Written Evidence Submitted by UK Research and Innovation (UKRI) (HNZ0091)

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Operating across the whole of the UK with a combined budget of more than £7 billion, UKRI brings together the seven research councils, Innovate UK and Research England.

SUMMARY

- **Hydrogen is a critical element of the mix of technological solutions that can help the UK meet its Net Zero commitments.**

- **To achieve Net Zero by 2050, the UK economy must undergo a widespread transition to clean energy sources. Hydrogen is an energy option that can help with the process of decarbonisation, especially for those sectors whose energy needs cannot be readily met through electrification (such as industrial processes and domestic heating).**

- **Hydrogen presents many opportunities for these purposes; it can be used as fuel for heat, transport, a vector for energy storage, a feedstock into industrial processes and as an alternative fuel, which will increase the resilience of our energy system.**

- **We can meet Net Zero targets in fuel by using the two available zero-carbon fuels – hydrogen and ammonia – synergistically and symbiotically.**

- **Convergence of UK academic strength, policy need, technology maturity and business readiness in the UK means the time is ripe to secure significant global market share in this emerging area.**

- **Hydrogen is not a ‘silver bullet’ that will solve all problems to reach Net Zero. It needs to be used alongside a suite of other technologies – for example, ammonia - to support the different energy requirements that exist across our society (heating, transport, industry). In the absence of a consensus view currently, research, innovation and demonstration are all essential to understanding how and where it will be best used, investigating the technologies that take full advantage of its capabilities, and demonstrating the commercial viability of those technologies so that they help to catalyse private sector investment and create new markets.**

- **Hydrogen's successful adoption at scale will involve engaging a wide range of stakeholders throughout, and taking a whole-systems approach. Policy decisions are also key to unlocking commercial development in hydrogen technologies and significant private investment in the production of hydrogen.**

- **UKRI investments remain critical to driving cutting-edge research into the technical challenges surrounding hydrogen production, supply and storage, and its varied applications, as well as the innovations that will transform existing sectors - including heating, transport, and industry – and anchor new hydrogen markets in the UK.**

Q1. How suitable are the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen", including: the focus, scale and timescales of the proposed measures; how the proposed measures - and any other recommended measures - could best be co-ordinated; 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 potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel?

UKRI welcomes the inclusion of hydrogen within the Government's Ten Point Plan (TPP) for a green industrial revolution. Hydrogen has a key role to play in helping the UK meets its commitment to achieving Net Zero carbon dioxide (CO_2) emissions by 2050, and there is a substantial body of evidence to show that hydrogen technologies can help achieve this ambition at lower cost or risk.

The UK has significant opportunity due to research strengths, commercial readiness and strategic need to meet Net Zero, to exploit hydrogen as contributor to future energy needs and economically, with many world-class projects being supported with funding from the UK Government. UK business are keen to take advantage of the opportunities to capture a substantial share of global clean hydrogen markets, potentially worth £ trillions by 2050. However, without support for business innovation, demonstrators and transformation, and participation in international initiatives, UK supply chains risk becoming uncompetitive. This could lead to missed opportunities to create high-value jobs in the sector, and increased reliance on imports of key components. Appropriate policy choices underpinned by public funding are critical in catalysing the private sector investment needed to stimulate a reliable and competitively priced hydrogen market in the UK that will help boost the productivity of UK industry and attract inward investment.

Continued investment in research and innovation that tackles existing challenges remains critical for a successful hydrogen economy in the short and long term. UKRI can play a crucial role in the development of this hydrogen economy by supporting world leading research, technology development, deployment and supply chains to ensure the UK not only achieves the carbon benefit from hydrogen but also centres the UK as a globally leading supplier of technology.

The UK has a significant opportunity to exploit both the environmental and economic opportunities presented by hydrogen but only where policy, regulation and financial incentives are aligned. To unlock these opportunities, research is required in areas such as production (particularly green and bio-hydrogen), storage, distribution and use. Technology readiness level progression is not linear, making research essential as deployment unearths further challenges and questions. Support for business innovation is equally important in creating new markets for hydrogen technologies, both domestically and internationally, and the development of supply chains in which UK businesses are world leading. There is also a need for clear policy directions from government, for example on issues such as whether the UK will implement a hydrogen gas grid for heating, and the timescales in which this transition would take place.

Production

While the TPP's commitment to producing low carbon hydrogen (namely, 'blue' and 'green' hydrogen) at scale through investment in carbon capture, use and storage (CCUS) infrastructure is welcome, it is critical that R&D investment decisions are guided by a 'twin-track' approach to production. Both 'blue' hydrogen obtained from natural gas and electrolytic 'green' hydrogen from renewable sources are proven technologies. Attaching CCUS to conventional steam methane reformation (SMR) plants can help reduce CO_2 emissions arising from conventional hydrogen production by >80%, producing 'blue' hydrogen and 'blue' ammonia. However, despite being much cheaper than green hydrogen at scale, without 100% capture of CO_2, blue hydrogen is, by definition, not carbon neutral. The benefit of the twin-track approach is that it enables production to be brought forward at scale this decade, while at the same time scaling up green hydrogen which is likely to dominate the global market in the long term. Supporting projects that reduce the costs of electrolysis such as the ITM case study mentioned in the TPP should be a high priority.

Supply and storage

The supply of clean hydrogen is critical to the feasibility of hydrogen for large scale decarbonisation. The limited supply of clean hydrogen currently poses obstacles to carrying out feasibility studies and demonstration projects at the scale required for hydrogen technologies to become commercially viable. This is threatening industry confidence to invest in hydrogen technologies and risks delaying fuel switching. The Net Zero Hydrogen Fund provides an opportunity to support R&D that investigates and demonstrates ways to improve the supply and use of clean hydrogen at scale. It could also be extended to a range of large-scale hydrogen storage methods, include pressurised underground stores of hydrogen and modifying current ammonia storage and supply capability, as well as hydrogen transporters.

In addition to research and innovation funding that helps stimulate demand, adequate production, storage and supply infrastructure is essential for hydrogen to become a key part of the low-carbon energy system. Using zero-carbon fuels such as hydrogen and ammonia as a replacement for petrol and diesel will require a significant scale up of new refuelling infrastructure.

Government support will be critical in delivering the critical mass of refuelling stations required to make hydrogen (and ammonia) a commercially viable proposition.

Applications

As noted in the TPP, decarbonising heating remains a major challenge. Heating makes up 10% of the UK's carbon footprint, with domestic heating constituting a significant portion of this total[1]. At present, gas boilers are the primary means of heating buildings, but these will need to be phased out in order to meet Net Zero targets. Hydrogen is one of the two leading substitutes (the other being renewables). The UK government may wish to explore policy measures or incentives that will help accelerate the process of making gas boilers and existing heating systems hydrogen ready. This could create a market for hydrogen which supports investment in innovation built upon cutting-edge research. The proposal outlined in the TPP to pilot a Hydrogen Town before the end of the decade will serve as a useful means of studying the feasibility of rolling out such technologies nationwide. Determining the percentage of gas for heating that can safely be drawn from hydrogen needs to be addressed urgently, as this will determine the extent to which blending hydrogen with natural gas can be used to decarbonise heating. In particular, support for research into using more than the 20% blending referred to in the TPP would be a worthwhile investment.

The TPP briefly mentions the important role low-carbon hydrogen can play in decarbonising transport, but provides little detail on introducing proposed measures to accelerate adoption. Hydrogen fuel cells and ammonia-hydrogen blends for retrofitted zero-emissions engines represent effective tools for decarbonising transport markets that demand large amounts of energy. This would apply to heavy goods vehicles, which are - after passenger cars - the biggest contributor to domestic transport emissions in the UK, as well as rail, aviation and shipping, and other modes of transport that are required to cover greater distances outside urban settings.

Continued research and innovation into hydrogen carriers and their use for storage is also vital. Half of global hydrogen production is currently used to synthesise ammonia for fertilisers, using infrastructure that exists at a scale similar to cement and steel production. As agriculture is decarbonised, the ammonia storage and supply infrastructure used by the sector could also be harnessed towards the development of zero-carbon fuels for transport and other energy sectors. Liquid ammonia has a significantly higher energy density than compressed gaseous and liquid hydrogen. Ammonia-hydrogen fuel blends are currently being tested overseas as a fuel for turbines, internal combustion engines (ICEs) and fuel cells (such as solid-oxide fuel cells and alkaline fuel cells) without direct CO_2 emissions. The maritime sector has already begun to embrace hydrogen-ammonia fuel blends to power ships.

Furthermore, ammonia-based infrastructure can provide a UK-wide infrastructure for zero-carbon transport and can be an enabler of zero-carbon district heating. An ammonia plant that relies on

[1] https://www.ukgbc.org/climate-change/

blue hydrogen could be converted to green hydrogen use. This may require government incentives to reward the production of low carbon ammonia such that industry could justify the required investment. The ‘green’ ammonia produced could then be delivered to fuelling stations across the country, with refuelling stations able to store large quantities safely and economically.

Public acceptability

The widespread adoption of hydrogen technologies is also highly dependent on their public acceptability. People must be reassured about the safety and cost of using hydrogen in the home and for transport. Public perceptions of hydrogen as a fuel could be decisive in our ability to reach Net Zero. Close engagement with a wide range of stakeholders including trade associations and consumer groups is required to understand the public’s perception of hydrogen’s economic and societal benefits. This would help the UK establish an early adopter advantage across several different sectors.

Other considerations

Businesses involved in the manufacture of components for existing heating, transport and other industry sectors based on fossil fuels could be offered support to help them prepare for the advent of hydrogen markets, and to encourage diversification into the manufacture of components underpinning hydrogen-based energy systems. Funding for enhanced international R&D collaboration would also help bring about a better developed global market in hydrogen, facilitated by the development of international frameworks that harmonise certification and regulations. By becoming a living lab for hydrogen technologies, the UK can position itself as a favoured destination for international businesses to carry out research, development and demonstration, and attract inward investment.

An integrated approach is required, bringing together government, industry and academia, as well as representatives of wider society, to ensure any hydrogen plans are taken forward successfully. This would build on the work of the Hydrogen Advisory Council (HAC) and other existing groups. Life cycle analysis studies are key to ensuring a ready supply of data and information to inform decisions about which will help the UK to reach its Net Zero goals most quickly.

Q2. Describe the progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps that can build on this progress most effectively.

UKRI has supported over 100 projects researching, testing and demonstrating the commercial viability of hydrogen innovations across supply chains and transport modes, and across UK nations and regions. Key learnings from innovation projects UKRI has funded include:

a) achieving critical mass is important, with large-scale, high utilisation projects involving a greater number of stakeholders being more commercially successful on the whole;

b) commercial activities are unlikely to evolve beyond testing and demonstration without strong, long term policy and market incentives in place to align private investment behind public investment;
c) supply chains face several financial and non-financial barriers, some of which may be linked to businesses' lack of awareness of the opportunities of hydrogen; and
d) international collaboration has been critical in accelerating the commercialisation of new hydrogen technologies.

As noted in the government's recent Energy White Paper, trials have been vital in determining the practicalities of converting existing gas boiler appliances, and the way in which consumers experience hydrogen for heating in their own homes and workplaces[2]. This presents opportunities for the UK to establish an early mover advantage in what will become a global market for retrofitted appliances, and increases the likelihood that UK firms will win an international share of the market.

UKRI recognises that developing the supply chains to enable industrial fuel-switching applications to low-carbon hydrogen is a critical first step. Anchoring these value chains at the Industrial Clusters identified by BEIS in its Industrial Clusters Mission is key to demonstrating and validating their effectiveness before being rolled out nationwide. To this end, the development of the hydrogen economy can play an important part supporting the government's levelling-up agenda. Significant hydrogen production will be focused on key industrial locations around the UK, transforming these locations into key UK fuel suppliers, which will create thousands of jobs and attract significant capital investment.

UKRI has invested extensively in cutting-edge research into the use, supply, storage and application of hydrogen fuel, as well as innovation projects that trial these technologies commercial viability and real-world potential, as outlined in the Annex.

The government may also wish to look to examples of international best practice, including projects investigating the development of low carbon ammonia such as the Asian Renewable Energy Hub, which signal the potential for ammonia to be the traded zero-carbon fuel of the future[3].

Q3. Explain 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.

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[2] https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future/energy-white-paper-powering-our-net-zero-future-accessible-html-version
[3] https://asianrehub.com/ and https://www.airproducts.com/news-center/2020/07/0707-air-products-agreement-for-green-ammonia-production-facility-for-export-to-hydrogen-market

There continue to be a number of engineering and commercial challenges relating to hydrogen's adoption as a low-carbon energy source that well-funded research and innovation have a critical role to play in overcoming.

UKRI has invested extensively in cutting-edge research into the use, supply, storage and application of hydrogen fuel, as well as innovation projects seeking to demonstrate these technologies commercial viability and real-world potential. Examples of hydrogen-related research and innovation projects supported by UKRI are included in the **Annex** to this response.

Engineering/technical challenges

In consultation with the research community, UKRI has identified several research questions to be answered regarding hydrogen production, storage, distribution and use. These include:

a) Production: challenges include lowering the cost of producing low carbon hydrogen at a range of scales, encompassing concepts and material design for electrolysis, novel chemistry for hydrogen carrier production, ammonia synthesis and decomposition, and flexibility of response.
b) Hydrogen storage: challenges include identifying materials for storage, and the feasibility of sub-surface storage. Current methods for storing ammonia at scale can help inform further research in this area.
c) Distribution: areas of focus include research into pipeline resilience and the effects of hydrogen embrittlement.
d) Use: research is required into how best to use hydrogen in different sectors; this includes examination of its combustion and safety, exploring its potential as feedstock for industrial process, and its use in heating and transport, including ammonia for shipping.
e) Whole systems integration: how to integrate hydrogen into the energy system including coupling requirements with other technologies and understanding of trade-offs, hydrogen emissions in all parts of the value chain and understanding public perceptions.
f) Understanding the wider environmental impacts of hydrogen, thought to be an indirect greenhouse gas, prior to the technology and market evolving, to assist with the design and implementation of any mitigating measures that need to be embedded within the supply chain.
g) Further research into the synergies that exist between hydrogen and ammonia, and fuel blending.

'Green' hydrogen requires cost reductions to become a feasible energy source; it currently costs between two and three times more than 'blue' hydrogen, which is more costly than natural gas. This presents a barrier to its uptake by consumers and industry. However, in its 'Green hydrogen cost reduction' report, the International Renewable Energy Agency (IRENA) outlines how this can be achieved through strategies to reduce electrolyser costs through continuous research, innovation, performance improvements and upscaling[4].

[4] https://www.irena.org/publications/2020/Dec/Green-hydrogen-cost-reduction

In relation to challenges around storage, compressing hydrogen to the pressure required to obtain a useful energy density (200 to 700 atmospheres) is not only energy intensive; it requires vessels that can withstand that pressure. This often makes the vessels ten times heavier than the hydrogen within it. Hydrogen embrittlement of metals and leaks are also engineering challenges that need to be considered. The very low ignition energy of a hydrogen-air mixture means that extreme care must be taken to engineer systems without leaks. Liquefying hydrogen is another option for storage, but this is very energy intensive as it requires refrigeration of the hydrogen down to 20 Kelvin, and as such the production cost of liquid hydrogen is approximately double the production cost of gaseous hydrogen.

Distributing hydrogen by pipeline across long distances also presents significant engineering challenges. Due to the difficulties associated with storing pure hydrogen at sufficient density, transporting hydrogen in bulk by rail, road or ship is energy intensive and expensive. For example, transporting the same amount of energy as is contained in one road-going petrol tanker would require 15 equivalent-sized compressed gas hydrogen tankers or two equivalent-sized ammonia tankers.

To address these challenges, research is required to explore approaches to storing and distributing hydrogen, while business-led innovation can help establish the commercial case for the resulting technologies. This includes the development of commercially viable solutions using ammonia for large scale storage of renewable energy, enabling hydrogen fuel cell vehicle filling stations and off-grid, low-carbon electric vehicle charging stations. Several countries – notably Japan, Norway, Australia and Saudi Arabia – have invested in green ammonia as a way of supplying hydrogen.

Commercial incentives to drive innovation

From a commercial standpoint, one of the key barriers to hydrogen's more widespread uptake is cost compared to conventional gas, or untaxed petrol or diesel. There is also the risk that significant investment in commercial-scale hydrogen production may be hampered by value chain fragmentation, with sectors that stand to benefit from hydrogen fuel in the long run unwilling or unable to make the necessary long-term investments today to take advantage of the future growth in 'green' hydrogen markets. Investing in multiple decarbonisation strategies may also be very costly for UK consumers and businesses, with the result that each adopts a "wait-and-see" approach or cherry picks solutions that provide at most a limited benefit to the UK economy.

Another key commercial challenge is the current lack of clarity on the market for hydrogen. There is significant commercial interest in producing hydrogen (most of the large energy companies are exploring hydrogen as a potential area of activity) but without national and local understanding of the volume of hydrogen that would be demanded from these markets, significant investment in the UK from international companies is being held back.

Given hydrogen's potential cross-sector application, these risks could be mitigated through R&D, taking a 'whole-systems' approach to ensure that hydrogen is embedded in the low carbon energy system in a strategically coordinated manner. There are also opportunities to reform the current regulatory framework to incentivise the adoption of low or zero carbon heating and changes to regulations that unlock hydrogen's potential, for example by bringing forward more ultra-low emission zones. Working in partnership with bodies such as the British Standards Institution, there are opportunities for the government to promote flexible, dynamic hydrogen standards that keep pace with fast-changing markets, and are aligned to international standards to help support hydrogen technology exports. However, direct public investments (in the form of grants, loans etc) and reforms to the regulatory system to unlock the potential of research and innovation will be inconsequential without the creation of a clear hydrogen market, which must be the primary driver for private investment in hydrogen research and innovation.

Q4. What infrastructure will hydrogen as a Net Zero fuel require in the short- and longer-term? What are the associated risks and opportunities?

If the UK government chooses to prioritise hydrogen fuel for heating, there is a need to adapt current infrastructure – such as repurposing gas pipelines – to be able to accommodate and transport hydrogen in both a blended and pure form. Research by various groups across the UK suggest that, depending on where in the network it is used, embrittlement of pipework may be an issue. Gas boilers for heating homes will also need to be upgraded to be able to run off hydrogen instead. By the same token, critical CCUS infrastructure needs to be installed to enable 'blue' hydrogen utilisation.

There is a requirement to study the development of an ammonia-based zero-carbon fuel infrastructure. Large-scale infrastructure for ammonia storage and supply is already widely used in the distribution of fertilisers in places such as the United States and has an excellent safety record built over decades. Ammonia has similar physical properties to liquid petroleum gas; retrofitting existing technologies could therefore enable the UK to transition affordably with low disruption from fossil fuels to zero-carbon fuels.

Where larger transport consumption is expected, for example at a maritime port or airport, local or on-site hydrogen production should be considered, in order to circumvent supply challenges.

Q5. What is the balance of costs to benefits of using hydrogen to meet Net Zero targets, as well as the potential environmental impact of technologies required for its widespread use?

While hydrogen as a fuel does not produce CO_2 when burned, current methods of producing 'blue' hydrogen can catalyse its production. Half of all global hydrogen production currently happens through SMR, with only 2% from electrolysis (4% in the UK). If used without CCUS, SMR would be more carbon intensive than the direct burning of natural gas[5] [6]. Currently, CCUS plant technology has capture rates of 85-90%, meaning 10-15% of emissions are not captured[7]. While it should be technically possible to achieve capture rates of 99% using CCUS, doing so

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[5] https://www.theccc.org.uk/2018/11/22/hydrogen-is-a-credible-option-for-the-future-the-uk-must-now-prepare-for-the-key-decisions-on-zero-carbon-energy/
[6] https://www.theiet.org/media/4095/transitioning-to-hydrogen.pdf
[7] http://documents.ieaghg.org/index.php/s/CLIZIvBI6OdMFnf

brings an additional efficiency penalty for the power plant, meaning that even more energy is needed to produce the same amount of hydrogen. This in turn increases the amount of upstream fugitive emissions from the extraction and transportation of fossil fuels.

Reliance on CCUS will and needs to reduce over the longer term as we transition to 'green' hydrogen, produced by electrolysis coupled to renewables. 'Green' production methods will not produce CO_2 emissions and will give us access to truly zero carbon hydrogen at the necessary scale to meet our energy needs.

Q6. Describe 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 the optimal technology should be managed.

Different technologies will need to be deployed for different requirements and scenarios. For example, hydrogen may be the best option for heating homes in cities that have limited land and are on the gas network, whereas heat pumps may be the best solution for rural housing stock off the gas grid with available land. Where clean, affordable and reliable hydrogen is available at scale, it may offer similar levels of convenience that consumers and businesses have become accustomed to with oil or gas systems. These multiple markets make hydrogen an attractive proposal for investment, de-risking significant investment in production.

Hydrogen is necessary for important industrial processes such as steel manufacturing and ammonia production. For electrification, wind, solar and nuclear should be the UK's energy provision options. Batteries work best for short-term storage (from sub-second for fast frequency voltage response to intraday for, for example, domestic use). For long-term storage, other solutions will be required. Ammonia offers opportunities for this purpose.

There are other options to decarbonise different parts of our system. For decarbonising heat, another option is to deploy heat pumps which use either air or the ground as a source of heat. Heat pumps offer a much more efficient method of transforming renewable energy into heat as compared to generating hydrogen via electrolysis. Heat pumps also avoid the complication and safety risks of pumping hydrogen in the gas network. However, it should also be recognised that heat pumps produce lower grade heat than a gas boiler so will require either larger radiators or better insulation, or most likely both, solutions which may be difficult to implement in older buildings.

Low carbon fuels could be used where batteries are unfeasible, for example in large road vehicles or aircraft. There have been successful, world-leading demonstrations of large hydrogen powered vehicles, notably the Aberdeen Hydrogen Bus Project, part funded by UKRI, which has been a world leader in this area[8]. The HyDeploy consortium demonstration projects have also trialled the injection of hydrogen into existing gas networks, including one at the Keele University campus in Staffordshire[9].

[8] https://www.fuelcellbuses.eu/projects/hytransit

ANNEX – Examples of UKRI-funded research and innovation projects

Currently, UKRI funds research, innovation and training into hydrogen and alternative energy vectors for the generation, storage and utilisation of synthetic chemical energy and synthetic fuels, of which hydrogen is one. This includes research and innovation into materials and devices used for their generation and storage and any socio-economic and environmental issues associated with this. UKRI currently invests £13m in sustainable energy vectors (including hydrogen) and £14m in fuel cell technologies.

UKRI has invested in the Hydrogen and Fuel Cells Supergen Hub (H2FC) which seeks to address a number of key issues facing the hydrogen and fuel cells sector, specifically: (i) to evaluate and demonstrate the role of hydrogen and fuel cell research in the UK energy landscape, and to link this to the wider landscape internationally, (ii) to identify, study and exploit the impact of hydrogen and fuel cells in low carbon energy systems, and (iii) to create a cohort of academics and industrialists who are appraised of each other's work and can confidently network together to solve research problems which are beyond their individual competencies.

UKRI has invested in a world-leading Green Ammonia Demonstrator that could help deliver relevant R&D including technology demonstrations and projects with industry, specifically targeted at facilitating Net Zero. The Green Ammonia Demonstrator was designed, built and commissioned at the STFC Rutherford Appleton Laboratory in Oxfordshire in 2018 as the world's first roundtrip demonstration of green ammonia for energy storage (Power-to-Ammonia-to-Power). The project was part of the Siemens-led "Decoupled Green Energy" project funded by InnovateUK/EPSRC (£1.6m) and Siemens (£1m). On 1st October 2019, the demonstrator hardware was transferred from Siemens to UKRI-STFC to facilitate enable the its future use and expansion of this system as a research and development demonstrator and teaching resource.

UKRI's has also invested £31m in three UK Geoenergy Observatories, a network of observatories which will provide world-class data to understand how hydrogen can reduce our carbon emissions. Each observatory in Cheshire, Glasgow and elsewhere delivers a different body of knowledge that together will help us better understand how geoenergy can help to deliver the clean energy at the scale required to achieve Net Zero by 2050.

The Industrial Decarbonisation Challenge Fund – one of UKRI's Industrial Strategy Challenge Funds[10] (ISCF) – is funding Front-End Engineering Design (FEED) studies for large industrial CCUS and low-carbon hydrogen projects in preparation for final investment decisions by 2023/24. The Challenge forms part of a wider government commitment of around £1.6 billion for decarbonising industrial clusters. There is also potential for hydrogen to feature as part of the ISCF Transforming Foundation Industries challenge.

The Future Flight Challenge programme is funding projects considering the application of electric Net Zero propulsion to short range passenger aircraft. These projects include ones looking at the use of hydrogen fuel cells for aircraft and drones and the infrastructure required for their safe operation at airports.

(January 2021)

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[9] https://hydeploy.co.uk/
[10] https://www.ukri.org/our-work/our-main-funds/industrial-strategy-challenge-fund/