

Scottish Renewables has developed this policy position statement on green hydrogen in consultation with its members. This statement sets out the views of the Scottish Renewables membership on the significant role and economic opportunity presented by green hydrogen in the developing hydrogen economy and makes recommendations for Industry and Government in realising the potential.

Paper Structure

Section 1 sets out the industry view on green hydrogen, its general importance to net zero and its specific importance to Scotland. Section 2 contains the policy asks.

SECTION 1

Policy Context

Green hydrogen – zero-carbon hydrogen made using electrolysis powered by renewable energy - is set to play a key role in decarbonising the global energy system. Hydrogen will complement increasing electrification of the energy system by helping to decarbonise sectors that are hard to electrify and by creating a more flexible, resilient, and integrated energy system.

The UK Government's Energy White Paper and the Ten Point Plan, the Climate Change Committee's (CCC) 6th Carbon Budget published on 09 December 2020, The Scottish Government's Climate Change Plan update published on 16 December 2020 and the National Grid's Future Energy Scenarios published in July 2020¹, all assert the essential role hydrogen will play in achieving net zero.

With its abundant renewable energy resources, Scotland has the potential to generate a significant quantity of green hydrogen to both achieve its own net zero target and for export to the UK and Europe. Scotland needs to act quickly and decisively to support green hydrogen production to secure the economic benefits that are critical to achieve a green economic recovery.

National Grid's Future Energy Scenarios forecast that at least 190TWh of energy for hydrogen production for the UK is required in all net zero scenarios. The Hydrogen Assessment² estimates that by 2045 Scotland could produce up to 37GW of renewable generation producing 126TWh of green hydrogen if Scotland was an exporter of green hydrogen to the UK and EU markets. To achieve this, enhanced policy support is required to facilitate a route to market for commercial projects.

The CCC in their advice on the 6th Carbon Budget states that Government will need to explain how it will move hydrogen from being an "experimental technology to a commercial reality"³.

More detail on the hydrogen statements made in the Scottish Government's Climate Change Plan update, is set out in their Hydrogen Policy Statement⁴ published on 21 December 2020. The Policy Statement reflects a year-long hydrogen assessment project, setting out their vision of how Scotland could be a major player in the emerging global hydrogen market. This document states that "Scotland has in abundance all the raw ingredients necessary for the production of low-cost, clean hydrogen". To become a major player in the rapidly growing hydrogen market and meet the ambitions of 5GW of low and zero-carbon hydrogen set out by both The Scottish and UK Governments, Scotland needs to act quickly. It should do this by setting out its planned actions in a forthcoming Hydrogen Action Plan due in the second half of 2021 alongside £100 million in funding.

¹ National Grid, Future Energy Scenarios, 2020

² Arup, Scottish Hydrogen Assessment, 2020

³ CCC, Policies for the 6th Carbon Budget and Net Zero, December 2020

⁴ Scottish Government, Hydrogen Policy Statement, December 2020

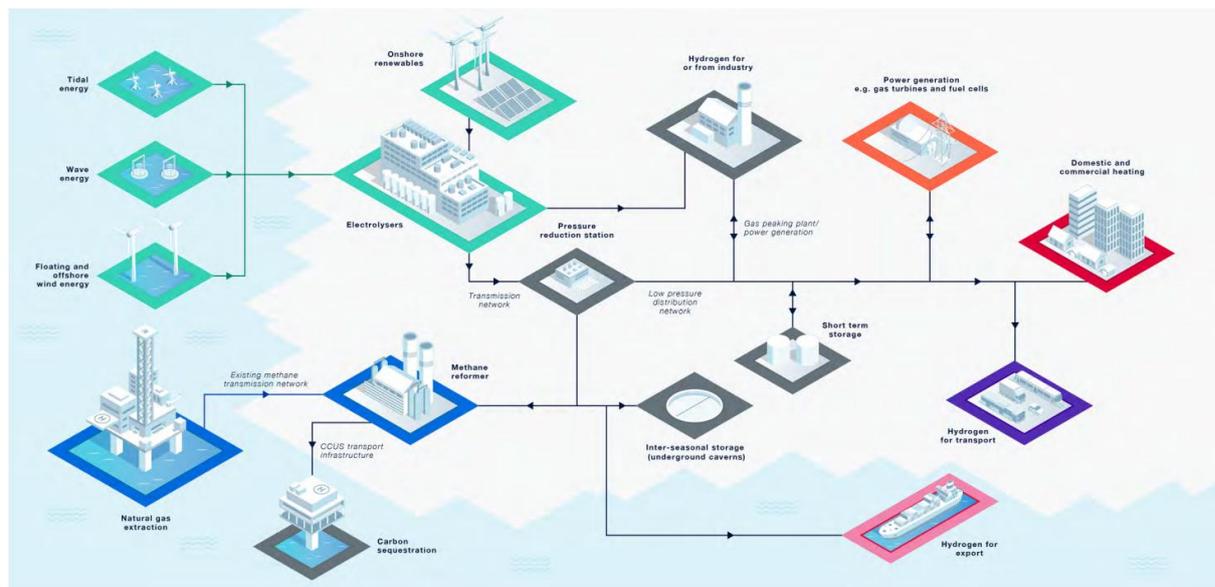
Hydrogen Production and Use

Hydrogen can be green, blue and grey, depending on how it is produced:

- *Green hydrogen is produced from renewable electricity and water. Green hydrogen has zero carbon emissions and only oxygen as a by-product.*
- *Grey is produced from fossil fuels. Grey hydrogen produces carbon dioxide as a by-product and is the method of most current hydrogen production.*
- *Blue is formed from fossil fuels but with most emissions captured by carbon capture and storage (CCS).*

As we move towards net zero and hydrogen demand increases, producing zero carbon hydrogen will be critical. This aligns with Scotland's extensive renewable capacity and its potential as an exporter of green hydrogen. Hydrogen has many potential applications within a net zero energy system including in transport, industry, power and potentially heat.

Figure 1 courtesy of Arup



The rollout of hydrogen in all these sectors is still developing and while there are a number of high potential applications in the short term, there is a degree of uncertainty regarding the areas in which hydrogen should play a role in the longer term. Green hydrogen production is also a relatively nascent industry where some costs are still relatively high, as was the case with renewable electricity production prior to huge cost reductions being realised. As with renewable electricity, it is expected that with increasing deployment and cost reduction green hydrogen production will ultimately be lower cost than blue hydrogen production.

Determining the appropriate applications for hydrogen in a net zero energy system requires an understanding of whole system economics, technology development and user

requirements. In the short term, it is essential that decision-making focuses on securing supply and demand for hydrogen and for this to be in low-regrets applications.

To achieve this, there needs to be clarity on the role for both market structure, regulatory environment and subsidy regime to enable both supply and demand. At the same time, there must be Government funding for research and development to identify the most cost-effective applications of hydrogen, and pilot projects to demonstrate these applications in order to inform future refinement and prioritisation.

Demand for Green Hydrogen

- ✓ **Transport** – hydrogen has significant potential in heavy fleet vehicles such as buses, HGVs and commercial fleet where range and refuelling durations may be more compatible with user requirements than electric vehicles. Trains, ferries and shipping/vessels are also high potential as appropriate hydrogen applications with opportunities to consider liquid fuels such as ammonia or methanol. These applications could be important in securing early and predictable demand in the short term. The Hydrogen Assessment predicted between 7-11TWh of Scottish of transport demand could be supplied by hydrogen.
- ✓ **Industry** – Replacing existing grey hydrogen with green and utilising hydrogen in industry's hard-to-electrify process including both process heat and chemical feedstock is likely to be essential to achieving net zero. The Hydrogen Assessment predicted between 7-19TWh of Scottish of industrial demand could be supplied by hydrogen.
- ✓ **Heating** – The ability of hydrogen to offer inter-seasonal storage may offer whole energy system benefits in a transition to renewable heat alongside electrification of heat and heat networks. However, more research is needed to determine the right balance of renewable heat solutions in the network and to determine if hydrogen is appropriate to play a significant role as a heating solution. The Hydrogen Assessment predicted between 0-35TWh of Scottish heat demand could be supplied by hydrogen.
- ✓ **Export** - Scotland's renewable resources are vast and significantly exceed indigenous demand. Scotland could be an exporter of hydrogen to energy scarce countries in Europe, such as Germany, which has declared an intent to import green hydrogen. However, this would be reliant on Scotland's ability to produce hydrogen that is cost competitive in an international market. The Hydrogen Assessment predicted up to 94TWh of Scottish green hydrogen export potential to the EU.

Why Scottish Green Hydrogen?

The Scottish Hydrogen Assessment Report⁵ and the Scottish Offshore Wind to Green Hydrogen Opportunity Assessment⁶ both provide the evidence base that demonstrates the huge opportunity for green hydrogen production via renewable energy in Scotland, citing Government support for energy projects, good planning processes, experienced workforce and good infrastructure as key reasons why green hydrogen should be developed in Scotland. This would meet both our net zero targets and help in the transition to a low-carbon economy. This is a chance for Scotland to lead the way in green hydrogen production and capture the economic benefits this would create.

62% of the UK's territorial waters (462,000 sq. km) are Scottish⁷, with this area representing 25% of Europe's offshore wind resource. Scotland has an abundance of renewable onshore and offshore wind resource that can be harnessed to produce green hydrogen and supply both Scotland and the rest of the UK. In addition, Scotland has a distinctive marine resource and is a world-leader in this area, for example, the world's first tidal-powered hydrogen generation production is in Orkney.

Scotland has so much renewable resource that it also has the potential to supply export markets in Europe that are unlikely to be able to meet their net zero targets with indigenous renewable resources such as Germany, the Netherlands and Belgium. It is likely that those countries will want to import green hydrogen rather than blue. Scottish green hydrogen needs to be cost effective and compete with green hydrogen from Europe and beyond. The Hydrogen Assessment modelled a scenario⁸ that suggested by 2045 Scotland could have 37GW of renewable generation producing 126TWh of renewable hydrogen, of which 94TWh would be produced for export. To maximise economic benefits the UK and Scottish Government's plans should recognise the export potential of Scottish Green Hydrogen and adopt a strategy that looks to maximise the opportunity over and above Scotland's needs.

Scotland has strong existing engineering and marine skills in the renewable industry and in the oil and gas sector and therefore we can capture more economic benefits and better enable a Just Transition if we move quickly and invest in our skills and supply chain in green hydrogen production and use. The Scottish Government forecast a £25 billion (bn) annual gross contribution to Scotland's Gross Value Added (GVA) with over 300,000 jobs supported by 2045, if Scotland adopted the most ambitious scenario detailed in the Hydrogen Assessment Project of becoming an exporter of green hydrogen to Europe⁹.

Scotland has the capacity to scale up quickly to meet demand. Green hydrogen can work in rural applications making use of onshore wind and marine renewables within integrated energy systems to supply localised demand and increase local energy resilience. Scotland's islands and rural areas, including Orkney and the Western Isles, are already playing a world leading role in the demonstration and deployment of green hydrogen. Green hydrogen co-located with demand in conjunction with increasing electrification can accelerate decarbonisation and could provide significant socio-economic benefits for Scotland's rural and coastal communities. Green hydrogen can also be produced in bulk from our offshore

⁵ Arup, Hydrogen Assessment Report, December 2020

⁶ Scottish Government, Offshore wind to green hydrogen: opportunity assessment, December 2020

⁷ <http://marine.gov.scot/data/facts-and-figures-about-scotlands-sea-area-coastline-length-sea-area-sq-kms>

⁸ Scottish Government, Hydrogen Policy Statement, December 2020

⁹ Scottish Government, Hydrogen Policy Statement, December 2020

wind, wave and tidal resources amongst others, again linking coastal and rural communities with economic growth.

Scotland has extensive infrastructure in its ports and existing pipelines that can be used to export green hydrogen to the rest of the UK and Europe.

The Scottish Hydrogen Assessment recognised green hydrogen production as the largest contributor to jobs in all scenarios with between over 70,000 to 310,000 jobs in its most ambitious scenarios relative to less than 20,000 for blue hydrogen. In contrast to grey and blue hydrogen, green hydrogen is of a higher purity and is zero-carbon, therefore its production should be prioritised as it makes a greater contribution to meeting our decarbonisation targets and offers a long-term solution, compared to other types of hydrogen and is likely to be prioritised in export markets. Green hydrogen could become cheaper than blue in the long-term as green hydrogen production costs decrease due to improved electrolysis technology and the scaling up of technology. The Scottish Offshore Wind to Green Hydrogen analysis¹⁰ suggests a long-term outlook of the levelised cost of hydrogen (LCoH)¹¹ falling towards £2/kg.

¹⁰ Xodus Group, Scottish Offshore Wind To Green Hydrogen Opportunity Assessment, December 2020

¹¹ The LCoH method is based on the Levelised Cost of Energy (LCoE) which is used in the renewable energy sector where the lifecycle costs of renewables are presented as cost per energy output unit.

Why Scotland must act now

Scotland needs to move quickly to capture the extensive economic benefits. Other nations across Europe and globally have already published hydrogen strategies and have made significant policy and fiscal commitments to developing a hydrogen economy.

The UK and Scottish Government recognise that hydrogen is critical to net zero both having made commitments to 5GW of hydrogen production by 2030. But there are significant gaps in the fiscal commitment and wider policy and regulatory support required to kick start the UK and Scottish hydrogen economy. Early investment in skills and supply chain and growth of an indigenous market are critical to creating and securing between 70,000 to 310,000 Scottish jobs.

The Scottish Government's Hydrogen Action Plan, due for publication in 2021 must provide targeted action and interventions which unlock private sector investment. The UK Government must accelerate action to match Scotland's ambition, and the UK Hydrogen Strategy published in August 2021 should recognise the key role Scotland will play in realising the UK's hydrogen economy and net zero targets.

There are already a great many hydrogen projects underway both in Scotland and the rest of the UK, moving towards building the evidence base and deployment; we need to capture this momentum and work towards scaling up and commercialising the industry.

Some of the projects being developed in Scotland include:

Building Innovative Green Hydrogen Systems in an Isolated Territory (BIG HIT) - The Orkney BIG HIT project launched in 2018, aims to develop hydrogen production capacity and the breadth of use cases in the islands, with a focus on creating a roadmap for the replication of project outcomes in other island communities internationally. A further electrolyser was deployed on Shapinsay (the first one deployed on Eday, in 2016), where it has been powered by a community wind turbine, producing fuel for local use in catalytic boilers which provide heat to a school, demonstrating the use of hydrogen in meeting heat demand cleanly, even in an off-gas network community. The project included deployment of a hydrogen refuelling station on Orkney Mainland, alongside a fleet of electric vans equipped with fuel cell range extenders. Tackling various sources of energy demand in disparate sectors, this project has demonstrated the breadth of possible applications for hydrogen in decarbonisation.

ERM-Dolphyn, off the coast of Aberdeen – green hydrogen will be developed at scale from floating offshore wind turbines. The development plan for the project has a target date for the operational start-up of the 2MW prototype facility by summer 2024. A 10MW full scale pre-commercial facility is planned to follow by 2027, with full scale commercialisation shortly afterwards. ERM believes through their Dolphyn project a 400 turbine 'farm' (20 x 20 array) will have a capacity of 4GW.

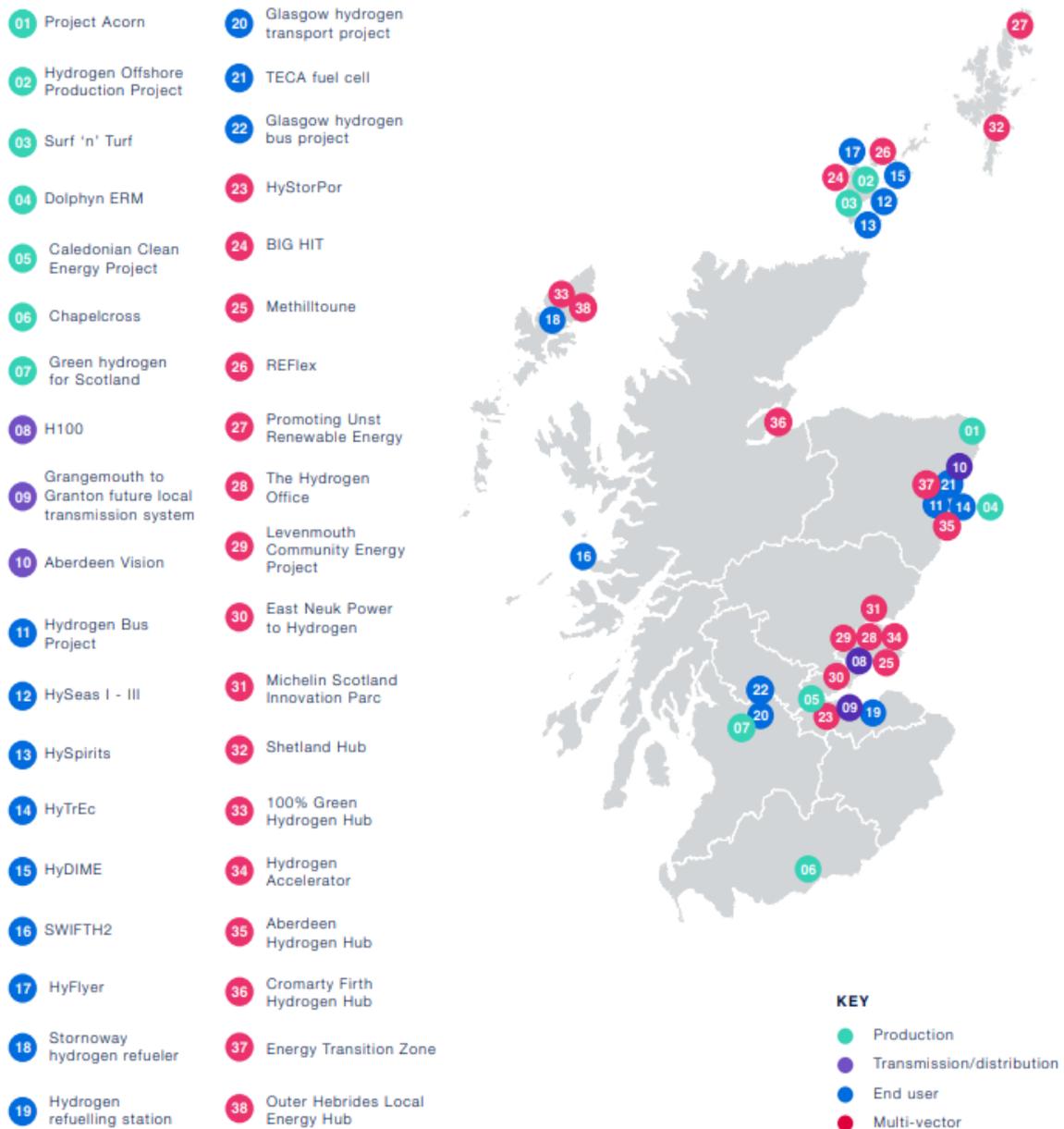
North of Scotland Hydrogen - this is a series of scalable green hydrogen projects based in the Cromarty Firth which will supply green hydrogen to the distilleries in the area. It is a partnership between Pale Blue Dot Energy, Port of Cromarty Firth, ScottishPower, Glenmorangie and Whyte & Mackay. The distillers operate a number of sites in the region

and are keen to develop 'net zero whisky'. Port of Cromarty Firth is working with HITRANS, The Highland Council, SGN and others, to realise the full potential from this opportunity and to position Scotland as global leaders in green hydrogen technologies.

Hydrogen Ferries, Western Isles - Point and Sandwick Trust, in collaboration with industry partners Wood, Siemens-Gamesa, Engie, ITM, CMAL, Johnston Carmichael have published a feasibility study on using new island wind farms to produce zero-carbon green hydrogen fuel for future types of clean emission ferries operating on the established Caledonian MacBrayne routes.

H100, Fife – This is a green hydrogen-to-homes heating network on the Fife coast, where householders will be given the option of plugging into the hydrogen network. This project in Levenmouth will bring 100% renewable hydrogen into homes in 2022, providing zero-carbon fuel for heating and cooking. In the project's first phase, the network will heat around 300 local homes using clean gas produced by a dedicated electrolysis plant, powered by a nearby offshore wind turbine.

Figure 2 taken from Arup's Hydrogen Assessment Project



SECTION 2

Policy Recommendations

It is essential that decisive policy-making action is taken to realise the many benefits of developing a green hydrogen economy, including the economic benefits in terms of jobs and GVA; the contribution it makes to a Just Transition away from oil and gas and helping to protect thousands of workers' jobs; and helping to meet net zero by 2045. To achieve this, we make the following recommendations:

Policy	Responsible body
To attract investment and create confidence in the sector, The Scottish Government should set a green renewable hydrogen target of 3GW by 2030	Scottish Government
<p>This 3GW target should be underpinned by an Action Plan that uses a whole system planning approach that:</p> <ul style="list-style-type: none"> • Includes early identification of potential hydrogen demand clusters and commercial-scale green hydrogen production projects. • Identifies the most cost-effective priorities for the initial deployment of hydrogen in Scotland. • Identifies the key barriers to deployment of the green hydrogen economy in Scotland and articulates the actions that will be taken to address them. • Identifies the supporting infrastructure, including storage, distribution and shipping, that will be required to support the emergence of a green hydrogen economy in Scotland and articulates a pathway to ensuring this infrastructure is put in place. • Articulates a support mechanism that incentivises investment in both the supply and demand side of the clusters, projects and priorities identified to attract international investors. • Provides flexible funding programmes covering each part of the hydrogen value chain with ring fenced and prioritised support for green hydrogen production. • Identifies the places in Scotland where hydrogen is expected to be the most cost-effective or practical method of decarbonising heat and ensures that the evidence base that is required to make informed decisions on heat decarbonisation in a Just Transition is prioritised and accelerated. • Articulates how hydrogen infrastructure will be treated in the planning and consenting system, ensuring that the planning system is fully supportive of Scotland's hydrogen ambitions. 	Scottish Government

<p>To support the acceleration of an indigenous market of green hydrogen production, in parallel with supporting the supply chain to maximise economic benefits, additional funding is required.</p> <p>The Scottish Government should conduct a review with industry to research and identify funding priorities to kick-start the hydrogen economy in Scotland. These priorities would allow Scotland to get an early movers advantage and secure supply chain and build evidence by supporting research and innovation, supply chain development, feasibility and development, and capital for construction/operation. Most economic opportunity comes from green hydrogen, therefore most of the funding should be targeted there. This fund should be scaled up to ensure that Scotland can achieve the maximum economic benefits of a developing green hydrogen economy with funding ring-fenced for the development of green hydrogen.</p> <p>To ensure the most effective use of this funding the Scottish Government should:</p> <ul style="list-style-type: none"> • Understand what funding is needed to support green hydrogen research projects. Key areas that we need to focus on are innovation and efficiency that drives cost reduction. • Understand what funding is needed to support feasibility and demonstration projects. • Understand what funding is needed to provide capital and operational support including initial price support to support the deployment of green hydrogen supply. 	<p>Scottish Government</p>
<p>The Scottish Government should work in collaboration with the UK Government to ensure:</p> <ul style="list-style-type: none"> • Green hydrogen is prioritised and accelerated given its economic contribution potential and cost reduction trajectories. • The opportunities to combine Scotland offshore wind including floating offshore wind, with green hydrogen production to supply UK and EU markets should be assessed and prioritised. • A clear vision of the scope and scale of the supply chain and export ambitions for the hydrogen economy is articulated to ensure this can be built into the development of the hydrogen economy from an early stage. • A commitment to working with international stakeholders to help realise green hydrogen export potentials. • A decision is rapidly made on the governance and regulation of the emerging hydrogen economy and that 	<p>Scottish Government, UK Government</p>

<p>decision making allows consideration of the overall energy system and delivery of net zero. This should include a decision on which existing regulatory bodies will be responsible for the various aspects of the emerging hydrogen economy and if wider reform is necessary.</p> <ul style="list-style-type: none"> • All regulatory bodies in Scotland and the UK must incorporate the achievement of net-zero into their functions and we need rapid clarity of government regulations within the emerging hydrogen economy. • The role of gas networks in the hydrogen economy is clearly articulated as is how this role contributes to the achievement of net-zero. 	
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Business Models

<p>In order to support green hydrogen projects and grow the supply chain, The UK Government should introduce a separate business model for green hydrogen which:</p> <ul style="list-style-type: none"> - Includes separate allocation processes and separate pots for green and blue hydrogen, as the 'one size fits all' approach may constrain the development of green hydrogen. - Includes ring-fenced funding for green hydrogen. - Considers how the reference price is set and articulates how Government and industry should work in collaboration on this. - Clarifies the pathway for green hydrogen projects, with a clear roadmap for green production with particular emphasis on setting a target for its deployment. - Recognises the value of green hydrogen plus its economic benefits 	<p>UK Government</p>
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To maximise economic benefits, the UK and Scottish Governments should recognise the export potential of Scottish green hydrogen and adopt a strategy that looks to maximise the opportunity over and above Scotland's needs.