

Hydrogen Action Plan



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Hydrogen Production Definitions

Renewable Hydrogen (also referred to as Green Hydrogen)	Produced via electrolysis of water using renewable electricity and is zero carbon.
Low-carbon Hydrogen (also referred to as Blue Hydrogen)	Produced via reforming natural gas or biogas in conjunction with carbon capture with high capture rates and is very low-carbon.
Unabated Hydrogen (also referred to as Grey Hydrogen)	Produced via reforming natural gas. This process produces hydrogen and carbon dioxide that is emitted to the atmosphere.
Biomass Gasification with carbon capture and storage for the production of hydrogen	Less developed negative-emissions technology which could become part of the energy mix.

Ministerial Foreword

As a government, we are convinced that hydrogen, alongside renewable electricity, will play an extremely important part in our energy system going forward. Electrification will do the heavy lifting in our march towards net zero, but there are parts of our economy and energy system that are very difficult to electrify, and hydrogen could provide a solution for sectors such as heavy-duty on and off-road transport, shipping, aviation and industrial high temperature heat. Innovative and smart climate action will also include the use of hydrogen in the production of synthetic fuels and in energy storage solutions to help increase flexibility and balance the grid and there is some scope for hydrogen to support parts of our domestic heating systems.



Scotland has vast renewable energy resources. Subject to planning and consenting decisions and finding a route to market, we have a potential pipeline of over 40 GW of offshore wind generation projects. This could enable the use of surplus electrons for the creation of low-cost renewable hydrogen. This generating potential opens up new economic opportunities for our nation to become a leading producer and exporter of renewable hydrogen. International demand for hydrogen is growing, with Germany, the EU and the UK Government all increasing their respective hydrogen production ambitions in 2022.

Countries that need hydrogen are now looking beyond their borders to nations that can produce and provide that hydrogen at scale. Given how well-placed Scotland is to service future export markets for hydrogen and hydrogen derivatives at scale, hydrogen, powered by renewable electricity, could present Scotland's greatest industrial opportunity since oil and gas was discovered in the North Sea.

We are already embracing the development of a hydrogen economy here in Scotland by making available £100m in capital funding for renewable hydrogen projects. The first tranche of our hydrogen investment programme, the £10m Hydrogen Innovation Scheme, opened in June 2022 and is supporting innovation in the production, storage, and integration of renewable hydrogen in our energy system.

Our priority is to get as much renewable hydrogen into the energy system as quickly as possible, while also supporting the establishment of low-carbon hydrogen production at scale in the 2020s, linked to carbon capture and storage (CCS). Economic impact estimates based on scenarios developed for the Scottish Government indicate the development of a hydrogen economy in Scotland could mean between 70,000 to over 300,000 jobs could be protected or created with potential Gross Value Added (GVA) impacts of between £5 billion and £25 billion a year by 2045 depending on the scale of production and the extent of exports.¹

In this Hydrogen Action Plan, we confirm our commitment to support the development of the hydrogen sector in Scotland and reconfirm our ambition of at least 5 GW installed renewable and low-carbon hydrogen production capacity by 2030 and 25 GW by 2045.

¹ [Scottish hydrogen: assessment report - gov.scot \(www.gov.scot\) \(2020\)](https://www.gov.scot/resources/documents/2020/09/Scottish-hydrogen-assessment-report-2020.pdf)

Hydrogen has a role to play across Scotland, in our islands and rural places, communities, cities and industrial clusters. Strategies for production and application are expected to vary across these geographic regions and we are committed to realising the growth opportunities of hydrogen for our regions and local communities. We will therefore support the establishment of strategically important regional hubs of hydrogen activity across Scotland, recognising the differing resources, strengths, and focuses of each location.

Our draft Hydrogen Action Plan was published in 2021. Since then a suite of studies and reports have been commissioned by the Scottish Government and its agencies to help us identify and understand the opportunities and potential barriers to the growth of our hydrogen economy in Scotland. These include the development of supply chain opportunities, including electrolyser manufacturing, production costs analysis, hydrogen demand and use case, as well as hydrogen production location requirements and export infrastructure, all of which will aid and inform the development of our hydrogen policies.

A strong, collaborative relationship with business will be required to accelerate renewable hydrogen production from onshore renewables by the middle of this decade, increase demand across sectors, improve supply chain and skills capability, and establish the necessary infrastructure to store, transport and distribute hydrogen to where it is needed.

Hydrogen production from onshore renewables will pave the way for gigawatt-scale hydrogen production linked to offshore wind and carbon capture utilisation and storage (CCUS) towards the end of the decade and the establishment of several regional hydrogen hubs servicing industry, heat and multi-modal transport, alongside the export market.

It is clear that hydrogen represents a pivotal opportunity for both decarbonisation and the economy and is a key driver in our just transition. Scotland has the resources, the people, and the ambition to realise the benefits of becoming a leading hydrogen nation. This is our ambition – but government cannot achieve it alone. Joint action will be required by the Scottish Government, UK Government and businesses working together to realise our hydrogen future.

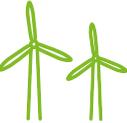
I hope this clear signal of intent, founded on evidence and engagement, and set out in this Hydrogen Action Plan will allow industry and investors to respond with confidence. The global hydrogen market is developing rapidly, international partnerships are already being established and forward hydrogen supply contracts for off-takers are already being signed, and so, with shared ambition, co-ordination, collaboration and pace, we look toward to achieving a sustainable energy transition and realising our exciting hydrogen future. When we think hydrogen, we think Scotland.



Michael Matheson MSP

Cabinet Secretary for Net Zero, Energy and Transport

Scotland has the opportunity to become a leading nation in the production of reliable, competitive, sustainable hydrogen

<p>Scotland's hydrogen ambition</p>	<p>Ambition of 5 GW of hydrogen production capacity by 2030 and 25 GW by 2045</p>	<p>Our 5 GW by 2030 renewable and low-carbon hydrogen ambition can be translated to more than 450,000 tonnes of hydrogen produced annually for both domestic and international use</p>	
<p>Scotland's renewable potential</p>	<p>Subject to planning and consenting decisions and finding a route to market, we have a potential pipeline of over 40 GW of offshore wind projects</p>	<p>Our supply of renewable energy is likely to provide more than we need for domestic electrification, so would enable us to use surplus electrons for the creation of low-cost renewable hydrogen</p>	
<p>Domestic potential</p>	<p>Hydrogen economy in Scotland has potential GVA (Gross Value Added) impacts of between £5 billion and £25 billion a year by 2045 depending on the scale of production and extent of exports</p>	<p>Developed scenarios suggest the hydrogen economy in Scotland could support the protection or creation of between 70,000 to over 300,000 jobs protected or created</p>	
<p>Export potential</p>	<p>REPowerEU sets a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of renewable hydrogen imports by 2030</p> <p>Global hydrogen demand could reach 115 Mt by 2030</p>	<p>By 2045 approximately 3.3 Mt (126 TWh) of renewable hydrogen could be produced in Scotland with approximately 2.5 Mt (94 TWh) exported to the UK and other European markets annually</p>	
<p>Funding commitment</p>	<p>£100 million of funding made available for renewable hydrogen projects</p>	<p>Hydrogen Innovation Scheme designed to support research & innovation in renewable hydrogen production, storage and distribution launched June 2022</p> <p>Green Hydrogen Fund targeting support for renewable hydrogen production opens in 2023</p>	

Think Hydrogen Think Scotland

Introduction

Our world leading climate change targets to achieve net zero greenhouse gas emissions by 2045 and a 75% reduction by 2030 against the 1990 baseline, mean that across our economy we need to move at an unprecedented pace to deliver the innovation, investment, regulation and market environment that will enable the required step change towards net zero.

Hydrogen could be an important tool to help lower our greenhouse gas emissions and to minimise our impacts on the climate. The sixth Carbon Budget Report from the Climate Change Committee² suggests that hydrogen production in the UK could scale up to 90 TWh by 2035 – equivalent to nearly a third of the size of the current power sector in the UK.

Hydrogen provides a sustainable alternative to burning fossil fuels and can be used to decarbonise many parts of our economy, including industry, transport, power and heat. In the transport sector, for example, hydrogen can provide the zero carbon energy-dense fuels that will help decarbonise key parts of the sector, such as some heavy road vehicles, parts of the rail network, marine vessels and aviation. Transported through the gas grid it could help decarbonise commercial premises and make a contribution to decarbonising home energy use. For energy-intensive industries, switching to hydrogen is considered one of the few viable options for significant decarbonisation in the next decade. An overview of some of the sectors where hydrogen might be more or less likely adopted as a route to decarbonisation based on current alternatives and available opportunities is presented in Part 2 of this Action Plan.

To have a thriving hydrogen economy, we need both domestic and international demand for hydrogen. Our ambition is for Scotland to become a leading producer and exporter of hydrogen and hydrogen derivatives for use in the UK and in Europe, with the first hydrogen delivered from Scotland to mainland Europe in the mid-2020s. The opportunity for Scotland within the developing global hydrogen market is significant. Increasing European demand for alternative energy sources, to reduce dependency on fossil fuels, means that the supply of renewable hydrogen will play a major role not just in the energy transition but in enabling security of supply across Europe through diversification of fuels and supply sources. The Hydrogen Action Plan supports the objectives within the National Strategy for Economic Transformation³ in respect of maximising new market opportunities. Indeed, the development of the hydrogen economy will help build on Scotland's strengths to win an ever-greater share of domestic and international market opportunities.

In Scotland, aligning early hydrogen production coupled with market demand is imperative. Hydrogen for transport could be a big part of this, with demand being as high as 14.9 TWh a year by 2045 if affordable supply is in place.⁴ Hydrogen vehicles are already on the road in Scotland and this Action Plan sets out how we can build on this success. Alongside electricity and low carbon fuels, hydrogen and its derivatives such as ammonia and e-methanol have the potential to reduce transport emissions and create green jobs.

2 [The Sixth Carbon Budget. The UK's Path to Net Zero \(www.theccc.org.uk\) \(2020\)](https://www.theccc.org.uk)

3 [Scotland's National Strategy for Economic Transformation - gov.scot \(www.gov.scot\) \(2022\)](https://www.gov.scot)

4 [Zero Emission Energy for Transport Forecasts: National | Transport Scotland \(2022\)](#)

Hydrogen is anticipated to play a useful role in delivering large-scale and long-term energy storage in an integrated energy system and has the potential to replace or augment the critical balancing and resilience services that natural gas storage provides to the electricity system today. Hydrogen could play a wider role in our journey to a zero carbon electricity system both through the production of renewable hydrogen from our huge renewable resources when demand for power is low, as well as the potential for hydrogen-fuelled turbines to meet demand and provide valuable system services – replicating the function currently provided by fossil fuel-powered generation. Renewable hydrogen production offers the potential to help overcome electricity grid capacity issues and offset the need for bill payers to fund constraint payments. Also, exporting hydrogen to other parts of the UK and Europe provides a new revenue opportunity for renewable energy developers that may reduce or potentially eliminate reliance on Contracts for Difference.

We are taking a regional approach to our support for the development of the hydrogen economy in Scotland to recognise the variety of natural assets, skills and potential applications for hydrogen across different geographic areas of Scotland. Hydrogen will play a key role in decarbonising our industrial clusters, supporting the just transition of the workforce in high-carbon sectors in the northeast of Scotland and provide opportunities for our islands and rural communities to maximise the benefit of their vast access to renewable resources. A key focus is the development of Regional Hydrogen Energy Hubs, described in more detail in Part 2, that will help to deliver the benefits of hydrogen in each of these regions.

In line with our statutory obligations, a Strategic Environmental Assessment (SEA) has been carried out on this Hydrogen Action Plan. The assessment did not identify direct significant adverse effects but made recommendations on how minor adverse effects could be reduced or avoided, or potential benefits could be enhanced. A robust regulatory environment will be key to avoiding potential environmental impacts, including close regulation and monitoring of water abstraction, desalination of water and disposal of brine. To that end, we have formed a Scottish Regulatory Steering Group, comprised of key regulators, to provide advice on matters such as the environment and health and safety.

Further detail on how the recommended mitigation and enhancement actions will be considered during the implementation of the Action Plan, including in the development of the regulatory, planning and consenting framework, will be detailed in our SEA Post-Adoption Statement.

Hydrogen Policy Development and Delivery



Our Hydrogen Policy Statement⁵ published in 2020 described the potential role hydrogen could play in Scotland to achieve net zero. **The Scottish Government Hydrogen Policy Statement:**

- confirmed support for the strategic growth of a hydrogen economy in Scotland;
- set out an ambition of 5 GW of renewable and low-carbon hydrogen production by 2030 and 25 GW by 2045;
- committed £100m funding towards the development of our hydrogen economy;
- confirmed that both renewable and low-carbon hydrogen will play an increasingly important role in our energy transition to net zero in 2045, with the need to see as much renewable hydrogen in the energy system as quickly as possible and support the establishment of low-carbon hydrogen production at scale in the 2020s linked to carbon capture and storage (CCS);
- set out how Scotland's abundant natural resources, skills and supply chain offer the potential for large scale production of renewable hydrogen from offshore wind to be a key driver of the hydrogen economy in Scotland;
- confirmed support for the demonstration, development and deployment of hydrogen;
- committed to drive technological progress and advance innovation by unlocking public and private funds for innovation development, and support demonstration for key hydrogen technologies, such as fuel cells and electrolyzers;
- recognised the need for pace – the need to start now and grow quickly to capitalise on opportunities within the domestic and global hydrogen market;
- committed to actively seek international collaboration in the development of our shared hydrogen economy and fully explore our hydrogen export potential;
- committed to support the transition and growth of Scotland's existing supply chain, including in the development of skills and manufacturing capacity, that can play a significant role in the hydrogen economy both domestically and internationally;

⁵ [Scottish Government Hydrogen Policy Statement - gov.scot \(www.gov.scot\) \(2020\)](https://www.gov.scot/resources/documents/2020/06/Scottish-Government-Hydrogen-Policy-Statement-2020.pdf)

- committed to exploring the opportunities for negative-carbon hydrogen, combining the potential to use bioenergy to produce hydrogen with CCS; and
- committed to engage with the UK Government on the development of a UK policy and regulatory framework for hydrogen, business models, market mechanisms, carbon pricing, feed in tariffs, fuel economy standards, renewable fuel standards and zero emission vehicle mandates – all of which are important for raising market certainty and investor confidence.

Our Hydrogen Action Plan sets out what the Scottish Government will do and how we will work with others to implement the strong strategic approach required to support the development of the hydrogen economy in Scotland. This will support our efforts to reduce greenhouse gas emissions from our energy system, primary and manufacturing industries, homes and transport, while ensuring a just transition.

The actions in this plan are designed to:

- drive Scotland's hydrogen production capability to meet an ambition of 5 GW of renewable and low-carbon hydrogen by 2030 and 25 GW by 2045;
- address current barriers to the uptake of hydrogen including high production costs;
- support the growth of Regional Hydrogen Energy Hubs;
- encourage demand for hydrogen by supporting hydrogen use and developing our supply chain capability;
- support the realisation of the economic benefits of Scotland's hydrogen export potential;
- secure broad economic benefit from public sector and private sector support for development of regional hydrogen production and use; and
- encourage the development of a strong hydrogen sector in Scotland that supports a just transition to net zero.

How much Hydrogen is 5GWs?

Our **5GW ambition by 2030** is for installed production capacity of hydrogen which includes both **renewable and low-carbon hydrogen**.

We can translate this to more than **17.5 TWh** and over **450,000 tonnes of hydrogen**.

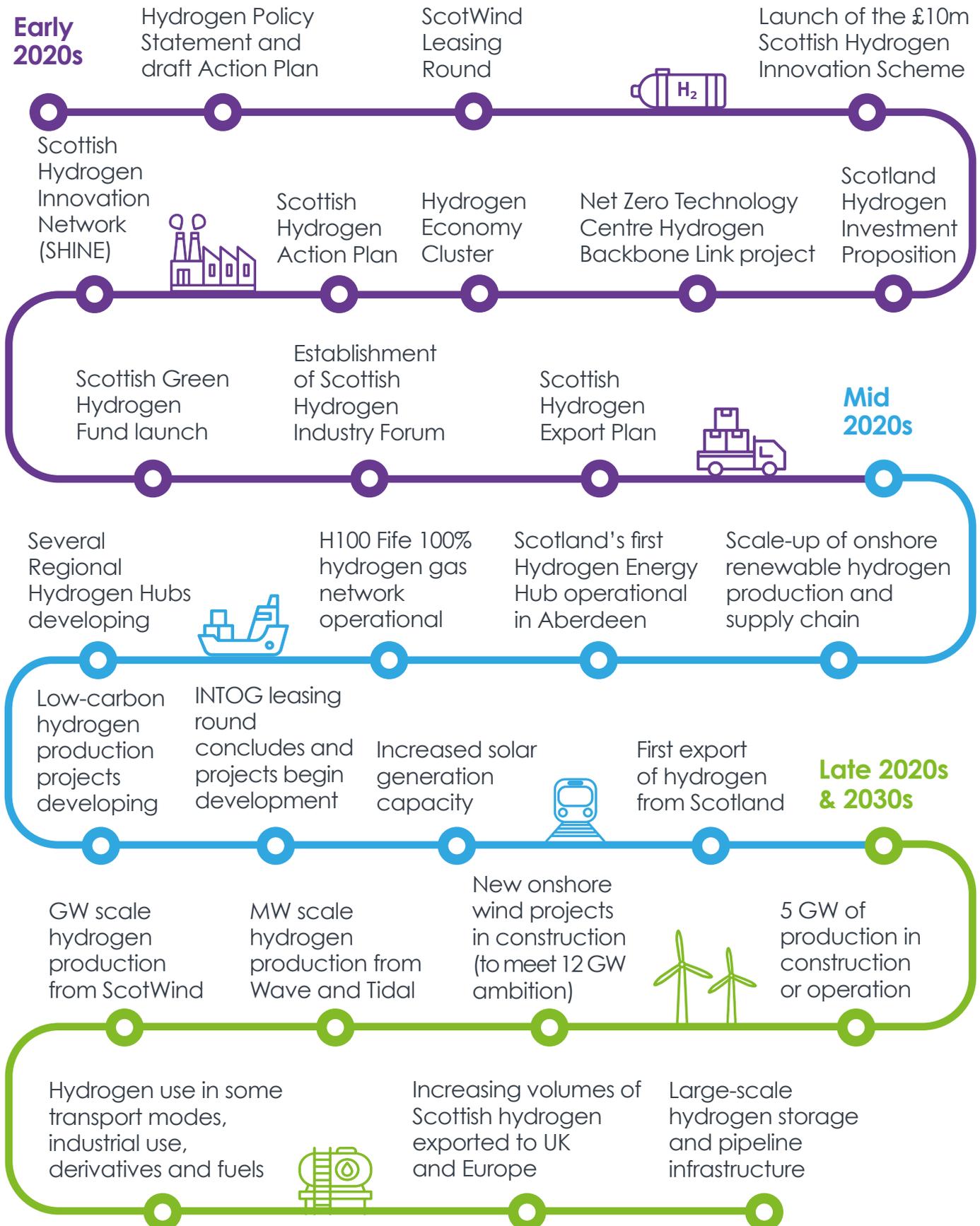


For scale reference,
Scotland's total energy
demand per annum is **161 TWh**.

5GW of hydrogen

could produce energy equivalent to
15% of Scotland's total energy demand.

The Hydrogen Economy Journey



Part 1 – A Unique Opportunity for Scotland

1.1 Scotland's hydrogen potential

Scotland's unique selling point is the combination of its natural resources, infrastructure and skilled energy workforce, which could enable it to become a low-cost producer of hydrogen in Europe. Scotland has an abundance of wind, both onshore and offshore, tides, and reliable water resources with which to support electrolysis. We also have a highly experienced oil and gas sector that is pivoting towards the deployment of hydrogen technology as part of the energy transition.

Our ambition for hydrogen production is closely aligned with our expanding capacity ambitions for both offshore and onshore wind. The Scottish Offshore Wind to Green Hydrogen Opportunity Assessment,⁶ which was published alongside the Scottish Hydrogen Assessment report,⁷ sets out Scotland's renewable hydrogen production potential as 25 GW by 2045, dependent on market conditions. The rate of growth of renewable hydrogen production in Scotland will be influenced by several factors, including market demand and the cost of renewable hydrogen produced in Scotland. However, it is Scotland's vast opportunity for renewable generation that sets it apart from other parts of the UK and Europe and provides the potential to produce industrial-scale renewable hydrogen this decade and for decades to come.

1.2 Onshore wind

Scotland has excellent onshore wind expertise and is recognised as having one of the best wind regimes anywhere in the world in which to deploy projects. Development of renewable energy presents an immense opportunity for Scotland to lead by example – showing how a clean energy future is possible at home, and as a net exporter of renewable energy, attracting further investment and ensuring our progress to net zero is environmentally and economically beneficial.

The draft Onshore Wind Policy Statement⁸, published on 28 October 2021, sets out our ambitions for onshore wind in Scotland out to 2030. It highlights the huge potential for this technology, assesses the significant economic opportunity of future deployment, particularly with regards to green recovery aspirations, and outlines an ambition to deploy a further 8-12 GW of installed onshore and island wind by 2030. A significant portion of this generation capacity may not be able to connect to the grid so hydrogen production could be a very attractive enabler. The final Onshore Wind Policy Statement will be published shortly.

A strong onshore wind sector will support the development of a range of small to large-scale renewable hydrogen projects.⁹ In the South of Scotland alone, there are already 28 projects consented and awaiting construction or under construction to a total of 1 GW to add to 1.45 GW (2021) installed capacity and a further 1.6 GW in planning. As these hydrogen production projects come online, they will aim to improve energy system efficiency by addressing renewable intermittency, which will enable production at times of excess electricity supply.

6 [Offshore wind to green hydrogen: opportunity assessment - gov.scot \(www.gov.scot\) \(2020\)](https://www.gov.scot/publications/offshore-wind-to-green-hydrogen-opportunity-assessment/pages/1-1-introduction.aspx)

7 [Scottish hydrogen: assessment report - gov.scot \(www.gov.scot\) \(2020\)](https://www.gov.scot/publications/scottish-hydrogen-assessment-report/pages/1-1-introduction.aspx)

8 [Onshore wind - policy statement refresh 2021: consultative draft - gov.scot \(www.gov.scot\) \(2021\)](https://www.gov.scot/publications/onshore-wind-policy-statement-refresh-2021-consultative-draft/pages/1-1-introduction.aspx)

9 Small is considered to be <50 MW, medium 50-200 MW and large >200 MW

In the immediate term, the Scottish Government will focus activity and investment to accelerate renewable hydrogen production from onshore wind developments that are constrained or awaiting grid connection. This will thereby help to establish supply chain capability, secure domestic demand and lay the foundational hydrogen infrastructure ahead of the anticipated gigawatt-scale hydrogen production associated with offshore wind towards the end of this decade.

1.3 Offshore wind

Scotland benefits from a large maritime zone and substantial wind resource across the region. This makes it a key provider of offshore wind, not only to deliver its own net zero targets but also to help achieve net zero goals for the UK and, potentially, Northern Europe. Within Scottish waters, there are currently just under 2 GW of operational offshore wind projects and a further 3.82 GW of projects consented or under construction.¹⁰ There are also 4.2 GW of projects with lease options ahead of ScotWind leasing results.

The outcome of the ScotWind offshore wind leasing round was announced in early 2022. A total of 20 projects, with a combined capacity of 27.6 GW, secured lease options.¹¹ These are expected to generate billions of pounds of investment in Scotland's economy over the next 20 years. Many of the successful applicants for ScotWind leases are considering hydrogen production as part of their plans.

A planning round for innovation and targeted oil and gas decarbonisation (INTOG) opened on 24 August 2022, with the specific purpose of facilitating offshore wind development to decarbonise oil and gas infrastructure operations and contribute towards net zero.

Some INTOG projects may have excess capacity beyond powering oil and gas platforms. Where possible, conversion to hydrogen as a form of storage for later use or transfer to another user offers a way to capitalise on that excess and provides potential further opportunities for the Scottish economy through the hydrogen supply chain. These will support the ambition outlined in our Hydrogen Policy Statement of generating 5 GW of hydrogen by 2030. INTOG exclusivity awards will be announced in early 2023.

INTOG will potentially enable the delivery of up to a further 5.7 GW of new offshore wind projects targeting oil and gas decarbonisation, with a further potential 0.5 GW to test new technologies or solutions including hydrogen production in Scottish waters.

1.4 Just Transition

We are committed to a just transition to net zero, which means working with people, businesses and communities across Scotland to ensure they have a clear role in decision-making, that they can access support and advice, that costs to users are kept as low as possible and that the benefits of the transition are spread fairly.

¹⁰ [Scottish Energy Statistics Hub - Renewable Electricity Capacity \(shinyapps.io\)](#):
[Scottish Energy Statistics Hub - Renewable Electricity Pipeline \(shinyapps.io\)](#)

¹¹ [Three ScotWind Clearing project agreements confirmed - News - Crown Estate Scotland \(2022\)](#)

The growth of a strong hydrogen sector offers significant opportunities for regional and local economic benefit, creating new high-quality green jobs in our rural communities, islands and cities, and new opportunities for those currently working in high-carbon sectors. Our analysis, based on a broad range of production scenarios, indicates that a strong hydrogen sector in Scotland could support up to 300,000 new or secured jobs across all skill levels by 2045.¹² Many of the skills required already exist in various sectors, including our renewable and offshore industries.

As is outlined in this document, we will work with key partners to provide targeted support to develop skills programmes and to help people, companies, and communities to connect to the opportunities created by the growing hydrogen economy. This includes a commitment to support those with relevant skills in high-carbon sectors to transition to new green jobs, as well as support for the development of new skills. We will set out more detail on our approach to supporting a just transition in the Energy Strategy and Just Transition Plan in 2023, which considers hydrogen as part of a whole-system approach to the just transition and will be supported by our energy evidence base.

1.5 CCUS

Achieving the deep decarbonisation of industrial energy and industrial heat demand will require large volumes of renewable and low-carbon hydrogen and other decarbonisation solutions to be produced and deployed. We are determined to ensure the strategy for deployment of these technologies will enable decarbonisation at pace and cannot be used to justify unsustainable levels of fossil fuel extraction or impede Scotland's just transition to net zero. Low-carbon hydrogen production should also achieve the highest technically possible emissions capture rates.

The deep decarbonisation of our industrial and electricity sectors will require the timely development of carbon capture, utilisation and storage (CCUS), in parallel with the development of hydrogen technologies. These underpin our route to net zero and support a secure and resilient energy system, while supporting employment for those currently working within our industrial sector and highlighting the importance of a just transition.

This is particularly evident in industrial clusters such as Grangemouth. Six out of seven of the largest industrial emitters, as well as a multitude of smaller sites, are located within 50km of Grangemouth.¹³ All credible pathways to net zero will rely to some extent on the decarbonisation of this cluster. Many processes at Grangemouth are high temperature processes or processes that involve the transformation of chemicals. The options available to decarbonise these processes are extremely limited, which is why hydrogen combined with CCUS has been selected as one of the most promising solutions to help decarbonise this cluster. Indeed, this is the preferred pathway for many industrial clusters across the UK and globally.

¹² [Scottish hydrogen: assessment report - gov.scot \(www.gov.scot\)](https://www.gov.scot/publications/scottish-hydrogen-assessment-report/pages/100-to-150.aspx)

¹³ [Deep decarbonisation pathways for Scottish industries: research report - gov.scot \(www.gov.scot\) \(2020\)](https://www.gov.scot/publications/deep-decarbonisation-pathways-for-scottish-industries/research-report/pages/100-to-150.aspx)

CCUS will establish the opportunities to decarbonise industry and pave the way for establishing the transportation and storage infrastructure to support the growing hydrogen economy in Scotland. CCUS also enables negative emissions technologies in the bioenergy sector and for capturing emissions directly from the air through direct air capture (DAC) plants. Notably, direct air capture technology combined with an anaerobic digestion plant is currently being demonstrated at Crofthead in Dumfries and Galloway, operated by Carbon Capture Scotland.

The Scottish CCUS Cluster encompasses industrial, power, low-carbon hydrogen production and DAC projects, and the CO₂ transport network required for permanent storage of captured emissions. The Scottish Cluster has been awarded the status of 'reserve cluster' in Track-1 of the UK Government's cluster-sequencing process. We are committed to supporting the continued growth and development of the Scottish Cluster to ensure that Scotland reaches its net zero goals by 2045.

Part 2 – Building a Hydrogen Sector

Scotland's businesses are well positioned to help support and join the emerging hydrogen economy. Established sectors such as oil and gas, subsea, maritime, onshore and offshore renewables, chemicals and petrochemicals, and aerospace contain a wealth of skills and capacity, and hydrogen represents an attractive diversification opportunity for those sectors as the nation continues its energy transition.

The developing hydrogen economy will require a strong domestic supply chain across the whole hydrogen value chain, including engineering, manufacturing, consultancy and design. Scottish companies are already engaged or actively interested in moving into the expanding hydrogen sector, and we will support businesses through our hydrogen supply chain development programme in order to mobilise investment along supply chains.

2.1 Support for innovation and demonstration

In recent years, the Scottish Government has supported a variety of projects that have helped demonstrate the use of hydrogen in the decarbonisation of key sectors. Alongside this portfolio of demonstration projects sits a suite of investments in crucial research and development. Alongside our aim to accelerate the development of industrial scale renewable hydrogen projects, we will also continue to foster demonstration, innovation and workforce skills development.

Actions we will take:

- **Investing in early projects** – We will encourage the public and private sector in Scotland to work together to demonstrate these technologies as much of the learning takes place before a single molecule of hydrogen is even produced.
- **Building relationships** – We will gain valuable knowledge of how to work with others to assess, approve, consent and regulate these projects, as well as to address deployment constraints and challenges, including high production costs.
- **Mobilise investment** – We will continue to support projects on the journey to decarbonisation.

Progress to date:

- **Hydrogen Innovation Scheme (HIS)** – In 2022 we launched our Hydrogen Innovation Scheme, designed to support research and innovation in hydrogen production, storage and distribution. The HIS has received high levels of market interest.
- **The Scottish Hydrogen Innovation Network (SHINE)** – Created in 2022, SHINE provides an entry point for Scottish and European companies to access more than twenty Scottish research and development centres in academic and commercial settings. The resulting innovations will increase the competitiveness of technologies and enable collaborative partnerships.
- **Hydrogen Accelerator** – The Hydrogen Accelerator, hosted by the University of St Andrews and supported by Scottish Government, brings together government, business and researchers to enable efficient implementation of hydrogen technologies and primarily focuses on the transport sector.

- **Hydrogen buses** – The Scottish Government, through the Energy Transition Fund, has contributed £15m over the past few years to assist the city of Aberdeen in its drive to deploy its fleet of hydrogen buses.
- **Hydrogen for heavy duty vehicles** – We have published the findings of the Scotland's Zero Emission Mobility Industry Advisory Group (IAG)¹⁴ on enhancing Scotland as a destination for innovation and investment in the design and build of zero emission niche and heavy-duty vehicles, including those fuelled by hydrogen. We are also supporting the development of LOCATE, a drivetrain testing facility supporting the development of hydrogen niche and heavy duty vehicles.
- **Zero Emission Mobility Innovation Fund** – In June 2022, in partnership with Scottish Enterprise, we launched the Zero Emission Mobility Innovation Fund to accelerate the manufacturing and deployment of heavy duty zero emission vehicles, including hydrogen vehicles.
- **Hydrogen transport demonstrations** – We have supported hydrogen demonstration projects in the transport sector including the development of Scotland's first hydrogen powered train.
- **H100 Fife project** – The Scottish Government has provided £6.9m towards SGN's H100 project to understand the role hydrogen can play in decarbonising heat using the gas network.
- **Gordonbush Hydrogen project** – SSE Renewables and Siemens Gamesa Renewable Energy plan to produce and deliver renewable hydrogen using renewable energy from SSE's Gordonbush Extension Wind Farm in Sutherland in the Scottish Highlands. The Gordonbush hydrogen project, with Scottish Government funding, will aim to demonstrate a replicable and low-cost solution as an enabler to move on to electrolysis at scale at demand centres and for export.

2.2 Sector development and supply chain capability

As part of our efforts to develop the supply chain in Scotland, it is important to communicate to companies operating in the energy and other sectors the scale of the future hydrogen economy in Scotland, UK and Europe and the potential opportunities this presents for Scottish companies.

Actions we will take:

- **Support agencies** – Our Enterprise Agencies stand ready to facilitate engagement throughout Scotland and support companies with capabilities that could be transitioned to the hydrogen sector. The Expert Support service offers tailored advice to companies interested in entering the hydrogen supply chain.
- **Supportive policy** – We will focus on creating positive socio-economic impact in the short and longer term aided by the development of a strong skills base to ensure Scotland's hydrogen market develops early, with access to a skilled workforce and enabling a skills transition.

14 [Transport Scotland Zero Emission Mobility Industry Advisory Group Report \(transport.gov.scot\) \(2022\)](#)

- **Encourage Scotland's academic and research** – The Scottish Hydrogen Innovation Network (SHINE) will support the necessary close collaboration between academia, industry and governments to ensure knowledge exchange and learning across projects. This is needed to assist in closing key gaps in knowledge regarding the production and cost reduction, use, transport and storage of hydrogen as well as its integration into the wider energy system.
- **Financial support** – We will support the development of the earlier tiers of the supply chain by investing in innovation and demonstration to enable commercial scale-up.

Progress to date:

- **Building A Hydrogen Sector event** – This event, held by the Scottish Government in partnership with Transport Scotland, Scottish Enterprise, Highlands and Islands Enterprise, and South of Scotland Enterprise, brought together over 200 representatives from business, government and academia in September 2022 to discuss emerging supply chain opportunities and how to develop capabilities in the hydrogen supply chain in Scotland.
- **Enterprise Agencies events** – A series of events led by the enterprise agencies were held earlier in 2022 in Inverness, Dumfries and Dundee with the aim to mobilise the development of the Scottish hydrogen supply chain and to maximise brokerage opportunities between producers, project developers and supply chain companies. There was an excess of 300 attendees in attendance across the three events, with many of these participants being new to exploring the supply chain or off-take opportunities. This has stimulated collaborations and follow-up activity across Scotland.
- **Assessment of Electrolysers report¹⁵** – The Scottish Government commissioned Arup to deliver a study that considered electrolyser manufacturing globally to support a better understanding of the supply chain opportunities in Scotland. The report set out the component parts of the three main electrolyser technologies and provided an assessment of the existing companies operating in Scotland that possess the possible capability to manufacture electrolyser component parts, as well as recommendations to encourage higher levels of electrolyser manufacturing in Scotland.

¹⁵ [Assessment of electrolysers: report - gov.scot \(www.gov.scot\) \(2022\)](https://www.gov.scot/resources/documents/2022/07/Assessment-of-electrolysers-report-2022.pdf)

2.3 Map of current and planned hydrogen projects

End User

- 01 Eden Mill distillery
- 02 Glasgow Hydrogen Gritters
- 03 HECTOR project
- 04 HyDIME
- 05 HyFlyer
- 06 HySeas III
- 07 HySpirits
- 08 HyTransit Project – Aberdeen Hydrogen Buses
- 09 Hytec and Hytec2
- 10 Kirkwall Airport Decarbonisation
- 11 Liquid Organic Hydrogen Carriers (LOHC) for the transportation of hydrogen
- 12 Project HyLaddie
- 13 Scottish Hydrogen Train project
- 14 TimberLINK
- 15 Uist Distilling Company
- 16 HIMET

Multi-vector

- 17 Aberdeen Hydrogen Hub
- 18 Aberdeen Vision
- 19 BIG HIT
- 20 GENCOMM – AD
- 21 ITEG – Integrating Tidal Energy into the European Grid

- 22 North of Scotland Hydrogen Programme
- 23 OHLEH – Outer Hebrides Local Energy Hub
- 24 Orion Project
- 25 PITCHES
- 26 ReFLEX (Responsive Flexibility) Project
- 27 SWIFTH2
- 28 The PURE Project
- 29 Flotta Hydrogen Hub
- 30 Inverness hydrogen transport hub
- 31 Argyll Hydrogen Hub
- 32 GreenNH3
- 33 Hy2Go
- 34 Holistic Low-Carbon Energy Facility/ Renewable Energy Village
- 35 INEOS Low-Carbon Hydrogen Plant
- 36 Inverurie Energy Hub

Production

- 37 Arbiekie Distillery
- 38 Aberdeen City Hydrogen Energy Storage (ACHES)
- 39 Acorn CCS
- 40 Acorn Hydrogen
- 41 Chapelcross Initiative
- 42 Dolphyn Project
- 43 Edinburgh International Festival decarbonisation project
- 44 Green Hydrogen for Glasgow

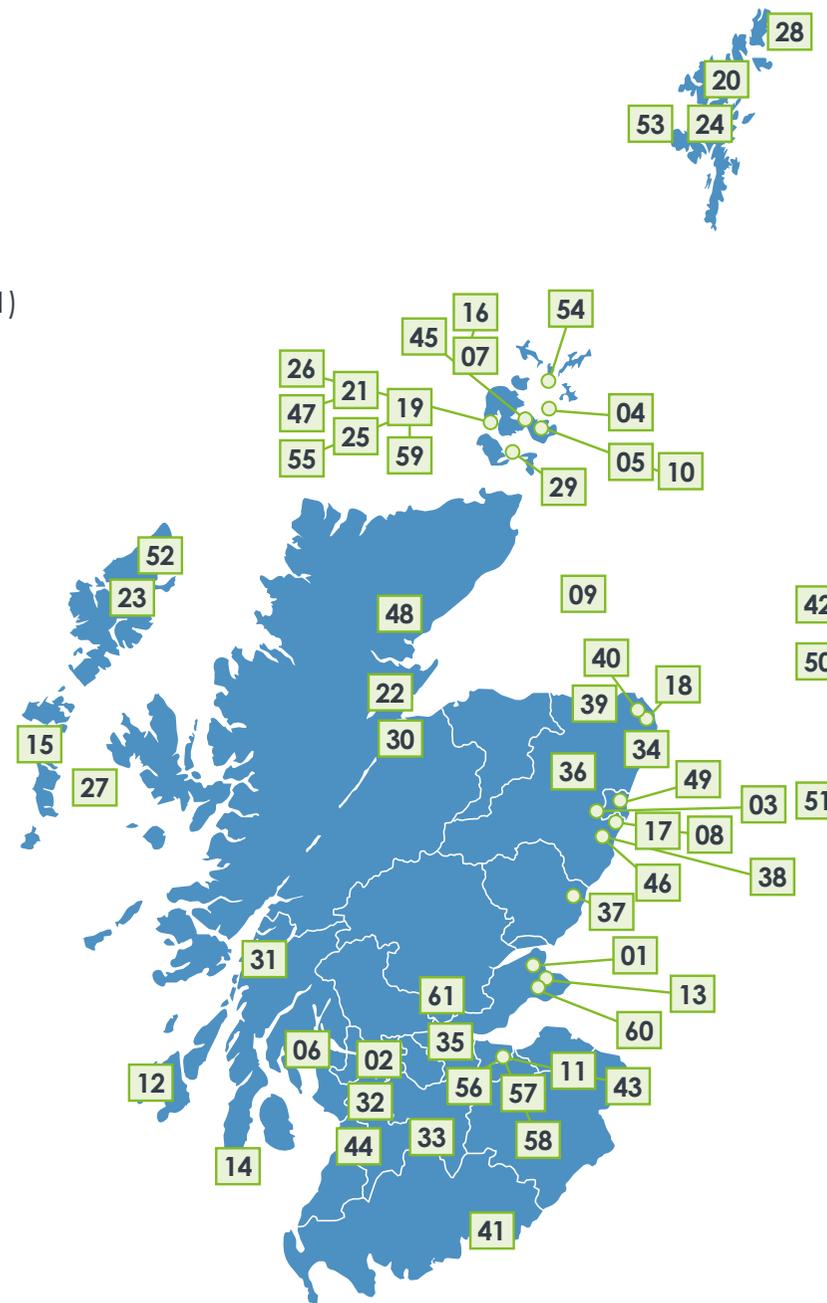
- 45 Hammars Hill Green Ammonia project
- 46 Kittybrewster Refuelling Station
- 47 Surf 'n' Turf
- 48 Gordonbush Hydrogen Demonstrator Project
- 49 Hydrogen Turbine 1 (HT1)
- 50 ERM Dolphyn – Commercial scale demonstration
- 51 Project Haldane
- 52 Comhairle nan Eilean Siar – Net Zero Hub
- 53 Northern Horizons

Storage

- 54 Eday Flow Cell Battery Project
- 55 HyAI
- 56 HyStorPor Project
- 57 HyProducer: Cascade Tank System for Hydrogen Storage & Delivery from LOHC
- 58 Bulk scale storage and transportation of hydrogen using LOHC
- 59 SHyLO: Solid Hydrogen at Low pressures

Transmission/distribution

- 60 H100 Fife project
- 61 Local Transmission System – Grangemouth to Granton



2.4 Regional hydrogen energy hubs

A Regional Hydrogen Energy Hub is a geographic location (region, city, island, industrial cluster) that is host to the entire hydrogen value chain, from production, storage and distribution to end-use. Regional Hydrogen Hubs will include multiple end-users with applications ideally covering more than one sector.

The establishment of sector-coupling hydrogen production hubs capable of simultaneously servicing transport, heat and industry needs will provide an effective energy integration opportunity for hydrogen and a critical step in increasing the scale of the hydrogen economy in Scotland. Hubs will create economies of scale by aggregating local demand across multiple sectors, driving cost efficiencies and facilitating knowledge sharing.

Areas across the North and South of Scotland and the Islands, are rapidly developing as potential future centres of hydrogen production and demand as well as our industrial centres such as the Grangemouth industrial cluster. Led by industry and the private sector, several regional hydrogen clusters or hubs are forming. Some are already producing renewable hydrogen and supporting demand for hydrogen fuels, e.g. Aberdeen, while others are advancing to renewable hydrogen production, such as the Green Hydrogen for Glasgow project, which uses hydrogen production from the renewable energy generated by the Whitelee Wind Farm operated by Scottish Power. Early investment in infrastructure for production and distribution will be important for the development of regional hubs.

There are several characteristics that might determine the suitability of a location for a hydrogen energy hub, including their proximity to energy supply and feedstock for production, high local demand and connectivity to onshore and offshore transportation infrastructure and networks, as well as in many cases proximity to port facilities to enable access to export markets. Our islands benefit from many of the characteristics that would enable them to develop as hubs of hydrogen production, meeting local demand and providing potential solution to grid curtailment issues. We also know that low-cost production of hydrogen is a key consideration underpinning transition planning – the transportation and storage of hydrogen adds to the overall cost per unit and therefore it makes sense to co-locate production with multiple off-takers.

Actions we will take:

- **Encourage relationships** – Aggregation of cross-sectoral demand and co-location of the whole hydrogen value chain minimises the cost of essential supporting infrastructure and makes the hub model an efficient pathway to producing hydrogen at scale and increasing demand.
- **Hydrogen hub location awareness** – A study will be published early in 2023 to describe, quantify and map, in detail, the potential hydrogen demand in Scotland across multiple sub-sectors in industry and transport. The aim is to help hydrogen suppliers to identify off-takers more easily, in proximity to the production site where possible.
- **Supportive policy** – The Scottish Government's supportive policies and investment, alongside that of private investment and UK market frameworks and funding, are required to enable regional hydrogen hubs across Scotland to reach a final investment decision.

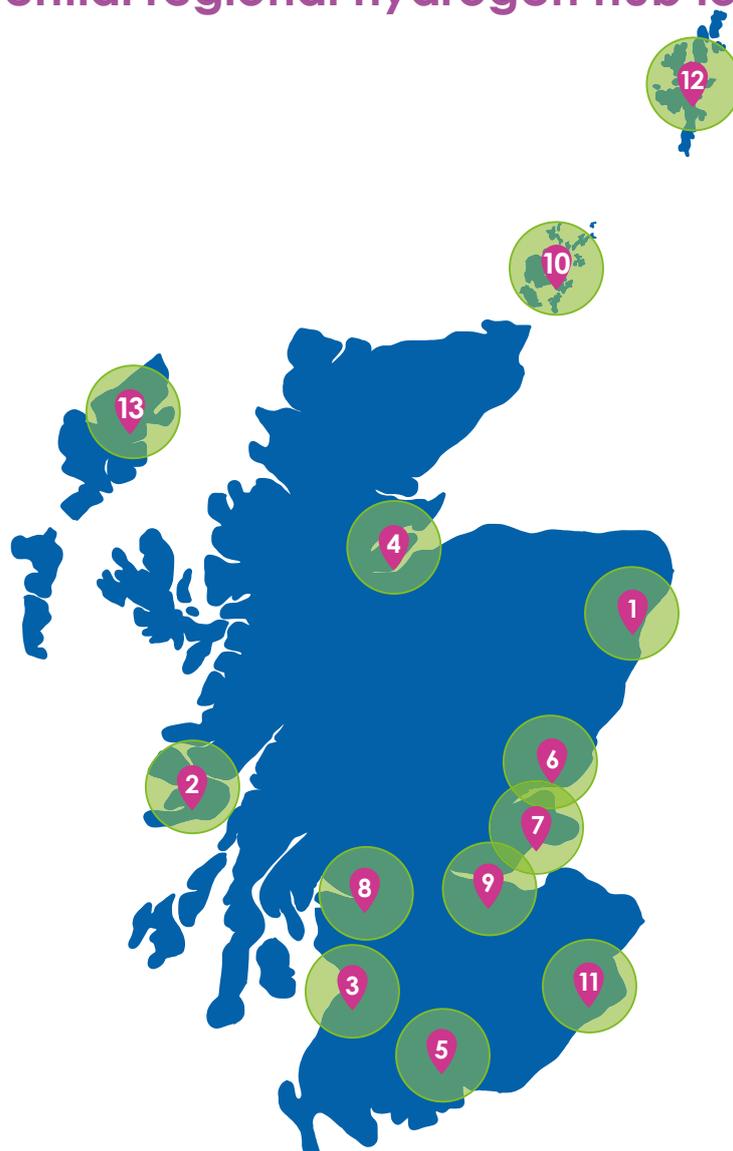
Progress to date:

- **Cromarty Distilleries Project** – Scottish Power and Storegga are developing the Cromarty Distilleries Project as part of the North of Scotland Hydrogen Programme. The Phase 1 project aims to have a 35 MW electrolyser facility operational by the end of 2024, producing up to 14 tonnes of renewable hydrogen per day to meet local distillery demands and prove the technology at this scale. The project will initially supply renewable hydrogen to local distilleries operated by Diageo, Glenmorangie and Whyte & Mackay, and the supply chain supporting those distilleries, before expanding into a broader Cromarty regional solution for heat and transport needs whilst also enabling hydrogen export via the Port of Cromarty Firth.
- **Outer Hebrides Local Energy Hub** – The Outer Hebrides Local Energy Hub, is being supported via the UK and Scottish Government Islands Growth Deal and the Scottish Government's Green Growth Accelerator. The Outer Hebrides, Orkney and Shetland Islands have excellent wind conditions and have the potential to develop significant onshore and offshore wind generation through both community-owned and commercial renewable energy generators.
- **Island Pilot projects** – We will work with at least three islands over this Parliament to enable them to become fully carbon-neutral by 2040, as forerunners to a net zero Scotland by 2045. Supporting projects to help create circular economies and explore more sustainable transport options.
- **Production Site studies** – Enterprise Agencies published a Hydrogen Production and Export Locations Site Requirements Study ¹⁶ that assessed the required inputs including water supply and land area required for production, related infrastructure, considerations for hydrogen export, and planning and consenting. The study assessed production for both renewable and low-carbon hydrogen, determining detailed site requirements for hydrogen production sites at 200 MW, 500 MW and 1 GW scale. A follow on report on smaller scale production site requirements (<100MW) and overlap with locations with constrained or curtailed wind capacity is underway and will help inform and enable quicker development of hydrogen production sites.

Case Study: Flotta Hydrogen Hub – This multi-billion-pound project would utilise a repurposed area of the existing Flotta Terminal to create a renewable hydrogen hub powered by offshore wind projects in the seas around Orkney. The plan is to progressively transform the site, allowing conventional oil and gas operations to continue whilst the renewable hydrogen facilities are developed. The project's location at Scapa Flow makes it a potential site for domestic supply, international export and maritime refuelling. The project is being led by Repsol Sinopec, the Flotta Terminal owner, TotalEnergies, Macquarie's Green Investment Group and Uniper. The renewable hydrogen production facility at Flotta Terminal could be powered with renewable energy from the West of Orkney Windfarm that is under development by Offshore Wind Power Limited (OWPL) after its successful bid for the Scotwind N1 zone.

16 [Hydrogen Production and Export Locations: Site Requirements Study \(scottish-enterprise.com\)](https://www.scottish-enterprise.com) (2022)

2.5 Map of potential regional hydrogen hub locations



1. Aberdeen

Aberdeen is developing as one of Europe's most advanced hydrogen cities with hydrogen initiatives including: the deployment of over 90 hydrogen vehicles; a renewed fleet of 25 double-decker hydrogen buses; a range of light duty fuel cell vehicles for council fleets and a local car sharing club; trials of hydrogen-fuelled refuse trucks and road sweepers; the commissioning of a megawatt-scale stationary fuel cell as part of Aberdeen's recent new conference centre development; adaptation of facilities for hydrogen fleet maintenance and upskilling of fleet technicians; and two public hydrogen refuelling stations operating since 2015. The Scottish Government has invested over £15m from our Energy Transition Fund to take forward the development of the Aberdeen Hydrogen Hub. The development of the new South Harbour, the UK's largest marine infrastructure project, is currently underway and the adjacent Energy Transition Zone (ETZ) is set to become a catalyst for high-value manufacturing, R&D and hydrogen development. It is also in proximity to Acorn CCUS and Acorn Hydrogen project further up the coast at St Fergus.

2. Argyll & Islands

Machrihanish Airbase Community Company (MACC) Hydrogen Futures aims to establish a renewable hydrogen production and distribution site at Machrihanish Airbase on the Kintyre Peninsula. A former military aerodrome, Machrihanish has been transformed into a community-owned business park offering over 1,000 acres (400+ hectares) of unique properties, development land and assets, as well as its own airport.

3. Ayrshire

Ayrshire is emerging as a hub of hydrogen activity. Hunterston, a former nuclear power station, could be an ideal landing point for nearby offshore wind farms, with industrial scale options for hydrogen production and export, strong grid connections and existing marine infrastructure. Prestwick Aerospace, home to Scotland's aerospace sector, offers emerging opportunities to service the aviation sector and which could emerge as one of hydrogen's key end-users.

4. Cromarty

The North of Scotland Hydrogen Programme aims to develop a state-of-the-art hub to produce, store and distribute renewable hydrogen to the local area, the UK and Europe. Ideally located close to large-scale renewable resources, there is a driving ambition for the region to become a hydrogen economy, with huge local demand for renewable hydrogen from distilleries, industry, transport and domestic applications.

5. Dumfries & Galloway

Centrally located in the UK, Dumfries & Galloway offers easy access to existing gas transmission pipelines (including the Scotland to Northern Ireland Pipeline) and future 'Project Union' (National Grid) and 'European Backbone' transmission infrastructure. The area already has an emerging hydrogen supply chain cluster, including hydrogen-enabled industrial boilers, and key development sites include Chapelcross, which offers up to 500 acres of development potential.

6. Dundee

Ideally located next to several offshore wind farms, Dundee has ambitions to deploy hydrogen production, refuelling infrastructure and hydrogen vehicle fleets. Michelin Scotland Innovation Parc (MSIP) is a key site, focused on driving innovation and R&D in sustainable mobility and low-carbon energy and offering a wide range of industrial spaces, cutting-edge research facilities and a Skills Centre of Excellence.

7. Fife

Fife's world-first H100 hydrogen network will install hydrogen into around 300 homes to provide customers with renewable hydrogen for their heating needs – produced using electricity from an offshore wind turbine. The project is built on the legacy of Fife's pioneering Hydrogen Office that launched in 2011 with a 750 kW wind turbine and 30 kW electrolyser and subsequently added a solar PV, smart microgrid, fleet of 17 hydrogen vehicles, 250 kW of electrolysis and 100 kW fuel cell.

8. Glasgow

The Sustainable Glasgow initiative aims to make Scotland's largest city net zero by 2030, with projects including deploying hydrogen refuse collection vehicles and new refuelling infrastructure. The nearby Whitelee wind farm, one of Europe's largest onshore wind farms, plans to have the UK's largest electrolyser at 20 MW, while the Hy2Go project proposes a renewable hydrogen production park off the M74 motorway.

9. Grangemouth

Scotland's largest industrial area, Grangemouth offers numerous opportunities to decarbonise. A new energy plant is due to be commissioned in late 2023, designed to fuel switch to hydrogen in the future, and a large-scale hydrogen production plant could export captured carbon offshore for permanent storage via the Acorn project, while SGN could repurpose existing pipeline to transport hydrogen from Grangemouth to Edinburgh. In September 2022, INEOS announced plans to deliver a world-scale low-carbon hydrogen plant expected to be operational by 2030 that aims to reduce emissions at the plant by one million tonnes per year.

10. Orkney

The Flotta Hydrogen Hub is a proposed industrial-scale renewable hydrogen production facility on an existing oil terminal in Orkney. Utilising renewable energy generated via a ScotWind offshore wind development, this project could export significant quantities of hydrogen to Europe and the UK gas grid at St Fergus, forming the foundation for an international maritime renewable hydrogen refuelling hub. The existing hydrogen cluster in Orkney on the islands of Eday and Shapinsay continues to grow and develop as a critical part of the European Marine Energy Centre.

11. Scottish Borders

The Scottish Borders boasts large onshore windfarms and easy access to the East Coast's offshore windfarms, via Eyemouth harbour, and the European Hydrogen Backbone initiative. Main gas transmission pipelines to England cross the area, as will new 'Project Union' infrastructure, local engineering firms offer strong electrolyser supply chain potential and therefore the area is an ideally situated location for regional hydrogen hub development.

12. Shetland

The ORION Clean Energy Project will shape Shetland as a world-leading clean energy hub. Renewable hydrogen from the abundant wind, wave and tidal resources, aims to power homes, businesses and vehicles, electrify oil and gas installations, and serve export markets using existing infrastructure, including Shetland Gas Plant and Sullom Voe, and the deep-water port and oil terminal.

13. Western Isles

The Outer Hebrides Energy Hub aims to maximise the area's abundant onshore and offshore wind resources, producing enough renewable hydrogen to power the islands, as well as for export to the UK domestic and international markets.

2.6 Hydrogen uses

In some sectors of our economy, hydrogen is more likely to provide a path to decarbonisation, while in others hydrogen is less likely to make an impact due to the availability of more effective solutions such as electrification.

We expect direct electrification to do the heavy lifting in decarbonising the energy system, but we also recognise the contribution hydrogen can make as part of an integrated energy system. Direct electrification should be maximised where appropriate, but there remain some important parts of our energy system where decarbonisation through hydrogen, either via the use of gaseous hydrogen or hydrogen derivatives, may be the more effective solution.

While the nature of hydrogen as an energy vector means that it can theoretically be used across many sectors of the economy, some sectors are more likely than others to adopt hydrogen as an optimal solution.

The likeliness of hydrogen being adopted will depend on technical parameters such as efficiency. Other regional factors such as resource availability and availability of infrastructure will be of importance on a case-by-case basis. For example, this could be the case for distilleries in Scotland. While the decarbonisation of distilleries would theoretically favour electrification routes, the remote nature of many distilleries across Scotland might favour hydrogen implementation that could benefit from on-site power sources that are otherwise hindered by grid limitations.

There are sectors that already have extensive experience in the use of hydrogen for their applications and these are the most likely to adopt the use of renewable or low-carbon hydrogen. In Scotland, this includes the use of hydrogen in industry for refining or the production of fertilisers where unabated hydrogen as an industrial feedstock is already in use.

In other instances, the lack of a cost-effective direct electrification solution is likely to favour the transition to hydrogen. This could be the case for the metallurgic industry where high temperature flame applications are currently less likely to achieve decarbonisation through electrification. Different uses of hydrogen could also become more viable through the development of hydrogen hubs where heavy industry – i.e. refineries, chemicals, fertiliser and steel manufacturing – develop alongside other uses such as shipping, freight transport, pipeline export (domestically and internationally) and power infrastructure.

Subject to price and availability, hydrogen in the transport sector could act as a complementary energy source alongside electrification, providing an option to parts of the transport sector such as heavy duty vehicles and parts of the rail network, when full electrification is challenging. As outlined in the Zero Emission Energy for Transport Report¹⁷, hydrogen is unlikely to play a significant role in the decarbonisation of some forms of road transport, such as cars or light goods vehicles, due to the suitability and availability of battery electric vehicles for these applications. However, hydrogen and hydrogen-based fuels or electro-fuels (e-fuels) could play a more significant role in the decarbonisation of the maritime and aviation industries as well as in some high-temperature flame industrial applications. In these sectors, hydrogen converted into synthetic liquid e-fuels, such as e-methanol, e-methane, liquid e-hydrocarbons, e-formic acid or e-ammonia, could

¹⁷ [Zero Emission Energy for Transport Forecasts: National | Transport Scotland \(2022\)](#)

offer certain advantages over liquid or gaseous hydrogen. Hydrogen has low volumetric energy density that adds costs and challenges when transporting and storing it. Converting hydrogen into e-fuels with higher energy density could reduce some of these challenges as e-fuels can often use existing infrastructure, although this benefit needs to be considered against the additional conversion losses and costs to produce these fuels. In these instances, e-fuels might pose a more suitable alternative than the combustion of hydrogen or its use in fuel cells.

We do not consider that hydrogen will play a central role in the overall decarbonisation of domestic heat and therefore cannot afford to delay action to decarbonise homes this decade through other available technologies. The potential for hydrogen to play a role in heating buildings depends upon strategic decisions by the UK Government that will be made over the coming years and the Scottish Government will continue to urge the UK Government to accelerate decision-making on the role of hydrogen in the gas grid.

The gas industry is testing options for blending hydrogen into the gas network up to the limit that can be safely used in existing appliances. Using a blend of hydrogen up to 20% by volume has the potential to generate carbon savings from gas use by up to only 6-7% on current GB grid gas consumption.¹⁸ There is also potential for some parts of the gas grid in Scotland to be converted to 100% hydrogen in the 2030s and beyond.

Hydrogen might have a role to play in the decarbonisation of Statutory Independent Undertakings (SIUs), which are gas networks in Scotland not connected to the national gas network. This is the focus of a partnership between SGN and RWE¹⁹ that will investigate the decarbonisation of homes and businesses connected to the local gas networks of Campbeltown, Stornoway, Oban, Thurso and Wick.

Availability of hydrogen may also offer a role for many Scottish NHS sites to enable a switch-over of heat source without disrupting the delivery of health services.

Additionally, an electricity system built around renewable energy supply will require the integration of hydrogen to provide flexible capacity for reliable backup and strategic energy storage for resiliency. Paradoxically, the more we strive for electrification, the more we depend on intermittent renewable generation and the more energy storage is required to balance the system.

Government can assist the growth of the sector with the development of supportive policies, investment and the introduction of market intervention such as business models. Many of the uses of hydrogen across the Scottish economy will be based on the suitability of hydrogen for each application as well as regional, logistical and market factors. It is also worth noting the nascent nature of the hydrogen sector with technology readiness levels still in development.

18 [Hydrogen transport and storage infrastructure: consultation on business model designs, regulatory arrangements, strategic planning and the role of blending \(publishing.service.gov.uk\)](https://publishing.service.gov.uk/government/consultations/hydrogen-transport-and-storage-infrastructure-consultation-on-business-model-designs-regulatory-arrangements-strategic-planning-and-the-role-of-blending) (2022)

19 [RWE and SGN announce green hydrogen partnership for domestic heat in Scotland \(www.rwe.com\)](https://www.rwe.com) (2022)

A hierarchy of uses is presented below that is based on our current understanding of the sector and provides our view of some of the hydrogen uses that are more or less likely to develop, based on current alternatives and available opportunities. This has been produced by considering a range of influencing factors such as economic, technical and logistical issues and will be taken into account as part of our considerations as we design support for the transition to a net zero economy.

Fewer alternatives
and significant
market opportunity



Many alternatives
and less certain
market opportunity

Fertilisers (ammonia), Chemical Feedstock, Refineries,
Energy exports via pipeline and ship, Methanol

Distilleries, Steel production, High-temperature
industrial heat

Long-term energy storage, Off-grid portable power
generators, Maritime (other than small vessels), Aircraft

Heating in SIUs, Heavy road vehicles

Rural and island grids, Uninterruptable power
supplies, District heating, Commercial heating,

Low-temperature industrial heat, Maritime-small
vessels, Rail, Domestic heating

Power system balancing, Short-term energy
storage, Light road vehicles (cars, vans etc)

Part 3 – The Renewable Hydrogen Export Opportunity

Scotland's draft Hydrogen Action Plan outlined our potential to become a leading producer and exporter of low-cost renewable hydrogen to partner nations in Europe. Since its publication in November 2021, geopolitical events have triggered growing global momentum around the development of international hydrogen markets, with countries across Europe increasing the scale and the pace of their hydrogen production and import targets.

In light of this accelerated European ambition and demand, this chapter sets out the current estimate of the scale of the export opportunity, Scotland's competitive advantage and the initial actions we will take at home and abroad to support Scottish companies to participate in and benefit from the development of the international hydrogen market.

3.1 Scotland's ambition

Our ambition is for Scotland to be a leading producer and exporter of hydrogen and hydrogen derivatives for use in the UK and in Europe, with the first hydrogen delivered from Scotland to mainland Europe in the mid-2020s.

The opportunity for Scotland within the developing global hydrogen market is significant. Increasing European demand for alternative energy sources and chemical feed stocks, to reduce dependency on fossil fuels, means that the supply of renewable hydrogen will play a major role not just in the energy transition but in enabling security of supply across Europe through diversification of fuels and supply sources.

The European Union has recently set a target to import 10m tonnes (Mt) of hydrogen by 2030, with recent reports indicating that global hydrogen demand could reach 115 Mt by 2030.²⁰

Hydrogen produced in Scotland could play a significant role in supplying these growing, local and overseas markets. Our 5 GW by 2030 renewable and low-carbon hydrogen ambition can be translated as approximately 0.45 Mt of hydrogen produced annually for both domestic and international use. What's more, the Scottish Hydrogen Assessment, completed in 2020, estimated that by 2045 approximately 3.3 Mt (126 TWh) of renewable hydrogen could be produced in Scotland with approximately 2.5 Mt (94 TWh) exported to the UK and other European markets annually.

However, the opportunity for Scottish businesses extends beyond the trade of hydrogen or hydrogen-derived products and includes the opportunities to increase trade in goods and services across the hydrogen supply chain. Our analysis indicates that the development of a renewable hydrogen sector in Scotland, with a strong focus on export, could support up to 300,000 jobs and contribute up to £25bn to Scotland's GVA by 2045.

The European Commission has estimated that Europe's capacity to manufacture electrolyzers will have to increase tenfold in only three years – from 1.75 GW now, to 17.5 GW by 2025.²¹ This represents both a challenge and an opportunity for supply chains. The Scottish Government's Assessment of Electrolyzers report (2022)²² indicated that there is strong potential for Scottish companies to supply key elements to the electrolyser market – such as process equipment, electrical components and others.

20 [Global Hydrogen Review 2022 – Analysis - IEA \(www.iea.org\) \(2022\)](https://www.iea.org/publications/Global-Hydrogen-Review-2022-Analysis)

21 [European Electrolyser Summit \(pdf\) \(hydrogeneurope.eu\) \(2022\)](https://hydrogeneurope.eu/)

22 [Assessment of electrolyzers: report - gov.scot \(www.gov.scot\) \(2022\)](https://www.gov.scot/publications/assessment-of-electrolyzers/report/pages/12.aspx)

The Scot2Ger²³ study, completed in early 2022, reinforced Scotland's capability to supply renewable hydrogen and derivatives to Germany as early as 2025. It also demonstrated the feasibility of building the full supply chain, paving the way for further exploration of hydrogen export from Scotland.

3.1.1 Scotland's natural advantage and technical expertise

Scotland's extensive renewable resources, proximity to centres of demand, supportive government policy environment, academic strengths, and over sixty years of transferable experience and skills from established sectors, such as oil and gas, mean we are primed to be a major player on the global export market.

Extensive renewable resources

Scotland's geographical advantage, with vast wind, wave and tidal resources, provides a huge potential for the early deployment of large-scale hydrogen production, firmly positioning Scotland at the forefront of a growing global industry. We already have 13.5 GW of renewable capacity in place as well as increasing onshore wind capacity in development.

ScotWind is the world's largest commercial round for floating offshore wind and puts Scotland at the forefront of offshore wind development globally with potential to deliver 27.6 GW of offshore wind power. 14 out of 20 of the successful ScotWind projects plan to use floating technology, nearly 18 GW of total capacity from the leasing round – which also presents potential for hydrogen production.

Proximity to centres of demand

Scotland, due to its close geographic proximity to growing centres of hydrogen demand in Europe, being only 700km and 750km from the coastlines of the Netherlands and Germany respectively, benefits from lower transport costs and durations than many other potential hydrogen exporting nations, with shipping taking as little as two days.

This proximity, and existing infrastructure connectivity to Europe, offers the potential to not only export hydrogen by ship, but also to establish new pipelines or to repurpose existing pipeline infrastructure to facilitate the transport of hydrogen from Scotland to Europe.

Pipelines are the cheapest option for the transportation of large volumes of hydrogen across long distances. However, it is likely that multiple options, including marine vessel transportation of liquid hydrogen, green ammonia and methanol, and Liquid Organic Hydrogen carrier (LOHC), could all be used for export at different scales depending on off-taker requirements.

23 [Scot2Ger Development of a Green Hydrogen Supply Chain from Scotland to Germany \(evaluationsonline.org.uk\) \(2022\)](https://evaluationsonline.org.uk)

Established infrastructure

Scotland's port facilities and existing energy infrastructure, along our extensive coastline and on our islands, offer the potential to develop multiple large-scale hydrogen hubs with export routes through ports, terminals, and pipelines. Due to their coastal, and often rural nature, many of these sites have abundant access to water, have land available for development and are near future gigawatt-scale offshore wind developments and potential new pipelines.

In the North Sea, the repurposing of existing oil and gas assets that are approaching end-of-life and decommissioning can support the cost-efficient scale-up of the hydrogen economy in Scotland. This offers the potential for oil terminals and ports to be expanded or redeveloped to support the ship-based export of hydrogen and the option to re-purpose existing natural gas pipelines for the transport of hydrogen.

Industry expertise, skills and supply chain

With over 60 years of expertise in offshore engineering and oil and gas, Scotland has unrivalled expertise in developing energy infrastructure.

Scotland also benefits from a high-quality academic knowledge base, as well as a highly skilled workforce, with over 65,000 people²⁴ currently working in our energy sector and a large talent pool with expertise in:

- Gas storage and distribution;
- Safety planning, regulation, and enforcement for hazardous gases;
- Handling of high-pressure gases;
- Offshore and subsea engineering;
- Design and production engineering;
- Manufacture of storage vessels, compressors, balance of plant; and
- Plant maintenance.

Stable and supportive political environment

There is a clear and supportive policy framework and political environment in Scotland, the commitment to ensuring a supportive regulatory framework, and supportive UK and Scottish investment programmes through:

- Scotland's Emerging Energy Technologies Fund;
- The UK Net Zero Hydrogen Fund; and
- The UK Hydrogen Business Model.

24 [Growth sector statistics - gov.scot \(www.gov.scot\) \(2022\)](https://www.gov.scot/resources/documents/2022/04/Growth-sector-statistics-2022.pdf)

Track record of supporting and advancing hydrogen and energy technologies

Scotland has a proven track record of supporting and advancing innovation in hydrogen and other energy technologies, with several pioneering world-first renewables projects, including:

- The world's first deep-water wind project;
- The world's first off-grid renewable energy system;
- The world's first floating wind farm; and
- The world's first tidal-powered hydrogen electrolyser.

3.2 Unlocking the Economic Opportunity

Against the backdrop of growing demand and Scotland's natural advantage, the Scottish Government has an international vision for our hydrogen economy. It is our ambition for Scotland to become a net exporter of hydrogen and hydrogen derivatives, supplying UK and EU markets by the mid-2020's. We will also harness the export opportunities across hydrogen supply chains, to further support job creation and economic growth. By internationalising our hydrogen economy in this way, we will attract inward investment to ensure Scotland's hydrogen sector has the capital and infrastructure to scale at pace and meet both domestic and international demand.

To realise this vision, the Scottish Government will develop a Hydrogen Sector Export Plan (HSEP), which will be published in 2023. The HSEP will outline how the Scottish Government will use its trade and investment levers to support the development of an international market for Scotland's hydrogen sector, enabling businesses to capitalise on the export opportunities linked to hydrogen. There are several factors that will be critical to realising Scotland's export ambitions and the HSEP will provide clarity on the actions the Scottish Government will take in these areas, to enable our exports to grow. They include:

- Identifying Scotland's international competitive advantage and target markets;
- Identifying and addressing key market access barriers;
- How we will work with the UK Government;
- How we will build relationships with international export partners; and
- Export support for Scotland's hydrogen businesses.

Between now and the publication of the HSEP, the Scottish Government will continue to develop clear positions on the points above. The actions we will take to do this, as well as the progress we've made thus far, are outlined below.

3.2.1 Building our evidence base

It is crucial we have a strong evidence base in place to inform how we deploy our trade and investment levers, to maximise the impact of the policy decisions and actions that we will set out in the HSEP. We will build our understanding in two key areas ahead of publication.

- 1. Scotland's international competitive advantage and priority export markets** – In line with our existing approach to export prioritisation, outlined in *A Trading Nation*,²⁵ the Scottish Government will identify where Scottish hydrogen and hydrogen derivatives, as well as goods and services across hydrogen supply chains will be able to compete with international competitors. As part of this process, we will additionally confirm which export markets will be a priority.
- 2. Identifying market access barriers** – In line with commitments set out in Scotland's *Vision for Trade*,²⁶ we will identify measures or procedures that restrict the trade of hydrogen, hydrogen derivatives and goods and services across hydrogen supply chains.

²⁵ [A Trading Nation - a plan for growing Scotland's exports \(www.gov.scot\) \(2019\)](https://www.gov.scot/publications/a-trading-nation/pages/1-to-4.aspx)

²⁶ [Scotland's Vision for Trade \(www.gov.scot\) \(2021\)](https://www.gov.scot/publications/vision-for-trade/pages/1-to-4.aspx)

Actions we will take:

Building on the Hydrogen Investment Proposition, '*Think Scotland, Think Hydrogen*'²⁷ published in September 2022 and to ensure our HSEP takes an evidence-based approach we will continue to gather data, market intelligence and insights to develop our understanding in these areas. We will take the following actions:

- **Sector engagement** – As a priority we will engage with the sector, including through the establishment of an export-focused industry-government forum, allowing the Scottish Government to gather critical industry feedback relating to exports.
- **International network** – We will use our extensive international network, including Scottish Development International's network of market specialists, our international hubs, GlobalScots and Scotland Europa and Trade Envoys, to gather crucial market intelligence.
- **Research and analysis** – We will continue to gather data to inform our understanding of Scotland's international competitive advantage, priority export markets and market access barriers, engaging with academics, think tanks and consultants where relevant.
- **Market access barriers** – We will use our international network and other resources such as the UK Digital Market Access Service to collect information and monitor the primary market access barriers facing the hydrogen sector, with a focus on regulatory barriers.

Progress to date:

- **Scot2Ger feasibility study** – At COP26 in Glasgow, the Scot2Ger feasibility study was announced. The resulting report confirmed Scotland's capability to become an exporter of renewable hydrogen and derivatives to Germany. Supply chain opportunities were also explored and identified.
- **Net Zero Technology Centre (NZTC) Transportation study** – The first phase of the Marine Transport of Liquid Organic Hydrogen Carriers (LOHC) project, led by the NZTC, concluded that LOHC is a viable means of transporting hydrogen in the short to medium term, in large quantities. We will continue to work with the NZTC and a consortium of partners in phase two of the project, which will carry out a feasibility assessment for a pilot trial for the shipment of LOHC from Scotland to the northern European mainland.
- **ClimateXChange cost of hydrogen production study** – We commissioned a study to assess the cost of producing renewable hydrogen in Scotland.²⁸ The study examined each part of the hydrogen supply chain to identify current costs and barriers. It identified that the cost of producing renewable hydrogen in Scotland is expected to at least halve between 2022 and 2045 for production pathways directly connected to wind farms, with electricity costs acting as the biggest driver of hydrogen cost reductions from 2030 onwards. We will be conducting follow-up research in early 2023 to expand the scope of the original study.
- **Scotland's Industry Directories** – Scottish Industry Directories,²⁹ maps the businesses operating across Scotland's hydrogen sector. The Enterprise Agencies are undertaking significant work to update this directory, making it much more comprehensive.

27 [Scotland's Hydrogen Investment Proposition \(sdi.co.uk\) \(2022\)](#)

28 [Cost reduction pathways of green hydrogen production in Scotland \(climatexchange.org.uk\) \(2022\)](#)

29 [Scottish Industry Directories, Green Hydrogen \(directories.scot\) \(2019\)](#)

3.2.2 Working with the UK Government

Informed by our evidence base, the Scottish Government will engage closely with the UK Government to ensure Scotland's export interests are embedded into their policy plans. In their 2022 Sector Development Action Plan,³⁰ the UK Government set out the actions it will take to position the UK as a future exporter of low-carbon hydrogen. These actions include ongoing opportunities assessment through a Global Market Intelligence Tracker, promoting UK hydrogen exports in international trade agreements and the development of a set of recommendations to enhance UK hydrogen sector competitiveness.

Actions we will take:

These actions will impact Scotland's capability to access critical export markets and this will be explored further in the HSEP. To inform this we will take the following actions:

- **Trade negotiations and policies** – Work with the UK Government to ensure the UK's trade negotiations and policies support the development of a global hydrogen market.
- **Regulatory landscape** – Collaborate with the UK Government to ensure the UK's standards, regulations and certification schemes support the needs of Scotland's hydrogen sector and are strategically aligned with Scotland's priority export partners.
- **International Regulatory Cooperation (IRC)** – Where mechanisms for cooperation are reserved, we will ask the UK Government to prioritise cooperation with like-minded trading partners, including the European Commission, to facilitate the smooth international trade of hydrogen.
- **Trade promotion** – We additionally ask that the UK Government work with the Scottish Government, including our overseas offices and SDI, to promote Scottish hydrogen, hydrogen derivatives and goods and services across supply chains within priority export markets.

Progress to date:

We have already been actively collaborating with the UK Government on several key challenges:

- **Regulations and certification schemes** – The regulatory regime for hydrogen in Scotland, the UK, and the EU is still evolving and is likely to change at pace in the coming years. We are working closely with the UK Government to ensure the development of regulations and certification schemes create an enabling environment for exporting hydrogen from Scotland and reduce any potential for market access barriers, including divergence between EU and UK regulations.

30 [Hydrogen sector development action plan - GOV.UK \(www.gov.uk\) \(2022\)](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/107112/hydrogen_sector_development_action_plan_-_gov_uk_(2022).pdf)

3.2.3 Building relationships with international export partners

It is essential that Scotland builds strong working relationships with key export partners, to identify opportunities, share knowledge and best practice, progress our export aspirations and address market access barriers. Informed by our evidence base, the HSEP will outline how we will utilise and progress our relationships with international partners to support our export aspirations and Scottish businesses.

Actions we will take:

We will take the following actions to build and cement existing partnerships and progress identified challenges:

- **Under2 Coalition Hydrogen Taskforce** – Scotland is co-leading the Green Hydrogen Taskforce with the South Australia State Government, as part of the Under2 Coalition's Net Zero Future Policy Forum. This project will facilitate dialogue between governments on achieving a global renewable hydrogen market.
- **International network** – Continue to participate actively in international hydrogen cooperation fora, such as Hydrogen Europe, the Vanguard Initiative, European Regions Research and Innovation Network, and others. These enable stakeholders across regions to share lessons, join up innovation assets and identify joint project and funding opportunities.
- **Memoranda of Understanding (MOUs)** – We will progress the MOUs we have signed with partners in Northern Europe to enable us to build on potential renewable hydrogen trade links and engage on the development of our domestic hydrogen sectors and the global hydrogen economy.
- **International Regulatory Cooperation (IRC)** – In line with the *Vision for Trade*, we are seeking opportunities for IRC with like-minded trading partners to support Scottish exports of hydrogen, including opportunities for Scottish expertise to inform the development of international hydrogen related regulations and standards. Where international regulatory barriers are identified, we will utilise mechanisms for IRC within our competence to help reduce trade barriers.

Progress to date:

- **Under2 Coalition Hydrogen Taskforce** – We have developed a draft prospectus that outlines the work the taskforce will carry out over the next year to develop a global market for renewable hydrogen and are working on recruiting additional members to the group.
- **MOUs** – We have signed a number of agreements with partner governments in Northern Europe on hydrogen, committing to working together in developing the skills, supply chains and technical requirements that will underpin our hydrogen economies. Since signing a memorandum of understanding (MOU) to cooperate on renewable hydrogen and hydrogen technologies with Hamburg in December 2021, we have signed an MOU with North-Rhine Westphalia in March 2022 and a Letter of Intent with Bavaria in May 2022.
- **International network** – The Scottish Hydrogen Investment Proposition was published in September 2022 and has been accompanied by a comprehensive engagement programme, led by Scottish Development International (SDI), which has included hosting overseas delegations from locations such as Germany, India, Oman and UAE, as well as delivering trade events in key overseas markets. Through the GlobalScot network, opportunities for collaboration are being explored in Germany, France and the Netherlands.

3.2.4 Export support for Scotland's hydrogen businesses

The Scottish Government already has a robust approach to supporting our exporters to grow their exports into critical markets in support of the Scottish economy.

SDI provides a wide range of support for new and existing exporters that is signposted on the Scottish Enterprise Exports & International Markets site. This includes:

- Access to international market research and guides on specific market and sector opportunities;
- Support to start exporting through the Preparing to Export programme;
- A range of export training, webinars and events; and
- Expert advice through the GlobalScot network and Chambers of Commerce across Scotland.

This support is already available to support Scotland's emerging hydrogen export opportunity and is embedded into the Team Scotland approach taken by our Enterprise Agencies to ensure that Scotland is strongly positioned to capitalise on the economic opportunity presented by hydrogen.

As part of the development of a full HSEP in 2023, we will provide details of the export support available to companies on a sub-sector basis and in terms of international markets as these mature. This will build on the increasing scale and capacity of hydrogen businesses and the Scottish supply chain as it develops domestically and will ensure that internationalisation and the opportunity to export are a fundamental element of their growth.

Actions we will take:

We will continue to progress our existing plans in this area and ensure that our evidence base informs how we deploy our support:

- Building on the work outlined above, we will develop a Hydrogen Sector Export Plan in 2023, that will demonstrate the support being made available to export from Scotland to critical international markets, based on Scotland's competitiveness.

Part 4 – Scotland’s Hydrogen Actions

To ensure Scotland is in the best possible position to achieve our ambition of 5 GW of renewable and low-carbon hydrogen capacity by 2030, we will focus actions to support meeting the following six key challenges:

<p>Scale up hydrogen production in Scotland</p> <p>Support the acceleration of Scottish renewable and low-carbon hydrogen projects and work with others to address potential barriers and constraints</p>	<p>Facilitate the development of a domestic market</p> <p>Stimulate demand in domestic use aligned to the scale up of local and regional hydrogen production</p>	<p>Maximise benefits of integrating hydrogen into the energy system</p> <p>Create an integrated energy system, that includes hydrogen electrolysis, to enable better management of the supply and demand of energy</p>
<p>Actions</p>		
<ul style="list-style-type: none"> • Launch – £90m Green Hydrogen Fund to support hydrogen pathfinder projects up to 2025/26. • Ensure the regulatory, planning and consenting framework for renewable developments supports the scale-up of hydrogen at pace. This will be achieved whilst ensuring biodiversity is protected, restored and enhanced. • Ensure our ambition for onshore and offshore wind development in Scotland supports our 5 GW by 2030 hydrogen ambition. • Build an evidence base to understand the extent of domestic hydrogen demand. • Support spatial planning in enabling the establishment of hydrogen projects. • Support the Scottish CCUS Cluster to produce low-carbon hydrogen at scale. • Ensure low-carbon hydrogen produced and used in Scotland is compatible with our climate ambitions. • Not support new hydrogen production where CO₂ is unabated. 	<ul style="list-style-type: none"> • Support development of Regional Hydrogen Hubs where production is coupled with multiple end-use applications thus helping to stimulate demand. • Support Scottish industries to use hydrogen in their decarbonisation plans. • Create an environment for the public and private sector to co-design technology and infrastructure pathways for the application of hydrogen in transport and deliver coincident benefits for jobs and supply chains. • Help facilitate the rollout of the infrastructure needed for hydrogen vehicles to operate in Scotland. • Work collaboratively with the transport sector to drive down the cost of hydrogen in transport applications and encourage uptake of both hydrogen and battery- electric vehicles. • Make Scotland a global centre of expertise for innovation in hydrogen mobility technologies, collaborate with international partners and grow our hydrogen mobility manufacturing base. • Maintain dialogue with SGN and National Grid to understand the role hydrogen can play in meeting our heat decarbonisation targets. • Continue to press the UK Government to expedite progress on amending regulations and legislation to support hydrogen blending and accelerate decisions on the role of 100% hydrogen in the gas grid. 	<ul style="list-style-type: none"> • Work with electricity and gas network operators to realise system benefits of hydrogen. • Explore the use of hydrogen as an energy storage and balancing asset to the national electricity grid and the national gas grid. • Ensure hydrogen development is planned where it can best be supported by available water resources. • Support the establishment of hydrogen transportation infrastructure to support the export of hydrogen to the rest of the UK and Europe.

<p>Growing and transitioning Scotland's supply chain and workforce</p> <p>Support the growth and transition of companies and workforce skills development that will underpin our future hydrogen economy</p>	<p>Establish and strengthen international partnerships and markets</p> <p>Ensure Scotland is prepared to play a key role in meeting the growing demand for hydrogen from import countries in Europe</p>	<p>Strengthen research and innovation</p> <p>Drive critical research and technological advancements and stimulate collaboration and knowledge sharing</p>
<p>Actions</p>		
<ul style="list-style-type: none"> • Support Scottish Hydrogen Supply Chain through the development of a Hydrogen Economy Cluster. • Provide the supply chain with a clear line of sight to opportunities by creating a visible pipeline of projects. • Work with industry and partners to establish the skills to underpin our energy transition. • Continue to support a growing Scottish skills base in hydrogen for transport. 	<ul style="list-style-type: none"> • Strengthen existing relationships and develop new bilateral partnerships. • Develop a supportive framework to realise Scotland's hydrogen export potential. • Promote Scotland's interests overseas and boost inbound and outbound trade and investment missions to secure opportunities for Scottish companies in the international hydrogen market and drive inward investment. • Build the evidence base and support international cooperation on the development of infrastructure, transport routes and international supply chains. • Engage with the UK Government to ensure Scotland's export interests are embedded in policy, trade and regulatory planning. 	<ul style="list-style-type: none"> • Drive technological progress and advance innovation in Scotland via our Hydrogen Innovation Scheme. • In partnership with our enterprise agencies, establish a Scottish Hydrogen Innovation Network to provide support to the hydrogen research and innovation ecosystem in Scotland. • Support multi-national collaboration on research and innovation challenges. • Fund a Hydrogen Business Development service, delivered through the Energy Technology Partnership.

Action themes and key actions

4.1 Scaling up hydrogen production in Scotland

To realise our 5 GW by 2030 and 25 GW by 2045 ambitions, we will support the acceleration of the pipeline of Scottish renewable and low-carbon hydrogen projects and work with others to address potential barriers and constraints.

THE SCOTTISH GOVERNMENT WILL:

- 1. Launch our Emerging Energy Technologies Fund (EETF) to support hydrogen pathfinder projects up to 2025/26.**
 - The £90m Green Hydrogen Fund will open in early 2023 with a call for proposals for renewable hydrogen projects.
- 2. Ensure the regulatory, planning and consenting framework for renewable developments supports the scale-up of hydrogen at pace. This will be achieved whilst ensuring biodiversity is protected, restored and enhanced.**
 - We will publish consenting guidance on the development of large-scale hydrogen production facilities in Scotland and its waters in 2023.
 - We will work with the UK Government, regulatory authorities and industry to assess regulatory requirements and ensure the necessary action is taken to address any gaps and issues, working to ensure, where appropriate, any consenting framework for hydrogen production works in tandem with existing consenting frameworks for renewable electricity and maximises development opportunities where onshore renewable generation is constrained or consented and not grid connected.
 - We will ensure the marine planning processes supports the delivery of hydrogen electrolysis at sea.
- 3. We expect the majority of our 5 GW ambition by 2030 to come from renewables. We will therefore ensure our ambition for onshore and offshore wind development in Scotland supports our 5 GW by 2030 hydrogen ambition.**
 - Scottish Government's hydrogen and wider renewables policy development and implementation will be aligned.
 - We will work with the electricity system operators to explore opportunities to use the value of constraints as a means of incentivising demand to accelerate hydrogen from constrained wind.
 - Innovation and Targeted Oil and Gas decarbonisation (INTOG) leasing round will enable offshore wind development to decarbonise oil and gas infrastructure operations, maximising further opportunities for the Scottish economy through the hydrogen supply chain and uses.
 - We will progress the Iterative Plan Review for the Sectoral Marine Plan for Offshore Wind Energy.
- 4. Build an evidence base to understand the extent of domestic hydrogen demand.**
 - We will undertake a research programme to build the evidence base to help develop our understanding of hydrogen demand across sectors, to inform the hierarchy of use and future devolved policy decisions.

5. Support spatial planning in enabling the establishment of hydrogen projects.

- The National Planning Framework 4 (NPF4) will enable the infrastructure we will need to support the net zero transition, including renewable, low-carbon and zero emission technologies, such as hydrogen developments. Once approved and adopted, NPF4 will be a long-term plan looking to 2045 that will guide spatial development, set out national planning policies, designate national developments and highlight regional spatial priorities, and so will influence planning decisions, including for hydrogen developments, across Scotland.

6. Support the Scottish CCUS Cluster to produce low-carbon hydrogen at scale.

- We continue to support the Scottish CCUS Cluster, which will enable carbon capture, utilisation and storage across a diverse set of emitters, thus enabling low and ultimately negative-carbon hydrogen production in Scotland. £80m of the £180m Emerging Energy Technologies Fund has been identified to support the development of CCUS and CCS-enabled negative emissions technologies in Scotland.

7. Ensure low-carbon hydrogen produced and used in Scotland is compatible with our climate ambitions.

- We will continue to align with the UK Government in the development of a Low-Carbon Hydrogen Standard (LCHS) in our funding for low-carbon hydrogen projects. The LCHS provides a detailed methodology for calculating greenhouse gas (GHG) emissions associated with low-carbon hydrogen production, requiring hydrogen producers to meet a GHG emission intensity of 20g CO₂e/MJLHV of produced hydrogen or less for the hydrogen to be considered low-carbon.
- Low-carbon hydrogen production should achieve the highest technically possible emissions capture rates. We will ensure that publicly funded support for low-carbon hydrogen produced in Scotland meets the LCHS.

8. Not support new hydrogen production where CO₂ is unabated.

- We encourage industry to transition as quickly as possible away from production and use of unabated hydrogen and achieve the lowest possible emissions rates as part of their decarbonisation planning. We will not support via Scottish Government funding the development of new, industrial development where carbon emissions are unabated. There is no expectation of additional grey hydrogen production, as any such development will require to demonstrate the implementation of a decarbonisation strategy at point of operation. This could include fuel switching, carbon capture, and energy efficiency and must be in line with our statutory climate change targets. This includes new industrial sites for the primary purpose of producing hydrogen where CO₂ is unabated.

4.2 Facilitating the development of a domestic market

To establish a strong hydrogen economy in Scotland that can support the growing global market, a strong, sustainable domestic market must also be established. This will require immediate actions to accelerate demand and to scale up local and regional hydrogen production as well as a strategic focus on growth areas such as industry and transport to ensure technological progress, development of economies of scale and reduction of the cost of hydrogen.

THE SCOTTISH GOVERNMENT WILL:

9. Support the development of Regional Hydrogen Hubs where production is coupled with multiple end-use applications thus helping to stimulate demand.

- The EETF will support the development stages of regional hydrogen hubs where production, storage and distribution with multiple end-use applications will help to aggregate demand and improve the economic benefit of the projects.

10. Support Scottish industries to use hydrogen in their decarbonisation plans.

- Supporting the deployment of, or studies into, energy efficiency or deeper decarbonisation projects including fuel switching to renewable or low-carbon hydrogen via the Scottish Industrial Energy Transformation Fund.
- We will facilitate 'Net Zero Transition Manager' roles, embedded within high-emitting manufacturing sites, to identify and progress decarbonisation opportunities, including low-carbon hydrogen, to contribute to the long-term sustainability of industrial businesses. We will act on the recommendations of the Scottish Net Zero Roadmap.
- Through the Grangemouth Future Industry Board, we will focus efforts to support the development of the hydrogen economy at Grangemouth. We will map potential local hydrogen users to understand how best to support the development of hydrogen applications in Scotland's major industrial region.

11. Create an environment for the public and private sector to co-design technology and infrastructure pathways for the application of hydrogen in transport, and deliver coincident benefits for jobs and supply chains.

- We are supporting the work of Scotland's Hydrogen Accelerator.
- We will ensure that publically funded hydrogen for transport demonstration projects share what they have learnt and encourage the private sector to do the same.
- As part of the co-design process for the Energy Strategy and Just Transition Plan, we will work with stakeholders to identify any barriers to hydrogen's use in transport and the actions needed. This will include considering the regulatory, commercial and practical barriers, as well as user confidence and skills.

12. Help facilitate the rollout of the infrastructure needed for hydrogen vehicles to operate in Scotland.

- With our partners in the MultHyFuel project, we will produce guidance for organisations looking to put in hydrogen refuelling infrastructure. This will include examples of risk assessments and of safe designs for hydrogen refuelling stations in a multi-fuel context. It will include layout recommendations and define the hazardous area around the H2 dispenser.
- We will carry-out a multi-modal hydrogen refuelling feasibility study, which will cover business cases and technical requirements.

13. Work collaboratively with the transport sector to drive down the cost of hydrogen in transport applications and encourage uptake of both hydrogen and battery-electric vehicles.

- We will continue our work with public and private sector bodies on enhancing the role of fleet investments as enablers of technology deployment, including hydrogen.

14. Make Scotland a global centre of expertise for innovation in hydrogen mobility technologies, collaborate with international partners and grow our hydrogen mobility manufacturing base.

- Building on the findings of the Industry Advisory Group, we will continue to develop Scotland's ecosystem for innovation in hydrogen technology, particularly in niche and heavy-duty vehicles.
- We are addressing barriers to the growth of a competitive transport hydrogen technology supply chain in Scotland. Including through our Zero Emission Mobility Innovation Fund, delivered in partnership with Scottish Enterprise, to accelerate the manufacturing and deployment of heavy duty zero-emission vehicles, and through our Zero Emission Mobility Academic Network which supports links between academia and industry to support the development of innovative zero emission technologies.

15. Maintain dialogue with SGN and National Grid Gas Transmission to understand the role hydrogen can play in meeting our heat decarbonisation targets.

- We have invested £6.9m in the H100 Fife project and will continue to support the development of evidence on the potential role of hydrogen in decarbonising heat including the potential expansion phases of the H100 Fife project.
- We will support initial action by SGN on their pathway to converting large segments of their network to 100% hydrogen, wherever those actions are commensurate with keeping options open and limiting consumer costs.
- Ahead of UK Government decisions on the future of the gas grid, we will undertake a programme of work to identify regions and areas such as rural island areas, SIUs and locations adjacent to hydrogen hubs, that are most likely to have access to hydrogen in the future, and consider high-potential areas for the use of hydrogen for heat in Scotland.
- We will work with the Gas Network Operators and the UK Government to explore opportunities for increasing the blend of up to 20% hydrogen in the existing gas network.
- We will identify ways to support projects which seek to demonstrate renewable hydrogen production and blending in the gas network.

16. We will continue to press the UK Government to expedite progress on amending regulations and legislation to support hydrogen blending and accelerate decisions on the role of 100% hydrogen in the gas grid.

- Alongside other action in reserved areas to support delivery of our Heat in Buildings Strategy, we will urge the UK Government to accelerate decisions on the role of hydrogen in the gas grid.
- We will continue to press the UK Government to progress the consultation on enabling and requiring hydrogen-ready boilers. The Scottish Government is seeking to commission independent laboratory testing of hydrogen boilers to determine what – if any – greenhouse gas emissions are produced from the combustion of 100% pure hydrogen (under normal operating conditions). Once the testing has concluded, in early 2023, we will set out our position on the use of 100% hydrogen for space and hot water heating in new buildings.

4.3 Maximising the benefits of integrating hydrogen into our energy system

An integrated energy system, that includes hydrogen electrolysis, can allow better management of the supply and demand of energy. Renewable hydrogen production can play a critical role in supporting the realisation of Scotland's ambitions for 8-12 GW onshore wind and 8-11 GW of offshore wind by 2030. Converting renewable power into hydrogen can provide developers with new routes to market and may change the investment proposition for new and existing renewables generation. Collaborative action in the short term will explore the optimal integration of hydrogen technology into our energy system as an energy store and to provide flexibility, resilience and balancing to the wider energy system.

THE SCOTTISH GOVERNMENT WILL:

17. Work with electricity and gas network operators to realise system benefits of hydrogen.

- In partnership with Scotland's electricity and gas network operators, we will identify the integration challenges and service opportunities which hydrogen production presents within our power and gas grid networks. This will include exploring the role of hydrogen as a storage asset for electricity network grids.
- We will work with UK Government, Ofgem and the energy network sector to ensure that regulation and market structure support and reward hydrogen projects for the full range of benefits they deliver to the wider energy system.
- We will evaluate the most advantageous locations for hydrogen electrolysis to reduce electricity constraints and deliver maximum value. A study on the role that hydrogen can play to alleviate curtailment was commissioned through ClimateXChange and is due to be published in December 2022.

18. Explore the use of hydrogen as an energy storage and balancing asset to the national electricity grid and the national gas grid including the repurposing of existing national grid pipelines for hydrogen use, transportation and storage.

- Reflecting the critical role that hydrogen can play as a low-carbon energy source providing flexibility, resilience and balancing to the wider energy system. We will develop a vision for the role of hydrogen storage as an integrated part of the hydrogen and wider energy systems.
- To take this forward we are undertaking a detailed study to determine the role that hydrogen can play as an energy storage solution.
- We are also continuing to work with SGN and the University of Edinburgh to explore the options for the geological storage of hydrogen, through the HyStorPor project.

19. Ensure hydrogen development is planned where it can be best supported by available water resources.

- Our Enterprise Agencies have completed the Production Site Requirements Report³¹ that set out site requirements for large-scale renewable and low-carbon hydrogen production plants. Building on the production site requirements report, we will work with Scottish Water and industry to understand and map how water resources and infrastructure are distributed within Scotland and water availability for hydrogen production as part of our wider GIS-mapping activities.

31 [Hydrogen Production and Export Locations: Site Requirements Study \(scottish-enterprise.com\)](https://www.scottish-enterprise.com) (2022)

20. Support the establishment of hydrogen transportation infrastructure to support export of hydrogen to the rest of the UK and Europe.

- We will fund the Net Zero Technology Centre Transition Programme and the Hydrogen Backbone Link project to position Scotland within developing pan-European hydrogen infrastructure including export capability to supply hydrogen to Europe as part of an extensive hydrogen transport and distribution system. The project will include concept studies and technology development of new pipelines and the re-purposing and optimisation of existing onshore and offshore pipelines. Phase 1 is complete. Under Phase 2 the Net Zero Technology Centre have been awarded £2.12M from the Just Transition Fund to support the delivery of its Hydrogen Offshore Production Project (HOP2). HOP2 aims to repurpose existing gas assets for offshore hydrogen production scaled 500 MW to 1 GW.

4.4 Enabling the growth and transition of Scotland's supply chain and workforce

Scotland's existing oil and gas and energy supply chains can transfer many of the critical engineering and management skills important to establishing the stable and secure production of affordable large-scale hydrogen. The Scottish Government is committed to supporting the growth and transition of companies and workforce skills development that will underpin our future hydrogen economy.

Our Enterprise Agencies, Skills Agencies, Scottish Water, Transport Scotland, Scottish Development International and other government and public bodies, including Marine Scotland and Crown Estate Scotland, are working collaboratively to drive the hydrogen economy agenda forward and respond to opportunities as they arise.

Scottish Enterprise has adopted hydrogen as one of its eight National Programmes in order to provide a strong focus on identifying and maximising opportunity for economic benefit and assist our policy ambitions for this growing sector.

THE SCOTTISH GOVERNMENT WILL:

21. Through our Enterprise Agencies activity build support for the Scottish Hydrogen Supply Chain through the development of a Hydrogen Economy Cluster.

- The Hydrogen Economy Cluster will raise awareness of the opportunities in the hydrogen economy, support a Team Scotland approach and provide practical steps to help companies realise opportunities in hydrogen and associated low-carbon markets. The cluster will be pan-Scotland and will play a key role in helping the energy and oil and gas supply chain move into hydrogen production, distribution and/or key areas of hydrogen demand such as transport and low-carbon heat.

22. Provide the supply chain with a clear line of sight to opportunities by creating a visible pipeline of projects.

- We have completed and published our Assessment of Electrolysers³² report. This was an important first step in understanding the hydrogen value chain in Scotland and we will continue to encourage supply chain engagement throughout Scotland and attract companies and potential OEMs.
- In September 2022, the Scottish Government held a supply chain event that brought together key players and stakeholders from across industry, government and academia to explore and discuss Scotland's developing capabilities in the sector, the emerging opportunities and the vision for the future.
- Together with our Enterprise Agencies, trade associations and other relevant stakeholders we will explore the requirement for an online tool to ensure that companies have clear visibility and access to information about upcoming hydrogen projects in order to maximise the potential for Scottish content.
- We will establish a Hydrogen Forum between industry and government to help drive forward the hydrogen economy in Scotland collaboratively, ensure Scottish Government policy and action remains responsive to technological and market developments and maximise the decarbonisation and economic benefit for businesses and communities.
- We will publish an interactive GIS hydrogen Mapping Tool which maps and charts all hydrogen activity and projects in Scotland.

32 [Assessment of electrolysers: report - gov.scot \(www.gov.scot\) \(2022\)](https://www.gov.scot/resources/consultations-petitions/ip/ip-2022-01-01/assessment-of-electrolysers-report-gov.scot-2022)

23. Work with industry and partners to establish the skills to underpin our energy transition.

- We have commissioned, through ClimateXChange and in consultation with Skills Development Scotland, a piece of work to map out the current and forecasted hydrogen skills landscape to build an evidence base regarding current hydrogen skills and key skill shortages.
- This is part of a wider piece of work to ensure wider investment in skills and competitive opportunities for Scotland. This will ensure investment in skills, including work-based learning, further and higher education, and upskilling and reskilling, is fully aligned with our economic ambitions for a net zero transition, through our forthcoming Climate Emergency Skills Action Plan refresh.
- We will continue to work with industry to assess the workforce demand for a hydrogen economy, including assessing areas of transferability in existing offshore and onshore energy production. We will ensure future skills actions and provision to 2030 is informed by this work and training programs are tailored to meet the demand for new specialist skills, promoting opportunities for STEM students, graduates and hydrogen engineers.
- OPITO, the global safety and skills organisation for the energy industry, has been awarded £5m from the Scottish Government's Just Transition Fund to support the delivery of an Energy Skills Passport. This will work to create a long term 'skills guarantee' for workers in carbon-intensive sectors and develop the specialist skills and workforce required to underpin the hydrogen economy.

24. We will continue to support a growing Scottish skills base in hydrogen for transport.

- We will continue to explore the skills gaps for hydrogen transport applications in delivering the Climate Emergency Skills Action Plan.
- We will continue to work with the Energy Skills Partnership on the Transport Hydrogen Skills Development Project. Building on the findings of the 2021 Transport Scotland HDV Skills Baseline Report, this project will support improved Scottish capabilities in Scottish colleges to deliver hydrogen for transport training for both technicians and business leaders and deliver hydrogen for transport education material for upper primary and secondary school pupils, as well as young adults.

Case study: Hydrasun – Based in Aberdeen, Hydrasun is a market leader in the provision of integrated fluid transfer, power and control solutions to the oil and gas, energy, industrial and marine industries worldwide. Over the last six years, Hydrasun has successfully completed over 20 projects within the hydrogen market in the UK and Europe across the mobility, power and industrial sectors. The company has diversified their range of products and services to position themselves as a supply chain and systems integrator in the emerging hydrogen markets.

Hydrasun has also established a Hydrogen Skills Academy. The Academy delivers an industry-first suite of training and competency development programmes that will enable trained and skilled personnel to install, commission, maintain and operate hydrogen systems.

4.5 Establishing and strengthening international partnerships and markets

Scotland is committed to working collaboratively with international partners to develop the global hydrogen economy more quickly. We will continue to support Scottish companies to participate in the global hydrogen supply chain, work with our international partners to share expertise and develop the sector more quickly, and to ensure Scotland is ready to play a key role in meeting the growing demand for hydrogen from import countries in Europe.

THE SCOTTISH GOVERNMENT WILL:

25. Strengthen existing relationships and develop new bilateral partnerships.

- We will strengthen our existing international relationships and look to develop new collaborations on renewable hydrogen development with partner countries. We have, in 2021/22 secured several MOUs with partner countries to build hydrogen markets and our shared hydrogen economy, including agreements with Denmark, Hamburg, Bavaria, Occitania, and North Rhine-Westphalia.
- As part of the Net Zero Futures Forum, Scotland will co-lead a taskforce with South Australia that brings together Under2 Coalition governments to collaborate and share knowledge on the opportunities and challenges of developing the international hydrogen economy.

26. Develop a supportive framework to realise Scotland's hydrogen export potential.

- We will work with the UK Government, industry and partners to develop Scotland's Hydrogen Sector Export Plan (HSEP) to be published in 2023.

27. Work with our overseas offices and Scottish Development International to promote Scotland's interests overseas and boost inbound and outbound trade and investment missions to secure opportunities for Scottish companies in the international hydrogen market and drive inward investment.

- Working through our global network of trade and investment offices, we will promote plans for the export of hydrogen as well as international trade opportunities for Scottish hydrogen companies. This includes inbound delegations, inviting influencers, sectoral representatives and companies to engage with the sector first-hand. We will also engage with national sectoral organisations, with Scotland's partner hydrogen states, with key conference platforms and business forums, and with individual companies, to promote Scottish expertise and capacity.
- In September 2022, we published the Scottish Hydrogen Investment Proposition, which set out the benefits of investing and locating in Scotland and the opportunities within the hydrogen sector for both manufacture and production.
- This written proposition will be followed by a suite of digital assets to showcase Scotland's renewable and low-carbon hydrogen opportunities and strategic investment sites.

28. Build the evidence base and support international cooperation on the development of infrastructure, transport routes and international supply chains.

- In addition to funding provided to NZTC to assess Scotland's capability to link to the European Hydrogen Backbone initiative [see Action 20] we support collaboration between Scottish ports and key ports in northern Europe, in order to develop the relationships and the necessary and compatible export/import infrastructure. For example, we will support NZTC and a consortium of partners on phase two of the Marine Transport of Liquid Organic Hydrogen Carriers (LOHC) project, which will carry out the feasibility assessment for a pilot trial for the shipment of LOHC from Scotland to the northern European mainland.
- We have also undertaken a review of ports and terminal infrastructure preparedness for hydrogen export. This is detailed in the first phase of the production sites requirement report, which has now been completed.
- Our Enterprise Agencies supported the Scot2Ger project. A summary report on the findings of the Scot2Ger pre-feasibility study was published by Scottish Enterprise in June 2022 (See Part 3). The study confirmed the capability of Scotland to supply renewable hydrogen and derivatives to Germany, as well as the feasibility of building a supply chain. The study also highlighted that demand for hydrogen in Germany is immediate and increasing rapidly.

29. Engage with the UK Government to ensure Scotland's hydrogen interests are embedded in its domestic and international policy, trade and regulatory planning.

- We will urge the UK Government to ensure that regulations do not act as a barrier to trade and investment, and to collaborate internationally to ensure standards developed for hydrogen in the UK align with international frameworks to allow a buoyant export market to be established.

4.6 Strengthening research and innovation

Scotland already benefits from a strong hydrogen research and innovation landscape with many organisations and institutes working across different hydrogen technologies. We will continue to support these existing assets to drive critical research and technological advancements and stimulate collaboration and knowledge sharing.

THE SCOTTISH GOVERNMENT WILL:

30. Drive technological progress and advance innovation in Scotland via our Hydrogen Innovation Scheme.

- In June 2022, we launched the £10m Hydrogen Innovation Scheme, the first tranche of the Emerging Energy Technologies Fund, to support innovation in hydrogen production, storage and distribution technology. This funding aims to drive advancements in hydrogen technology to improve the cost-competitiveness of renewable hydrogen and to support the development of Scotland's world class test and demonstration facilities.

31. In partnership with our Enterprise Agencies, establish a Scottish Hydrogen Innovation Network to provide support to the growing hydrogen research and innovation ecosystem in Scotland.

- The Scottish Hydrogen Innovation Network will provide an overarching framework for Scotland's growing portfolio of hydrogen innovation assets. This will enable increased collaboration between those assets to increase the impact of their work and avoid duplication of effort while also ensuring that Scotland's company base is aware of the innovation capability that exists in Scotland and enable them to engage with the suite of facilities effectively to commercialise new products and services to accelerate technology deployment and lower production costs. The network will also help to enhance Scotland's international hydrogen innovation reputation by showcasing all that we have to offer.

32. Support multi-national collaboration on research and innovation challenges.

- In 2021 we launched the Scotland-Germany Hydrogen Research Scheme, through the Royal Society of Edinburgh, which supports four collaborative projects between research institutes in Scotland and Germany.
- We will also work with the UK Government to support the success of the Mission Innovation Clean Hydrogen Mission and participate in Hydrogen Europe's Regional Pillar.
- We will support Scottish participation in applications for EU funding for innovation through the Clean Energy Transition Partnership and the Clean Hydrogen Partnership, building on significant Scottish successes in previous EU hydrogen funding programmes.
- Scotland will co-lead workstreams of the Vanguard Initiative's new Hydrogen Pilot alongside other European regions. This cooperation forum will help grow the European network of SME's and innovation assets in hydrogen, focusing on specialised manufacturing.

33. Fund a Hydrogen Business Development service, delivered through the Energy Technology Partnership, to accelerate knowledge exchange between academia and enterprises to stimulate innovation in the hydrogen sector.

- We are continuing to work with the Energy Technology Partnership in support of their Hydrogen Theme. This includes the funding of a Hydrogen Business Development Manager, now in operation. The Hydrogen Business Development Manager facilitates pooling of academic knowledge and expertise to enable co-ordinated research activities, leading to new areas of innovation. The Hydrogen Business Development Service facilitates collaboration between industry and the academic research community, through events, forums and a £100k engagement fund.
- ETP's Hydrogen Industry Engagement Funding Call launched in June 2022 to support innovative SME projects that are aimed at renewable and low-carbon hydrogen storage, products, processes, and systems.

Part 5 – Investing in Our Renewable Hydrogen Future

The Emerging Energy Technologies Fund (EETF) is a £180m package of funding up to 2025/26 that will provide capital support to accelerate low-carbon infrastructure projects and unlock private sector co-investment that will be essential to deliver net zero. The Fund will make £100m available to support renewable hydrogen projects in line with our Hydrogen Policy Statement.

In June 2022, we launched the first tranche of the EETF through the £10m Hydrogen Innovation Scheme (HIS). The remaining £90m Green Hydrogen Fund will follow in early 2023.

Funding principles

The Scottish Government's hydrogen funding programme will support the development of a hydrogen economy in Scotland, facilitate a just transition and help overcome challenges to scaling up hydrogen production and deliver lasting benefits for business and communities.

The production of renewable hydrogen involves proven technologies, but the deployment of these technologies requires private and public sector investment to bring forward projects and support their commercial scale-up.

The Scottish Government's hydrogen funding programme is complementary to funding offered by the UK Government, including the Net Zero Hydrogen Fund.

In the period up to 2025/26, the Scottish Government will invest in the emerging hydrogen sector through its capital funding programme focusing on the following types of activity:

- Regional renewable hydrogen production hubs;
- Renewable hydrogen production linked to demand case; and
- Innovation.

The establishment of regional and local production of renewable hydrogen will facilitate the potential to scale up quickly and this will play an important role in helping build the domestic market demand. We wish to see as many renewable hydrogen projects as possible coming forward for potential support from the £100m hydrogen funding we are making available. The production of renewable hydrogen from onshore renewables by the mid-decade and in particular, production from onshore wind generation, that is constrained or that cannot be connected to the electricity grid, is the key focus of our hydrogen investment programme in this Parliamentary term in order to inject the necessary pace into the establishment of a thriving hydrogen sector in Scotland.

We also wish to provide support for the development stages of large-scale regional renewable hydrogen energy hubs which will require engineering and technical design development to enable Final Investment Decisions to be reached for these strategically important projects.

The roll-out of renewable hydrogen production linked to domestic demand and the establishment of regional renewable hydrogen hubs represents new and sustainable economic activity and a transition opportunity for our Scottish supply chain.

Scotland's success in the deployment of hydrogen demonstration has cemented our reputation abroad as a nation which can foster emerging sectors, and the Scottish Government has supported a variety of successful projects that have helped demonstrate the use of hydrogen in the decarbonisation of key sectors.

Building on this track-record, and with an emphasis on balancing support for supply and demand and supply chain opportunities along the whole value chain, we will continue to fund appropriate pre-commercial projects to accelerate demand and support the sector to move beyond small pilot stage to large scale commercial projects.

Innovation and research across hydrogen production, storage, distribution and end-use technologies will be central to driving the efficiencies, performance optimisation and cost reduction that will underpin the growth of commercial scale renewable hydrogen projects.

The £10m EETF Hydrogen Innovation Scheme aims to support Scottish researchers and innovators to drive innovation to support innovative renewable hydrogen production, storage and distribution solutions as well as the development of test and demonstration facilities in Scotland that will support the realisation of our 5 GW by 2030 ambition and ensure Scotland benefits from and contributes to the global research and innovation network through international collaboration.

Future Decision Making

The actions and funding principles set out in this document are intended to enable government, industry and academia to work together to lay down some of the early building blocks required to enable the growth of a strong and sustainable hydrogen economy in Scotland.

The Action Plan implementation will be monitored to ensure that it stays current and responsive to developments at a UK and international level and that our actions deliver the maximum impact. We will also work with key partners throughout the lifetime of the Action Plan to evaluate progress and to assess the support that will be required to accelerate the realisation of our hydrogen future.

The opportunity for Scotland is substantial, and we are committed to working in partnership to realise it.



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