Written Evidence Submitted by OGTC

(HNZ0016)

1. The suitability of the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen", including:

   a. The focus, scale and timescales of the proposed measures;
   b. How the proposed measures – and any other recommended measures – could best be co-ordinated;
   c. The dependency of the Government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and
   d. Potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel.

a. the focus, scale and timescales of the proposed measures;

The UK Government's announced plans for "Driving the Growth of Low Carbon Hydrogen" are welcomed for the following reasons:

- The UK's existing infrastructure mean it is well placed to realise a target of 5GW of low carbon hydrogen production capacity by 2030.
- Hydrogen technology is ready for initial deployment, but costs are still high. Increased deployment will allow economies of scale to develop, thus becoming more affordable and competitive with traditional fossilised fuel sources.
- Investment in R&D for Hydrogen generation is however needed to drive innovation and reduce the cost for low and zero carbon hydrogen generation at scale.

OGTC and Offshore Renewable Energy (ORE) Catapult recently published their Reimagining a Net Zero North Sea: An Integrated Energy Vision for 2050 report, which set out direction for the UK net zero offshore energy system. It concluded that by investing in technology to create an integrated net zero North Sea, the UK can a supplier, rather than a buyer, of affordable clean energy solutions. The country can retain its competitive position in energy skills and capability, growing jobs over the next three decades to 232,000 and offsetting expected employment losses. Up to £416bn of investment is needed over the next 30 years but could deliver £125bn per year to the UK economy.

To achieve these benefits however, it is important to develop technology innovation and to deliver it through the UK domestic Supply Chain. The Integrated Energy Vision for 2050 assumes a 60% of local content in the Net Zero technology deployed in the North Sea. This will stimulate the development of the UK hydrogen supply chain, and create a potential new export market, whereby the UK can supply surplus green hydrogen to parts of mainland Europe. The UK mustn't depend on imported technology for hydrogen, but instead take the opportunity to become an exporter of both hydrogen and the technology for its production. Goldman Sachs estimates the green hydrogen industry in Europe could attract >€2 trillion of investments by 2050, supported by the EU Hydrogen Strategy, of which €400 million for Hydrogen Power Plants and €400 million for Electrolysers[1].

[1] Green hydrogen: the next transformational driver of the utilities industry, Goldman Sachs Research, September

b. How the proposed measures – and any other recommended measures – could best be co-ordinated;

A clear cross sector plan, based on the CCC 6th Carbon Budget report and its balanced pathway and built around existing industrial clusters, is needed to coordinate the deployment of these measures in a coordinated way, ensuring the Hydrogen generated finds a market in the UK, that Hydrogen based appliances and industrial turbines are supplied with domestic hydrogen, and that the transport of Hydrogen from generation to consumption is guaranteed.

It's also crucial to coordinate R&D efforts and ensure Knowledge Transfer across the value chain, and between Government, Industries, and Innovation Agencies.

c. The dependency of the Government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and

The Government "twin track" approach of supporting both Blue and Green Hydrogen is the correct strategy. Blue hydrogen is a critical intermediate solution as we transition to net zero. It will be an important bridge to green hydrogen and at half the cost, will help build a hydrogen economy and create demand. Without this, harnessing the full potential of green hydrogen could be at risk.

As expressed by the Committee on Climate Change in the 6th Carbon Budget, Hydrogen from Natural Gas with associated CCS will need to scale up in the next 10 years while Green Hydrogen (from Electrolysis) will start growing only in the 2030s, developing a hydrogen economy by 2050 to a scale that is comparable to existing electricity use[2].

Blue Hydrogen requires CCS to deliver the Net Zero ambition, but that is also an opportunity, as it enables the development of CCS technology and infrastructure which will benefit Industrial and residual gas-based power decarbonisation, and eventually the storage of CO2 captured directly from air or from the ocean (OGTC launched a call for ideas in November for low TRL technologies for direct air capture and seawater capture of CO2).

Several CCS projects are already in development in the UK, including the Acorn Project and Net Zero Teesside, which will help to accelerate the delivery of blue hydrogen.

The development of enhanced SMR reactor membranes and catalysts, along with alternative production methods and high-capacity sorbents, would drive significant costs savings in the blue hydrogen sector, until the green hydrogen sector matures.

d. Potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel.

BEIS presented in August the results of a consultation on business models for CCUS and Hydrogen[3]. A poll within the Industry members of NECCUS (the alliance driving the decarbonisation roadmap for the Scottish Industrial Cluster) expressed support for a model combining Contractual payments to producers and regulatory returns. Contractual models (in

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2020, https://www.goldmansachs.com/insights/pages/green-hydrogen.html

[2]Sixth Carbon Budget, Committee on Climate Change, December 2020 https://www.theccc.org.uk/publication/sixth-carbon-budget/

[3] Business models for low carbon hydrogen production, Department for Business, Energy & Industrial Strategy (BEIS), August 2020, https://www.gov.uk/government/publications/business-models-for-low-carbon-hydrogen-production

which the hydrogen producer receives a subsidy which covers the incremental cost of low carbon hydrogen above the carbon-intensive alternative fuel) may give more certainty to producers, while regulatory models (allowing the hydrogen producer to earn a regulated return on costs) may be easier to implement, given existing institutional capabilities.

It is worth noting that the options for a Hydrogen commercial model are not mutually exclusive, and that obligations or end user subsidies may be required alongside producer supports to encourage demand.

It's also important that the commercial model for Hydrogen and that for CCS are aligned, given the criticality of Blue Hydrogen in the next decade,

2. The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress.

There are several promising projects in the UK, including many in what is known as Scotland's 'Hydrogen Coast', including the Aberdeen Vision, the SGN H100 project, Acorn H2 and CCS, the Scottish Industrial Cluster Decarbonisation Roadmap (SNZR) and the Orkney Projects.

Scottish Gas Network's (SGN) H100 project team are developing a world-first hydrogen network in Levenmouth that 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. The project is the first of its kind to employ a direct supply of clean power to produce hydrogen for domestic heating.

It's important that we leverage these projects also to understand consumer barriers to deployment at scale, and the role of hydrogen compared to alternative heating technologies .

Effective planning and coordination of hydrogen production, storage and distribution as part of our wider energy system is essential to build on this progress, and ensuring synergies between end-uses are realised and conflicts avoided.

3. The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the Government could best address these.

Engineering and Commercial Challenges

The Committee for Climate Change (CCC) scenarios suggest that the national demand for hydrogen could reach 270 TWh by 2050. However, low carbon hydrogen production today is sparse, and several technology challenges must be overcome before deployment at commercial scale is possible.

In September 2020, OGTC published the 'Closing the Gap' report, co-funded by Scottish Government and written in collaboration with Wood Mackenzie. The report highlights the technology gaps for affordable hydrogen, and what areas of innovation would benefit most from investment.

- For blue hydrogen production (produced from natural gas with CCS and currently the cheapest and largest scale production method), improvements in the separation processes for hydrogen and CO2 (hydrogen membranes and CO2 sorbents, respectively) will significantly improve the yield and carbon capture.

- The high capital cost of electrolysers is a major obstacle but can be offset through optimisation of use of lower power prices, operational improvements, consistent power supply, and use of grid control software.
- Focusing on scaleup and automation can reduce cost by over 30% by 2030 and lead to large capex reduction after 2040. This has been demonstrated with lithium-ion battery production.
- PEM electrolysers today use expensive high-performing materials, but similar performance lower-cost electrode catalysts could reduce capital cost by 5%-10%. The European electrolyser market alone could be worth £3.7 billion by 2025, which could present an opportunity of around £0.8 billion for the UK[4].
- Saltwater electrolysis – fundamental for efficient offshore production – has unique challenges. PEM electrolysers require water treatment systems even with drinking-grade water supply. Since salt can corrode and form chlorine and other toxic gases, membrane desalination technology is required.
- Challenges with storage and transportation include pipeline repurposing, underground storage and effective hydrogen carriers.[5]

Measures to Address Challenges

OGTC is joining forces with The Offshore Renewable Energy Catapult, The Energy Systems Catapult, The High Value Manufacturing Catapult, The Aerospace Technology Institute and the Advanced Propulsion Centre. Collectively these centres represent extensive expertise and experience working with industry, academia and government in technology innovation.

The collaboration is focused on identifying cross-sector key gaps to unlock a Hydrogen based economy and on designing and delivering R&D and technology innovation programs to address them. This End to End Virtual Hydrogen Technology Centre, which has been proposed in a submission for the Treasury CSR, can enable the development of a skilled hydrogen supply chain, deepening the knowledge base in the UK. It will enable the development of a skilled hydrogen supply chain, deepening the knowledge base in the UK, by acting as a focal point for collaboration between centres and across the value chain.

A government dedicated Hydrogen Innovation Fund to support this initiative would dramatically accelerate the development and deployment of technology to increase the decarbonisation potential and cut the cost of hydrogen solutions by half within the decade.

Demonstration of the safety of hydrogen switching for industrial processes is also essential. There is the need to consider the integration of decarbonisation roadmaps for industrial clusters with the development of local area energy plans to enable investment in hydrogen infrastructure in the right places at the right time. Industry also requires stronger policy incentives to invest in emissions reduction through improving industrial processes, fuel switching, and technology innovation[6].

There are many non-technical barriers, including public acceptance and consumer appeal for low carbon heating technologies, including hydrogen, for heating. Programmes such as BEIS Hy4Heat[7] are contributing critical evidence to the potential use of hydrogen for heating in the

[4] Study on early business cases for H2 in energy storage and more broadly power to H2 applications, Tractebel and Hinicio, June 2017 https://www.fch.europa.eu/sites/default/files/P2H_Full_Study_FCHJU.pdf
[5] Hydrogen in a Green Recovery, Submission to the Hydrogen APPG Inquiry, OGTC, June 2020
[6] Local Area Energy Planning: Supporting clean growth and low carbon transition, Energy Systems Catapult, October 2018 https://es.catapult.org.uk/wp-content/uploads/2018/12/Local-Area-Energy-Planning-Supporting-clean-growth-and-low-carbon-transition.pdf
[7] https://www.hy4heat.info/

UK, alongside HyNet[8] in demonstrating hydrogen production with CCS. Early demonstration of 100% hydrogen networks and boilers is essential to prove the safety case, address consumer concerns, and maintain this as an option for decarbonising heat. By 2033, all sold boilers must be ready for a Hydrogen conversion.

Better evidence is needed on the feasibility of technical integration and large-scale conversion of existing gas heated homes to electric heat pumps through programmes such as BEIS Electrification of Heat Demonstration Project[9].

4. The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities.

The UK has the resources required to develop a world class hydrogen economy due to its abundance of resources. Considering current production methods – either based on natural gas or renewables - the UK has circa 40% of Europe's low-cost wind resource[10], and the oil & gas industry targets production of 1 million barrels of oil & gas across the UK in 2035 and beyond[11].

In addition to natural resources, the UK also has physical assets primed to support a transition to Hydrogen. This is evidenced through the significant work being completed across the country on industrial clusters and is strengthened when considering the re-purposing of existing oil & gas physical assets.

This includes, although is not limited to, oil & gas reception terminals, existing offshore infrastructure, and a world leading oil & gas supply chain with transferrable skills to build and deliver a UK Hydrogen economy.

However, there is a need to strengthen network price controls to support decarbonisation by incentivising and taking forward whole systems local area energy planning and develop a much better understanding of options for decarbonising local energy systems across the UK. This would help to inform national decisions related to hydrogen production, infrastructure and use (including repurposing of the gas grid) that supports net zero objectives. This also has the potential to link to local industry strategies including consideration of regional hydrogen production and use.

5. Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use.

The Reimagining a Net Zero North Sea report, conducted by OGTC and Offshore Renewable Energy (ORE) Catapult, highlights that investment in R&D has the potential to generate capex savings between 2020 and 2050 of up to 61% equalling £55 billion for Green Hydrogen, and of 32% equalling £6.5 for Blue Hydrogen. With hydrogen a crucial player in a transformational energy system driven by offshore wind and green hydrogen in 2050, a total of £416 billion investment across the energy system would deliver £125 billion per year to the UK economy.

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[8] https://hynet.co.uk/

[9] Electrification of heat demonstration project, Department for Business, Energy & Industrial Strategy (BEIS), closed August 2019 https://www.gov.uk/guidance/electrification-of-heat-demonstration-project#:~:text=The%20Electrification%20of%20Heat%20Demonstration,of%20the%20barriers%20to%20deployment.

[10] Our energy, our future: how offshore wind will help Europe go carbon-neutral, Wind Europe, November 2019 https://windeurope.org/about-wind/reports/our-energy-our-future/

[11] Roadmap 2035: A Blueprint for Net Zero, OGUK, September 2019 https://roadmap2035.co.uk/roadmap-2035/

Hydrogen alone has the potential to support between 50,000 to 125,000 direct and indirect jobs and generate about £300 billion of economic value between 2030 and 2050. The significant investment required to reduce the cost of hydrogen production will be offset by the benefits it provides to the UK economy by 2050.

6. The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in which the optimal technology should be managed.

Advantages & Disadvantages

In terms of advantages compared to alternative options, hydrogen is extremely versatile. It can be burned to create heat or turned straight into electricity in a fuel cell, and consequently the possible applications of hydrogen are numerous across a range of sectors. The emissions are just pure water, which can be collected and reused.

However, since the relative volume of hydrogen is so high, it often needs to be compressed. Hydrogen, due to it being a very small molecule, requires compression and thus making storage and transportation extremely difficult. It's also very reactive and can therefore be unstable and potentially dangerous if handled incorrectly.

Applications

The UK has 28 million homes, 85% of which are connected to the gas network with many not suited for electrification. Hydrogen has the potential to be an alternative fuel for some of the UKs housing stock.

There are multiple possible applications for hydrogen across industry, electricity generation and heating. Some industrial processes are not well suited to electricity as a low-carbon energy source; and hydrogen could provide a very valuable resource for managing peak electricity demand in an energy system with significant amounts of installed renewable generation capacity. Transport and heating are potentially important end-uses for hydrogen in delivering net zero but within each there are applications and locations where it is likely to be more suited. A blanket approach for these sectors is unlikely to be effective in achieving a net zero economy.

Hydrogen provides a clean alternative to natural gas for high-temperature industrial processes such as glass and metal manufacturing. Although there is industrial hydrogen demand, for example, in ammonia manufacturing, currently the hydrogen is not low carbon.

To deliver on our net zero commitments, significant hydrogen switching could be required across industry, heavy transport, shipping and aviation, with annual volumes in the range of 200-300TWh by 2050 equivalent to billions of pounds as part of a UK low carbon hydrogen economy[12].

Parts of the transport sector, such as shipping, heavy goods vehicles and aviation, are not easily electrifiable. There is a potentially significant role for hydrogen in shipping, which appears attractive from a carbon abatement perspective. Hydrogen is also being explored for

[12] Innovating to Net Zero, Energy Systems Catapult, March 2020, Innovating to Net Zero: UK Net Zero Report - Energy Systems Catapult

aviation applications, including directly for short-haul flights and as an intermediary in the production of e-fuels for other types of flights.

	Emissions (Million Tonnes)	**% of UK emissions**
Industry	67.5	15%
Heavy Transport	35.3	8%
Domestic Heating	76.5	17%

Hydrogen can be used as a fuel for aircraft when it is combusted in a hydrogen-burning engine or reacted in a fuel cell which powers electric motors. Despite the higher gravimetric energy density compared to kerosene, hydrogen's requires larger volume for storage, which in turn requires larger tanks aircraft and adjusted aircraft designs. The technical challenge for aircraft design is significant. However, given the significant reduction in emissions associated with hydrogen propulsion, increased research and development efforts should continue to explore and accelerate its application for air transport. Considering non-CO2 emissions, and the uncertainties of these effects, estimates show that hydrogen-combustion could reduce climate impact in flight by 50 to 75 percent, and fuel-cell propulsion by 75 to 90 percent. This compares to about 30 to 60 percent for synthetic aviation fuels[13]. The ATI programme is already funding one project to develop a hydrogen fuel cell powered aircraft, with more in the pipeline.

Transport currently accounts for almost a third of UK emissions ad continues to rise[14]. Hydrogen can be used as a zero-emission fuel for cars, trucks, buses and trains. Hydrogen buses are being used successfully in Aberdeen and London, and both cities have plans to expand existing fleets. The UK HySEAS project is evaluating the potential for hydrogen passenger ferries in Orkney, while in Germany, hydrogen trains are already in operation.

(January 2021)

[13] Hydrogen-powered aviation: A fact-based study of hydrogen technology, economics, and climate impact by 2050, McKinsey, May 2020

[14] Reducing emissions: 2019 progress report to Parliament, Committee on Climate Change, July 2019 https://www.theccc.org.uk/wp-content/uploads/2019/07/CCC-2019-Progress-in-reducing-UK-emissions.pdf