level two support is more detailed than level one, identifying more specific areas of opportunity in the hydrogen market.

Further schemes are in development to support companies' diversification plans, to be announced on the Scottish Enterprise business support website.

Business Gateway provides businesses with support, though this is not specific to the hydrogen industry. It is a publicly funded service 'contributing to the economic well being of Scotland by providing access to free business support services.' The support offered includes one-to-one business advice, market intelligence reports on specific sectors, business development programmes and more. The advice is available to all businesses in Scotland, from start-ups to established businesses. It could prove valuable for businesses looking to enter the hydrogen market or expand their current offering.

Similarly, the Supplier Development Programme Scotland is not specific to the hydrogen sector but provides 'training and information to improve the competitiveness of local businesses and social enterprises.' The Programme is primarily targeted at companies looking to do business with public sector bodies. Given that the Aberdeen Hydrogen Hub project and projects associated with ETZ are subject to Public Procurement Regulations (as it is a public-private partnership), training and advice on how to tender for public contracts could be valuable to the supply chain.

Aberdeen City alongside the other 31 councils in Scotland, all use the Supplier Development Programme to support local businesses and social enterprises to raise awareness of contract opportunities, and projects and to develop their capability to bid successfully for public procurement contracts. This service is not wholly specific to public procurement, as the Programme also works with corporate companies looking to open up their supply chain and promote local project delivery. This could be a useful service for bidders looking to engage in any future phases of the Aberdeen Hydrogen Hub project, or further public or public-private partnership hydrogen projects, and raise awareness of projects such as the ETZ Hydrogen Campus.

ETZ Ltd's Energy Transition Supply Chain Pathway and Challenge Fund is supporting the development of company plans to enter new energy markets, identify capital requirements and provide access to capital funding for implementing these plans. The Challenge Fund delivers capital investment grants to help energy supply companies realise opportunities. Grant support focuses on accelerating company market entry into low carbon sectors, leading to new facilities, equipment installation and upgrades to existing infrastructure.

Industry/technical support

The **Energy Transition Zone Ltd** (ETZ) is a 'private sector-led and not-for-profit company spearheading the North-East of Scotland's energy transition ambition.'[32] One of ETZ's ambitions is to establish a Hydrogen Campus in the Altens area of Aberdeen.

This campus would include **Green Hydrogen Test and Demonstration Facilities**, the establishment of which would remove the need for costly investment for individual companies in their own test and demonstration facilities. The campus is considered suitable for attracting an electrolyser manufacturer to the area, which as discussed in this report, is currently one of the key supply chain gaps in the hydrogen industry.

Another not-for-profit organisation located in Aberdeen is the **Net Zero Technology Centre** (NZTC) who work 'with industry, government and academia driving technology innovation to accelerate the energy transition to net zero.'[33] NZTC co-invest and collaborate with businesses with a view to deploying new technologies. They offer support to businesses, including technology advisory services and the 'TechX' start-up accelerator programme which equips 'start-ups with the funding, tools, resources and training they need to evolve and grow, accelerating their path to commercialisation and beyond.'[34]

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