

Draft Hydrogen Action Plan



Contents

Ministerial Foreword	Page 3
Introduction	Page 5
Part 1 – Hydrogen Economy: Route Map to 2030 and 2045	Page 14
Part 2 – Actions to Meet our Vision, Ambition, and Commitment	Page 23
1. Scaling up hydrogen production in Scotland	Page 24
2. Facilitating the development of a domestic market	Page 27
3. Maximising the benefits of integrating hydrogen into our energy system	Page 36
4. Enabling the growth and transition of Scotland's supply chain and workforce	Page 38
5. Establishing and strengthening international partnerships and markets	Page 41
6. Strengthening research and innovation	Page 45
Part 3 – Investing in Our Renewable Hydrogen Future	Page 47
Annex A – Scottish Government Hydrogen Funding Landscape	Page 48

Ministerial Foreword

The Hydrogen Policy Statement was published in December 2020. Within it, the Scottish Government confirmed our strong support for a strategic approach to the development of the hydrogen economy in Scotland and set a clear ambition of 5GW installed hydrogen production capacity by 2030 and 25GW by 2045. The draft Hydrogen Action Plan is a companion document to the Policy Statement and should be read alongside it.

In this draft Hydrogen Action Plan we set out the necessary actions over the next five years to implement the key policy positions and ambitions set out in our Hydrogen Policy Statement. These actions will help put us on the pathway to becoming a leading nation by 2045 in the production of reliable, competitive, sustainable hydrogen and provide the potential to secure Scotland's future as a centre of international excellence as we establish the innovation, skills and supply chain that will underpin our energy transition.



Scotland's demonstration of hydrogen production and use over the past few years has cemented our reputation as a nation that can foster emerging sectors and get things done. We are determined to build on this reputation, work in partnership with others to assemble our resources, and focus on the actions that will enable and support the emerging hydrogen sector in Scotland to grow, to move beyond the demonstration phase and to maximise opportunities at commercial scale. To help us achieve this we have committed £100 million of funding towards the development of our hydrogen economy over the next five years.

Hydrogen has a role to play across Scotland in our islands and rural communities, cities and industrial clusters, and strategies for its production and application are expected to vary across these geographic regions. We are committed to realising the benefits of hydrogen to our regions and local communities and so will support regional hubs of hydrogen activity across Scotland, recognising the differing resources, strengths and focuses of each location.

Scotland's businesses are well positioned to help support 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. We know that Scottish companies are already engaged or actively interested in moving into this area but we are aware that the hydrogen industry is not a fully established sector as yet and we will support this early development through a hydrogen supply chain development plan and mobilising investment along supply chains.

We are keen to play our role in the development of hydrogen in the UK, European and international markets. Scotland is well placed in terms of proximity and infrastructure connectivity to key locations in Northern Europe that are unlikely to be able to produce enough renewable hydrogen to meet their own decarbonisation requirements and currently developing import strategies. Scotland has the potential to produce significant quantities of renewable hydrogen from our offshore and onshore wind resources and our potential wave and tidal power which is vastly greater than our indigenous demand. We also have the potential to produce low-carbon hydrogen at a large industrial scale.

Scotland's access to low-cost renewables, supplies of natural gas, carbon storage, utilisation of existing distribution infrastructure, proximity to demand, and our innovation support landscape can all contribute to greater efficiencies and thus reducing the cost base. Combined, these position Scotland to produce and then export the lowest-cost renewable and low-carbon hydrogen in Europe. However, our plans to accelerate the hydrogen economy in Scotland will not happen on their own and we will need to work with industry and with the UK Government to apply both devolved and reserved powers in alignment, to support the hydrogen economy.

Scotland has the opportunity and capability to benefit from a just transition away from fossil fuels and to marshal the existing energy sector skills and company base to produce large volumes of renewable and low-carbon hydrogen. This transition will not only help reduce Scotland's emissions, and support meeting Scotland's challenging greenhouse gas emissions targets, but will also allow Scotland to develop a role as an exporter of hydrogen to other partner nations and to create and protect jobs and generate significant economic opportunities for communities across Scotland.

We have the resources, the assets, the people and the ambition to achieve this.



Michael Matheson MSP

Cabinet Secretary for Net Zero, Energy and Transport

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

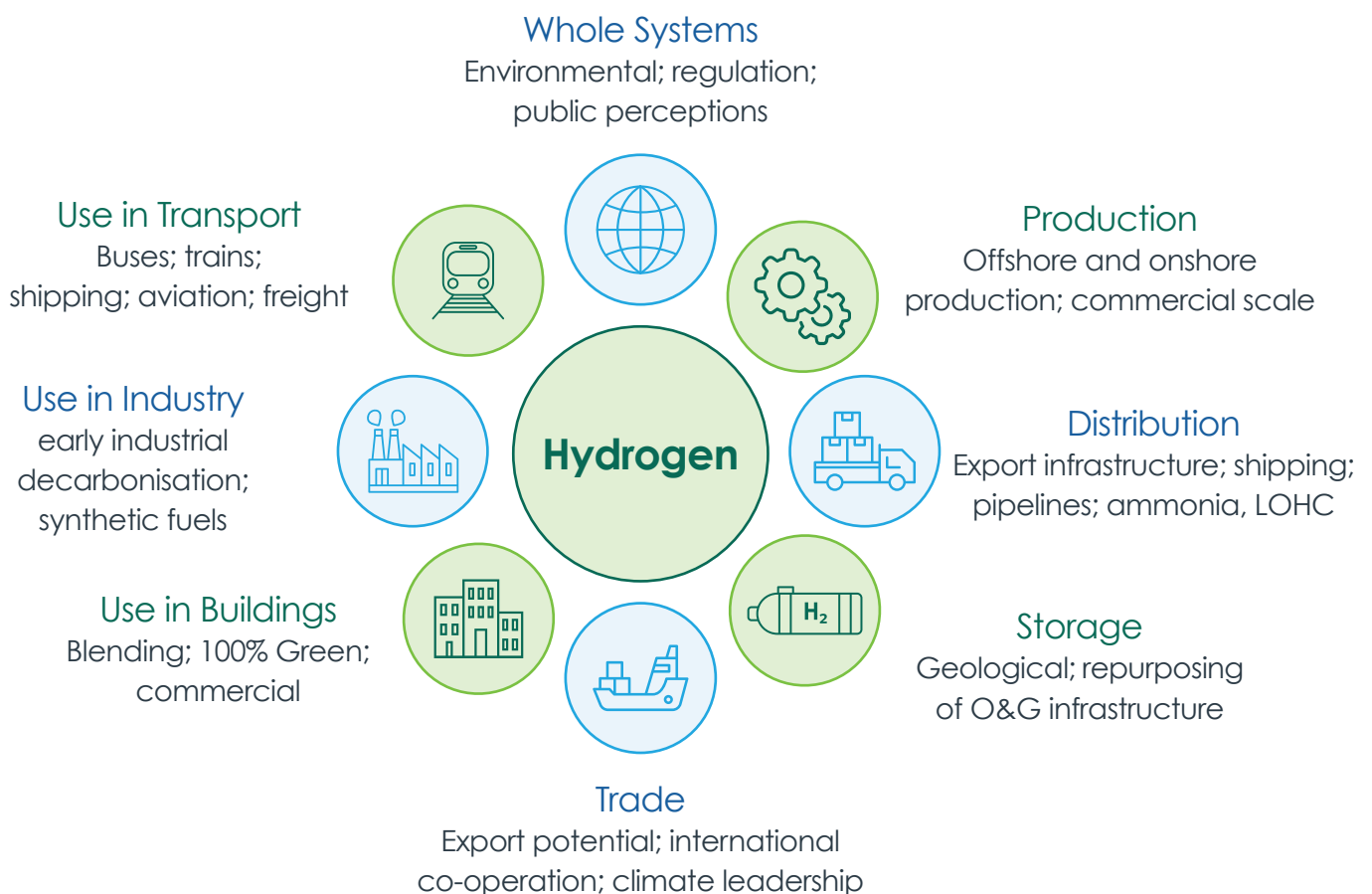
Introduction

Scotland was amongst the first countries in the World to declare a climate emergency and we understand the urgency of moving our economy and society to generating net zero greenhouse gas emissions.

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 will need to move at an unprecedented pace to deliver the innovation, investment, regulation and the 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 Committee on Climate Change suggests that hydrogen production will scale up to 90TWh hours by 2035 – that is nearly a third of the size of the current power sector in the UK.

Hydrogen Economy in Scotland



Hydrogen Production Definitions

Renewable hydrogen is produced using renewable electricity and is zero carbon.

Low-carbon hydrogen is produced by reforming natural gas in conjunction with carbon capture and storage and is very low-carbon.

Biomass gasification with CCS for the production of hydrogen is a less developed negative emissions technology but nevertheless could become part of the energy mix.

Unabated Hydrogen is produced from the reforming of natural gas. This process produces both hydrogen and carbon dioxide which is emitted to the atmosphere.

We believe that producing renewable and low-carbon¹ hydrogen at scale and showing that it can be used to meet challenging energy demands from difficult-to-decarbonise sectors will be a key part of the next stage of Scotland's energy transition pathway.

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 required to help decarbonise key parts of the sector, such as larger vehicles with heavy duty cycles including lorries and buses, agricultural vehicles, trains, marine vessels and aviation. Transported through the gas grid it can help decarbonise our heat demand at home and in our commercial premises. Also, for energy-intensive industry, switching to renewable and low-carbon hydrogen is considered one of the few viable options for significant decarbonisation in the next decade.

We are exploring the role of hydrogen in an integrated system to better understand the opportunities hydrogen presents to deliver large scale and long-term energy storage for the energy system, and the potential to replace or augment the critical balancing and resilience services that natural gas storage provides to the energy 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 resource when demand for power is low, as well as the potential for hydrogen turbines to meet demand and provide valuable system services – replicating the function currently provided by fossil fuel-powered gas and diesel generators.

We will take a regional approach to our support for the development of the hydrogen economy in Scotland to recognise the different natural assets, skills and potential applications for hydrogen across different geographic areas of Scotland. Hydrogen may play a key role in decarbonising our industrial clusters, supporting the just transition of the workforce in high carbon sectors in the North East 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 of this action plan will be to support the development of Regional Hydrogen Energy Hubs, described in more detail in Section 1, that will help to deliver the benefits of hydrogen in each of these regions.

We recognise that there are a number of challenges to realising the potential of hydrogen in our energy transition and the size of global markets, including the high cost of hydrogen

¹ Further detail on the different types of hydrogen production is set out in the [Hydrogen Policy Statement](#).

production in comparison to high carbon fuels. There is significant potential for long-term cost reduction through innovation, economies of scale and access to low-cost renewable electricity; however, the scale of hydrogen's role in our energy system will ultimately depend on a number of factors including its cost relative to its alternatives. We will build on existing research to establish an expected cost trajectory for hydrogen produced in Scotland.

In line with our statutory obligations, a Strategic Environmental Assessment has been carried out on this Hydrogen Action Plan. The recommended mitigation and enhancement actions will be taken into account in the implementation of the Action Plan including in the development of the regulatory, planning and consenting framework.

Our Hydrogen Policy Statement described how hydrogen has a potentially very important role to play in Scotland achieving 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 5GW of renewable and low-carbon hydrogen production by 2030 and 25GW by 2045.
- committed £100 million 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, the need to see as much renewable hydrogen in the energy system as quickly as possible and support the establishment 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.

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- committed to exploring the opportunities for negative carbon hydrogen, combining the potential to use bioenergy to produce hydrogen with CCS.
 - 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.

This draft Hydrogen Action Plan sets out what the Scottish Government will do and how we will work with others over the next five years to implement the strong strategic approach required to support the development of the hydrogen economy in Scotland, to support our efforts to reduce greenhouse gas emissions from our energy system, industry, 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 5GW of renewable and low-carbon hydrogen by 2030 and 25GW 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 and export potential.
- secure broad economic benefit from public sector and private sector support for development of regional hydrogen production and use.
- encourage the development of a strong hydrogen sector in Scotland which supports a just transition to net zero.

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.

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 indicates that a strong hydrogen sector in Scotland could support up to 300,000² jobs across all skill levels by 2045. Many of the skills required already exist in our renewable and offshore industries.

As is outlined in Part 2 of 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 our forthcoming Energy Strategy and Just Transition Plan in 2022. This plan will consider hydrogen as part of a whole-system approach to the just transition, and will be supported by our oil and gas evidence base.

Scotland's unique selling point is 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 technical oil and gas sector which 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. This is explored further in the Scottish Offshore Wind to Green Hydrogen Opportunity Assessment which was published alongside the Scottish Hydrogen Assessment report³ in December 2020. There are also key learnings to be taken from the development of the renewables sector in Scotland for the emerging hydrogen sector.

2 [Scottish hydrogen: assessment report - gov.scot \(www.gov.scot\)](https://www.gov.scot/publications/scottish-hydrogen-assessment-report/pages/10-to-15.aspx) In the 2030s our assessments suggest the hydrogen economy will be worth between £2.5bn and £6bn in GVA to Scotland and we have the potential to be supporting between 31,000 and 81,000 jobs. In the 2040s the hydrogen economy could be worth between £5.7bn and £25.9bn in GVA to Scotland and we have the potential to be supporting between 68,000 and 313,000 jobs

3 <https://www.gov.scot/publications/scottish-offshore-wind-green-hydrogen-opportunity-assessment/>

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 Statement⁴, published on 28 October 2021, sets out the Scottish Government's ambitions for onshore wind in Scotland out to 2030 in the context of our 2045 net zero emissions commitment. It outlines the huge potential for this technology, and assesses the significant economic opportunity of future deployment, particularly in light of green recovery aspirations. Subject to consultation, we are committed to securing an additional 8-12GW of installed onshore wind by 2030.

A strong onshore wind sector will support the development of a range of small- and large scale renewable hydrogen projects. As these hydrogen production projects come on line they will assist the efficiency of the energy system by addressing renewable intermittency with production by electrolysis at times of excess electricity supply. A new Onshore Wind Policy Statement will be published in 2022.

Offshore Wind

Scotland has one of the largest maritime zones in Europe and some of the highest concentrations of wind energy in the world. 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 2GW of offshore wind farms constructed and a further 4GW in development.

The latest round of offshore seabed leasing, ScotWind, closed in July 2021. This could generate a further 10GW of wind power, and billions in pounds of investment over the next 20 years. Successful bidders will be announced in early 2022 and further regular leasing rounds are planned in the forthcoming years.

A planning round for innovation and targeted oil and gas decarbonisation (INTOG) with the specific purpose of constructing offshore wind farms by 2025/26 to decarbonise oil and gas infrastructure operations, support oil and gas decommissioning, and contribute towards net zero launched on 25 August 2021. INTOG will deliver between 3-4GW of capacity and some 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, supporting the ambition outlined in our Hydrogen Policy Statement of generating 5GW of hydrogen by 2030.

⁴ <https://www.gov.scot/publications/onshore-wind-policy-statement-9781788515283/>

CCS Cluster

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 the 300,000 people⁵ currently working within our industrial sector, highlighting the importance of a just transition.

The creation of low-carbon hydrogen, utilising carbon capture and storage (CCS) at commercial scale, will establish the opportunities to decarbonise industry, transport and heat, as well as other sectors, and pave the way for establishing the transportation and storage infrastructure to support the growing hydrogen economy in Scotland. CCS also enables negative emissions technologies in the bioenergy sector and for capturing emissions directly from the air through direct air capture (DAC) plants. When hydrogen is produced from a bio-energy feedstock and combined with CCS it can deliver negative emissions. Negative emissions technologies will play a critical role in meeting emissions reduction targets.

The Scottish CCS 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 the UK Government's cluster-sequencing bid process along with a commitment from the UK Government to continued engagement with the cluster through Phase 2 of the sequencing process to ensure its development and planning continues. We remain committed to supporting the continued growth and development of the Scottish Cluster to ensure that Scotland reaches its net zero goals by 2045.

An Integrated Energy System

Achieving the deep decarbonisation of industrial energy and 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 must 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.

The growth of renewables and a hydrogen economy are complementary – we need a strong renewables sector to support the timely development of a range of small and large scale renewable hydrogen projects. An integrated energy system, that includes hydrogen, and the establishment of hydrogen production hubs capable of simultaneously servicing transport, heat and industry needs will provide an effective energy integration opportunity for hydrogen. We will aim to provide targeted support to accelerate and maximise the production of renewable hydrogen in Scotland, recognising that the development of low-carbon hydrogen production facilities will provide essential pipeline and compression infrastructure that can be shared with larger scale renewable hydrogen as this comes on line.

5 <https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/>

It is a vision such as this that is guiding the development of our policies in this Action Plan.

Use of hydrogen can act as a complementary energy source alongside electrification, as well as offering a compelling solution for sectors where full electrification is challenging. This may make it appropriate for industrial applications for energy intensive industries and some forms of transport, including, for example road freight, hydrogen trains on lines which would be very expensive to electrify, buses, and shipping.

We are also undertaking work to identify high-potential areas for the use of hydrogen for heat in Scotland. The first part of this work is underway and will establish an expected cost-trajectory for renewable hydrogen produced in Scotland to 2030 and 2045. This will help develop our understanding of hydrogen demand, potential hierarchy of use and future devolved policy decisions.

Our analysis tells us that in the next five years it is clear that industrial use of hydrogen and the use of hydrogen in the transport sector will create the initial demand for increasing volumes of hydrogen.

Case Study – Whitelee Renewable Hydrogen Project

ScottishPower is developing Scotland's largest renewable hydrogen project at Whitelee Windfarm, the UK's largest onshore windfarm. The 20MW green hydrogen production facility is expected to be consented in late 2021, with up to 8 tonnes of green hydrogen being available in early 2023. This flagship project will be critical in demonstrating the deployment of green hydrogen at scale, building upon Scotland's renewable energy foundations.

The renewable hydrogen facility will be powered by the mix of technologies at Whitelee which includes a new solar farm, battery energy storage system and the existing windfarm. The project would be capable of providing enough zero-emission hydrogen to power up to 550 hydrogen buses to travel from Glasgow to Edinburgh and back again each day.

With the strategic location just south of Glasgow, the scale of production should ensure renewable hydrogen is available for transport and industrial applications across the region.

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**.

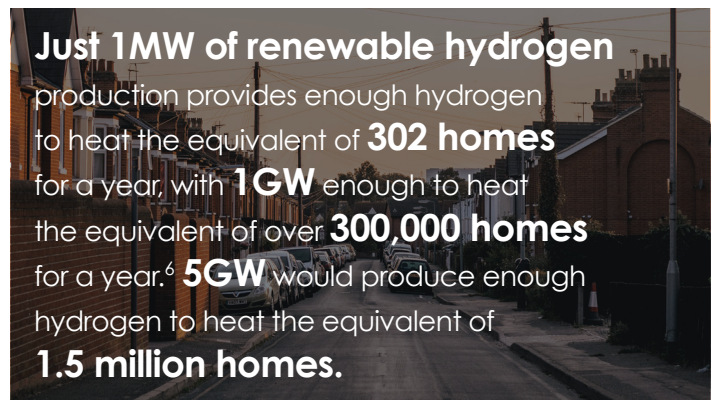
We can translate this to approximately **27.5 TWh** which equates to approximately **790'000 tonnes of hydrogen**.



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

5GW of hydrogen

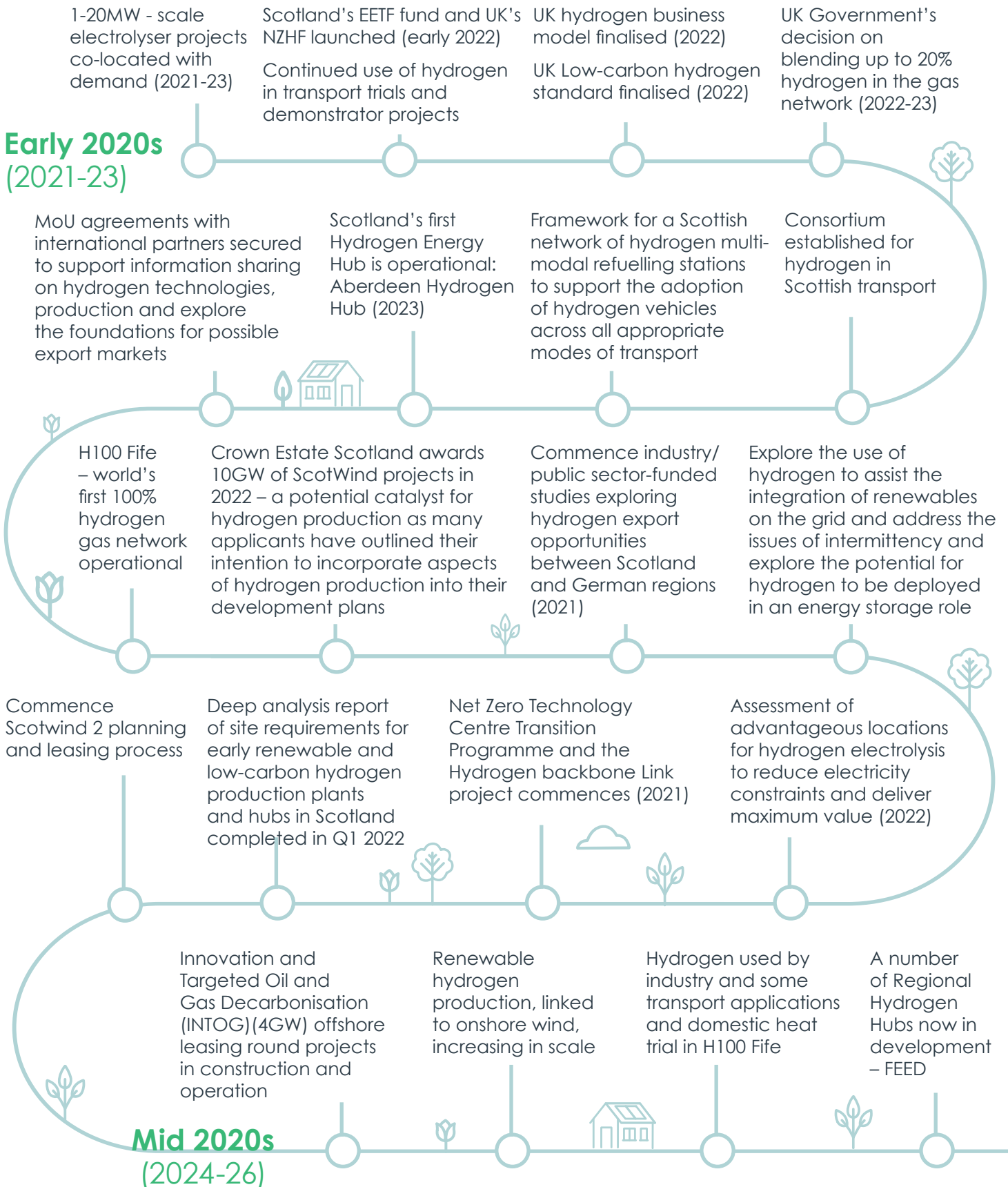
would produce energy equivalent to **15% of Scotland's total energy demand**.



⁶ Heating Value of 39.4kW/kg and annual consumption of 12,000kWh per year for an average house. $12,000/39.4 = 304.6\text{kg}$, 1000kg (1 tonne) = $1000/304.6 = 3.3$ homes - 1MW of electrolytic hydrogen production produces 92 tonnes of hydrogen p.a. = to 302,000 homes.

Part 1 – Hydrogen Economy: Route Map to 2030 and 2045

The Hydrogen Economy Journey



The journey to net zero

UK Government decision on the gas network to enable planning for delivery beyond 2030 (2026)

Hydrogen storage beginning to be deployed

Scottish Hydrogen Export Plan developed

ScotWind 3 process begins

Late 2020s (2027-29)

Offshore wind developments including floating offshore wind projects linked to large-scale renewable hydrogen production

Multiple regional hydrogen hubs in construction and operation

Renewable hydrogen production, linked to onshore wind developments, supporting management of constrained electricity

Large-scale CCUS-enabled low-carbon hydrogen production developments in operation

Progress on cost reduction leading to a broad range of off-takers including industry, transport and initial export contracts

Scotland's first floating offshore wind hydrogen production in operation

5GW renewable and low-carbon hydrogen production capacity in Scotland

Increasing commercial roll-out of hydrogen options in heavier-duty transport modes

2030s

Large-scale hydrogen storage deployed

Economies of scale and technology innovation driving significant reduction in produced cost of hydrogen

Export of hydrogen to UK and Europe increasing in scale

Whole system energy strategy ambitions realised

[100% renewable electricity; ambition for 8-12GW onshore wind and 11GW offshore wind; over a million homes and the equivalent of 50,000 non-domestic properties converted to zero or low emissions heating]

25GW production capacity ambition

Scotland established as an enduring and reliable key exporter of hydrogen to Europe

2040s



Learning by doing

Over the past few years, the Scottish Government has supported a variety of projects which have helped demonstrate the use of hydrogen in the decarbonisation of key sectors, such as transport, through our funding of hydrogen buses, for heat through our funding for the H100 Fife project and in using hydrogen production to overcome the perennial problem of grid capacity constraints at the edges of our energy system on our islands, remote and rural communities.

The portfolio of projects is exemplified in our Orkney Islands where our initial funding of hydrogen projects at the European Marine Energy Centre (EMEC) has helped to accumulate a £65 million portfolio of projects. Working closely with Highlands and Islands Airports Limited (HIAL) and EMEC we have funded the introduction of a hydrogen-powered Combined Heat and Power unit to help meet the additional energy needs of Kirkwall Airport as it moves forward with its decarbonisation agenda. We are working with HIAL and key stakeholders to explore how this innovative technology can be replicated in other airport environs. Likewise, our initial funding of hydrogen buses in Aberdeen has helped establish the infrastructure to support an ecosystem of over 60 hydrogen-fuelled vehicles, which has in turn been a catalyst for the development of the North East of Scotland into one of the key model hydrogen regions in Europe.

Alongside this portfolio of demonstration projects sits a suite of investments in crucial research and development. Our funding of the Hydrogen Accelerator, hosted by the University of St Andrews, is supporting the implementation of hydrogen technologies into Scotland, and we are also working with partners including the Michelin Scotland Innovation Park and the University of Strathclyde to develop testing facilities to support the development of hydrogen vehicles through Scotland's vehicle supply chain.

The foresight to invest in these early projects has allowed the public and private sector in Scotland to work together to demonstrate these technologies and very importantly to 'learn by doing'. This approach has been a big part of the success story not only for our technical partners in these projects but from the public sector side too and indeed much of the learning takes place before a single molecule of hydrogen is even produced – as we gain valuable knowledge of how to work with others to assess, approve, consent, regulate and manage the contractual relationships necessary to deploy these projects, and how best to address constraints and challenges, including high production costs.

Our approach to cost reduction has been informed by the knowledge base developed through these early demonstration and research projects. The actions included in this plan will support a decrease in the cost of hydrogen production by increasing the scale of hydrogen production, supporting the growth of regional hubs that will provide a cost-effective model in the short term, and by supporting technology innovation.

Map 1 - Some of Scotland's Current Hydrogen Projects

End User

- 01 Cloverhill's Aberdeen Hydrogen First
- 02 Eden Mill distillery
- 03 Glasgow Hydrogen Gritters
- 04 HECTOR project
- 05 HyDIME
- 06 HyFlyer
- 07 HySeas III
- 08 HySpirits
- 09 Hytransit Project - Aberdeen Hydrogen Busses
- 10 Hytec
- 11 JIVE 2 - Dundee Hydrogen Transport
- 12 Kirkwall Airport Decarbonisation
- 13 Liquid Organic Hydrogen Carriers (LOHC) for the transportation of hydrogen
- 14 Project HyLaddie
- 15 Scottish Hydrogen Train project
- 16 TimberLINK
- 17 Uist Distilling Company

Multi-vector

- 18 Aberdeen Hydrogen Hub
- 19 Aberdeen Vision
- 20 BIG HIT
- 21 East Neuk Power to Hydrogen
- 22 GENCOMM - AD
- 23 ITEG - Integrating Tidal Energy into the European Grid
- 24 North of Scotland Hydrogen Programme
- 25 OHLEH - Outer Hebrides Local Energy Hub

- 26 Orion Project
- 27 PITCHES
- 28 ReFLEX (Responsive Flexibility) Project
- 29 SWIFTH2
- 30 PURE Energy Centre
- 31 Flotta Hydrogen Hub

Production

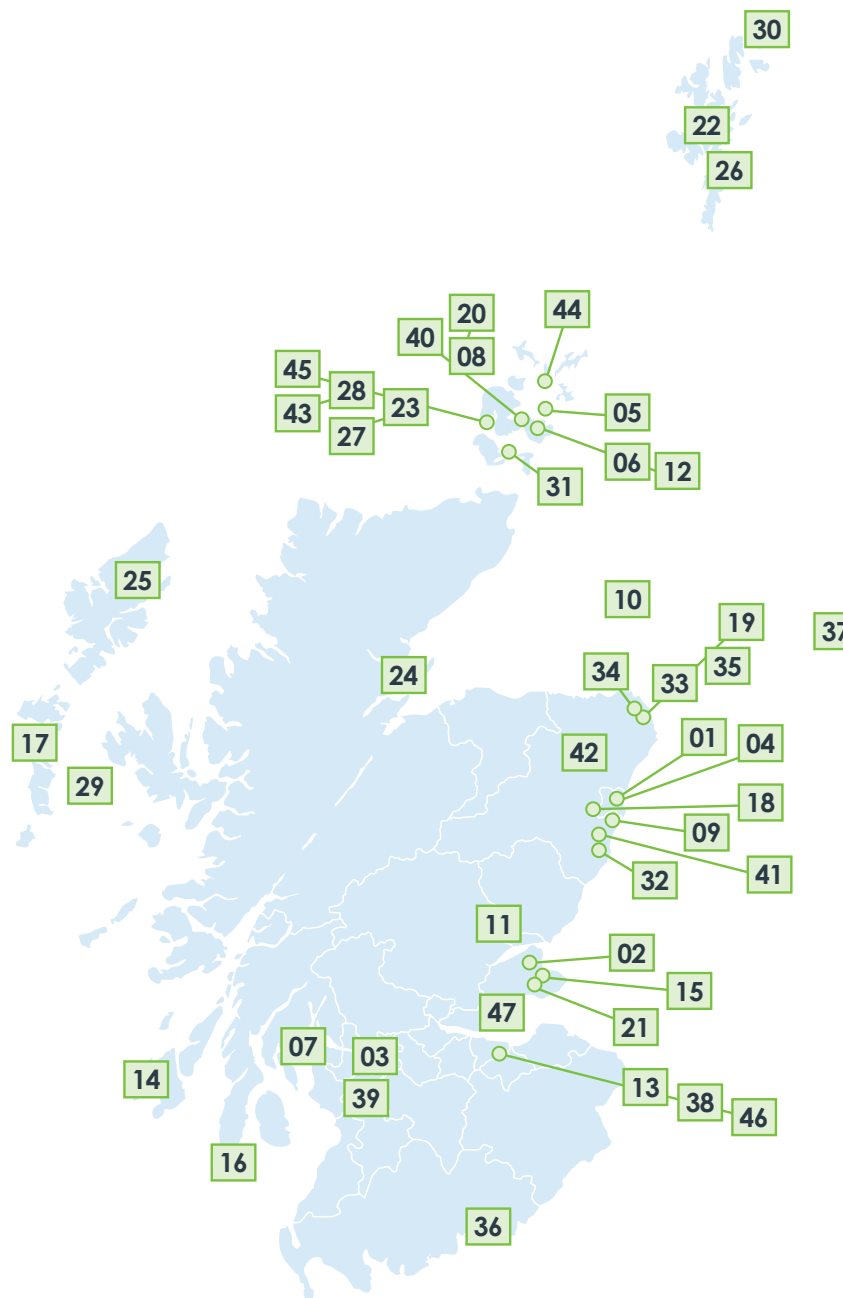
- 32 Aberdeen Hydrogen Centre (ACHES)
- 33 Acorn CCS
- 34 Acorn Hydrogen
- 35 Caledonia Clean Energy Project
- 36 Chapelcross Initiative
- 37 Dolphyn Project
- 38 Edinburgh International Festival decarbonisation project
- 39 Green Hydrogen for Glasgow
- 40 Hammars Hill Green Ammonia project
- 41 Kittybrewster Refuelling Station
- 42 Skelmonae Green Hydrogen
- 43 'Surf 'n' Turf'

Storage

- 44 Eday Flow Cell Battery Project
- 45 HyAI
- 46 HyStorPor Project

Transmission/distribution

- 47 H100 Fife project



Regional Hydrogen Energy Hubs

The creation of regional hydrogen energy hubs this decade will help to achieve our ambition of maximising the emissions reduction and economic benefits from the developing hydrogen economy. They will also support Scotland's ambition to become a global leader in the emerging renewable hydrogen market enabled by our abundant offshore renewables resources.

Hydrogen hubs are geographic locations where hydrogen producers are co-located with multiple users and potential exporters. This 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.

There are a number of 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, 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.

Overlaps and linkages are emerging between the location of Scotland's current hydrogen development and the sites of Scotland's main industrial emissions. 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 make sense to co-locate production with multiple off-takers.

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.

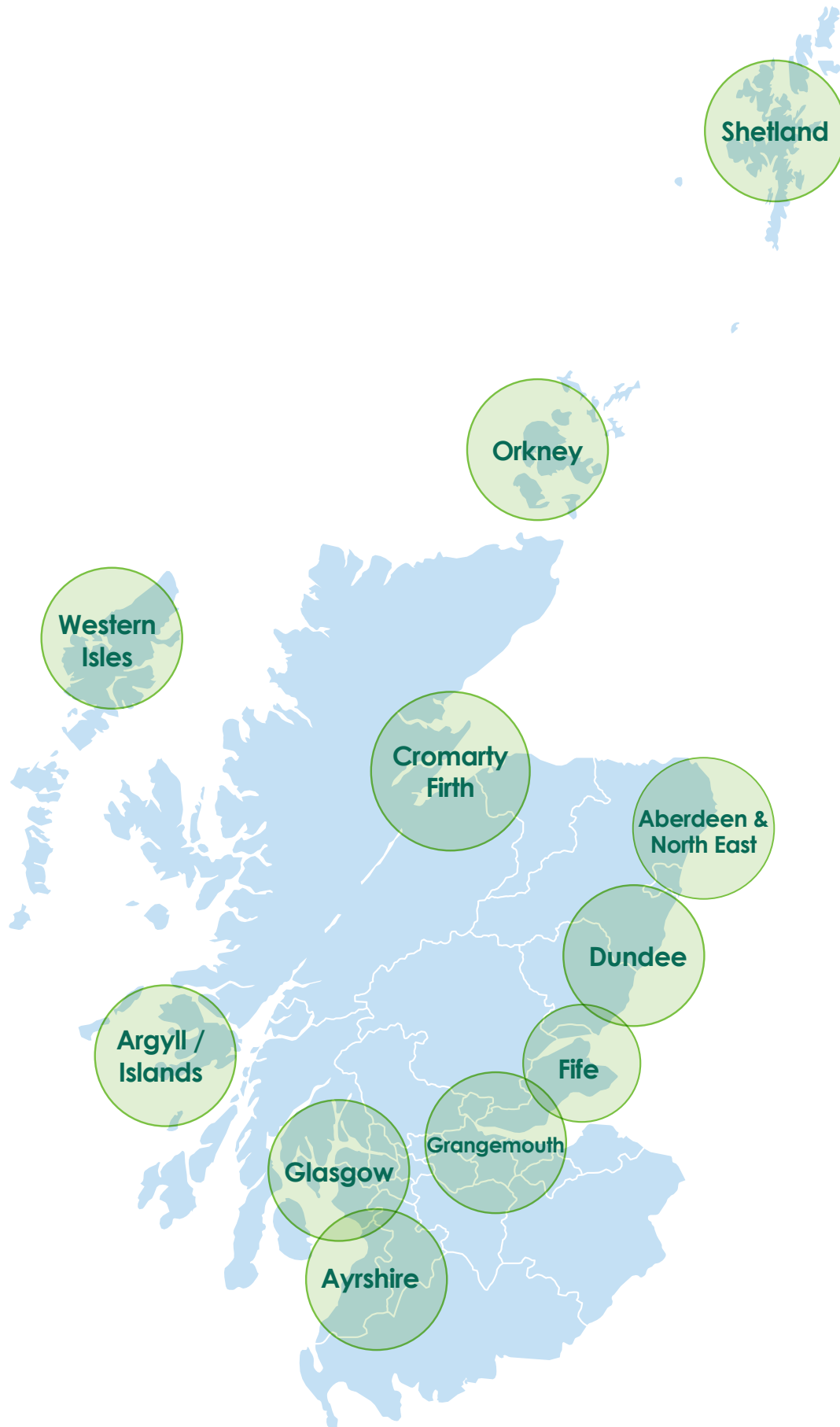
Led by industry, and the private sector, several regional hydrogen clusters or 'hubs' are forming. Some are already producing renewable hydrogen and supporting demand for hydrogen fuels, e.g., Aberdeen, while others are advancing to renewable hydrogen production, such as the Hydrogen for Glasgow project that links to hydrogen production from the renewable energy generated by the Whitelee Wind Farm operated by Scottish Power.

Additional areas and projects, from the North of Scotland and Islands to the South of Scotland, are rapidly developing as potential future centres of hydrogen production and demand including the Grangemouth industrial cluster. Scottish Power and Storegga are also developing the Cromarty Distilleries Project as part of the North of Scotland Hydrogen Programme. The Phase 1 project aims to have a 35MW 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 and 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.

Our islands also benefit from many of the characteristics that would enable them to develop as hubs of hydrogen production and demand. The Outer Hebrides, Orkney and Shetland Islands have some of the best wind conditions in Europe and have the potential to develop significant onshore and offshore wind generation through both community-owned and commercial renewable energy generators. This renewable energy could be used to produce renewable hydrogen via electrolysis that supports the location of Hydrogen Energy Hubs with large scale local demand ambitions, for example the Outer Hebrides Local Energy Hub, which is among the projects being supported via the UK and Scottish Government Islands Growth Deal and the Scottish Government's Green Growth Accelerator.

In our Programme for Government we made a commitment to support Carbon Neutral Islands, including pilots for islands to run on 100% renewable energy, create circular economies, and explore more sustainable transport options. 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.

Map 2 – Potential Location of Regional Hydrogen Hubs



Aberdeen Hydrogen Hub

Aberdeen is one of Europe's most advanced hydrogen cities. The City has implemented a wide range of hydrogen initiatives including: a hydrogen fleet of over sixty vehicles, a renewed fleet of 25 double-decker hydrogen buses, a range of light duty fuel cell vehicles into Council fleets and a local car sharing club, trials of hydrogen-fuelled refuse trucks and road sweepers, and commissioning of a megawatt-scale stationary fuel cell as part of Aberdeen's recent new conference centre development, plus two public hydrogen refuelling stations operating since 2015.

Building on these successful deployments we are investing over £15 million from our Energy Transition Fund to continue our support of Aberdeen City to build their vision of the Aberdeen Hydrogen Hub.

The Aberdeen Hydrogen Hub is a broad programme of work to develop a comprehensive investment in infrastructure for the production of and use of renewable hydrogen, its distribution, storage, and refuelling across the region to support the growth of broader transport fleets and the deployment of new applications. Aberdeen City's experience in both the developing hydrogen sector and the established, high-value energy and supporting services sector existing in the region will enable this initial public funding to leverage significant private investment into the expansion of hydrogen fuel supplies for both imminent and future requirements in the city and deliver on both economic benefits and the regional/national Net Zero and Energy Transition agenda.

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, drive cost efficiencies and facilitate knowledge sharing. The Scottish Government will, over the next five years, continue to create a supportive policy environment and alongside private investment enable the creation of a network of renewable and low-carbon hydrogen production hubs near demand centres in towns and cities across Scotland.

Locational mapping

We have developed an Interactive GIS Hydrogen Mapping Tool which maps, and charts all of the hydrogen activity and projects in Scotland. Our GIS hydrogen map has multiple levels of key information on the location of constrained renewables electricity, road, rail and ferry routes and nodes of activity and other key infrastructure important to the systemic development and integration of hydrogen production in Scotland. This GIS Interactive Hydrogen Mapping Tool will be developed further and launched in 2022 as a web-ready tool for public access. This free to access tool will support project development and planning. We will work with stakeholders to ensure it remains up-to-date and can be developed further in future to be of maximum benefit to industry.

Hydrogen Production – Detailed Site Selection Study

To be successful, the development of renewable and low-carbon hydrogen technologies and large-scale deployment will be paramount to the success of Scotland's ambition to achieve 5GW of hydrogen production by 2030.

Scottish Enterprise recently published a report by the Net Zero Technology Centre and Offshore Renewable Energy Catapult which examined the opportunities and challenges for Scotland in developing early, hydrogen production in Scotland⁷.

This report sets out the key characteristics of a site to support the development of a large-scale renewable and low-carbon hydrogen production facility. This includes aspects relating to feedstock, power supply, size and suitability of the land, the ability of the local area to support the development, and export routes to market for the hydrogen.

We have commissioned further work to determine detailed site requirements for hydrogen production sites at 200MW, 500MW and 1GW scale and will include consideration of the site requirements for hydrogen export from Scotland, from both a storage and conversion perspective and a marine infrastructure perspective. Site requirements for offshore hydrogen production will also fall under the scope of this work.

This report will be concluded in Spring 2022 and will identify key consent and licensing requirements and inform policy and funding decisions.

Scotland's Renewable Hydrogen Potential

Scotland's ability to generate renewable hydrogen at scale was clearly demonstrated by the Offshore Wind to Green Hydrogen Opportunity Assessment and Scottish Hydrogen Assessment undertaken in 2020, which indicated Scotland's renewable hydrogen production potential as 35GW by 2045, dependent on market conditions. The rate of growth of renewable hydrogen production in Scotland will be influenced by a number of factors, including market demand and the cost of renewable hydrogen produced in Scotland. We are building on our existing evidence base by undertaking work to identify the expected cost-trajectory of renewable hydrogen produced in Scotland to 2030 and 2045. This will provide critical evidence to support our understanding of the extent of the role that renewable hydrogen will play in a domestic and global market.

⁷ <https://www.scottish-enterprise.com/media/4109/development-hydrogen-production-in-scotland.pdf>

Part 2 – Actions to Meet our Vision, Ambition, and Commitment

To ensure Scotland is in the best possible position to achieve our ambition of 5GW of hydrogen capacity by 2030, over the next five years we will focus on the implementation of short-term actions to support meeting the following six key challenges:

- Scaling up hydrogen production in Scotland
- Facilitating the development of a domestic market
- Maximising the benefits of integrating hydrogen into our energy system
- Enabling the growth and transition of Scotland's supply chain and workforce
- Establishing and strengthening international partnerships and markets
- Strengthening innovation and research

As the hydrogen market develops so too will our policy and actions. The actions set out in this draft Action Plan are not exhaustive and we would welcome views on them. In order to maximise the decarbonisation and economic benefit for businesses and communities from the establishment of a hydrogen economy we will utilise our industry-government forums to ensure Scottish Government policy and action remains responsive to technological and market developments over the next five years.

Action themes and key actions

1. Scaling up hydrogen production in Scotland

Scotland's vast onshore and offshore wind capacity means it has the potential to produce sustainable, low-cost renewable hydrogen at scale. To realise our 5GW by 2030 and 25GW by 2045 ambitions, action must be taken in the immediate term to support and accelerate the developing pipeline of Scottish renewable and low-carbon hydrogen projects and to eliminate any potential barriers such as regulatory, planning or infrastructure constraints.

	What	How	Timeframe
1	Launch our £100m renewable hydrogen development fund (EETF) to support hydrogen pathfinder projects in the next five years.	A call for proposals for renewable hydrogen projects and infrastructure will be launched in Q1 2022. More detail on what the £100m hydrogen development programme will support is found in section 3.	2021-26
2	Ensure the regulatory, planning and consenting framework for renewable energy and hydrogen developments supports the scale-up of hydrogen production at pace.	<p>We will undertake a review of existing legislation, regulation and standards to assess how the current legislative framework supports hydrogen development in Scotland, and, where necessary, will take action, where it is within devolved competence, to ensure a co-ordinated approach and address any gaps or issues.</p> <p>We will work to ensure, where appropriate, any consenting framework for hydrogen production works in tandem with existing consenting frameworks for renewable electricity, in order to maximise opportunities for development on key sites such as wind farms, and make efficient use of constrained renewable generation.</p> <p>We will ensure the marine planning processes support the delivery of hydrogen electrolysis at sea.</p> <p>We will publish planning consent guidance on the development of large-scale hydrogen production facilities in Scotland and its waters.</p>	<p>2022-23</p> <p>2021-26</p> <p>2021-26</p> <p>2022</p>

What	How	Timeframe
<p>3</p> <p>Ensure our ambitions for onshore and offshore wind development in Scotland support our 5GW by 2030 hydrogen ambition.</p>	<p>We will work with the electricity system operators to determine how best to accelerate hydrogen from constrained wind and address curtailment payments. Views are welcome on the consultation on the draft Onshore Wind Policy Statement which launched on 28 October 2021.</p> <p>We will deliver a planning round for Innovation and Targeted Oil and Gas decarbonisation (INTOG) with the specific purpose of constructing offshore wind farms to decarbonise oil and gas infrastructure operations, maximising further opportunities for the Scottish economy through the hydrogen supply chain and uses.</p> <p>Accelerate delivery of future offshore wind plans and leasing rounds through the development of a clear roadmap for future offshore wind leasing in Scotland.</p> <p>We will also develop the data to allow us to monitor and report on progress towards our 5GW hydrogen ambition on an annual basis</p>	<p>Ongoing</p> <p>2025-26</p> <p>Ongoing</p>
<p>4</p> <p>We will build on our evidence base to understand the extent of the role renewable hydrogen is likely to play in a domestic and global market.</p>	<p>The first part of this work is underway and will establish an expected cost-trajectory for renewable hydrogen produced in Scotland to 2030 and 2045. This will help develop our understanding of hydrogen demand, potential hierarchy of use and future devolved policy decisions.</p>	<p>Ongoing</p>
<p>5</p> <p>Support spatial planning in enabling the establishment of hydrogen projects.</p>	<p>Align our National Planning Framework with our hydrogen policy and Hydrogen Action Plan</p>	<p>2021</p>

	What	How	Timeframe
6	Support the Scottish Cluster to deliver on its ambition to produce low-carbon hydrogen at scale.	We will continue to support the Scottish Cluster which will enable carbon capture deployment across a diverse set of emitters and a robust and resilient multi-option transport and storage system. The Scottish Cluster is required to enable low- and ultimately negative-carbon hydrogen production in Scotland. £80m from the £180m Emerging Energy Technologies Fund has been identified to support the development of CCUS and CCS-enabled negative emissions technologies in Scotland.	Ongoing
7	Ensure low-carbon hydrogen produced and used in Scotland is compatible with our climate ambitions.	<p>We will continue to work with the UK Government in the development of a UK Hydrogen Standard which will use methodology for calculating greenhouse gas (GHG) emissions associated with low-carbon hydrogen production and will set maximum acceptable levels of GHG emissions associated with low-carbon hydrogen production.</p> <p>In the interim, Scottish grant funding for low-carbon hydrogen projects will be conditional on capture rates of at least between 90-95%.</p>	2021-22
8	We will not support new hydrogen production where CO₂ is unabated.	<p>We will set eligibility criteria for Scottish Government funding support for the development of new industrial plants for the primary purpose of hydrogen production in Scotland which will require the demonstration of compliance with the UK low-carbon hydrogen standard on its introduction.</p> <p>We will integrate the UK low-carbon hydrogen standard into our funding schemes and investment decisions. Ahead of the low-carbon hydrogen standard, Scottish Government funding will not be awarded to new industrial sites for the primary purpose of producing hydrogen where CO₂ is unabated.</p> <p>We will confirm our commitment to encourage industry to transition away from production and use of unabated hydrogen as part of the forthcoming Energy Strategy Refresh.</p>	2021-22

	What	How	Timeframe
9	<p>We will ensure that hydrogen development in Scotland is planned where it can be best supported by available water resources.</p>	<p>Our Enterprise Agencies have commissioned work to develop detailed plans and analysis of site requirements for early renewable and low-carbon hydrogen production plants and hubs in Scotland providing a detailed set of future site requirements. This report will be concluded in Spring 2022.</p> <p>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.</p>	<p>2022</p> <p>2021-26</p>

Case Study – Low-Carbon Hydrogen for Industrial Decarbonisation: INEOS

INEOS has announced its commitment to the Paris Agreement targets and to meet the Scottish Government’s 2045 net zero target by outlining a £1bn investment to continue its decarbonisation of operations at its Grangemouth site.

INEOS Grangemouth’s Net Zero Roadmap involves a move to the production and use of hydrogen by all businesses at the Grangemouth site accompanied by carbon capture and storage of at least one million tonnes per annum of CO₂ by 2030 and delivering emissions savings of more than 60% across the site by 2030.

This includes investment in a world-scale 700MW low-carbon hydrogen production plant, and associated plant optimisation, to reduce CO₂ emissions.

Switching to low-carbon hydrogen is the main route to decarbonise energy-intensive chemical and industrial clusters such as Grangemouth. It enables effective transition via integration with existing steam and power generation units.

Low-carbon hydrogen production will also initiate investment in the hydrogen networks which are vital for a robust hydrogen economy, and seed investment in other uses of hydrogen, such as for transport and heat.

The roadmap supports Scotland to transition to a net zero economy while securing high-value manufacturing jobs and attracting new investment – the essence of a just transition.

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. Focus will be placed on driving technological progress and economies of scale to reduce the cost of hydrogen and ensure it is an economically viable option for sectors such as transport, industry, heat.

The Scottish Hydrogen Assessment indicates that the transport sector, alongside industry, will most likely form the initial areas of high demand for hydrogen in Scotland.

Economies of Scale

	What	How	Timeframe
10	We will support the development of appropriate Regional Hydrogen Hubs where production is coupled with multiple end-use applications thus helping to stimulate demand.	The Emerging Energy Technologies Fund (EETF) will provide strategic support to developing regional hydrogen hubs that combine production, storage and distribution with multiple end-use applications. This sector coupling approach will help to aggregate demand and improve the economic benefit of the projects.	2021-26
		We will provide over £15m from the Energy Transition Fund to support the establishment of the Aberdeen Hydrogen Hub.	2020-24

Industry

	What	How	Timeframe
11	We will support Scottish industries to use hydrogen in their decarbonisation plans.	We will invite energy-intensive manufacturers to apply for match-funded grants via the Scottish Industrial Energy Transformation Fund (SIETF) to support the deployment of, or studies into, energy efficiency or deeper decarbonisation projects such as fuel switching to renewable or low-carbon hydrogen.	2021-25
		We will facilitate a number of non-revenue generating '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.	2022
		We will take action on the recommendations of the Scottish Net Zero Roadmap.	2023
		Through the work of the Grangemouth Future Industry Board we will focus efforts to support the development of the hydrogen economy at Grangemouth. We will work to map a range of local interests in hydrogen, with a view to understand the best ways to support the development of hydrogen applications, including industrial use, in Scotland's major industrial region.	2021
12	No support for new unabated hydrogen production.	We will no longer support via Scottish Government funding schemes the development of new, industrial development where carbon emissions are unabated. Such development will require to demonstrate the implementation of a decarbonisation strategy at point of operation e.g. fuel switching, carbon capture, and energy efficiency. This includes new industrial sites for the primary purpose of producing hydrogen where CO ₂ is unabated.	2021

Transport

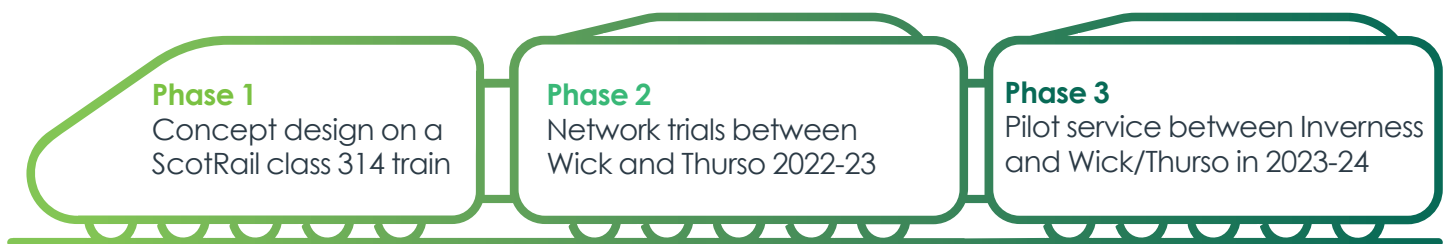
	What	How	Timeframe
13	<p>Mission and Partnership</p> <p>We will create an environment for the public and private sector to co-design technology and infrastructure pathways for the application of hydrogen in transport, and deliver coincident benefits for jobs and supply chains.</p>	<p>We will establish a consortium for hydrogen in Scottish transport to shape and support delivery of the Hydrogen Action Plan in the transport sector.</p>	<p>Summer 2022</p>
14	<p>Infrastructure</p> <p>We will co-design with industry and publish a framework for enabling infrastructure to underpin Scotland's move to a zero emission transport system, including hydrogen and electricity as complementary fuels, both essential to the decarbonisation of transport.</p>	<p>We will produce forecasts for hydrogen and electricity demand across all transport modes – from cars through HGVs and trains to ships and planes – across all parts of Scotland. We will engage with businesses and industry on these forecasts in tandem with the Energy Strategy refresh.</p> <p>Working with the consortium for hydrogen in Scottish transport, we will co-design a framework for and establishing a network of hydrogen multi-modal refuelling stations to support the adoption of hydrogen vehicles across all appropriate modes of transport.</p> <p>We will join the multi-national effort to standardise hydrogen road refuelling stations in Europe. [See Action 36.]</p>	<p>Summer 2022</p> <p>2022-23</p> <p>Spring 2022</p>

	What	How	Timeframe
15	<p>Vehicles</p> <p>We will 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.</p>	<p>In partnership with the consortium for hydrogen in Scottish transport, we will explore detailed options for driving down the cost of hydrogen in transport applications, and consider how best to enable further hydrogen vehicle projects. This work will build on learning from existing Scottish rail and bus projects to support the piloting and demonstration of hydrogen propulsion across a range of transport modes.</p> <p>We will share lessons learned from existing support schemes, including on zero-emission buses, in order to support cost reduction and promote innovative business models.</p> <p>While regulations on the Renewable Transport Fuel Obligation (RTFO) are reserved to the UK Government, the Scottish Government will review and develop our funding support for zero-emission vehicles to ensure that it is complementary to subsidy available for hydrogen production.</p> <p>We will continue our work with public bodies on enhancing the role of fleet investments as enablers of technology deployment, including hydrogen.</p> <p>We will work with the UK Government and approval and safety bodies on the development of a proportionate and supportive system of standards and regulation around wider issues which will affect the successful development of the emerging hydrogen vehicle and fuel cell industry.</p>	<p>2022-23</p> <p>Ongoing</p> <p>Ongoing</p> <p>Ongoing</p> <p>Ongoing</p>

	What	How	Timeframe
16	<p>Wider ecosystem</p> <p>We will further develop Scotland's zero-emission mobility ecosystem, aiming to make Scotland a global centre of expertise for innovation in hydrogen mobility technologies, and growing our hydrogen mobility manufacturing base.</p>	<p>We will publish the findings of the Scotland's Automotive Industry Advisory Group's on enhancing Scotland as a destination for innovation and investment in the design and build of heavy and niche vehicles.</p> <p>Building on the findings of the IAG, we will continue to develop Scotland's ecosystem for innovation in hydrogen technology, particularly in heavy-duty vehicles, encompassing the LOCATE powertrain testing facility, the Michelin Scotland Innovation Parc, the Driving the Electric Revolution Scotland (DERS) Industrialisation Centre, and the Hydrogen Accelerator at the University of St Andrews.</p> <p>We will continue to develop support to address barriers to the growth of a competitive transport hydrogen technology supply chain in Scotland. We will do this working with partners on initiatives such as the Sustainable Mobility Scotland Cluster Builder and the Low-Carbon Transport Expert Support scheme.</p>	<p>Winter 2021</p> <p>Ongoing</p> <p>Ongoing</p>
	<p>We will continue to support a growing Scottish skills base in hydrogen for transport. We wish to see further demonstration of hydrogen transport applications and will continue to support suitable projects coming forward.</p>	<p>We will continue to explore the skills gaps for hydrogen transport applications in delivering the Climate Emergency Skills Action Plan. We will do this collaboratively, in a Team Scotland approach bringing together Transport Scotland, Skills Development Scotland, alongside, for instance, the Energy Skills Partnership, the Hydrogen Accelerator, and Michelin Scotland Innovation Parc (MSIP) Skills Academy.</p>	<p>Ongoing</p>

What	How	Timeframe
	<p>As part of this approach, we'll 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:</p> <ul style="list-style-type: none"> - support improved Scottish capabilities in Scottish colleges to deliver hydrogen for transport training for both technicians and business leaders; - deliver hydrogen for transport education material for upper primary and secondary school pupils as well as young adults. 	<p>By April 2022</p>
<p>17</p>	<p>We will continue to promote Scotland's expertise on hydrogen for mobility internationally and work with partners overseas on opportunities for collaboration on technical and policy issues.</p>	<p>Ongoing</p>

Hydrogen in Rail



Heat

	What	How	Timeframe
18	<p>We will continue to work with SGN and National Grid Gas Transmission to provide evidence on the role gas decarbonisation can play in meeting our targets, and a timeline for resolving uncertainties.</p>	<p>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.</p> <p>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.</p> <p>We will undertake a strategic review working with stakeholders, including network companies, local authority and delivery partners, to identify regions and areas most likely to have access to hydrogen in the future, and considered high-potential areas for the use of hydrogen for heat in Scotland</p> <p>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.</p> <p>We will identify ways to support projects which seek to demonstrate renewable hydrogen production and blending in the gas network.</p>	<p>2021-26</p> <p>2021-26</p> <p>2021-22</p> <p>Ongoing</p>

What	How	Timeframe
19	<p>We will continue to press the UK Government to take urgent action to facilitate decarbonisation of heat in buildings, in line with our Heat in Buildings Strategy.</p> <p>Alongside other action in reserved areas to support delivery of our Heat in Buildings Strategy, we will urge the UK Government to expedite progress on amending regulations and legislation to support hydrogen blending, accelerate decisions on the role of 100% hydrogen in the gas grid and to enable our ambition to maximise volumes of renewable hydrogen in our energy system as quickly as possible.</p> <p>We will continue to press the UK Government to progress the consultation on enabling and requiring hydrogen-ready boilers.</p>	<p>Ongoing</p> <p>Ongoing</p>

Case Study – Hydrogen Innovation: PlusZero

PlusZero is an innovative Scottish clean power start-up supporting the decarbonisation of the outdoor events sector with a renewable hydrogen-based clean power solution.

The outdoor events sector, is estimated to emit 1.2 million tonnes of CO₂ per annum in the UK.

PlusZero provides portable, zero-carbon hydrogen combustion engine generators fuelled by renewable hydrogen that can replace the carbon emitting and polluting diesel generators the sector currently relies on.

PlusZero sources the renewable hydrogen used to fuel its generator from its own and partner electrolyser facilities in the Western Isles and Orkney, creating new markets for Island renewable electricity producers.

PlusZero, supported by the Scottish Government and key technical expert partners Logan Energy, Abbott Risk Consulting and CMB.TECH, is demonstrating its hydrogen clean power solution with Edinburgh Festival event partners during Edinburgh's 2021 cultural events programme, including powering performances by artists at the Edinburgh International Festival's Contemporary Music venue in August 2021.

PlusZero's demonstration programme will culminate at Edinburgh's Hogmanay and will be followed by the launch of the company's commercial clean power service in 2022.

3. Maximising the benefits of integrating hydrogen into our energy system

The Hydrogen Policy Statement recognised that an integrated energy system, that includes hydrogen electrolysis, can allow better management of the supply and demand of energy. By allowing an increasing use of renewable electricity generation, renewable hydrogen production can play a critical role in supporting the realisation of Scotland's ambitions for 8-12GW onshore wind and 11GW 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.

	What	How	Timeframe
20	<p>Work with electricity and gas network operators to realise system benefits of hydrogen.</p>	<p>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.</p> <p>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.</p> <p>We will continue to work with key stakeholders to evaluate the most advantageous locations for hydrogen electrolysis to reduce electricity constraints and deliver maximum value. A report from the first stage of this work will be published in Spring 2022.</p>	<p>2021-26</p> <p>Spring 2022</p>

	What	How	Timeframe
21	<p>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.</p>	<p>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.</p>	2021-26
22	<p>Support the establishment of a Hydrogen Transportation and Distribution infrastructure to support our ambition to export hydrogen to the rest of the UK and Europe.</p>	<p>We will fund the Net Zero Technology Centre Transition Programme and the Hydrogen Backbone Link project which will position Scotland in a leading role for the development of pan-European hydrogen infrastructure including export capability. It will address the opportunity for Scotland and the rest of the UK to supply hydrogen to Europe as part of an extensive hydrogen transport and distribution system. The project will undertake concept studies and subsequent technology development for the re-purposing and optimisation of existing pipeline infrastructure both onshore and offshore.</p>	2021-24

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. We will take action to ensure at-risk sectors and regions benefit from a just transition to net zero by supporting the growth and transition of companies and workforce skills development that will underpin our future hydrogen economy.

Our Enterprise Agencies, Scottish Water, Transport Scotland, Scottish Development International and other areas of government and public bodies, including Marine Scotland and the 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 seven National Programmes in order to provide a strong focus on identifying opportunity for economic benefit and assist our policy ambitions for this growing sector.

	What	How	Timeframe
23	We will work with the Enterprise Agencies to build support for the Scottish Hydrogen Supply Chain through the development of a Hydrogen Economy Cluster.	In the delivery of this project, we will work closely with organisations like SHFCA, NECCUS and others, helping to build on the excellent services they offer. 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.	2022
24	We will provide the supply chain with a clear line of sight to opportunities by creating a visible pipeline of projects.	We will work in partnership with our Enterprise Agencies, trade associations and other relevant stakeholders to explore the requirement for an online tool to ensure that companies have clear visibility and access to information about upcoming hydrogen project opportunities in order to maximise the potential for Scottish content. We will work with our Enterprise Agencies to analyse what is currently available in this respect, identify gaps, and provide an update in the Energy Strategy refresh.	2022

What	How	Timeframe
<p>25</p> <p>We will work with industry and partners to establish the skills to underpin our energy transition.</p>	<p>We 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 Climate Emergency Skills Action Plan.</p> <p>We will work with industry to assess the workforce demand for a hydrogen economy. 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, particularly in regional locations where projects are likely to be based, e.g. through the new National Energy Skills Accelerator (NESA) being established in Aberdeen, to prepare the workforce for the energy transition and to provide access to new skills and capabilities required for delivering the net zero agenda.</p> <p>We will engage with industry and partners to assess how the Just Transition Commission's recommendation to create a long term 'skills guarantee' for workers in carbon-intensive sectors, could help to develop the specialist skills and workforce required to underpin the hydrogen economy.</p> <p>We will work with the National Manufacturing Institute Scotland (NMIS) and the sizeable Scottish manufacturing support network to help companies reduce their barriers to innovation and transition to new market opportunities.</p>	<p>2022</p>

What	How	Timeframe
26	<p>We will 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.</p>	2021-24

5. Establishing and strengthening international partnerships and markets

Analysis completed in the Scottish Hydrogen Assessment in 2020, showed that Scotland has the capability to produce quantities of hydrogen far greater than are required for a domestic market. Over the next few years, we will focus on taking action to secure the role of Scottish companies in the global hydrogen supply chain, to work with our international partners to share expertise and develop the sector more quickly, and to ensure Scotland is prepared to play a key role in meeting the growing demand for hydrogen from import countries in Europe.

	What	How	Timeframe
27	We will work with industry to produce a Hydrogen Export Plan.	We will work with industry to explore the steps needed to realise Scotland's hydrogen export potential and to secure global supply chains. The Hydrogen Export Plan will consider the short-term export opportunities around skills and the supply chain, as well as the economic opportunity for Scotland represented by the export of renewable hydrogen in the longer term.	2022-26
28	We will work to ensure our ports and terminal infrastructure matches our ambitions for a hydrogen economy.	<p>We will undertake a review of ports and terminal infrastructure preparedness for hydrogen export building on work on key production sites led by our Enterprise Agencies.</p> <p>We will also encourage collaboration with key ports in northern Europe, for example Rotterdam and Hamburg, in order to develop the relationships and the export/import infrastructure required, ensuring that Scotland's export and northern Europe's import infrastructures are compatible.</p>	<p>2022</p> <p>Ongoing</p>

	What	How	Timeframe
29	We will support the development of hydrogen transport options and international supply chains from Scotland to European customers.	In addition to funding provided to NZTC to, amongst other projects, assess Scotland's capability to link to the European Hydrogen Backbone initiative [see Action 22] our Enterprise Agencies will support the Scot2Ger project, and the analysis of the business case for a demonstration project to start in early 2022 for the delivery of renewable hydrogen produced in Scotland to customers in Germany by 2024.	2022
30	We will press the UK Government to take the action necessary at a UK-level to facilitate the smooth international trade of hydrogen, in line with Scottish export ambitions.	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.	Ongoing
31	We will work with our overseas offices and Scottish Development International (SDI) to boost inbound and outbound trade and investment missions to secure opportunities for Scottish companies in the international hydrogen market.	This includes inbound delegations such as that planned in Spring 2022 from Germany, inviting influencers, sectoral representatives and companies to engage with the sector first-hand and build future business. In the other direction it includes engaging with national sectoral organisations, with Scotland's partner hydrogen states, with key conference platforms and business fora, and with individual companies, to promote Scottish expertise and capacity.	Ongoing

	What	How	Timeframe
32	We will develop a Hydrogen Outreach Programme.	Working through our global network of trade and investment offices, we will promote plans for export of hydrogen as well as international trade opportunities for Scottish hydrogen companies. Utilising the SDI outreach programme, which is active in markets across the world, we will engage over 280 internationally headquartered hydrogen companies that have been identified as potential targets for Foreign Direct Investment.	2021-22
33	We will work to strengthen existing relationships and develop new bilateral partnerships.	<p>In addition to strengthening our existing international relationships in relation to renewable energy, we will look to develop new collaborations on renewable hydrogen development with partner countries including, but not limited to, Germany, Belgium, the Netherlands, Denmark, Canada, Australia, Japan and France.</p> <p>We are seeking to secure MOUs with partner countries to build hydrogen markets and our shared hydrogen economy, such as our new and planned agreements with Denmark, Hamburg and North Rhine-Westphalia. Also, following the recommendations set out in the final report of our Franco-Scottish research project⁸ on hydrogen and offshore wind, we will work with partners in France, and in particular Occitanie Pays de la Loire and Brittany, to pursue collaboration and trade agreements.</p>	<p>2021-26</p> <p>2021-22</p>

8 <https://www.gov.scot/publications/fostering-future-scottish-french-research-development-collaboration-floating-wind-green-hydrogen/pages/7/>

Case Study – Regional Hydrogen Energy Hub: ORION

The ORION project aims to provide Shetland with secure and affordable clean energy whilst protecting the environment and developing a new industry.

ORION strategic partners Shetland Island Council (SIC), Net Zero Technology Centre (NZTC), University of Strathclyde and Highlands and Islands Enterprise (HIE) are working with industry and key stakeholders to evaluate opportunities to maximize value and transition Shetland from an established oil and gas centre to a renewable energy hub.

The ORION project has three key aims:

- Create renewable hydrogen for export at industrial scale by harnessing offshore wind power.
- Transform Shetland's current dependency on fossil fuels to affordable renewable energy.
- Enable offshore oil and gas sector just transition to net zero by electrification.

Delivering these aims will place Shetland at the heart of clean energy developments, create a highly skilled workforce in the isles, and provide economic security for years to come.

The ORION project has set several ambitious local and regional targets:-

- Produce local wind-powered renewable hydrogen in Shetland by 2025.
- Sustain and create five hundred skilled jobs by 2030.
- Reduce carbon emissions for Shetland and become net zero by 2030.
- Contribute to reduce emissions from oil and gas infrastructure to become net zero by 2030.
- Eradicate fuel poverty in Shetland by 2035.
- Harness offshore wind to produce renewable hydrogen, producing over 10% of the estimated UK hydrogen demand by 2050.

6. Strengthening research and innovation

Scotland already benefits from a strong hydrogen research and innovation landscape with a large number of 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.

	What	How	Timeframe
34	<p>We will launch a Scottish Hydrogen Innovation Fund to drive technological progress and advance innovation in Scotland.</p>	<p>We will ring-fence £10m of the Emerging Energy Technologies Fund to support innovation and development over the next five years.</p> <p>This will support a series of hydrogen innovation challenges to continue to drive advancements in hydrogen technology to improve the cost-competitiveness of renewable hydrogen.</p> <p>More detail on the Fund will be shared in early 2022 as part of the launch of the EETF.</p>	2021-26
35	<p>We will, 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.</p>	<p>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 able to engage with the suite of facilities effectively to commercialise new products and services. The network will also help to enhance Scotland's international hydrogen innovation reputation by showcasing all that we have to offer in one place and helping international stakeholders to engage with Scotland.</p>	2022

What	How	Timeframe
<p>36</p> <p>We will support multi-national collaboration on research and innovation challenges.</p>	<p>This will include, for example, working with the UK Government to support the success of the Mission Innovation Clean Hydrogen Mission and participating in Hydrogen Europe's Regional Pillar.</p> <p>We will support Scottish participation in applications for EU funding for innovation through the Clean Hydrogen for Europe Partnership, building on significant Scottish successes in previous EU hydrogen funding programmes.</p> <p>We will provide funding support to the three-year MultiHyFuel project, which aims to ensure the safe deployment of hydrogen refuelling stations alongside other fuels within the UK and across Europe.</p>	<p>2021-26</p> <p>Ongoing</p> <p>2021-24</p>
<p>37</p> <p>We will support the Scottish academic and research community to further hydrogen research.</p>	<p>For example, in 2021 we will launch a £150k research call to support collaboration between academics and applied research institutes in Scotland and Germany to tackle key challenges across the production, storage and distribution of hydrogen.</p>	<p>November 2021</p>

Part 3 – Investing in Our Renewable Hydrogen Future

The Emerging Energy Technologies Fund (EETF) is a £180m package of funding over five years that will provide capital support to accelerate low-carbon infrastructure projects that will be essential to deliver net zero. The Fund will make £100 million available to support renewable hydrogen projects in line with our Hydrogen Policy Statement.

Funding principles

The purpose of our hydrogen funding programme is to 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.

We are conscious that our funding programmes need to be delivered alongside and in complement to those offered by the UK Government, including their Net Zero Hydrogen Fund, and we will work closely with them as we finalise the design of EETF.

During the next 5 years, 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
- Innovation

Within the five-year horizon of the Action Plan we believe the establishment of regional and local production of renewable hydrogen will play an important role in helping build the domestic market demand, which may have the potential to scale up quickly (as described in Part 1). We wish to see renewable hydrogen projects coming forward for potential support from the £100m hydrogen funding programme. This will be a key focus of our funding support over the next five years.

During the lifespan of this Action Plan, large-scale renewable hydrogen production projects from offshore or onshore will require engineering and technical design development to enable final investment decisions to be reached later this decade.

All these represent new and sustainable economic activity and transition opportunity for our Scottish supply chain.

Scotland's success in the deployment of on-the-ground hydrogen demonstration has cemented our reputation abroad as a nation which can foster emerging sectors and get things done, and the Scottish Government has supported a variety of successful projects

which have helped demonstrate the use of hydrogen in the decarbonisation of key sectors.

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 Scottish Hydrogen Innovation Fund, to be launched in early 2022 as part of the EETF, will aim to support Scottish researchers and innovators to drive innovation that will support the realisation of Scotland's 5GW by 2030 ambition and to ensure Scotland benefits from and contributes to the global research and innovation network through international collaboration.

Scope

The scope of the Scottish Government £100m hydrogen funding programme, will be designed to bring forward a portfolio of renewable hydrogen projects. Any funding provided under the EETF will be complementary to the UK Government Net Zero Hydrogen Fund and in compliance with appropriate subsidy control rules.

Timeline

We are finalising the eligibility and project assessment criteria for the EETF, and invite will views on this from stakeholders ahead of a call for projects in early 2022.⁹

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. It is important that the Action Plan stays current and responds to developments at a UK and international level. We will develop appropriate governance arrangements to provide oversight and strategic direction to allow us to adapt our approach where necessary to ensure 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 this progress throughout the second half of the decade.

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

⁹ Scottish Government Draft Hydrogen Action Plan Consultation: <https://consult.gov.scot/energy-and-climate-change-directorate/hydrogen-action-plan>

Annex A – Scottish Government Hydrogen Funding Landscape

A just transition to net zero by 2045 will require substantial investment across sectors. The low-carbon funding landscape stretches across various sectors and is populated by schemes offered by the Scottish Government, UK Government and the public sector.

Within this landscape, there are several key areas of Scottish Government funding where resources may be available to support hydrogen projects and technologies.

Funds	Target Group	£
Emerging Energy Technologies Fund (Hydrogen/CCUS/NETs)	Business/Industry	£180m (2021-26) £180m breakdown: £100m hydrogen £80m CCUS/NETS
Energy Transition Fund	Business	£62m (2020-25)
Energy Investment Fund	Third Sector	£60m
Community & Renewable Energy Scheme (CARES)	Community/Third Sector	£8.25m (2021-22)
Successor to the Low-Carbon Infrastructure Transition Programme (LCITP)	Public and Private Sector	£400m (2021-26)
Low-Carbon Manufacturing Challenge Fund	Business	£50m
Scottish Industrial Energy Transition Fund (SIETF)	Business/Industry	£34m (2021-26)
Green Supply Chain Development Fund	Business	£50
Green Jobs Fund	Enterprise Agencies	£100m (2021-26)
Green Business Support Fund	Business	£50m
Green Growth Accelerator Programme – unlocking £200 million of public and private investment in low-carbon infrastructure projects across Scotland, underpinned by Scottish Government funding.	Local Authorities	£200m +
Switched-On Fleets	Public Sector	£12m
Scottish Zero Emission Bus Challenge Fund – support for the cost of zero-emission buses and the associated charging or refuelling infrastructure.	Public and Private sector	£50m



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