House of Commons

Science and Technology Committee

First Special Report - The role of hydrogen in achieving Net Zero: Government Response to the Committee's Fourth Report

First Special Report of Session 2022–23

HC 1257

House of Commons

Science and Technology Committee

First Special Report - The role of hydrogen in achieving Net Zero: Government Response to the Committee's Fourth Report

First Special Report of Session 2022–23

Report, together with formal minutes relating to the report

Ordered by the House of Commons to be printed 29 March 2023

HC 1257
Published on 30 March 2023
by authority of the House of Commons

Science and Technology Committee

The Science and Technology Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Government Office for Science and associated public bodies.

Current membership

Greg Clark MP (*Conservative, Tunbridge Wells*) (Chair)

Aaron Bell MP (*Conservative, Newcastle-under-Lyme*)

Dawn Butler MP *(Labour, Brent Central)*

Chris Clarkson MP (*Conservative, Heywood and Middleton)*

Tracey Crouch MP (*Conservative, Chatham and Aylesford)*

Katherine Fletcher MP (*Conservative, South Ribble*)

Rebecca Long-Bailey MP *(Labour, Salford and Eccles)*

Stephen Metcalfe MP *(Conservative, South Basildon and East Thurrock)*

Carol Monaghan MP (*Scottish National Party, Glasgow North West*)

Graham Stringer MP (*Labour, Blackley and Broughton*)

Christian Wakeford MP (*Labour, Bury South*)

Powers

The Committee is one of the departmental select committees, the powers of which are set out in House of Commons Standing Orders, principally in SO. No. 152. These are available on the internet via www.parliament.uk.

Publication

Committee reports are published on the Committee's website at www.parliament.uk/science and in print by Order of the House.

Committee staff

The current staff of the Committee are: Ian Cruse (Second Clerk) Gina Degtyareva (Senior Select Committee Media Officer), Emma Dobrzynski (Committee Operations Officer), Dr Claire Housley (Committee Specialist), Dr Claire Kanja (Committee Specialist), Dr Faten Hussein (Clerk), Hafsa Saeed (Committee Operations Manager), and Ben Shave (Committee Specialist)

Contacts

All correspondence should be addressed to the Clerk of the Science and Technology Committee, House of Commons, London, SW1A 0AA. The telephone number for general inquiries is: 020 7219 2793; the Committee's e-mail address is: scitechcom@parliament.uk.

You can follow the Committee on Twitter using @CommonsSTC.

First Special Report

On 19 December 2022 the Science and Technology Committee published its Fourth Report of Session 2022–23, *The role of hydrogen in achieving Net Zero* (HC 99). The Government Response was received on 23 February 2023. The Response is appended to this Report.

Appendix: Government Response

Government Response – House of Commons Science and Technology Committee report on the role of hydrogen in achieving net zero

Recommendations

ID 1

To meet the 2050 Net Zero target, decisions need to be urgently taken by the government, which will help define hydrogen's place in the UK's overall decarbonisation strategy. These decisions should be integrated across government, in policy areas such as those identified in the Ten Point Plan for a Green Industrial Revolution. Decisions on hydrogen should be made in an international context and take into consideration the approaches of other countries both in terms of lessons to be learned and collaborations to be pursued. The government should, in the next two months, outline a series of decision points between now and 2050 that will determine the role of hydrogen in the UK, in each policy area identified in the Ten Point Plan for a Green Industrial Revolution. This should be accompanied by an outline of the scientific and technological progress that needs to be made to allow hydrogen to play its part in our energy system.

Response

Government has a leading role to play in the development of the low carbon hydrogen economy, providing the necessary market frameworks and funding support to deliver commercialisation of new technologies which will support meeting the UK's net zero commitments.

Government recognises the need to provide greater clarity, where possible, on the role of hydrogen in the future UK energy system. In addition to the Committee's recommendation, there are similar proposals in the Net Zero Review (Jan 2022). The Net Zero Review calls for the government to develop an ambitious 10-year roadmap for the scaling up of hydrogen production and confirm the long-term funding envelope available for hydrogen.

In 2023, the hydrogen economy is at an early stage of development. It would be challenging and risky to be overly prescriptive of hydrogen's overall place in the UK's decarbonisation plan, ahead of gaining insights from pathfinder projects throughout the 2020s. This is why the government is supporting early production, distribution, and use of low carbon hydrogen in the UK, and early anchor projects, which will be critical for generating more insights on the cost, benefits and impacts of using hydrogen as well as deployment of alternative decarbonisation options.

Government set out key strategic decisions and milestones to 2030 and beyond in the Hydrogen Strategy Roadmap, which was published in the UK Hydrogen Strategy (Aug 2021). These include the decision on hydrogen blending into gas distribution networks by up to 20% by volume, anticipated in 2023; and strategic decisions on hydrogen for heat in 2026 which will be informed by the 100% hydrogen 'Neighbourhood Trial' planned for 2024 and 'Village Trial' planned for 2025. Trials for hydrogen and battery electric HGVs to establish their feasibility, deliverability, costs and benefits will also steer future policy direction. Government continues to assess the need for appropriate market intervention to support hydrogen to power generation which complements existing and announced support packages for the hydrogen supply chain, with an external study currently in progress. All of these decisions are expected to have important implications for the overall volume of hydrogen used in the UK energy system as well as the infrastructure and technology requirements out to 2050, and subsequently the nature and timing of further decisions in the future.

In the UK Hydrogen Strategy, government set out its best current understanding of the range of hydrogen production and use in 2050. Analysis published in the UK Hydrogen Strategy indicated that low carbon hydrogen may increase from minimal use currently to comprising 20–35 per cent of the UK's final energy consumption in 2050 - equivalent to 250–460 TWh and similar in scale to present electricity use.

Recognising this longer-term uncertainty in 2050, government wants to ensure current and future businesses can take near term decisions on new research and development priorities. In the Net Zero Research and Innovation Framework (2021), government sets out key research and innovation (R&I) needs in hydrogen into the 2030s and beyond. Challenges identified include demonstrating low carbon hydrogen production methods as efficient, reliable and low-cost at increasing scales and demonstrating effective, low-cost methods of bulk hydrogen transportation and storage. Investment in discovery research, as well as development and scaling-up of current prototypes, should increase the chances that new technologies not yet ready for commercial deployment will be available in the future. This Framework lays the foundation for net zero R&I planning within government, which is intended to be followed shortly by a Net Zero Research & Innovation Delivery Plan. This will set out government's current portfolio of R&I programmes which are helping support innovative businesses to develop the next generation of technologies needed to deliver net zero.

ID 2

Hydrogen has several distinctive features as a low-carbon gaseous fuel and could contribute to the UK's energy system, including through improving resilience and energy security. Whilst in some applications hydrogen is less efficient compared to alternative low-carbon technologies, the wider energy system benefits of deploying hydrogen must be acknowledged, and we welcome the Government's whole systems approach in its Hydrogen Strategy. Consideration should be given to broader benefits, such as system resilience and national security, as well as price competitiveness as a fuel, in implementing the Hydrogen Strategy.

Response

System level thinking has been a key element of the government's approach to developing hydrogen in the UK. Low carbon hydrogen is just one among the many decarbonisation technologies that government expects to contribute to meeting net zero. As such the Net Zero Strategy points to the integrated policy approach being taken to deliver emission reductions in line with the UK's Carbon Budgets. The potential impacts on system resilience and energy security, particularly in terms of low carbon hydrogen production, are reflected in the increased ambition brought forward under the British Energy Security Strategy (BESS) – i.e. for up to 10GW of low carbon hydrogen production capacity by 2030, with at least half of this electrolytic hydrogen – as well as the direction of travel indicated in the UK Hydrogen Strategy and its subsequent updates. We are working across government energy policy development to ensure that hydrogen's potential to realise wider system benefits is realised, such as providing system flexibility and resilience to our power system and enabling more efficient utilisation of our growing renewable electricity production capacity.

ID 3

The Government has chosen at this stage to support the development of both green and blue hydrogen. We heard that the initial adoption of blue hydrogen will be cheaper than green hydrogen, and ready to use in certain niche industrial settings sooner. However, several analysts have argued that green hydrogen will become cheaper than blue hydrogen over time.

Response

Government has been clear in the UK Hydrogen Strategy and subsequent publications that it considers support for multiple production routes the most appropriate approach while building the hydrogen economy, including both water electrolysis (green hydrogen) and methane reformation with carbon capture, utilisation and storage (CCUS) (blue hydrogen). Electrolytic and CCUS-enabled production routes have different production characteristics, scale, cost profiles and wider system impacts suggesting both can have an important role. The Department for Business Energy and Industrial Strategy's (BEIS) Hydrogen Production Cost report suggested in 2021, under central fuel price assumptions, that CCUS-enabled methane reformation is the lowest cost production route but that electrolytic hydrogen costs are expected to decrease considerably over time, with green hydrogen produced using curtailed electricity potentially becoming competitive with blue as early as 2025. As indicated in the UK Hydrogen Strategy Update to Market: July 2022, BEIS – and now the Department for Energy Security and Net Zero (DESNZ) - will continue to keep input cost under review when considering the role of various technologies in meeting government's production ambitions.

ID 4

There is uncertainty about the extent to which blue hydrogen can play a role in a Net Zero economy in the mid to long term, even if it may be cheaper and ready to deploy in certain industrial settings sooner than green hydrogen, as some industrial users already possess the necessary infrastructure. The Government should not be dependent on either blue or green hydrogen alone in the short-term. The Government's decision to continue using blue hydrogen should be dependent on the standard CO_2 capture rate reaching 95% by 2030 and in excess of 99% well in advance of 2050. In its response to

this Report the Government should set out its expectations of how much CO_2 could be captured in hydrogen production and which industrial settings it sees as being ready to utilise blue hydrogen prior to 2050.

Response

Government has established an approach which supports multiple hydrogen production technologies, including both electrolytic and CCUS-enabled hydrogen, as set out in 2021's UK Hydrogen Strategy. The Low Carbon Hydrogen Standard (LCHS) sets a maximum threshold for greenhouse gas emissions allowed in the production process for hydrogen to be considered 'low carbon hydrogen', and a methodology for calculating emissions. While the LCHS does not mandate a capture rate, there is an assumption that at least 85% would be achieved in order for CCUS-enabled technologies to comply with the current threshold. The Environment Agency is set to publish draft guidance on best practices for CCUS-enabled hydrogen production which may point to a minimum recommended capture rate. As indicated in the UK Hydrogen Strategy Update to Market: July 2022, hydrogen production projects eligible under Phase-2 of the Cluster Sequencing process are aiming for capture rates of 95% or more, enabling significant emissions reductions for end users relative to burning natural gas.

ID 5

Carbon capture, utilisation and storage (CCUS) technology should be an area of priority research interest for the Department for Business, Energy and Industrial Strategy (BEIS), and a strategic priority for UK Research and Innovation (UKRI).

Response

Between 2004 and 2021 the UK Government has invested over £346 million into CCUS Research, Development and Deployment (RD&D). This funding has ensured the UK remains at the forefront of CCUS Research and Innovation. Developing the skills, knowledge, and technology to allow the UK to deploy CCUS domestically and export its expertise around the world. In 2020 the UK Government confirmed Advanced CCUS and Greenhouse Gas Removal (GGR) innovation would be two of the ten priority areas of the £1 billion Net Zero Innovation Portfolio (NZIP). Specifically within the five-year NZIP (2021–2025), the following funding is being provided:

- £100 million has been invested by the UK Government (£70m from NZIP and £30 from NERC) into research and development of demonstration plants for GGR and Direct Air Capture (DAC) technologies. This is to support the ultimate deployment of First of a Kind commercial GGR facilities in the UK and develop the expertise and technology for potential export.

- £30 million has been allocated to the Hydrogen Bioenergy with Carbon Capture and Storage (BECCS) Innovation Programme to support technologies which can produce hydrogen from biogenic feedstocks and be combined with carbon capture to deliver negative greenhouse gas emissions. In 2022, Phase 1 of the programme supported 22 projects (£5m total) to scope and develop a feasible prototype demonstration project to be run in Phase 2. Phase 2 (£25m total) is aimed at selecting the most promising projects from Phase 1 and support their physical demonstration from 2023–2025.

- £20 million of funding has been allocated to CCUS Innovation 2.0 to develop and demonstrate next generation CCUS technology in the UK that can significantly reduce the cost of deploying CCUS. Previous innovation funding by BEIS (and its predecessor DECC) have been critical in the development of 8 Rivers' Allam-Fetvedt Cycle, Carbon Clean's CycloneCC technology and C-Capture's award winning non-amine solvent.
- £5 million of funding has allowed UK universities and companies to work with their European and International partners in the Third Call of the international Accelerating CCS Technologies (ACT-3) programme. As a founding member of the international ACT programme, the UK has joined the first three ACT calls that in total have funded over €96 million of collaborative CCUS innovation projects.

ID 6

Several countries are prioritising green hydrogen in their hydrogen strategies, and it seems likely that international interest in demonstrably low-carbon hydrogen, including green hydrogen, will continue to grow. This offers an opportunity for the UK to become a leader in green hydrogen production and development. The government needs to provide more clarity in its updates to market on the hydrogen strategy, with a view to guaranteeing significant green hydrogen development over the next decade. In its response to this Report, the Government should set out how it intends to support the development in the UK of green hydrogen projects at scale during this decade, to ensure that green hydrogen can be produced in the UK and so it can become cost-competitive with blue hydrogen. This should include additional efforts to reduce the cost of electrolysers.

Response

The BESS doubled the UK's ambition to up to 10GW of low carbon hydrogen production capacity by 2030, subject to affordability and value for money, with at least half of this coming from electrolytic hydrogen. The BESS also set out government's intention for up to 1GW of electrolytic hydrogen by 2025 alongside an aim to run annual Hydrogen Production Business Model (HPBM) allocation rounds for electrolytic hydrogen to bring this forward. These green hydrogen ambitions were recognised as internationally competitive in the Climate Change Committee's 2022 Progress Report to Parliament.

The Hydrogen Sector Development Action Plan (SDAP) highlighted electrolyser manufacture as an existing UK strength in the hydrogen supply chain. The signal provided by government's ambitions for electrolytic hydrogen production, coupled with actions in the SDAP to support supply chains, make electrolysers a potential growth area.

ID 11

The government should set a 2030 target for green hydrogen production to ensure that full-scale development of green hydrogen is incentivised to take place in the short term and to make it more likely that the UK develops a green hydrogen production capacity. The government should be clear whether any targets it sets are for capacity to produce, or are an expectation of how much hydrogen the UK expects to produce and use. The government should also indicate when grey hydrogen production will be phased out.

Response

The BESS doubled the UK's ambition to up to 10GW of low carbon hydrogen production capacity by 2030, subject to affordability and value for money, with at least half of this coming from electrolytic hydrogen. BESS also set out government's intention for up to 1GW of electrolytic hydrogen by 2025 alongside an aim to run annual HPBM allocation rounds for electrolytic hydrogen to bring this forward.

As indicated in the Hydrogen Strategy Update to Market: July 2022, Hydrogen produced by steam methane reformation without carbon capture (grey hydrogen) is not considered low carbon under the LCHS. For hydrogen to be considered low carbon under the LCHS (for example as a condition of business model support, or under the future hydrogen certification scheme), these producers would need to change hydrogen production method to one that is low carbon, or else retrofit industrial carbon capture technology with support from the Industrial Carbon Capture Business Model (ICC BM). Existing producers of hydrogen by steam methane reformation for use as a feedstock may also choose to become offtakers of newly produced low carbon hydrogen, supported through the HPBM, to displace or supplement the hydrogen they currently produce. The suite of major current and planned interventions, such as the UK ETS, the ICC BM and the HPBM, are expected to be sufficient to incentivise and support the decarbonisation or displacement of hydrogen currently produced by steam methane reformation without carbon capture. Government will continue to engage with existing industrial producers of hydrogen to test this thinking and will consider the most appropriate way of gathering further evidence to inform any future policy development as required.

ID 8

Energy storage for electricity generation is widely recognised as an important component of the Net Zero economy, and there are several potential technologies available for energy storage. Hydrogen has unique features as a means of energy storage, since as a clean-burning gas it can be transported through existing infrastructure and stored safely for long periods of time, if necessary. We welcome the government's recognition of the potential role of hydrogen as an important means of energy storage. The government should continue to provide the necessary policy support and infrastructure for grid-scale energy storage technologies. Findings from hydrogen energy storage trials should be recorded and shared between trials to ensure that as much is learned as possible.

Response

In the BESS, government recognised that hydrogen storage (along with transport) infrastructure would be an important enabler of the hydrogen economy to connect hydrogen producers with offtakers; and to align production with demand. The UK Hydrogen Strategy also recognised that for a future energy system with a lot of intermittent renewable power generation, hydrogen could be an important energy storage medium, i.e.: excess renewable power is converted into hydrogen through electrolysis (power-to-gas); this hydrogen is stored and is ready when needed and can be used as a fuel across the economy. This could include as a fuel for low carbon dispatchable power generation (gas-to-power). The availability of large-scale hydrogen storage is expected to be critical to enabling hydrogen fuelled power generation to operate flexibly, and so provide low

carbon capacity to complement intermittent renewable generation. In this respect, it has the potential to contribute to the delivery of the government's commitment for a fully decarbonised power sector by 2035 (subject to security of supply).

In the BESS, government also committed to designing a hydrogen storage infrastructure business model by 2025, which would be aimed at de-risking private investment in infrastructure projects. Government published a consultation on hydrogen transport and storage business models in August 2022. This consultation has now closed, with a response be published in due course.

Government will continue to engage with the hydrogen storage industry to support our understanding of the sector and the challenges facing it.

ID 9

Hydrogen can undoubtedly help key UK industrial sectors decarbonise. There is a widespread recognition of the importance of regulatory reform and an effective business model in incentivising a switch to low-carbon hydrogen use. We welcome the government's use of industrial clusters to trial the use of hydrogen. The government must design and establish effective mechanisms to capture and learn the lessons from these trials and demonstrably apply the lessons from the industrial clusters to be set up by 2025 to those which will be in operation by 2030

Response

DESNZ is monitoring and evaluating the processes and impacts of its policies in the low-carbon hydrogen space in industrial clusters and beyond to incorporate lessons learnt into future policy design and ensure accountability. As a first step for CCUS-enabled hydrogen in industrial clusters, DESNZ has recently commissioned a study to capture feedback about the design and delivery of the Track-1 Cluster Sequencing process to inform the development of the planned Track-2 process, through a series of interviews with industry and HMG officials. The report is expected to be published soon. Future work will be aimed at developing plans for impact monitoring and evaluations in the low carbon hydrogen policy space, covering CCUS-enabled, electrolytic and other hydrogen production technologies in operation in industrial clusters and beyond.

ID 11

Whilst there is lower round-trip efficiency compared to electrification, hydrogen vehicles have the advantage of shorter refuelling times and longer ranges. This therefore makes hydrogen a potentially viable alternative to electrification for HGVs, but widespread adoption of hydrogen in HGVs can only be achieved with an assurance that hydrogen will be widely available across the country. Whilst other countries have given commitments to hydrogen refuelling stations, the UK has been more reticent to date. More trials for heavy goods vehicles, beyond those already announced and forthcoming as part of the Zero Emission Road Freight demonstration programme, need to take place in the next five years to ensure that a firm decision can be made on the role of hydrogen in HGVs in time to develop the infrastructure needed to deliver carbon emission reductions. Trials could be localised to minimise the initial infrastructure requirements. Any early adoption of hydrogen HGVs is likely to require subsidy by the government to overcome the higher cost for the operators.

Response

The Zero Emission Road Freight Demonstrator (ZERFD) programme is intended to put hundreds of zero emission heavy good vehicles into operations on UK roads, alongside providing the relevant refuelling infrastructure to support them. The programme is intended to provide confidence to industry to invest in zero emission HGVs, create an evidence base on the use of different technologies in different use cases and provide private investors with the clarity needed to invest in new infrastructure. Multiple industry partners have expressed an interest to expand on the demonstrations funded as part of ZERFD by expanding the use of zero emission HGVs within their own fleets. All vehicles and associated infrastructure are due to be deployed by March 2025. The Future of Freight Plan made a commitment to collectively assess the whole freight sector's future energy and fuel needs through a Freight Energy Forum, through which government intends to convene industry stakeholders to develop a plan for infrastructure delivery. The government remains neutral on which technology may be best placed to decarbonise the UK's road freight fleet.

ID 12

We welcome the trials of hydrogen buses which are taking place in the UK. The government should continue to support such trials and come to a rapid view of the contribution that hydrogen-fuelled buses can make. Trials should consider the implications for other applications such as HGVs, and the decisions the trials will help to inform.

Response

The Department for Transport (DfT) continues to support the introduction of Zero Emission Buses (ZEBs) across the UK which includes both electric and hydrogen vehicles through green bus funding schemes. Both the current Zero Emission Bus Regional Areas Scheme and previous government schemes such as the Ultra-Low Emission Bus Scheme have supported the introduction of both Battery Electric buses and Hydrogen Fuel Cell buses and supporting infrastructure, depending on which technology was favoured by bus operators and local authorities. DfThave seen that, in the vast majority of cases, operators have a preference for battery electric buses for logistical and economic reasons. However, operators have indicated that hydrogen fuel cell buses may be advantageous on certain routes, for example on longer journeys or in rural areas.

The ZERFD programme will install a number of hydrogen refuelling stations to support the demonstrations of hydrogen fuel cell HGVs on UK roads, several of which could be available for use by other modes/ trials.

ID 13

Hydrogen has a modest but potentially critical role to play in decarbonising the rail network, where electrification is not suitable or cannot be delivered in time to contribute towards meeting Net Zero. Whilst trials and demonstration projects are underway in hydrogen trains, there is no clear plan to develop the role of hydrogen in this sector. Some countries, such as Austria and Germany, are already using hydrogen

trains. In response to this Report, the government should set out the lessons it has learned from the use of hydrogen trains overseas and how it will use this information in trials of hydrogen trains in the UK.

Response

The deployment of hydrogen trains overseas is generally at an early stage. DfT officials will continue to liaise with international colleagues to understand their approaches to hydrogen trains and the lessons they have learned from deploying them. Hydrogen technologies are included in the scope of the First of a Kind scheme, which offers support for the development of projects that will help decarbonise the railway or reduce harmful emissions. DfT officials will use learnings from international colleagues to shape any future hydrogen train trials supported by government.

ID 14

The government must identify, with industry, the train lines where it is unlikely that electrification will be viable before 2050 and start trials of hydrogen trains on these lines in the next five years.

Response

To decarbonise the rail network, government will undertake electrification of additional lines as well as deploying battery and hydrogen trains on lines where it makes operational and economic sense. While government intends to continue to support trials of hydrogen trains, it cannot commit to do this within the next five years on all lines where electrifying may be unviable since there are alternative solutions to hydrogen which may also prove appropriate.

ID 15

Hydrogen has an important role to play in decarbonising shipping and aviation, but parts of the transport industry want more clarity from government about the intended role of hydrogen since there are significant infrastructure requirements and substantial costs that need to be met. There are also significant infrastructure requirements associated with hydrogen deployment in aviation and shipping but the likely 'winner' from amongst the potential low-carbon technologies in these sectors has yet to emerge and the choice will be internationally, rather than domestically, determined. In its response to this Report, the government should set out its strategy for participation in international fora to shape a global outcome on the role of hydrogen in shipping and aviation.

Response

Maritime:

The UK is an influential member state of the International Maritime Organization (IMO), which is developing draft guidelines on lifecycle greenhouse gas intensity of marine fuels (including Hydrogen and Hydrogen-derived fuels) with the aim of finalising them in July 2023.

The UK is also a core member of the Zero Emission Shipping Mission (part of Mission Innovation), whose goal is to have at least 5% of the global deep-sea fleet (measured by fuel consumption) running on well-to-wake zero-emission fuels such as green hydrogen. DfT officials also attend and participate at the Maritime Technologies Forum.

Aviation:

A key principle of the government's Jet Zero Strategy is international leadership. This includes bringing the UK's world-leading expertise in sustainable aviation to bear in international fora, primarily the International Civil Aviation Organization (ICAO), the UN specialised agency for aviation. ICAO considers a 'basket of measures' to decarbonise the international aviation sector including technology improvements (including electric and hydrogen propulsion), fuel efficiencies, alternative fuels and market-based mechanisms. Accordingly, ICAO's recent feasibility study into a long-term aspirational goal for international aviation emissions reduction considered the possible emissions reductions from all these measures, including an increasingly important role for hydrogen. The government continues to promote the important role of hydrogen in this forum and negotiate to ensure that a suite of standards are in place to allow the certification of hydrogen aircraft in a timely manner. Where other international fora and bilateral cooperation can add value in the area of hydrogen powered flight, government will look to influence and capitalise on these relationships.

ID 16

The government should use its influence internationally, following its leadership of COP26 and involvement in Mission Innovation, to set standards and timelines for decisions on the role of alternative fuels and hydrogen within aviation and shipping. In these areas the government should seek to lead the development of standards that can be adopted internationally.

Response

Maritime:

Development is ongoing internationally and multilaterally. The UK is a leader in using gaseous hydrogen in shipping. The UK was the first country in the world to approve a hydrogen dual-fuel vessel (Hydrocat). DfT officials are using the UK experience to help shape gaseous hydrogen standards in international shipping.

Aviation:

The UK has played a leading role in the development, over the past decade, of comprehensive standards for the use of sustainable alternative fuels (SAF) in aviation. This culminated in the adoption by ICAO, in 2018, of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which credits the use of SAF, and in 2021, of comprehensive global sustainability standards for SAF. The government continues to promote the important role of hydrogen in ICAO in this forum and negotiate to ensure that a suite of standards are in place to allow the certification of hydrogen aircraft in a timely manner.

ID 17

Hydrogen could play a role in domestic heating, but the extent of its potential is still uncertain and looks likely to be limited rather than widespread. We are unconvinced its deployment will prove to be economically viable by the time the government has said it will determine the role of hydrogen boilers, in 2026.

Response

Given the diversity of buildings and consumers' needs, government recognises that no single solution can provide the best option for everyone for decarbonising heat. In all scenarios, heat pumps will have a significant role to play. Government is committed to scaling up deployment of heat pumps, with the aim to reach 600,000 installations a year by 2028, alongside heat networks.

It is important that government continues to assess the technical feasibility, costs, benefits, and other impacts of using hydrogen instead of natural gas to heat buildings in the UK. This will enable government to take decisions in 2026 on the role of low carbon hydrogen in heating.

As set out in the consultation on 'Improving boiler standards and efficiency', government is proposing to require that from 2026 all newly installed domestic-scale natural gas boilers be hydrogen-ready, to help reduce disruption involved in any future roll-out of hydrogen. The hydrogen-ready proposal is based on the assumption that these boilers cost the same as existing natural gas boilers once sales reach comparable levels. Government welcomes response to the consultation on boiler standards and intends to publish a response later this year, setting out updated thinking on mandating hydrogen-ready boilers.

ID 18

Overall, whilst there are a variety of possible applications of hydrogen technology across every sector of the UK economy, we agree with the government that on the basis of present knowledge and the technology available it seems that the role of hydrogen will be to decarbonise specific, limited areas where electrification is either not possible or clearly not optimal, such as the industrial clusters currently developing hydrogen capabilities. The clusters may also offer a future production option for some of the hydrogen required in other applications. The government should prioritise the use of hydrogen in those sectors where there is a genuine prospect of technical, feasible and economically viable deployment. The government should work closely with businesses and international partners to set, in the 2020s, a realistic strategy for the adoption and use of hydrogen in these sectors.

Response

The UK Hydrogen Strategy sets out a holistic approach to growing the hydrogen economy, including stimulating demand. Government continues to be guided by the principles it set out, including aiming to be market-led, primarily focused on helping sectors overcome barriers facing low carbon hydrogen uptake while allowing the market to determine the optimal technology mix.

As set out in the December 2022 Hydrogen Strategy update to the market, the Hydrogen Strategy Roadmap is supporting the design of policy that encourages early use cases, while bringing forward applications with the greatest strategic potential to support deep decarbonisation of the UK economy.

The HPBM, currently under development, will incentivise both production and use of low carbon hydrogen through the provision of ongoing revenue support, making hydrogen an attractive decarbonisation option across sectors. The Net Zero Hydrogen Fund (NZHF) is also providing the opportunity for offtakers to partner with producers to support the development of cohesive value chains and an initial market.

As a lead option for both early hydrogen use and in the longer term, government continues work on enabling fuel switching in industrial sectors. Government is also developing policy to help grow the market for low carbon industrial products. An example being the recently announced intention to sponsor the British Standards Institute to ensure that hydrogen-ready industrial-sized boiler equipment is covered by a Publicly Available Specification.

As the wider energy system transitions to net zero, government is also considering the important strategic role that low carbon hydrogen could play in meeting the UK's future power system needs. Government has commissioned research to support an assessment of the need and case for market intervention to support hydrogen to power applications in line with the corresponding Net Zero Strategy commitment. Additionally, the Review of Electricity Market Arrangements (REMA) is being used to assess how electricity markets can support hydrogen in the power system alongside other low carbon flexible technologies. The REMA consultation closed on 10 October 2022 and set out government's thinking up to that point. Government is currently analysing responses and aims to publish a consultation response in due course.

This also builds on measures set out earlier in the response aimed at developing our understanding of hydrogen use in sectors such as transport and heating. Government continues to work closely with businesses and international partners to further its awareness of the current hydrogen demand landscape and specific sector needs to develop. This will inform the actions government takes in ensuring hydrogen can play its role in decarbonising key sectors.

Government intends to continue to iterate its policy framework and provide updates on its strategy for unlocking hydrogen demand in the regular Hydrogen Strategy update to market publications.

ID 19

Metering is an essential component of any use case for hydrogen in domestic settings. We have heard that the current generation of gas smart meters are designed to measure volume flows of natural gas which are much lower than hydrogen volume flows for the same energy delivery, so are unlikely to be compatible. Larger volume capacity meters, or alternatives which measure mass flow, may be required.

Response

The Office for Product Safety & Standards (OPSS), part of BEIS, is responsible for the metrological accuracy of gas meters (i.e. ensuring meters correctly register the quantity supplied within the permitted margins of error) and supporting regulations.

For meter accuracy there must be a distinction between measuring of hydrogen blends (up to 20–23% hydrogen) and 100% hydrogen.

- Blending up to 20–23%; most meters are expected to continue measuring within the accuracy limits, although there has been limited testing to date but government plans to continue to work with meter manufacturers to provide assurance on accuracy requirements. Licenced energy suppliers ('suppliers') are responsible for the accuracy of the meters they use for billing. In a scenario where blending caused meters to exceed accuracy limits, the supplier would be legally responsible for removing and replacing those meters. OPSS is working with suppliers and meter manufacturers to build evidence that domestic meter types can remain in service where blending takes place.

- For blends above 23% to 100% hydrogen; it is expected that currently installed meters would not be appropriate for accurate hydrogen measurement. Current existing measuring technologies such as diaphragm, ultrasonic and thermal mass flow will be capable of measuring hydrogen at 100%, but the meters currently installed (using these principles) are calibrated for methane and would need to be replaced to measure the higher blends and up to 100% hydrogen.

The higher flow rates required for 100% hydrogen may steer the industry toward measurement of mass, but other technologies can also be developed for 100% hydrogen (so long as they are approved and meet the requirements of the regulations). For some technologies, or mixes of technologies, it is plausible that 'hydrogen ready' meters will be possible (but which may still need changes to their configuration/ firmware 'Over the Air' or 'in-situ', a function which is not commonly undertaken in domestic regulated measuring instruments), which can measure 100% natural gas (methane) and 100% hydrogen, and anything in between but government is not aware of any currently approved/available; and so it has not been possible to prove if they are suitable or economically viable.

ID 20

The energy regulator Ofgem has not worked on understanding hydrogen domestic metering and has not been able to say whether the current roll-out of smart meters will prove ineffective if hydrogen is used in domestic metering. Ofgem was also unable to provide cost estimates for how expensive a hydrogen-ready smart meter roll-out would be under different scenarios, or what the cost implications would be for the consumer. This has arisen, it was suggested to us, because the responsibility for domestic metering is no longer within the remit of Ofgem. Domestic metering is an issue that has been overlooked, and we are concerned that Ofgem is not fulfilling its specified remit of protecting the consumer.

Response

Smart meters are transforming the UK energy system, giving households and small businesses better visibility and control over their energy use and supporting cost-effective delivery of net zero emissions. The rollout underpins a flexible energy system, enabling the UK to use less imported fossil fuels, increasing our energy security and driving growth across Great Britain.

The rollout has passed the halfway mark and with 54% of all energy meters smart or advanced by the end of September 2022, they are becoming the default meter offer for Great Britain. Energy suppliers are obligated under their licence conditions to take all reasonable steps to install a smart meter where a meter is fitted for the first time or when an existing meter needs to be replaced.

Ofgem is responsible for regulating energy suppliers against their licence conditions. DESNZ is responsible for setting government policy and regulation relating to the rollout of smart meters.

Energy suppliers are responsible for the installation and maintenance of domestic meters (both for gas and electricity). Network operators and distributors are responsible for operating and maintaining the infrastructure that delivers gas and electricity to properties (Gas Distribution Network (GDN) companies for gas and Distribution Network Operators (DNO) for electricity).

Domestic metering has not been overlooked. Most gas smart meter manufacturers are actively developing hydrogen meter technology, in liaison with DESNZ. Some are working on 100% Hydrogen prototypes and all have existing smart meters which could work with a 20–23% blend, subject to further testing and assurance.

DESNZ regularly engages with meter manufacturers to keep them updated on hydrogen policy developments and is actively working with them to discuss testing accuracy and compliance with standard regulations of hydrogen-blend compatible devices.

ID 21

An urgent project on metering domestic hydrogen use needs to be undertaken. This should include an assessment of:

- **whether and when the current generation of gas smart meters need to be (a) adapted, or (b) replaced;**
- **what technology could and should be used in new meters to accommodate different fuels and to reflect the timing and pace of different transition scenarios; and**
- **the likely costs of domestic metering under the various scenarios.**

This work should be completed by the beginning of 2024 to ensure that a resilient approach to metering has been developed to underpin the government's decisions on the role of hydrogen in domestic heating and to lay the foundations for an appropriate pace of change should the decision be to adopt hydrogen for domestic heating.

Response

The current generation of gas smart meters could work on a 20–23% hydrogen blend, subject to further accuracy testing and assurance. This is currently being assessed by the OPSS. However, the current generation of smart meters would need to be upgraded to work on higher blends of hydrogen (i.e. 23-to 100%). Should 100% hydrogen be adopted for domestic heating, then government would need to consider options around how hydrogen smart meter deployment might be carried out as efficiently as possible taking into account the current replacement cycle. There are no material issues from a smart functionality perspective regardless of hydrogen concentration.

The £25m DESNZ-funded Hy4Heat programme concluded in 2022 and supported the development of accurate and SMETS-compliant meters for 100% hydrogen (as well as blends greater than 20%). This programme supported two manufacturers, one of whom delivered their smart meter in early 2022 with the other manufacturer expecting to deliver their meter in 2023.

There are two 100% hydrogen heating trials currently planned. Government has committed to support industry to begin a neighbourhood trial, located in Fife, by 2024, and a large village trial by 2025. Gas Distribution Network companies (GDNs) are developing detailed proposals for the trials which will include an assessment of the specifications and costs of meters required. Together with the results of the wider R&D and testing programme, evidence from the hydrogen heating trials will enable

the government to take strategic decisions in 2026 on the role of hydrogen in heat decarbonisation.

ID 22

Several countries including Germany, Japan and Singapore have well developed hydrogen strategies with significant public funding to support the development of infrastructure, production and use of low-carbon hydrogen. Through public-private partnerships, Germany and Japan have structures intended to enable the development of a regulatory framework and provide confidence to consumers for private investment. The UK's main international competitors in this field also tend to have specific bodies responsible for the delivery of their government's targets. Given the evidence received on the importance of whole systems performance, the government should designate or create a single department or agency with responsibility and accountability for delivering cross-departmental Net Zero commitments, including those relating to delivering the hydrogen strategy.

Response

DESNZ is accountable for net zero and, in partnership with Cabinet Office and HM Treasury, works to drive action across departments.

It is not unusual that government agendas span many departments. The main challenge with coordinating net zero across government is in ensuring that departments' incentives are aligned as closely as possible, so every department is completely committed to the action to deliver the objective, and that net zero is embedded in wider policy objectives.

There are several ways that government is ensuring this alignment, including:

- The Domestic and Economic Affairs (Energy, Climate and Net Zero) Cabinet Committee, which brings together departments to consider matters relating to energy, and the delivery of the UK's domestic and international climate strategy;
- Setting common goals, for example through the shared Outcome Delivery Plans – where the Net Zero Strategy approach incorporates the contributions needed across government;
- The commitments to sector strategies and the Net Zero Strategy as a whole – making public commitments, sector by sector, to show how departments are playing their part in achieving net zero.

ID 23

The government's hydrogen strategy and subsequent updates to the market provide a framework with an intention for further consultations rather than early or firm decisions. The government's understandable desire to keep its options open pending market and technological developments may not provide the clarity that investors require to proceed. The government needs to trade the risk of failing to meet Net Zero if decisions on how to reach it are not taken soon enough against the risk of pursuing unproven technologies or solutions that are not cost-effective which would then set the UK back at a later stage. Alongside the series of decision points between now and 2050 required to determine the role of hydrogen in the UK, the government should, in its response to this Report, set out clear criteria to identify the potential role of hydrogen in each sector.

Response

As the UK Hydrogen Strategy outlines, government is aiming to be market-led and technology-neutral, allowing the market to determine the optimal technology mix to decarbonise different sectors. Government also recognises the importance of working with industry to enable hydrogen demand to come forward.

For example, since hydrogen use is at an early stage in many cases government continues to fund and undertake research and studies to understand, develop and commercialise a range of hydrogen technologies across multiple end uses. This is intended to support the market determining the best mix of technologies. For example, government has:

- funded nine feasibility projects through the £26 million Industrial Hydrogen Accelerator competition, looking to produce evidence on end-to-end industrial fuel switching to hydrogen;
- progressed 21 phase 1 feasibility projects as part of the £55 million Industrial Fuel Switching 2 competition;
- allocated over £12 million through the second round of the Clean Maritime Demonstration competition, with seventeen projects exploring the use of hydrogen and/or hydrogen derived fuels in clean maritime solutions.

Government is also developing GHG emission phase out requirements across sectors to stimulate decarbonisation activity. For example, government recently consulted on significantly strengthening the emissions intensity limits, applicable from 2034 to new

build power plants bidding into the capacity market. In aviation, in 2025 government will introduce a SAF mandate requiring at least 10% (c.1.2 million tonnes) of jet fuel supplied in the UK to be made from sustainable sources by 2030. And all new HGVs on Britain's roads will be zero carbon by 2040. These kinds of measures can stimulate hydrogen development and uptake, particularly where electrification isn't viable.

Government also plays a role in considering strategic decisions on hydrogen use. Government continues to target a policy decision in 2023 on whether to allow up to 20% hydrogen blending (by volume) in GB gas distribution networks, and is building the necessary evidence base to determine whether blending meets the required safety standards, is feasible and represents value for money.

ID 24

There appear to be opportunities and advantages in the UK accelerating its decarbonisation of the economy by focusing on hydrogen and becoming a leader in low-carbon hydrogen production, distribution, and deployment for multiple purposes. But, as discussed in this Report there are still uncertainties which entail the risk that technologies do not prove reliable in time, or require excessive costs for consumers and taxpayers. We welcome the Hydrogen Sector Development Action Plan as a step towards making these choices.

Response

The primary focus of the Sector Development Action Plan (SDAP) is to set out actions being taken by government and industry to maximise the benefits to the UK from development of the hydrogen economy. The Plan sets out actions to attract investment, support supply chains, develop skills and secure trade opportunities. In these ways it is a Plan that aims to maximise value to the UK from the policy and regulatory framework for UK hydrogen.

ID 25

The government should identify its priorities for hydrogen in the economy and recognise the opportunity of hydrogen development in delivering Net Zero and developing a resilient energy system. In its response to this Report, the government should set out what further work has been done and what more is planned to identify the sectors where the UK has a competitive advantage that it can deploy and prioritise funding and large-scale deployment in those areas initially.

Response

As the UK Hydrogen Strategy makes clear, hydrogen has a potential role in a range of end use sectors, including transport, power and heat. The extent to which hydrogen could be used in some sectors – heating, for example – is subject to government decisions but, as the hydrogen economy develops, the government's approach is to maximise benefits to the UK across the full value chain.

To support that objective DESNZ is working to understand the capabilities and capacity of UK supply chains across the full value chain. Last year BEIS commissioned research to analyse supply chain requirements in hydrogen production, transmission, distribution

and storage, and the manufacture of fuel cells to 2050 in the UK. Further work to identify where the UK has competitive advantage across the hydrogen economy and appropriate support from government includes:

- building on the 2022 supply chain research to understand UK capabilities and capacity.
- international benchmarking to evaluate UK comparative advantages to overseas competitors, and the competitiveness of government levers for hydrogen.
- collecting and monitoring data from applications to the NZHF and HPBM to help identify potential gaps in UK capabilities.
- implementing the Sector Development Action Plan which includes actions government and industry are taking to support UK supply chains.

ID 26

Whilst much of the technology needed for hydrogen exists and can be scaled up with sufficient policy incentives, innovation in low-carbon hydrogen technology remains important. This includes both the further development of techniques and technologies that are already proven, and the further development, and bringing to-market, of projects that are less well-known. Funding bodies, like UKRI, having identified the need for such research, should reflect this in their funding programmes. In many cases, such research is more efficiently funded through our grants system than indirectly through subsidised deployment.

Response

Government agrees that innovation in low-carbon hydrogen technology is critical. Hydrogen is currently much more costly to produce and use than existing fossil fuels. Investment in discovery research, as well as development and scaling-up of prototypes of early-stage technologies, will increase the chances that new technologies will be commercially available in the future to reduce the cost and increase the convenience of using hydrogen. The government continues to make significant investments in hydrogen research and innovation through a number of programmes, run by government departments and bodies like UKRI. These programmes include grants and subsidised deployment, both mechanisms have a vital role in developing proven technologies and those that are more nascent. The Net Zero Research and Innovation Framework, published October 2021, represents a first statement of the UK's net zero research and innovation priority areas over the next 5–10 years including hydrogen.

The £1bn Net Zero Innovation Portfolio (NZIP) is a cross-cutting initiative led by DESNZ which funds projects over 2021–2025 to accelerate the commercialisation of innovative, low-carbon technologies, systems and business models (https://www.gov.uk/government/collections/net-zero-innovation-portfolio). It builds directly on the government's previous investments (£505m) in the Energy Innovation Portfolio (EIP). Hydrogen is one of ten themes within NZIP. Prioritisation within NZIP was supported by, among other inputs, data from the 2019 Energy Innovation Needs Assessments, which collated evidence and analysis on the role of different technologies in the UK's future energy system.

NZIP support is generally targeted at technology readiness levels (TRL) 4–7 (TRL 4: Laboratory Testing/Validation of Components/Process; TRL 7 Integrated Pilot System

Demonstrated). Hydrogen-focussed innovation competitions include the Low Carbon Hydrogen Supply 2 Competition, which provides up to £60m funding to support innovation in the supply of hydrogen, reduce the costs of supplying hydrogen, bring new solutions to the market, and ensure that the UK continues to develop world leading hydrogen technologies for a future hydrogen economy. A two-stream approach has allowed more novel technologies to be supported such as feasibility studies on use of plasmolysis to produce hydrogen, as well as large scale demonstrations of more mature technologies such as hydrogen production from floating offshore wind. Other NZIP competitions with projects testing the feasibility of hydrogen solutions include the Hydrogen BECCS competition, Industrial Fuel Switching 2 competition, Longer Duration Energy Storage competition and Red Diesel Replacement competition.

NZIP competitions provide either 100% funding through SBRI contracts (Small Business Research Initiative) or grant-funding where private sector investment is also obtainable, depending on the specifics of the competition. NZIP funding programmes are complementary to other opportunities for hydrogen funding support, such as the NZHF, which operates from TRL7 upwards, and hydrogen business models support.

UKRI is the UK's largest public funder of research and innovation (R&I) across the TRLs with a budget of over £8 billion. A significant portion of UKRI activity is targeted towards solving global energy challenges, and hydrogen R&I is seen as a key tool to grow the hydrogen economy and for the UK to reach net zero emissions by 2050.

UKRI takes an interdisciplinary approach to a wide-range of funding and support across research, innovation and skills activities across the whole hydrogen value chain and system.

For example, the Engineering and Physical Sciences Research Council expect to make an announcement in 2023 regarding new Hubs for Research Challenges and Systems Integration for Hydrogen and Alternative Liquid Fuels building on previous investment through its Hydrogen and Fuel Cell Supergen Hub. Innovate UK's up to £4.5m Hydrogen storage and distribution supply chain competition was announced in January 2022. Innovate UK has also awarded £6m to Hydrogen Innovation Initiative's Seed programme. This programme is a collaborative initiative between the Catapult Network, National Physical Laboratory, Net Zero Technology Centre, the Aerospace Technology Institute and Advanced Propulsion Centre, spanning the end-to-end hydrogen system, which will pilot innovation support for businesses, generate enabling knowledge and capability and help show where future investments are required.

Government is currently supporting subsidised deployment through the NZHF, which is aims to provide up to £240 million to support the development and construction of new low carbon hydrogen production plants. The Fund is open to multiple production technologies, including CCUS-enabled and electrolytic hydrogen, and targeted at projects that can deploy during the 2020s.The NZHF forms part of a suite of measures designed to stimulate the deployment of scalable low carbon hydrogen production.

Recent updates on HMG funding support for hydrogen R&I, including support offered through UKRI, the DfT, and the Ofgem Strategic Innovation Fund (SIF) can be found in the Hydrogen Strategy update to the market: December 2022.

ID 27

As with other low-carbon systems, there are costs associated with the development of infrastructure and the uptake of hydrogen use within every use case. The relatively higher prospective cost of low-carbon hydrogen will increase overall costs of, for example, manufacturing, transportation, or heating. There is a risk that because of these costs and impacts on end user prices, the companies and other entities forming these new hydrogen-based, low-carbon, value chains risk failure from non-competitiveness.

Response

Low carbon hydrogen has an important role to play in decarbonising vital UK industry sectors and provide flexible deployment across power, heat and transport, and potentially heat. The HPBM will provide revenue support to hydrogen producers to overcome the operating cost gap between low carbon hydrogen and high carbon counterfactual fuels, thereby incentivising both production and use of low carbon hydrogen through the provision of ongoing revenue support and making hydrogen an attractive decarbonisation option across sectors. Government is working to consider further appropriate measures to drive investment and deployment across the value chain, including, for example, exploring the need and case for further market intervention on hydrogen power.

Hydrogen transport and storage infrastructure will also be critical to enabling government's hydrogen ambitions as it will connect producers with consumers, and balance misalignment in supply and demand. However, lengthy development lead times, high capital costs and uncertain financial investment returns in a nascent market mean this infrastructure is unlikely to materialise without a supportive policy framework. For this reason, government committed in the BESS to designing new business models for hydrogen transport and storage infrastructure by 2025. Last year, government published a consultation on design options for these business models, and will publish its response in due course.

The UK is committed to protecting our industry from carbon leakage as our economy decarbonises, and currently does so through free allocation under the UK Emission Trading Scheme (ETS). We are currently reviewing our approach to free allocations, looking at ways to better target support for those most at risk of carbon leakage to ensure they are fairly distributed. In addition to this, government is exploring a range of approaches including carbon border adjustment mechanisms (CBAM), mandatory product standards (MPS) as well as measures to grow the low carbon economy (voluntary standards, product labelling and green procurement). Government has committed to develop a Low Carbon Hydrogen Certification Scheme by 2025 to underpin deployment of low carbon hydrogen and support future international trade.