Written Evidence Submitted by Energy Systems Catapult

(HNZ0066)

About Energy Systems Catapult

Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth. The Catapult is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research.

We take a whole-system view of the energy sector, helping us to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest cost.

Our responses on the topics listed in the Committee's call for evidence are set out below.

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

the focus, scale and timescales of the proposed measures;

With insights from ESC's extensive modelling capability and sector knowledge we support the high-level target of 5GWs of production capacity by 2030. Alongside this target there should be an increased emphasis on demand drivers/enablers, market building and systems thinking. We hope the hydrogen strategy can bring action in these areas. Below we detail evidence relevant to each of the targets in the 10-point plan before outlining the measures we think need to be added in the upcoming strategy.

5GWs of hydrogen generators by 2030

ESC's report 'Innovating to Net Zero' depicted different scenarios for how the UK could reach Net Zero emissions by 2050. The two scenarios 'Clockwork' and 'Patchwork' took different routes, one with mainly centralised action and an emphasis on technological innovation and the other based on decentralised action with widespread societal engagement.

This analysis was conducted using ESC's Energy System Modelling Environment (ESME). ESME is an optimisation model and finds the least-cost combination of energy resources and technologies that satisfy UK energy service demands along the pathway to 2050. Constraints include emissions targets, resource availability and technology deployment rates, as well as operational factors that ensure adequate system capacity and flexibility. Importantly, ESME includes a multi-regional UK representation and can assess the infrastructure needed to join up resources, technologies and demands across the country. This includes transmission and distribution networks for electricity and gas, and pipelines and storage for CO2.

For further information on the analysis conducted for this report and its outputs refer to https://es.catapult.org.uk/reports/innovating-to-net-zero/.

The capacity of hydrogen generators deployed by 2050 in the two scenarios is shown below.

Table 1- hydrogen production capacity in the two scenarios, Clockwork and Patchwork

Clockwork	(GW)	
	2020	2050
Fossil	0	1
Fossil CCS	0	37
Bio CCS	0	7
Electrolysis	0	0
Total	0.25	45.37

Patchwork		
	2020	2050
Fossil	0	2
Fossil CCS	0	7
Bio CCS	0	15
Electrolysis	0	18
Total	0.35	41

Both scenarios suggest a large potential role for hydrogen in enabling the UK's transition to Net Zero and therefore a major expansion in hydrogen generation capacity, of various technologies, over the next 30 years.

For an 80% reduction target hydrogen was a strategically important energy vector, but the overall quantity was typically limited to around 100TWh in 2050. For Net Zero, this now increase to 200-300TWh.

This analysis supports early action in the 2020s to develop hydrogen production at scale. This will bring several benefits:

- First, gathering the learnings needed to enable a hydrogen system will take several years. This information will be needed for Government and Industry to make informed decisions on key infrastructure pathways in the 2020s and 2030s and to remove the current barriers to hydrogen use.
- Second, if a hydrogen system which can generate, transport and use 250TWhs of hydrogen per year is then to be created this will require sustained investment for the following years to 2050. This is an ambitious undertaking and starting the transition at scale by 2030 makes sense.
- Third, early deployment may bring benefits for the UK economy beyond just decarbonisation by creating expertise in an important future global industry.

Therefore, ESC supports a target of 5GWs by 2030, as part of emerging strategy to develop a hydrogen economy as well as the creation of industrial clusters. More broadly, in addition to support for early deployment of hydrogen generation, we also support moves to strengthen the wider carbon policy framework across key emitting sectors. This should be seen as the primary driver to incentivise the development and deployment hydrogen as a low carbon energy vector, where it can contribute most value to enabling net zero. (as discussed below).

The optimal mix of hydrogen generation technologies is uncertain. Biomass gasification with CCS is typically deployed within our modelling but may not in practice be able to deliver the volumes of hydrogen likely to be needed. With speculative innovation measures, steam methane reforming at 99% capture rate looks highly appealing for hydrogen production. Any such facilities would produce constantly throughout the year, with the surplus during summer being placed into geological storage for use in winter. Without speculative innovation measures, methane reforming at a 95% capture rate is too high carbon to meet Net Zero.

In that case, electrolysis is preferred, but at higher cost this makes hydrogen less appealing overall. Our analysis also tested the possible role of advanced nuclear for hydrogen production, drawing on data from one of the engineering deep-dives in our wider Net Zero Insights programme. Across a range of cost assumptions, deployment of these HTGRs looked favourable in ESME, with annual production of 50-100TWh of hydrogen in 2050.

Therefore, we support different technologies being developed in the next decade to maintain optionality. Once cost trajectories and system value are clearer due to both international and domestic learnings, technologies can compete. Furthermore, current modelling suggests a combination of different technologies could be cost optimal.

In the short term, we see these as the innovation needs for hydrogen production:

- Very high carbon capture rates may be critical to ensuring a role for steam methane reforming (SMR+CCS).
- Electrolysis appears a more expensive option, but innovation (including learning by doing) can bring down cost and improve performance. Demonstrating electrolysis at scale in the 2020s should be a priority given implementation risks with SMR+CCS (which, if proven successfully, may then compete to deliver lower cost hydrogen to the consumer).
- Advanced nuclear technology for production of hydrogen could be an important new option, particularly where these facilities can operate flexibly between generation of electricity, hydrogen and heat, supporting multiple end use applications.

Our Patchwork and Clockwork scenarios also consider the end use of hydrogen.

Our data and analysis suggest low carbon hydrogen would be best used for decarbonising Industry in the 2030s with some use in long range heavy transport and off highway transport.

The scenarios show the use in both these areas growing to 2050 alongside a large role for hydrogen in electricity peaking plant, heating and shipping. It is important that trials and R&D are conducted in these areas to gather learnings, develop technologies and remove barriers to their deployment. There is some uncertainty over the best decarbonisation route for some applications, in these instances both options should be explored to collect evidence and enable future options and decision making.

Hydrogen Town

ESC supports the action needed to enable a hydrogen town and is in favour of place-based action to build local supply chains and inspire other regions. However, we suggest that the 'hydrogen town' could instead be one of several 'Net Zero Towns' or 'Low Carbon Towns' one with an emphasis on hydrogen. This approach would enable the right energy vector to be used in the correct place within an area rather than hydrogen being used when it is not the best solution. Most importantly with low carbon heating our Local Area Energy Planning (LAEP) modelling shows that different areas of the same town or city often have different cost-optimal low carbon heating solutions i.e regions near a source of waste heat may be better with a heat network or apartment blocks may be better off with electric heat pumps. As such we support the ambition of this target, but believe it would be more powerful if combined with other work to create several 'Net Zero/Low

Carbon Towns' which have robust hydrogen supply chains as well as pursuing other low carbon actions where best suited.

Local Area Energy Planning (LAEP) could support the development of these Net Zero/Low Carbon Towns. LAEP is a robust and consistent whole energy system analysis, combined with comprehensive and inclusive stakeholder engagement which identifies potential cost-effective and low regret solutions for a local area. It creates robust and actionable whole system decarbonisation plans for local areas which reflect the unique nature of a local area – its people, geography, building stock, energy system, ambitions and priorities.

It has been piloted in three different local areas - Newcastle, Bury (Greater Manchester) and Bridgend. ESC has been working with Ofgem and the Centre for Sustainable Energy to develop a LAEP guidance to support the development of consistent, robust and transparent local area energy plans and encourage the development and application of transparent and consistent methodological approaches across industry. Available at: https://es.catapult.org.uk/reports/local-area-energy-planning-the-method/

These new LAEP approaches can play a key role in facilitating the creation of robust whole system decarbonisation plans for local areas. As such, it could be valuable to link this process which could support country wide decarbonisation with the 'Net Zero/Low Carbon Towns' as a way to improve both their efficiency/success and replicability.

Lack of focus on demand drivers/enablers

Hydrogen as an energy vector and investment will be inherently linked to the rest of the energy system. To develop a hydrogen industry cost effectively there needs to be an increased focus on enabling entire hydrogen systems to develop. The necessary investment in hydrogen production will be lower if there is a clear supply chain and demand for the hydrogen. Hydrogen policy must consider demand in the following ways:

- First, the hydrogen demand drivers, such as policies pricing carbon or the availability of alternative low carbon options, in sectors that could use hydrogen in the short term should be considered. Our work within the Rethinking Decarbonisation Incentives project and more recently in Net Zero Carbon Policy highlights the uneven effective carbon prices across different UK energy uses and vectors:

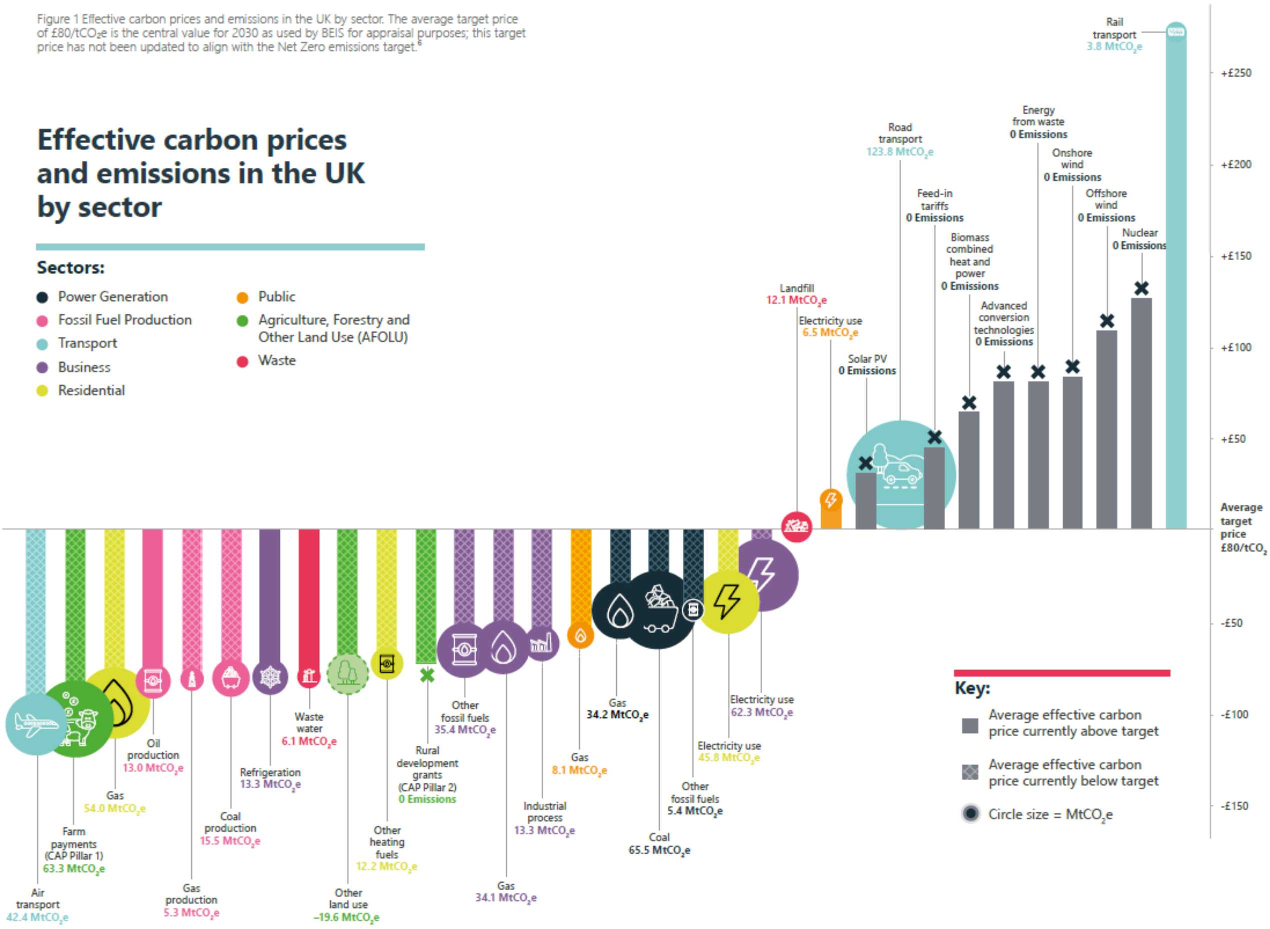

Figure 1 Effective carbon prices and emissions in the UK by sector. The average target price of £80/tCO2e is the central value for 2030 as used by BEIS for appraisal purposes; this target price has not been updated to align with the Net Zero emissions target.[6]

Effective carbon prices are the incentive or reward for a firm or individual to reduce emissions (in £/tCO2e) resulting from direct (e.g. explicit carbon pricing instruments, energy and fuel taxation, etc.) and indirect (e.g. reduced VAT on energy, subsidies for low and zero carbon options, etc.) carbon policies.

It is particularly important for the hydrogen economy that there is a more coherent economy-wide balance of decarbonisation incentives, given the flexibility of H2 to play a key role across a range of emitting sectors. A more coherent carbon policy framework will create incentives to drive hydrogen usage where it adds most value to the overall UK transition to net zero.

In Accelerating to Net Zero we explored the potential for a sector led approach to carbon policy that can accelerate progress during the 2020s from the incomplete and unbalanced pattern of current carbon policies towards a more coherent economy-wide carbon policy framework in the 2030s. This style of thinking which comprehensively considers long term carbon policy should be embedded in the hydrogen strategy.

- Second, there are significant regulatory and operational barriers currently to the transmission/distribution and use of hydrogen. A coordinated workstream possibly similar to the Smart Systems and Flexibility Plan, should be established to highlight barriers, coordinate change and drive fast action. This is key not only to remove barriers but also to improve confidence that hydrogen use will be enabled in the future. This work could have a wide remit to consider more than pure regulatory barriers (such as gas standards that do not allow hydrogen blending) and also consider the barriers to hydrogen conversion such as the lack of mechanism for deciding to convert an area to hydrogen.

These barriers must be removed in a coordinated way with a clear repository of information on the actions being taken and timelines for their removal. For a hydrogen economy to develop a wide array of stakeholders will need to engage and invest. Without a clear repository of information on Government/Industrial action it will be difficult for these diverse stakeholders to do so.

- Third, to signal a long-term demand for hydrogen and enable it to meet its full potential, trials should be conducted in area where they are needed to enable this option in the future. These trials can be used to gather learnings and to develop technologies and supply chains (such as in HGVs, hydrogen boilers or electricity generators).

This action together would:

- support the development of a hydrogen industry
- build investor confidence in the long term role for hydrogen
- place the UK at the forefront of new uses for hydrogen
- set the UK on a path to Net Zero.

As well as creating policy which considers hydrogen demand there also needs to be visibility of possible demand and supply projects to help connect these different elements and thereby build the market quicker at a lower cost. This may be difficult due to the large number of sectors that could use hydrogen in the coming decades. Therefore, this should be actively supported. The Catapult Network is working together to develop a dedicated vehicle to support hydrogen innovation and help support industry development in this way (outlined fully below).

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

A current initiative from the Catapult Network could help coordinate action. Recognising the opportunity for investment in hydrogen to support economic recovery and delivering net zero ambitions the Catapult Network is working together to create a new special purpose vehicle for delivery of an end-to-end programme of innovation to support government and industry in the creation of a UK hydrogen economy and the coordination and alignment of R&D activity. This is proposed to forge the strategic linkages across the value chain and create a focal point and connected innovation backbone.

As the connection between Industry, Academia and Government this new initiative will help coordinate action in this space as bringing together key stakeholders, different areas of expertise and new opportunities.

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

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

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

For the Milford Haven: Energy Kingdom project ESC are creating a systems architecture for a smart local energy system including the production, transport and use of hydrogen in the UK, its integration with electricity and gas vectors. This work extends beyond the technical interfaces and considers policy, markets, trading approaches, data, digital interfaces and the roles and responsibilities of different actors. This will consider potential future systems and use this to determine short term opportunities as well as detailing how projects should be created today to future proof them for future systems. Once the project has completed this work, the team would be happy to discuss with the relevant teams at BEIS

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

The analysis completed using the model ESME (outlined in section 1) could support this work. ESME is an optimisation model and finds the least-cost combination of energy resources and technologies that satisfy UK energy service demands along the pathway to 2050. Therefore, it can show the system value of hydrogen in the transition to Net Zero, as well as the impact of technology improvements on the transition.

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

Refer to section 1.

(January 2021)