Committee on Climate Change

Independent advice to government on building a low-carbon economy and preparing for climate change

The Sixth Carbon Budget and Welsh emissions targets – Call for Evidence

Background to the UK's sixth carbon budget

The UK Government and Parliament have adopted the Committee on Climate Change's (CCC) recommendation to target net-zero emissions of greenhouse gases (GHGs) in the UK by 2050 (i.e. at least a 100% reduction in emissions from 1990).

The Climate Change Act (2008, 'the Act') requires the Committee to provide advice to the Government about the appropriate level for each carbon budget (sequential five-year caps on GHGs) on the path to the long-term target. To date, in line with advice from the Committee, five carbon budgets have been legislated covering the period out to 2032.

The Committee must provide advice on the level of the sixth carbon budget (covering the period from 2033-37) before the end of 2020. The Committee intends to publish its advice early, in September 2020. This advice will set the path to net-zero GHG emissions for the UK, as the first time a carbon budget is set in law following that commitment.

Both the 2050 target and the carbon budgets guide the setting of policies to cut emissions across the economy (for example, as set out most recently in the 2017 Clean Growth Strategy).

The Act also specifies other factors the Committee must consider in our advice on carbon budgets – the advice should be based on the path to the UK's long-term target objective, consistent with international commitments and take into account considerations such as social circumstances (including fuel poverty), competitiveness, energy security and the Government's fiscal position.

The CCC will advise based on these considerations and a thorough assessment of the relevant evidence. This Call for Evidence will contribute to that advice.

Background to the Welsh third carbon budget and interim targets

Under the Environment (Wales) Act 2016, there is a duty on Welsh Ministers to set a maximum total amount for net Welsh greenhouse gas emissions (Welsh carbon budgets). The first budgetary period is 2016-20, and the remaining budgetary periods are each succeeding period of five years, ending with 2046-50.

The Committee is due to provide advice to the Welsh Government on the level of the third Welsh carbon budget (covering 2026-30) in 2020, and to provide updated advice on the levels of the second carbon budget (2021-25) and the interim targets for 2030 and 2040. Section D of this Call for Evidence (covering questions on Scotland, Wales and Northern Ireland) includes a set of questions to inform the Committee's advice to the Welsh Government.

Question and answer form

When responding, please provide answers that are as specific and evidence-based as possible, providing data and references to the extent possible.

Please limit your answers to <u>400 words</u> per question and provide supporting evidence (e.g. academic literature, market assessments, policy reports, etc.) along with your responses.

A. Climate science and international circumstances

Question 1: The climate science considered in the CCC's 2019 Net Zero report, based on the IPCC Special Report on Global Warming of 1.5°C, will form the basis of this advice. What additional evidence on climate science, aside from the most recent IPCC Special Reports on Land and the Oceans and Cryosphere, should the CCC consider in setting the level of the sixth carbon budget?
ANSWER:

Question 2: How relevant are estimates of the remaining global cumulative CO_2 budgets (consistent with the Paris Agreement long-term temperature goal) for constraining UK cumulative emissions on the pathway to reaching net-zero GHGs by 2050?
ANSWER:

Question 3: How should emerging updated international commitments to reduce emissions by 2030 impact on the level of the sixth carbon budget for the UK? Are there other actions the UK should be taking alongside setting the sixth carbon budget, and taking the actions necessary to meet it, to support the global effort to implement the Paris Agreement?
ANSWER:

Question 4: What is the international signalling value of a revised and strengthened UK NDC (for the period around 2030) as part of a package of action which includes setting the level of the sixth carbon budget?
ANSWER:

B. The path to the 2050 target

Question 5: How big a role can consumer, individual or household behaviour play in delivering emissions reductions? How can this be credibly assessed and incentivised?
Consumers must be at the centre of emissions reductions or the required actions will not have the political or public success required. Greta Thunberg and the Climate Rebellion movement demonstrate the power of citizens/consumers to set demand effective and

Question 5: How big a role can consumer, individual or household behaviour play in delivering emissions reductions? How can this be credibly assessed and incentivised?

timely action from Government and business, and to change public behaviour. However, if this action is not widely perceived by the public as fair, proportional and affordable there will be a backlash which will slow or reverse progress to Net Zero. There must be widespread public acceptance that Wind and Solar PV are now the cheapest forms of power generation and that if we invest now in other technologies, they too will become cost-effective.

We emphasise the key role of significant energy efficiency improvement across households, businesses and the public sector, without which a cost-effective transition to Net Zero is unlikely to be possible. Some low carbon technologies, such a heat pumps, will only operate effectively once a building has been made much more energy efficient than many are today. We note the findings of the recent Energy Efficiency Infrastructure Group (EEIG) report[6] which, among other things, highlighted a sharp fall in public energy efficiency investment[7] between 2012 and 2017, especially in England & Wales.

It is now widely accepted that a previous Government decision to step away from Net Zero consistent building standards for new homes was a major missed opportunity[8] which the current Future Homes Standard review being conducted by the Ministry of Housing, Communities & Local Government (MHCLG)[9] now offers scope to address.

It is estimated that around 80-85% of UK homes which will exist in 2050 have already been built, so the decarbonisation of existing properties is an even more important priority. Moreover, the Energy Company Obligation (ECO) scheme is now almost exclusively focused on those defined to be 'fuel poor' – whilst the Government's £9.2 bn Manifesto commitment was based around a wider national energy efficiency policy, to be defined, which also reaches other households and businesses.

One possible approach to incentivising energy efficiency improvement on a much wider scale would be to more towards a more consistent and appropriate carbon price signal across the whole economy. Currently, fossil fuels for power generation face a combined carbon tax of around £38/tonne, whilst consumption of natural gas by end consumers carries no such tax at all, and even £38/tonne appears to fall well short of the 'shadow' carbon price (social cost of CO_2 emissions) implied by future UK Carbon Budgets[10].

There is thus a case to redress this incentive shortfall, but in practice we consider that higher carbon taxes are unlikely to be sufficient (or timely) on their own. Moreover, behavioural economics suggests that individuals are more likely to respond to specific

[6] https://www.theeeig.co.uk/media/1063/eeig_net-zero_1019.pdf

[7] This includes the measures delivered via the Energy Company Obligation placed on household energy suppliers.

[8] See, for example: https://www.theeeig.co.uk/media/1026/fe-energy-efficiency-final-clean-250917.pdf

[9] https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings

[10] See, for example: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/05/GRI-POLICY-BRIEF_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf

Question 5: How big a role can consumer, individual or household behaviour play in delivering emissions reductions? How can this be credibly assessed and incentivised?

targeted incentives[11]. Accordingly, we suggest that policy makers should further develop the following approaches:

- some direct co-funding of energy efficiency measures from the 'public' purse[12] (cf. matched funding of overseas development aid projects spearheaded by charities);
- use of market-based mechanisms (such as ECO) which provide an incentive to deliver energy efficiency measures at least cost); and
- specific tax rebates (Council Tax, business rates, etc.) for those committing to improve the energy efficiency of their properties.

It is also important to ensure that regulation and incentives work effectively hand-in-hand. One of the more successful recent policy interventions has been the setting of more ambitious efficiency standards for electrical appliances and there should be extensive scope to extend this principle in future (e.g. to the incorporation of automated time-of-use design in 'smart' household appliances). Research to date[13] suggests that only a minority of households would be ready to adjust their real-time consumption to electricity spot price variations, without the support of such 'smart' technology.

Question 6: What are the most important uncertainties that policy needs to take into account in thinking about achieving Net Zero? How can government develop a strategy that helps to retain robustness to those uncertainties, for example low-regrets options and approaches that maintain optionality?

There are of course many uncertainties around a 30-year energy transition, but some of the most important include:

- future fossil fuel prices and thus the level of support required to deliver the transition to Net Zero;
- the available suite of 'candidate' cost effective, low carbon technologies which will be available by (say) 2040 – including not only the primary technologies themselves (e.g. the scale and capacity of wind turbines), but also their cost/performance (e.g. heat pumps, electric vehicles) and key ancillary technologies (e.g. for the long-distance transportation of hydrogen, either directly or via another 'vector' such as ammonia);
- crucially, the 'learning curve' of cost reduction as each of the key low carbon technologies is rolled out at commercial scale across the globe – examples being wind and solar power to date[14], or the scope for unit cost reduction in electrolysers to produce 'green' hydrogen in the future; and

[11] An excellent recent example is summarised here: https://hbr.org/2016/08/virgin-atlantic-tested-3-ways-to-change-employee-behavior

[12] Socialising part of the cost, via taxes or energy bills

[13] See, for example, this 2016 paper from the Cambridge Energy Policy Research Group: http://www.eprg.group.cam.ac.uk/wp-content/uploads/2016/05/1616-Text.pdf

[14] See, for example, DNV-GL's Energy Transition Outlook 2019 report, p. 39: file:///C:/Users/paulh/Downloads/DNV_GL_Energy_transition_Outlook_2019_lowres_single_20191115.pdf.

Question 6: What are the most important uncertainties that policy needs to take into account in thinking about achieving Net Zero? How can government develop a strategy that helps to retain robustness to those uncertainties, for example low-regrets options and approaches that maintain optionality?

- the growing operational challenges for Electricity System Operators and others in maintaining system stability and integrity as we move towards Net Zero, including an increased role for energy storage. Although the general trend is evident, it is not yet clear to what extent large, centralised, low carbon generating plants (e.g. nuclear, other generation with CCUS) will be maintained on the system.

We consider that the CCC (in 2019) was quite correct to identify key 'low regret' options for the period to 2030/2035 and in particular we note the need to demonstrate hydrogen plus CCUS before the end of this decade. There is a valuable opportunity to enhance the robustness of our strategy by learning lessons from elsewhere, e.g. the rapid development of hydrogen as a low carbon fuel in Japan and Germany and seeking technology break throughs which can accelerate progress to Zero Carbon for heating and transport.

Most of the 'candidate' large-scale hydrogen projects in the UK would be based on steam reforming of methane (often referred to as 'AMR' or 'blue hydrogen') plus carbon capture and storage. These will be complex and multi-faceted projects which will require socialised financial support[15] in the initial phase and a fully joined-up approach to policy and regulation across the whole of the relevant value chain. At the same time, it will be important for Government to maintain competitive and/or regulatory incentives for efficient investment and operations, wherever possible, whilst avoiding the unfortunate policy reversals which have so bedevilled previous attempts to promote CCUS investment in the UK. See our response to Qu. 31 for further detail

Question 7: The fourth and fifth carbon budgets (covering the periods of 2023-27 and 2028-32 respectively) have been set on the basis of the previous long-term target (at least 80% reduction in GHGs by 2050, relative to 1990 levels). Should the CCC revisit the level of these budgets in light of the net-zero target?

ANSWER:

Question 8: What evidence do you have of the co-benefits of acting on climate change compatible with achieving Net Zero by 2050? What do these co-benefits mean for which emissions abatement should be prioritised and why?

ANSWER:

DNV expect the historical cost learning rate for both offshore and onshore wind of around 16% per doubling of installed global capacity, to continue through to 2050

[15] Over and above any plausible carbon price incentive. It is widely estimated that the bulk cost of 'blue' hydrogen delivered via a First of a Kind (FOAK) project with AMR + CCS may be 4-5 times the current wholesale price of natural gas.

C. Delivering carbon budgets

Question 9: Carbon targets are only credible if they are accompanied by policy action. We set out a range of delivery challenges/priorities for the 2050 net-zero target in our Net Zero advice. What else is important for the period out to 2030/2035?

We have already identified or alluded to several key policy priorities in previous answers and we would expect many of them to be addressed in the forthcoming Energy White Paper. As indicated above, we would not draw any hard-and-fast line between policy and regulation; it is vital that the two are aligned as part of a holistic (joined-up approach) to an unprecedented challenge which will impact all of British society in a major way. We also note the need for large scale public education, information and communication, e.g. around the maintenance of a robust safety case as new and unfamiliar technologies (such as hydrogen) are rolled out at scale and the affordability of urgent investment in low carbon technologies and behaviours.

In our view, the most important policy and regulation priorities out to 2030/2035 include the following:

- Developing policy and regulation to support an acceleration of cost-effective offshore wind development. This is likely to involve material change to existing electricity transmission arrangements, both offshore and onshore. (See Qu. 29 for further detail.)
- Developing an appropriate policy and regulatory framework to support the demonstration of hydrogen plus CCUS at a large commercial scale before 2030. (See Qu. 31.)
- Setting a framework for delivering the £9.2 bn energy efficiency spending commitment in the Conservative election Manifesto and the Queen's Speech of December 2019.
- Establish a legal carbon footprint measurement and reporting system which investors can use to accurately access and communicate the sustainability of their portfolio so that they can manage climate change risk and attract "green funds". This can be a powerful tool for pivoting capital based in London towards green investments and away from brown investments.
- Delivering a credible and sustainable long-term policy for the support of low carbon heating (given the expiry of the current Renewable Heat Incentive, as soon as March 2021). This includes continued support for low carbon gas development (bio-methane and hydrogen). For bio-methane a promising pipeline of low carbon industry/project development is at risk of being prematurely curtailed.
- Reviewing the scope for greater deployment of (relatively low cost) onshore wind than has been achieved in recent year, at least in areas where there is community acceptance of such projects. If and where pursued, this is likely to require changes to the recently restrictive planning regime, especially in England.
- Ensuring a consistent and effective policy and regulation approach to facilitating low carbon transport (principally electric and hydrogen vehicles). This is not only a matter of national policy, but also regulation/incentives which promote the efficient use of constrained electricity and gas grids, public access to charging facilities and other local regulations (e.g. around parking facilities, Health & Safety and the use of roads).
- Joined-up consideration of the way in which recent and prospective regulatory change (e.g. the Targeted Charging Review of electricity network charging) is impacting the likely development of decentralised renewable projects.
- Finding ways to engage Local Authorities more effectively in the Net Zero transition and (including the capital spending regime) and release the latent power of Community Energy initiatives.

Question 9: Carbon targets are only credible if they are accompanied by policy action. We set out a range of delivery challenges/priorities for the 2050 net-zero target in our Net Zero advice. What else is important for the period out to 2030/2035?

- Effective sharing, learning from and adoption of international best practice in low carbon initiatives, policy and regulation – for which the UK Presidency of COP 26 will no doubt provide an excellent platform.
- An effective communications programme so that broad public support for investment in Net Zero and the adoption of new technologies is maintained and enhanced.

Question 10: How should the Committee take into account targets/ambitions of UK local areas, cities, etc. in its advice on the sixth carbon budget?

ANSWER:

Question 11: Can impacts on competitiveness, the fiscal balance, fuel poverty and security of supply be managed regardless of the level of a budget, depending on how policy is designed and funded? What are the critical elements of policy design (including funding and delivery) which can help to manage these impacts?

ANSWER:

Question 12: How can a just transition to Net Zero be delivered that fairly shares the costs and benefits between different income groups, industries and parts of the UK, and protects vulnerable workers and consumers?

ANSWER:

D. Scotland, Wales and Northern Ireland

Question 13: What specific circumstances need to be considered when recommending an emissions pathway or emissions reduction targets for Scotland, Wales and/or Northern Ireland, and how could these be reflected in our advice on the UK-wide sixth carbon budget?

ANSWER:

Question 14: The Environment (Wales) Act 2016 includes a requirement that its targets and carbon budgets are set with regard to:

- The most recent report under section 8 on the State of Natural Resources in relation to Wales;
- The most recent Future Trends report under section 11 of the Well-Being of Future Generations (Wales) Act 2015;
- The most recent report (if any) under section 23 of that Act (Future Generations report).

a) What evidence should the Committee draw on in assessing impacts on sustainable management of natural resources, as assessed in the state of natural resources report?

b) What evidence do you have of the impact of acting on climate change on well-being? What are the opportunities to improve people's well-being, or potential risks, associated with activities to reduce emissions in Wales?

c) What evidence regarding future trends as identified and analysed in the future trends report should the Committee draw on in assessing the impacts of the targets?

d) Question 12 asks how a just transition to Net Zero can be achieved across the UK. Do you have any evidence on how delivery mechanisms to help meet the UK and Welsh targets may affect workers and consumers in Wales, and how to ensure the costs and benefits of this transition are fairly distributed?

ANSWER:

Question 15: Do you have any further evidence on the appropriate level of Wales' third carbon budget (2026-30) and interim targets for 2030 and 2040, on the path to a reduction of at least 95% by 2050?

ANSWER:

Question 16: Do you have any evidence on the appropriate level of Scotland's interim emissions reduction targets in 2030 and 2040?

ANSWER:

Question 17: In what particular respects do devolved and UK decision making need to be coordinated? How can devolved and UK decision making be coordinated effectively to achieve the best outcomes for the UK as a whole?

ANSWER:

E. Sector-specific questions

Question 18 (Surface transport): As laid out in Chapter 5 of the Net Zero Technical Report (see page 149), the CCC's Further Ambition scenario for transport assumed 10% of car miles could be shifted to walking, cycling and public transport by 2050 (corresponding to over 30% of trips in total):

a) What percentage of trips nationwide could be avoided (e.g. through car sharing, working from home etc.) or shifted to walking, cycling (including e-bikes) and public transport by 2030/35 and by 2050? What proportion of total UK car mileage does this correspond to?

b) What policies, measures or investment could incentivise this transition?

ANSWER:

Question 19 (Surface transport): What could the potential impact of autonomous vehicles be on transport demand?

ANSWER:

Question 20 (Surface transport): The CCC recommended in our Net Zero advice that the phase out of conventional car sales should occur by 2035 at the latest. What are the barriers to phasing out sales of conventional vehicles by 2030? How could these be addressed? Are the supply chains well placed to scale up? What might be the adverse consequences of a phase-out of conventional vehicles by 2030 and how could these be mitigated?

ANSWER:

Question 21 (Surface transport): In our Net Zero advice, the CCC identified three potential options to switch to zero emission HGVs – hydrogen, electrification with very fast chargers and electrification with overhead wires on motorways. What evidence and steps would be required to enable an operator to switch their fleets to one of these options? How could this transition be facilitated?

ANSWER:

Question 22 (Industry): What policy mechanisms should be implemented to support decarbonisation of the sectors below? Please provide evidence to support this over alternative mechanisms.

a) Manufacturing sectors at risk of carbon leakage

b) Manufacturing sectors not at risk of carbon leakage

c) Fossil fuel production sectors

d) Off-road mobile machinery

ANSWER:

Question 23 (Industry): What would you highlight as international examples of good policy/practice on decarbonisation of manufacturing and fossil fuel supply emissions? Is there evidence to suggest that these policies or practices created economic opportunities (e.g. increased market shares, job creation) for the manufacturing and fossil fuel supply sectors?

ANSWER:

Question 24 (Industry): How can the UK achieve a just transition in the fossil fuel supply sectors?

ANSWER:

Question 25 (Industry): In our Net Zero advice, the CCC identified a range of resource efficiency measures that can reduce emissions (see Chapter 4 of the Net Zero Technical Report, page 115), but found little evidence relating to the costs/savings of these measures. What evidence is there on the costs/savings of these and other resource efficiency measures (ideally on a £/tCO2e basis)?

ANSWER:

Question 26 (Buildings): For the majority of the housing stock in the CCC's Net Zero Further Ambition scenario, 2050 is assumed to be a realistic timeframe for full roll-out of energy efficiency and low-carbon heating.

a) What evidence can you point to about the potential for decarbonising heat in buildings more quickly?

b) What evidence do you have about the role behaviour change could play in driving forward more extensive decarbonisation of the building stock more quickly? What are the costs/levels of abatement that might be associated with a behaviour-led transition?

ANSWER:

Question 27 (Buildings): Do we currently have the right skills in place to enable widespread retrofit and build of low-carbon buildings? If not, where are skills lacking and what are the gaps in the current training framework? To what extent are existing skill sets readily transferable to low-carbon skills requirements?

ANSWER:

Question 28 (Buildings): How can local/regional and national decision making be coordinated effectively to achieve the best outcomes for the UK as a whole? Can you point to any case studies which illustrate successful local or regional governance models for decision making in heat decarbonisation?

ANSWER:

Question 29 (Power): Think of a possible future power system without Government backed Contracts-for-Difference. What business models and/or policy instruments could be used to continue to decarbonise UK power emissions to close to zero by 2050, whilst minimising costs?

This question raises important points around the accelerated development of offshore wind, with the ambitious 2030 capacity target of 40 GW in mind. Despite the successful development of around 8.5 GW to date and a rapidly falling cost trajectory, a 'souped up BAU' approach is most unlikely to maintain the necessary pace of development.

For example, Crown Estates has started a new auction round for site leases and will need to organise very significant auctions in the next few years, stepping up annual incremental capacity to some 6,000 MW per annum from now to 2025. Without clear signalling and proper planning and advanced/anticipatory transmission system development, supply chains, particularly the electricity transmission cable manufacturers will be stretched too far with a real danger that this will involve inefficiencies, project delays and higher costs to the consumer. There needs to be a holistic, global approach to delivery.

As offshore wind farms scale up relative to the capacity of the onshore transmission system, connection and use-of-system costs are of increasing importance to overall project economics and financing. Given the ongoing 'targeted charging review' of electricity network charging arrangements being led by Ofgem, careful consideration needs to be given to the potential impact and the resulting future charging uncertainty vis-à-vis the need for long-term project investment and financing commitments at scale[16].

It is also likely that offshore transmission arrangements will need to evolve from the existing 'spoke' model (from individual wind farm to a dedicated landing point) and facilitate a much more 'networked' offshore system in which shared facilities and third party access become the norm in order to deliver cost-effective access from a growing number of locations located at increased distances from shore. Going forward, further consideration will also need to be given to the role of cross-border electricity interconnectors (traditionally conceived and delivered as point-to-point) can play in becoming a 'spine' to which offshore wind farms can connect, thus starting to deliver a long-discussed 'North Sea grid'.

Cross-sectoral policy and regulation is also likely to be called for, e.g. as regards the scope for offshore oil and gas platforms (which would otherwise be decommissioned) to offer transmission linkage 'hubs' in remote deep-water locations where the considerable cost of new bespoke facilities can be in part avoided.

As far as the future role of CfDs or PPAs is concerned, one significant and growing issue for wind farm developers is uncertainty around the future level of transmission charges[17].

[16] To put this in context, BNEF's 2019 New Energy Outlook forecasts global spending on Wind and Solar of $9.5 trillion between now and 2050: https://about.bnef.com/new-energy-outlook/

[17] Transmission use-of-system charges typically account for around 50% of total operating costs for an offshore wind farm.

Question 29 (Power): Think of a possible future power system without Government backed Contracts-for-Difference. What business models and/or policy instruments could be used to continue to decarbonise UK power emissions to close to zero by 2050, whilst minimising costs?

Future PPAs might potentially include pass-through of such costs, unless developers are allowed to purchase long term capacity at known indexed costs (as has been the case for many years with incremental GB gas transmission entry capacity).

Alternative arrangements would also provide greater certainty around the expected level of public support costs for offshore wind. One of the issues with CfDs plus the Levy Control Framework has been the way in which the quantum of financial support has varied with highly variable fossil fuel costs driving changes in the level of wholesale electricity market prices.

The shift to low carbon generation backed by CfDs, alongside the development of the Capacity Market, have already given Government and Ofgem a significantly greater role in the wholesale electricity market, in conjunction with the Electricity System Operator. Much of this is unlikely to be reversed, even if the required level of public support (subsidy) continues to fall over time.

In all these respects, and more, a holistic approach across public policy-makers, regulatory agencies and delivery bodies – engaging appropriately with developers and providers of finance – will be essential to the delivery of hugely challenging targets in a cost-effective manner.

Question 30 (Power): In Chapter 2 of the Net Zero Technical Report we presented an illustrative power scenario for 2050 (see pages 40-41 in particular):

a) Which low-carbon technologies could play a greater/lesser role in the 2050 generation mix? What about in a generation mix in 2030/35?

b) Power from weather-dependent renewables is highly variable on both daily and seasonal scales. Modelling by Imperial College which informed the illustrative 2050 scenario suggested an important role for interconnection, battery storage and flexible demand in a future low-carbon power system:

   i. What other technologies could play a role here?

   ii. What evidence do you have for how much demand side flexibility might be realised?

ANSWER:

Question 31 (Hydrogen): The Committee has recommended the Government support the delivery of at least one large-scale low-carbon hydrogen production facility in the 2020s. Beyond this initial facility, what mechanisms can be used to efficiently incentivise the production and use of low-carbon hydrogen? What are the most likely early applications for hydrogen?

The UK low carbon hydrogen project proposals currently in the public domain, span a wide range of possible applications: e.g. power generation; industrial process heating; residential energy distribution and supply; and certain types of low carbon transport (especially heavy goods vehicles, trains and public service fleets for which there is no readily available economic EV alternative).

If commercial scale hydrogen can be demonstrated at a cost which suggests that is a part of the least cost pathway to Net Zero, then in the longer term it could well find a market in all of these applications[18]. In the period to 2030, however, the over-riding priority is to realise a large-scale demonstration project; the application is not irrelevant, but it is a second-order consideration.

The immediate key objective should be to develop a policy, regulation and support framework which can facilitate a First of a Kind (FOAK) hydrogen project and then, with suitable adaptations, incentivise further hydrogen projects where they can contribute towards meeting Net Zero at reasonable least cost. Since most UK hydrogen projects would be based on AMR plus CCUS, this may well tie in with the Government's policy commitment[19] to CCUS deployment for the decarbonisation of industry and power.

In 2019, the Government took an initial step towards this objective with the BEIS consultation on business models for CCUS development[20], Chapter 5 of which dealt specifically with CCUS for hydrogen production. The Government reply to consultation responses remains pending, but one core idea was to adapt a Regulatory Asset Base (RAB) model of regulation which has already been applied to the Thames Tideway Tunnel and which the Government is also exploring for new nuclear power stations.

We see considerable potential in this approach, which could drive down the cost of capital significantly, but considerable further development would be required to ensure that it is 'fit for purpose' as far as hydrogen is concerned. In particular:

[18] See Figure 12 in this recent OIES paper for some estimates of the 'learning curve' potential for reduced hydrogen production costs between now and 2050. These will clearly depend on global (and not just UK) roll-out rates for these new low carbon technologies. For example, they estimate a cost of under €50/MWh for green hydrogen in 2050.

[19] From the background briefing for the Queen's Speech of December 2019: "We will support decarbonisation of industry and power by investing £800 million to build the first fully deployed carbon capture storage cluster by the mid-2020s."

[20] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819648/ccus-business-models-consultation.pdf

Question 31 (Hydrogen): The Committee has recommended the Government support the delivery of at least one large-scale low-carbon hydrogen production facility in the 2020s. Beyond this initial facility, what mechanisms can be used to efficiently incentivise the production and use of low-carbon hydrogen? What are the most likely early applications for hydrogen?

- There are various elements to an integrated hydrogen project (e.g. production, hydrogen pipelines, CO2 capture, transportation and storage), each of which have their own characteristics. They will probably require tailored policy and regulation frameworks, within a coherent and consistent approach to the project as a whole.
- Policy makers will need to decide how much (socialised) financial support they are willing to provide to a FOAK project, which risks could be socialised and which should be borne by the project sponsors, potentially as part of a risk/reward sharing mechanism based around an *ex ante* benchmark RAB.
- Whilst candidate FOAK hydrogen projects have different characteristics, there should be more scope for competition to secure funding and this will also need careful design to be effective and at the same time minimise the risk of 'policy failure' such that no project is implemented.
- With support from regulators, policy makers will also need to decide which elements of the hydrogen supply chain should remain a longer-term regulated monopoly; which can be opened to competition (either immediately or after an initial period); and what obligations should be placed on infrastructure owners (e.g. to offer Third Party Access) whilst preserving the prospect of investment viability.
- Making the link between FOAK and subsequent hydrogen projects, it is possible that CO2 storage and/or transportation facilities should be 'oversized' relative to immediate project needs and this anticipatory investment will need to be reflected appropriately in the policy and regulation framework.
- Policy makers are also likely to attach certain other conditions to any public support. These should certainly include the safety case, as a top priority; other possible criteria include sustainability (defining 'low carbon' hydrogen) and local supply chain development (procurement sourcing and 'green job' creation).

Question 32 (Aviation and Shipping): In September 2019 the Committee published advice to Government on international aviation and shipping and Net Zero. The Committee recognises that the primary policy approach for reducing emissions in these sectors should be set at the international level (e.g. through the International Civil Aviation Organisation and International Maritime Organisation). However, there is still a role for supplementary domestic policies to complement the international approach, provided these do not lead to concerns about competitiveness or carbon leakage. What are the domestic measures the UK could take to reduce aviation and shipping emissions over the period to 2030/35 and longer-term to 2050, which would not create significant competitiveness or carbon leakage risks? How much could these reduce emissions?

ANSWER:

Question 33 (Agriculture and Land use): In Chapter 7 of the Net Zero Technical Report we presented our Further Ambition scenario for agriculture and land use (see page 199). The scenario requires measures to release land currently used for food production for other uses, whilst maintaining current per-capita food production. This is achieved through:

- A 20% reduction in consumption of red meat and dairy
- A 20% reduction in food waste by 2025
- Moving 10% of horticulture indoors
- An increase in agriculture productivity:
  - Crop yields rising from the current average of 8 tonnes/hectare for wheat (and equivalent rates for other crops) to 10 tonnes/hectare
  - Livestock stocking density increasing from just over 1 livestock unit (LU)/hectare to 1.5 LU/hectare

Can this increase in productivity be delivered in a sustainable manner?

Do you agree that these are the right measures and with the broad level of ambition indicated? Are there additional measures you would suggest?

ANSWER:

Question 34 (Agriculture and Land use): Land spared through the measures set out in question 33 is used in our Further Ambition scenario for: afforestation (30,000 hectares/year), bioenergy crops (23,000 hectares/year), agro-forestry and hedgerows (~10% of agricultural land) and peatland restoration (50% of upland peat, 25% lowland peat). We also assume the take-up of low-carbon farming practices for soils and livestock. Do you agree that these are the key measures and with the broad level of ambition of each? Are there additional measures you would suggest?

ANSWER:

Question 35 (Greenhouse gas removals): What relevant evidence exists regarding constraints on the rate at which the deployment of engineered GHG removals in the UK (such as bioenergy with carbon capture and storage or direct air capture) could scale-up by 2035?

ANSWER:

Question 36 (Greenhouse gas removals): Is there evidence regarding near-term expected learning curves for the cost of engineered GHG removal through technologies such as bioenergy with carbon capture and storage or direct air capture of CO_2?

ANSWER:

Question 37 (Infrastructure): What will be the key factors that will determine whether decarbonisation of heat in a particular area will require investment in the electricity distribution network, the gas distribution network or a heat network?

ANSWER:

Question 38 (Infrastructure): What scale of carbon capture and storage development is needed and what does that mean for development of CO_2 transport and storage infrastructure over the period to 2030?

ANSWER: