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:
The estimations of the remaining global cumulative CO_2 budgets are of critical importance for constraining the UK pathway to reaching net zero GHG by 2050.

An in depth understanding in the role of UK cumulative emissions is dependent on UK policy for greenhouse gas removal (GGR) technologies, such as bioenergy and direct air CO_2 capture and storage (BECCS and DACCS). The accelerated development of a clear GGR policy is a priority in order to design an emissions pathway to net zero 2050.

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:
There is a global recognition that CCUS and production of low-carbon hydrogen, are required, particularly as they can decarbonise domestic gas, energy intensive industries, enable flexible low carbon power and GGR technologies. The UK is well positioned to become one of the first movers in CCUS and low-carbon hydrogen.

As a one of the first movers, the UK will be able to offer expertise and learning gained from the domestic deployment of CCUS and low-carbon hydrogen to the international community. Strong UK leadership and direction internationally can ensure CCUS deployment is realised at pace and scale in other jurisdictions in line with Paris Agreement targets.

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?

Alongside the setting of the sixth carbon budget, interim milestones for decarbonisation technologies are key to track deployment and encourage projects to progress. These milestones are particularly important for technologies like CCUS and hydrogen which are predicted to be developing at pace during the period of the next carbon budget.

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:
A revised and strengthened UK NDC that incorporates 2028-32 UK carbon budgets into a 2030 target will be desirable to underpin the level of ambition in the UK's recent law to bring all greenhouse gas emissions to net zero by 2050.

This will show the international community that the UK is a global climate leader and offers the UK an opportunity to demonstrate an example of good national practice, for example by introducing the process of revising near term climate milestones in light of net zero legislation.

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?

ANSWER:
The role of the consumer could play a major role in helping to establish a decarbonised product market and in turn reduce emissions. However, these reductions will only come into fruition with Government support for domestic producing industries which operate in an international market. For example, Government support may be required to help cover the additional operational costs of producing decarbonised products, or industrial producers will be priced out of international competitive markets.

One of the largest consumers in the UK is the public sector. The introduction of public sector procurement standards to support low-carbon products can have a material impact, not only for emissions reductions but also for the associated direct and indirect jobs. The introduction of a robust procurement policy will also reduce the carbon footprint the construction sectors, as often imported emissions are much larger than comparable domestically manufactured products. Decarbonising domestic supply through procurement policy will only amplify the carbon emissions disparity between domestic supply and imports.

To help low carbon product markets develop Government could introduce a low-carbon standard mark or sustainable labelling to certify the carbon footprint of products. This will have to evolve over time as the whole life chain emissions are considered, and global low-carbon product markets become established and standardised. Initially this can be assessed

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?

using an EU taxonomy style process which then gives products, produced in a defined sustainable way, a 'green' credential[6].

Interestingly, the low-carbon product influence on household behaviour may not be very large and is not sensitive to the cost of low-carbon materials in end consumer products. For example the additional price for the end consumer, using low-carbon steel produced with CCUS and other decarbonisation technologies will increase the price of a brand-new car by 0.5% or as little as £125 for a typical £25,000 car [7].

Whilst the introduction of the long-term mechanisms can establish systemic emissions reductions out to 2050, short term transition support actions such as consumer footprint concerns, social fairness, low hassle asks, safety, and low cost, can have positive effects whilst long-term mechanisms are considered introduced and refined.

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?

ANSWER:
The introduction of net zero into UK legislation has provided much needed clarity particularly for abatement technologies such as CCUS for energy intensive industries and the role of hydrogen. It is now clear all sectors must decarbonise. Government needs to accelerate the deployment of essential low-regrets technologies such as CCUS, GGR and hydrogen in the UK.

Whilst the deployment of CCUS and hydrogen is unquestionable, the scale and scope of the sector and the precise pathway to 2050 is still to crystallise. Government policy and strategy in the early 2020s will create the foundation for the sectors which will need reliable frameworks and markets to scale from 2030:

1. **The impact of Government intervention in the 2020s**. Government introducing a clear and robust investment framework and business models in the 2020s will enable and accommodate the scale up of CCUS, hydrogen and GHG removal technologies in the 2030s. It is important that as this framework is established Government support early CCUS projects with interim measures in order to lay the foundations for at scale deployment from 2030.
2. **CCUS development milestones**. The introduction of CCUS milestones will help create a decarbonisation pathway for industrial emitters, this will give certainty on the requirement for CCUS heading towards 2050. The Cost Challenge Task Force proposed three scenarios for the post 2030 scale up

[6] TEG, 2019. Taxonomy Technical Report. European Commission. Available at: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-taxonomy_en.pdf

[7] Material Economics, 2019. Industrial Transformation 2050 - Pathways to Net-Zero Emissions from EU Heavy Industry. Available at: https://materialeconomics.com/publications/industrial-transformation-2050

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?

of CCUS[8]. The very minimum trajectory reaching 75MtCO_2 storage per year by 2050, minimum milestones would give projects and emitters certainty.

Additional early Government clarity on the future scale of CCUS can help investors, industry and the associated supply chains prepare for a more accurate deployment trajectory to reach net zero.

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:
The recommendations for the fourth and fifth carbon budget were made with the 80% reduction in mind and include CCS for power and industry. In light of net zero legislation, the level of ambition for CCUS and hydrogen has now increased, this should be reflected in the fourth and fifth carbon budgets [9].

Since the publication of the fourth and fifth carbon budgets there has been technological advancements in many decarbonisation technologies including industrial carbon capture and hydrogen production and consumption. Additionally, the understanding of the role of these decarbonisation technologies in the energy system of a net zero UK has also increased. Updating the fourth and fifth carbon budgets to reflect the progression of decarbonisation technological understanding now will be important.

However, the CCC must remain aware that if updated for the period 2023-27, this gives very little time for Government policy to react, and appropriate policy support mechanisms and projects be developed. Nonetheless, the update will send strong signals to Government that deployment of essential technologies needs to be accelerated.

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:

[8] Cost Challenge Task Force, 2018. Delivering Clean Growth: The Cost Challenge Task Force Report. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

[9] The Committee on Climate Change, 2015. The Fifth Carbon Budget: The Next Steps Towards a Low Carbon Economy. Available at: https://www.theccc.org.uk/wp-content/uploads/2015/11/Committee-on-Climate-Change-Fifth-Carbon-Budget-Report.pdf

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?

The co-benefits of acting on climate change and reducing CO_2 emissions across all sectors have been well studied, particularly the benefits for the environment and population health[10]. The health and environment benefits associated with CCUS on the UK east coast alone have been estimated to cumulatively reach an economic benefit of £5bn by 2060[11].

Transition of UK energy intensive industries. CCUS is one of the only options to enable decarbonisation of 'hard to abate sectors'[12]. Decarbonising these industries with CCUS will ensure the UK retains domestic production, preserving and potentially creating many thousands of jobs across the UK. Preserving a decarbonised UK industrial sector will prevent offshoring of emissions to countries with more carbon intensive manufacturing processes**[13].**

The implementation of CCUS in the UK can also retain and create new highly skilled jobs. It has been estimated that by 2060, CCUS and the linked economy could create over 225,000 jobs[14].

Enabling greater optionality. Pre- or post- combustion CCUS can enable flexible and reliable power generation, particularly in times of high demand when renewable energy may be at low load factors. Additionally, BECCS can operate as a GGR 'baseload power', providing resilience to the electricity system.

Hydrogen production with CCUS can supply large volumes of low-carbon hydrogen which will enable early hydrogen markets and assist with the decarbonisation of several sectors[15].

Optionality for at scale GGR. CCUS uniquely offers the ability to remove CO_2 from the atmosphere and store it permanently. This can be achieved through bioenergy CCS (BECCS) and direct air capture with storage (DACCS).

[10] BEIS, 2018. Climate change mitigation: the co-benefits and possible adverse side effects. Available at: https://www.gov.uk/government/publications/climate-change-mitigation-the-co-benefits-and-possible-adverse-side-effects

[11] Summit Power, 2017. How Carbon Capture Will Boost the UK Economy: East Coast UK Carbon Capture and Storage Investment Study. https://doi.org/10.17868/67392.Available at:http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

[12] Material Economics, 2019. Industrial Transformation 2050 - Pathways to Net-Zero Emissions from EU Heavy Industry. Available at: https://materialeconomics.com/publications/industrial-transformation-2050

[13] Turner et al. 2019. Reframing the Value Case for CCUS: Evidence on the Economic Value Case for CCUS in Scotland and the UK. University of Strathclyde. Available at: https://strathprints.strath.ac.uk/67391/1/Turner_etal_CEP_2019_Reframing_the_value_case_for_CCUS_evidence_on_the_economic_value_case_for_CCUS.pdf

[14] Summit Power, 2017. How Carbon Capture Will Boost the UK Economy: East Coast UK Carbon Capture and Storage Investment Study. https://doi.org/10.17868/67392.Available at: http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

[15] Element energy, 2019. Hy-impact series. Hydrogen in the UK, from technical to economic A summary of four studies assessing the role of hydrogen in the UK net-zero transition. Available at: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/11/Element-Energy-Hy-Impact-Series-Summary-Document.pdf

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?

ANSWER:
If the UK is to achieve net zero urgent action is required in the 2020s to lay the foundations for at deep decarbonisation in the 2030s. For many essential decarbonisation technologies such as CCUS, hydrogen and GGR the UK is not as progressing fast enough to enable the at scale change and deep decarbonisation in the 2030s. There are several important priorities in addition to those outlined in the 2050 Net Zero advice:

1) **Business models**: Government need to establish viable commercial solutions for key technologies such as CCUS, hydrogen and GHG removal. This will enable the industries to develop at scale and could be a blueprint for others globally.
2) **Ability to scale up post 2030**: CO_2 transport and storage infrastructure should already in place for industrial hubs to access all major storage regions (Southern North Sea, Central North Sea, East Irish Sea) by 2030. The earlier this infrastructure is constructed and appropriately sized; the more industries can cost effectively utilise the service and decarbonise faster.
3) **Regional decarbonisation roadmaps**: regional specific decarbonisation roadmaps can give certainty to industry, investors, collaborative decarbonisation projects and the associated supply chain.
4) **Improved public energy literacy:** The energy transition will affect all levels of society, in order to successful reach the UK targets, the public will have to support decarbonisation projects across the country.
5) **Regulatory change and collaboration:** During the energy transition there will be many new technologies introduced. Regulation must be prepared to accommodate these changes, for example the expansion of gas standards to include biomethane and hydrogen blends.

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:
There are a number of areas where local and regional action is locally dependant, for example heating and industrial decarbonisation schemes. However, the overarching policy levers are held at a national level. The CCC should take the regional to national policy relationship into account and encourage the development of schemes which connect the two.

An example of national policy considering regional ambitions would be the development of regional decarbonisation roadmaps. As part of the Industrial Strategy Challenge Fund – Industrial Decarbonisation Challenge, industrial clusters can apply for funding from an £8m decarbonisation roadmaps fund. It is expected that most industrial regions will develop decarbonisation roadmaps which should be considered in the 6th carbon budget advice. In order to incorporate up to date information in the advice to Government, the CCC should engage bilaterally with industrial regions as these roadmaps are developed.

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:
Government policy design and funding has the ability to introduce the correct mechanisms to reduce and effectively manage impacts for the economy and society. Clearly the higher the level of budget ambition, the greater the impact on Competitiveness and Security of Supply.

Policy design for competitive industries must be able to manage international competitive impacts. This is particularly important for export-driven industry which will require support from government to pay for decarbonisation and remain on a level playing field, until the carbon differential is mitigated sufficiently between countries or appropriate carbon cost levelisation policies are introduced e.g. border price adjustments. In practice this means that support for industry, both upfront and in an interim mechanism is likely to led by Government.

Additionally, policy design for security of supply must value a resilient energy system. It is apparent that currently Government are not supporting a range of technologies, to build a resilient net zero energy system it is important that the power market develops sufficient dispatchable low-carbon supply, this will prevent excessive dependency on intermittent renewables and interconnectors. As CCUS is the only form of low carbon dispatchable power, a robust and coherent business model which can correctly value dispatchable power is vital.

In order for multi-sector projects such as those seen in industrial clusters to decarbonise, a holistic approach to policy design and funding is required. Currently, Government have announced substantial funding for the decarbonisation of industrial clusters, however, the funding has become siloed. For projects with many partners looking to collaboratively decarbonise, siloed funding pots aimed at one or two industrial sectors with no guarantee of successful dispersal adds unnecessary risk to projects and can prevent projects from progressing.

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:
The Government has an opportunity to implement proactive decarbonisation policy mechanisms which can benefit from the wider opportunities clean growth can offer. The HM Treasury funding net zero assessment due for publication in late 2020 will outline how net zero will be funded, and how those costs will be shared across society. The introduction UK content requirements for example can create supply chain demand and UK expertise, whilst also protecting the UK manufacturing sector. Previous UK content mechanisms such as the Offshore Supply Office (OSO), were key for the growth of the UK offshore oil and gas sector in the 1970s and 1980s.

Industries, on the other hand will require more focussed attention, this is particularly apparent for industries at risk of carbon leakage, where specific public support for transition will be required to level the playing field within the UK, and protect domestic production and jobs. The introduction of border carbon adjustments will allow the UK to introduce a long-

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?

term levelling mechanism for imports whilst supporting domestic production. This adjustment can vary over time to reflect the impact on the UK economy and consumer demand.

Regardless of the policy mechanisms, technologies which can have early material impacts on reducing CO_2 emissions are required. Improved energy efficiency can pave the way for more effective solutions for heating or industrial processes and lower the demand for low-carbon electricity and decarbonised gas (biomethane or hydrogen).

Ultimately, the just transition will require changes to society, both in lifestyle changes and in industries and homes. There needs to be an early dialogue and public engagement to outline the basics of the energy transition and the relative costs that society may incur. This is best led by local and regional Governments, who are best placed to understand the energy and demographic mix in local communities, and the decarbonisation journey those consumers will face.

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:

d) South Wales is home to one of the UK's largest industrial 'clusters', which is spread along the South Wales coastline, and includes large emitters such as steel plants and oil and gas refineries. The region hosts many heavy industries competing in an international market, as such industrial clusters like South Wales will need Government support to decarbonise if they at least maintain production and continue to offer benefits to the local community.

Government support mechanisms such as the recently announced Clean Steel Fund will offer much needed assistance for sector specific decarbonisation. Additionally, access to CO_2 storage infrastructure will help industries to retain jobs and decarbonise at lowest cost.

For South Wales, where there are few local CO_2 storage options, development of infrastructure in other UK and international storage provinces is a prerequisite, as this area will rely on shipping to transport CO_2 to either East Irish Sea or to international CO_2 storage sites (e.g. depleted Irish gas fields).

Successful delivery of these mechanisms may also provide additional co-benefits to the local community such as air quality improvements[16]. Decarbonising the Port Talbot steelworks, including CCS could reduce CO_2 emissions of the region as much as 50% and significantly improve the air quality.

Several industries in South Wales operate in international markets, the challenge of decarbonisation and additional costs without support mechanisms may make facilities unprofitable. Government support, compatible with business decision timelines is essential

[16] European Environment Agency, 2011. Air pollution impacts from carbon capture and storage. Available at: https://www.eea.europa.eu/publications/carbon-capture-and-storage

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?

to ensure that industries can make informed decisions and prevent unnecessary loss of employment.

Using currently established initiatives such as the Flexis Project* can provide support to low carbon energy supply and generation projects through their pre-existing international expertise focussed in Wales.

***FLEXIS (Flexible Integrated Energy Systems) is a £24 million research operation designed to develop an energy systems research capability in Wales which will build on the world class capability that already exists in Welsh universities.**

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:
The devolution to regional bodies will be an important mechanism to drive decarbonisation at a regional level and focus the decarbonisation pathway to best suit the industries and communities in those regions.

The decarbonisation pathways chosen by devolved powers must be compatible with neighbouring and national pathways. The national energy companies will be vital facilitators of this change, as such, coordination with electricity and gas network operators will be key. The Government also has a role to be well attuned to what the demands and requirement of devolved regions are, and how that can be incorporated early into a national strategy.

Local and devolved administrations have power over planning process and regulation on a regional level. For projects looking to decarbonise, these processes are one of the risks to deployment, and in some cases can add significant time to project timelines. If decarbonisation is to be realised at scale, local administrations need to streamline planning processes, and coordinate with other regions looking at similar projects. A clear, quick, coordinated and transparent process will encourage projects to progress and enable deployment at the rate required for the UK to meet its climate targets.

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:
For any company or sector to make informed decisions on hydrogen switching by 2030 (for fuel, transport, power, or industrial processes), clear visibility on costs and availability of hydrogen and associated infrastructure will be required. To do this, at scale production of hydrogen with CCS will be required. The first step of the hydrogen economy will be enabled by robust and investable business model(s) anchored by the development of CCUS clusters able to provide low-carbon hydrogen at scale. The business model(s) will unlock investment, give indications of costs and availability of hydrogen up to and beyond 2030.

The introduction of milestones and interim targets for the production of hydrogen and hydrogen infrastructure will be important steps which can give businesses long-term signals. Confidence from long-term targets with robust milestones can enable companies to make informed decisions and facilitate fleet changes inline with the proposed trajectory for hydrogen infrastructure and markets.

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:
Government support for the decarbonisation of the aforementioned sectors will be key. Carbon price, although an effective tool, is insufficient alone to support decarbonisation. The carbon price is linked to the global markets in the past has not been robust to encourage projects to take investment decisions[17]. As such sector specific Government policy will be required to drive deep decarbonisation.

For several sectors, *first-of-a-kind* decarbonisation projects will be very different from the *nth-of-a-kind* project. As such, early projects in the 2020s will require more interim underlying business model solutions and targeted policy mechanisms as longer term solutions are crystallised. This is particularly important for CCUS and low-carbon hydrogen which, as new sectors, will gain most from 'learning by doing'.

Mechanisms which may require further investigation as longer term solutions materialise include border carbon adjustments; CCUS and low-carbon hydrogen uptake obligations; and high carbon price floors.

[17] European Court of Auditors, 2018. Special report 24: Demonstrating carbon capture and storage and innovative renewables at commercial scale in the EU: intended progress not achieved in the past decade. Available at: https://www.eca.europa.eu/Lists/ECADocuments/SR18_24/SR_CCS_EN.pdf

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

The above statements are applicable to all sectors, many of which have been considered in the CCUS Advisory Group (CAG) report released in 2019[18]. Outlined below are potential solutions for the targeted sectors.

a) Manufacturing sectors at risk of carbon leakage:
   - OPEX support. OPEX support can assist the deployment of industrial CCUS, hydrogen production and protect against carbon leakage as other long-term mechanisms are developed and carbon prices rise.
   - Procurement policy.
   - Low carbon product standards.
   - Border carbon adjustments. This could present a long-term mechanism to support domestic decarbonised manufacturing and is something which Government should begin to consider, particularly in light of the European Commission's ambition to investigate the possibility of a border carbon adjustment as part of the 'European Green Deal'.

c) Fossil fuel production sectors:
   - Support for a comprehensive decommissioning/re-use roadmap for the UK offshore, including exploring the idea of infrastructure de- and re-activation and removal of liabilities upon de-activation, as proposed by Scottish Carbon Capture and Storage (SCCS).
   - Reuse policy to support the additional cost of decommissioning to a CCUS standard/ mothballing maintenance costs.
   - Mechanisms to promote the shared use of offshore energy generation and distribution infrastructure, especially as this migrates to renewable sources.
   - Joint partnerships initiatives between hydrogen industry (production, distribution and end use) and CCUS.

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:

[18] CCUS Advisory Group. 2019. Investment Frameworks for Development of CCUS in the UK, Final Report. Available at: http://www.ccsassociation.org/files/4615/6386/6542/CCUS_Advisory_Group_Final_Report_22_July_2019.pdf

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?

There is an increasing number of CCS projects supported by policy mechanisms often revolving around incentives or focussed direct support. Some these mechanisms in the context of CCUS:

- **The Netherlands SDE++:** The Dutch Government are implementing the SDE++ mechanism[19] which underpins CO_2 abatement with a guaranteed cost per tonne of CO_2 abated. Government signals have been key for both the Port of Amsterdam ATHOS[20] and Port of Rotterdam PORTHOS[21] industrial cluster CCUS projects progressing into feasibility and FEED study stages respectively.

- **Northern Light Project**[22]**:** The Norwegian Government has provided support for T&S development which has enabled its rapid development, encouraging industrial emitters to sign Memorandum of Understanding (MOU)[23]. To date there have been 14 MOUs signed, which has potential sent strong signals to founding projects, Government and the European Commission.

- **US Market (US 45Q tax):** the US 45Q tax credit created a market for CO_2 by increasing the amount of tax credit from $20 to $50 per ton of CO_2 for permanent sequestration and increased it from $10 to $35 for EOR purposes[24,25]. This effectively removed the 75 million tonne cap on the total amount of CO_2 injected underground.[26]

- **US Market (Low Carbon Fuel Standard):** the extension of the California (LCFS) in 2018, provides strong financial incentives to support the increase in deployment of CCS needed to meet climate targets at the lowest possible cost.[27]

[19] Netherlands Enterprise Agency, 2019. Simulation of sustainable energy production. Available at https://english.rvo.nl/subsidies-programmes/sde

[20] ATHOS. More information at: https://www.portofamsterdam.com/en/request-athos

[21] PORTHOS. More information at: https://www.rotterdamccus.nl/en/the-project/

[22] Northern Lights Project. More information at: https://northernlightsccs.com/en/about

[23] Equinor, 2019. European cooperation on Carbon Capture and Storage. Available at: https://www.equinor.com/en/news/2019-09-cooperation-carbon-capture-storage.html

[24] National Petroleum Council, 2019. Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture and Storage in the United States. Available at: https://dualchallenge.npc.org/downloads.php

[25] Congressional Research Service, 2018. Carbon Capture and Sequestration (CCS) in the United States. Available at: https://fas.org/sgp/crs/misc/R44902.pdf

[26] National Petroleum Council, 2012. Topic Paper 27, Carbon Capture and Storage. Available at: https://www.npc.org/FTF_Topic_papers/27-CCS.pdf

[27] Global CCS Institute, 2019. The LCFC and CCS Protocol: An overview for policy makers and project developers. Available at: https://www.globalccsinstitute.com/wp-content/uploads/2019/05/LCFS-and-CCS-Protocol_digital_version.pdf

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?

- **US Market (Utility Cost Recovery Mechanisms):** the **UCRM**[28] which allows US States to authorize utilities to pass on the costs of carbon capture technology to ratepayers.

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

ANSWER:
The development of CCUS and low-carbon hydrogen production will be essential to enable the just transition of the fossil fuel supply sector. For most of the value chain there are overlapping applications of jobs, services, supply chain, skills both nationally and internationally.

There has been much discussion on workplace implications of the just transition. The UK oil and gas sector has a highly skilled workforce, that operates both in the mature North Sea basin and globally, providing expertise and skills to basins around the world. It also has a longstanding reputation for innovation.

The skills of the UK oil and gas workforce are directly transferable to the deployment of CCUS at scale and could not only enable the establishment and growth of a UK CCUS industry, but also lay the basis for UK exporting its CCUS skills and services worldwide. CCUS will also extend the lifetime of employment in associated services-based roles, and provides opportunity to reuse certain oil and gas infrastructure which would otherwise be decommissioned.[29]

Provided the Government progress with CCUS and low-carbon hydrogen deployment in the 2020s, the fossil fuel sector could transition to support a significant proportion of up to 2 million 'green collar' jobs by 2030.[30] Low-carbon hydrogen production and an active CCUS sector will ensure offshore jobs and value chains are retained whilst diversifying the low-carbon energy portfolio of the UK.

[28] C2ES, Center for Climate and Energy Solutions. U.S State Energy Financial Incentives for CCS. Online map tool, accessed in January 2020. Available at https://www.c2es.org/document/energy-financial-incentives-for-ccs/

[29] Office for National Statistics, 2018. UK Labour market: October 2018. Available at: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/october2018

[30] BEIS, 2018. Climatee experts asked for advice on net zero target. Online Press Release. Accessed January 2020. Available at https://www.gov.uk/government/news/climate-experts-asked-for-advice-on-net-zero-target

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:
One of the applications of low-carbon hydrogen produced with CCS is in domestic and industrial heating. To ensure produced low-carbon hydrogen can be included as a building decarbonising fuel, the end use infrastructure must be in place.

The UK has more than enough skills available today to facilitate the switch to hydrogen heating. However, whilst not lacking, the demographic of the gas engineer community is aging. It has been estimated that 1,500 – 3,000 plumbers are needed per season (winter/summer) for seven years to convert 3.7 million gas meter points to convert North England to a hydrogen network[31]. If expertise in gas engineering is to be retained and facilitate the conversion and operation of a decarbonised gas network in 2050, there is a need for companies and Government to encourage the recruitment and training of young engineers.

For existing gas engineers and plumbers, the skill sets they possess are largely transferable. Industries have been developing hydrogen safe appliances in anticipation of the energy transition. Early signals from Government will trigger gas distribution companies to begin the upskilling of the current workforce to be hydrogen proficient, this would not be an intensive re-training.

Along with the above training and conversion opportunities, employees will need to abide by new and revised regulations and standards for hydrogen distribution and use. This has been mostly industry activity overseen by the HSE. The Government (BEIS) and Ofgem (NIA, NIC) have enabled the now nearly completed safety work by the Gas Network Operators

[31] H21, 2018. H21 North of England Report. Available at: https://www.northerngasnetworks.co.uk/event/h21-launches-national/

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?

and projects including HyHouse, H21, H100, Hy4Heat and HyDeploy. All actual work is done under the current Gas Act and Health and Safety at Work Act.

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?

ANSWER:
At the moment a Contracts for Difference mechanism has supported a narrow set of technologies such as offshore wind, solar PV and a single new-nuclear generator. As the UK begins the journey towards net zero, a number of new generation technologies (such as CCS for natural gas and BECCS) will be needed.

The CfD is a successful mechanism and it is hard to envisage being able to achieve net zero with new generation technologies without a CfD (or very close equivalent). The CfDs which could be signed for new generation facilities may need to be 20-25 years long, if signed in 2025, these will endure until well into the 2040s. There is currently no credible alternative, and it is too early now to suggest mechanisms which could support enduring regimes in the period of the sixth carbon budget.

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 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?

a) The CCSA agree that pre- or post- combustion CCS from natural gas-powered generation can fulfil the energy demands for the remaining generation. CCS in energy systems modelling has traditionally been limited by a perceived upper limit of 90% capture rate. In reality the residual emissions power generation with CCS can be lower than 5% and even approach 100% with minimal additional costs[32]. Incorporating high capture rates in net zero energy systems modelling will lead to greater optionality with power generation and CCS.

b)

I) **BECCS.** Bio-energy with CCS may be useful in providing some level of energy security. The UK may also become a hub for GGR through BECCS due to the level of available (and well characterised) geological CO_2 storage, increasing potential power generation from BECCS to 200 TWh.[33] There are limitations to BECCS which are discussed in response to Questions 35 & 36.

Hydrogen production and storage. Hydrogen has the capability to provide the day to week to inter-seasonal scale energy resilience in high demand scenarios for both power generation and heating which, if electrified at current technology levels, will require an unrealistic reserve of battery storage capacity to fulfil. Hydrogen also has the benefit of shifting production

[32] IEAGHG, 2019. Towards Zero Emissions CCS in Power Plants Using Higher Capture Rates or Biomass. IEAGHG Technical report 2019-02. Available at: http://documents.ieaghg.org/index.php/s/YKm6B7zikUpPgGA?path=%2F2019%2FTechnical%20Reports

[33] Committee on Climate Change, 2018. Biomass in a low-carbon Economy. Available at: https://www.theccc.org.uk/publication/biomass-in-a-low-carbon-economy/

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?

from peaks to low demand periods [34,35,36,37].By 2050, as required load factors fall due to renewable build-out, hydrogen power is expected to become more cost effective than gas power with post-combustion CCUS.

DACCS vs electrolysis – Government need to begin to consider how surplus electricity from high generation days is utilised. Realistically in these scenarios four technology areas will be competing for the same clean electricity: 1) Hydrogen production from electrolysis and storage; 2) Energy storage technologies such as batteries and pumped hydro; 3) Direct air capture and storage; 4) Synthetic fuel production using surplus electricity, electrolysed hydrogen and CO_2 from BECCS or DACCS.

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?

ANSWER:
To start a hydrogen economy from the 2030s, there will need to be multiple sources of low-carbon hydrogen production distributed across the country. Aiming for several hydrogen facilities to be online in 2030 will send strong signals to both Government and industry and

[34] National Renewable Energy Laboratory. 2009. Lifecycle Cost Analysis of Hydrogen Versus Other Technologies for Electrical Energy Storage. Available at: https://www.energy.gov/sites/prod/files/2014/03/f10/46719.pdf

[35] H21, 2018. H21 North of England Report. Available at: https://www.northerngasnetworks.co.uk/event/h21-launches-national/

[36] Element Energy, 2019. HyNet Series: Study 2: Net zero hydrogen. Hydrogen production with CCS and bioenergy. Available at: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/11/Element-Energy-Hy-Impact-Series-Study-2-Net-zero-Hydrogen.pdf

[37] IEA, 2019. The future of hydrogen. Available at: https://www.iea.org/reports/the-future-of-hydrogen

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?

ultimately indicate the sense of scale required for both hydrogen production and CCUS from 2030.

Increased level of hydrogen production ambition is achievable, at least five proposed CCUS clusters projects have low-carbon hydrogen production and storage playing an important role in 2030. Industrial hydrogen ambition shows that an updated 2030 hydrogen production target would be realistic and would encourage Government to accelerate hydrogen sector business models and policy development.

In order to establish a hydrogen economy from 2030, investment decisions will have to be made in the mid-2020s. For projects to pass FID an investable hydrogen business model will have to be in place. The CCUS Advisory Group investigated the potential mechanisms to support hydrogen production[38]. It was concluded that:

- **Revenue support** for low-carbon hydrogen production is best provided by the beneficiaries of the end-use of the energy delivered using low-carbon hydrogen. The costs could be socialised across these gas users generally, or more specifically funded by electricity consumers for those volumes used to generate electricity, for example tax revenue where it is used in industry, and other gas consumers for the remainder.
- **Potential mechanisms for delivering funding** for low-carbon hydrogen production include: funding revenue collection through a RAB structure; premium payments from specific users; a low-carbon Hydrogen CfD; an Obligations-based system; an incentive scheme like the RHI scheme; or HMG grants.

In 2020, the Government need to consult on the hydrogen business models and **prioritise the development of hydrogen policy in line with CCUS policy** to ensure that informed decisions can be made for projects looking at both CCUS and low-carbon hydrogen production.

Multiple opportunities for the early applications of hydrogen[39] exist:

- Use in industrial processes (for example in the production of ammonia and refining)
- Blending with natural gas
- Fuel switching energy feedstock for some energy intensive industries
- Transport fleets (goods, buses, trains and ferries)
- Power generation (local wire and large scale)

[38] CCUS Advisory Group, 2019. INVESTMENT FRAMEWORKS FOR DEVELOPMENT OF CCUS IN THE UK. Available at: http://www.ccsassociation.org/files/4615/6386/6542/CCUS_Advisory_Group_Final_Report_22_July_2019.pdf

[39] IEA, 2019. The future of hydrogen. Available at: https://www.iea.org/reports/the-future-of-hydrogen

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:
The Renewable Transport Fuels Obligation (RTFO) now allows sustainable aviation fuel to claim Development Renewable Transport Fuel Certificates (dRTFCs). However so far, no dRTFCs have been awarded because no plant has yet been built, and the challenge of getting the first commercial plants in this sector financed (without which, the rapid supply growth that is necessary can never begin) remains very high.

The Government should act on the following items to allow this sector to deliver:

- Recognise and share the risk that private investors need to take in order to finance these first plants.
- Support the rapid deployment of CCUS, with a business model that incentivises industries that can deliver negative CO_2 emissions. If CO_2 transport and storage were available in the UK, low-carbon fuel production facilities with CCS, such as waste-to-fuel plants, could save significant emissions compared with conventional fuel, making projects more attractive and reducing the overall cost of achieving net zero.
- Recognise the value of low-carbon fuels, even from non-renewable sources such as captured CO2. Currently the RTFO only rewards the conversion of renewable material into fuels. Renewable waste for example cannot economically be separated from the fossil fraction, and to turn the fossil fraction into fuel offers substantial GHG savings over burning it to make electricity.
- Recognise that offset schemes need to be revisited in more detail, the revenue streams from certification systems could be used to support sustainable fuel projects
- The Government must also recognise the associated opportunities. This includes inward investment, air quality improvements in the event of a significant modal shift and opportunities for domestic ferries that use hydrogen.[40]

It is essential that the initial commercial sustainable aviation fuel plants come on-line in the next few years, if there is any chance of scaling up this technology in the decades to come. This hinges on how emerging technology deployment is supported. Therefore, supporting the uptake and commercialisation of sustainable aviation fuels should be a viewed as a strategic UK priority, and requires long-term policy stability and financial support for the scaling-up and rollout of sustainable fuel production capacity. Government support and incentives for private investment will be crucial in the development of commercial and sustainable jet fuel solutions.

[40] Wood, 2019. Scottish Western Isles Ferry Transport using Hydrogen (SWIFTH2) – Feasibility Report. Available at: http://www.pointandsandwick.co.uk/wp-content/uploads/2019/07/Scottish-Western-Isles-Ferry-Transport-using-Hydrogen-Feasibility-Report.pdf

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:

It is expected by 2030 that there will be at least one CCUS project operating with material GGR, with several industrial CCUS clusters incorporating an element of GGR technology through BECCS or biomethane reformation with CCS. There are five factors which could be *perceived* to constrain the rate of GHG removal in the UK:

1) **Availability of sustainable bioenergy**: The CCSA recognise the limitations on the availability of biomass, however in the UK an amount of BECCS is possible within sustainability and "fair-use" constraints of bioenergy.
2) **Implementation of an investable GGR:** A GGR business model which rewards for the removal of CO_2 from the atmosphere is vital for the sector to be realised. Given the long development and construction timescales required to meet this the CCC 2030 BECCS recommendations, policy development for a GGR business model must commence as soon as possible.

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?

3) **Capture technology**: In 2020 there are very few constraints and even the perceived 90% CO_2 capture rate limit for post combustion CCS can be economically viable at 99% CO_2 capture rate [41]. Capture rates will not be a constraint for GGR with CCS technologies in 2030.
4) **Access to CO_2 transport & storage infrastructure**: Access to infrastructure is not a limitation of BECCS or DACCS, but is confined by overarching CCS deployment policy. By 2030 it is expected that most major industrial clusters will have access to available CO_2 storage infrastructure.
5) **Powering DACCS and surplus clean electricity policy**: Direct Air Capture (DACCS) is a climate driven technology with no significant co-benefit, as such it is more difficult to predict the rate of deployment as there are currently no economic incentive to remove CO_2 from the atmosphere. Furthermore, negative emission DACCS requires the surplus (/competitive price) of renewable energy on the grid.
6) **Technology Development**: Direct Air Capture (DACCS) technologies are in general at a much lower Technology Readiness Level (TRL 1-5) than other GGR including BECCS (TRL 8-9)[42] [43]. As such, before 2035 DACCS may only reach pilot/demonstration phase in the UK (subsidised by Government research and innovation grants).

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:
Learning curves for post-combustion bioenergy CCS will be similar to other CCS learning curves. The CO_2 capture technology as with other CCS projects uses flue gases. The CO_2 capture technology as with other CCS projects uses flue gases, which provided appropriate pre-treatment of the biomass, will be chemically similar to other post-combustion capture processes.[44]

The CO_2 storage aspect of CCS, BECCS and DACCS is technologically neutral as the CO_2 streams will have to meet a minimum specification – cost reduction in learning by doing will

[41] IEAGHG, 2019. Towards Zero Emissions CCS in Power Plants Using Higher Capture Rates or Biomass. IEAGHG Technical report 2019-02. Available at: http://documents.ieaghg.org/index.php/s/YKm6B7zikUpPgGA?path=%2F2019%2FTechnical%20Reports

[42] National Petroleum Council, 2019. Meeting the Dual Challenge. A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage. Volume I – Report Summary. Available at: https://dualchallenge.npc.org/files/CCUS%20Dec.12%20REPORT%20SUMMARY%2012-16-19.pdf

[43] Zero Carbon Humber Partnership, 2019. A Roadmap for the World's First Zero Carbon Industrial Cluster: Protecting Jobs, Fighting Climate Change, Competing on the World Stage. Available at: https://www.zerocarbonhumber.co.uk/wp-content/uploads/2019/11/Capture-for-Growth-Zero-Carbon-Humber-V4.9-Digital.pdf

[44] IEAGHG, 2019. Towards Zero Emissions CCS in Power Plants Using Higher Capture Rates or Biomass. IEAGHG Technical report 2019-02. Available at: http://documents.ieaghg.org/index.php/s/YKm6B7zikUpPgGA?path=%2F2019%2FTechnical%20Reports

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?

be the same regardless of the source of CO_2. Even in a single project, with modular upgrades, cost reductions and learning can be had in each deployment phase.

For DACCS, there is for a need for technological advancement in capture technologies, particularly as atmospheric CO_2 concentrations are orders of magnitude lower than point source flue gases. Nonetheless, there are several technologies at low-mid TRL which are looking for pilot and demonstration opportunities in the early 2020s with a view to deployment at scale from the 2030s, a dedicated funding package to research direct air capture technologies and enable pilot projects in the UK linked to cluster T&S facilities could secure early supply chain expertise in this field.

At present, carbon abatement costs per tonne using DACCS are high, however there are examples where national and state policy in the United States of America are enabling direct air capture projects to progress[45].

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:
Heat decarbonisation strategy is inherently local and as such regional actors will be key to understand the regional context, including existing resources, infrastructure, and demand. For the UK to transition to a low carbon heating system, Government will have to work closely with regional authorities to make best use of the proximal low carbon resources, using a more decentralised approach.

Ultimately, the local and regional policy will be the driver to which decarbonised heat pathway a particular region takes. This will have to be compliant within a national framework and where possible synergies well with neighbouring regions.

There are several factors that will determine whether the decarbonisation of heat in a particular area will favour the use of one energy network or the combination of several networks. The deployment of heat networks will have to be compliant with regional policy for heat decarbonisation using decarbonised gas. For example, for a city or region which has electrified heating, an isolated heat network using hydrogen will not be cost efficient. Some factors which may be of key importance include:

- Proximity to CCUS clusters
- Access to gas networks
- Gas pipeline composition
- Reliable supply of decarbonised gas (biomethane or hydrogen)

Other related factors could include: population density; energy efficiency/demand profile of buildings/housing stock and geothermal potential (for example radio-thermal granites, deep saline aquifers, ground sourced heat pumps or proximity to abandoned coal mines).

[45] Oxy and Carbon Engineering, 2019. Accessed 04/02/2020 Available at https://carbonengineering.com/news-updates/carbon-engineering-expanding-capacity-of-commercial-dac-plant/

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?

Additionally, in order to deploy net zero compliant heat networks, the associated energy source will be low-carbon electricity or decarbonised gas (biomethane or hydrogen). Regional heat decarbonisation policy will affect hydrogen and biomethane infrastructure deployment and will fundamentally decide whether heat networks are viable for that region.

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:

Please see the standalone CCSA response to Question 38 submitted alongside this document.

The Sixth Carbon Budget and Welsh emissions targets

Call for Evidence

Question 38 only

Response by the Carbon Capture and Storage Association

5th February 2020

The Carbon Capture and Storage Association (CCSA) is pleased to provide a response to the Committee on Climate Change's "The Sixth Carbon Budget and Welsh emissions targets – Call for Evidence". The CCSA brings together a wide range of specialist companies across the spectrum of Carbon Capture, Utilisation and Storage (CCUS) technology, as well as a variety of support services to the energy sector. The CCSA exists to represent the interests of its members in promoting the business of CCUS and to assist policy developments in the UK, EU and internationally towards a long-term regulatory framework for CCUS as a means of abating carbon dioxide (CO_2) emissions.

The response to Questions 1-37 of the Call for Evidence have been submitted alongside this standalone answer in the template provided.

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?

The question above has two clear components, specifically focussing on the scale and development pathways of CCUS to 2030 and 2050. The answers below investigate each of these in detail. Regardless of the net zero pathway predicted from UK energy and climate modelling, it is clear that CCUS is essential to reach the UK climate targets and the development of infrastructure is a vital component of the energy transition.

Scale of CCUS development needed

To reach our climate target of net zero by 2050, the there is a broad range of CO2 storage predictions in 2050 based on 80% CO2 reduction and net zero scenarios [1,2,3]. Nonetheless, these

[1] Cost Challenge Task Force, 2018. CCUS Cost Challenge Taskforce Report. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

[2] Energy Systems Catapult, 2018. Still in the mix? Understanding the system role of carbon capture, usage and storage. Available at: https://es.catapult.org.uk/news/still-in-the-mix-understanding-the-role-of-carbon-capture-usage-and-storage/?download=true

ranges and current industry consensus agree that 75Mt-175Mt of CO_2 needs to be stored per year in 2050[4]. In order to cost effectively handle these CO_2 volumes, CO_2 transport and storage infrastructure will be needed in all three offshore storage regions (Southern North Sea, Central North Sea and East Irish Sea). Doing so will ensure coastal industrial clusters on the East and West Coast of the UK can have access to readily available storage.

Regardless of the exact CO_2 abatement requirement in 2050 it is clear that CCUS is a sector that needs to be scaled from nothing today to abating material volumes of CO_2 (many 10s of million tonnes of CO_2 per year) in around 20 years. By comparison, offshore wind took almost 20 years to scale to the stage where it was abating approximately 10 $MtCO_2$ p.a.[5] This clearly shows that we need a step change in ambition to deliver a CCUS programme that is consistent with net zero.

In addition to 'scale' defined in the context of abatement and infrastructure requirements, there are other dimensions that should be considered;

- **Cumulative Storage Scale:** For the period to 2050 roughly 900 to 2,200 $MtCO_2$ of storage will be required and for ten-year periods after 2050 approximately 750 to 1,750 MtCO2 will be required (assuming a flat storage profile from 2050). Capacity is not a limiting factor as the UK is blessed with ample geological storage capacity, with over 500 identified storage sites[6], totalling 78.1 GT of storage capacity (at an average of 135Mt per site). Five of the most suitable sites alone have approximately 895Mt of potential combined capacity[7], which is a material amount towards 2050 storage capacity requirements.
- **Geographical Scale:** The largest UK industrial clusters, source point emitters and associated population centres are located in coastal regions across the country, this demonstrates the need for CO_2 infrastructure on both the East and West coasts. Some nations have limited CO_2 storage options, due mainly to unfavourable geology or restrictive national policy. For these nations the option to export $CO_2$for storage could be a viable strategy, as such, the possibility of international scale networks should be considered.
- **Sector Scale**: It is very clear from analysis that the CO_2 transport and storage infrastructure will be utilised by multiple sectors directly (industry, power, greenhouse gas removals) and indirectly via hydrogen and advanced fuels. While there is uncertainty over exact decarbonisation pathway for these sectors, there is very high confidence that all sectors will use CCS to some extent.

---

[3] Pale Blue Dot, 2016. Progressing Development of the UK's Strategic Carbon Dioxide Storage Resource. A Summary of Results from the Strategic UK CO2 Storage Appraisal Project. Available at: https://www.eti.co.uk/programmes/carbon-capture-storage/strategic-uk-ccs-storage-appraisal

[4] Committee on Climate Change, 2019. Net Zero: The UK's contribution to stopping global warming. Available at: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

[5] Cost Challenge Task Force, 2018. CCUS Cost Challenge Taskforce Report. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

[6] CO2 Stored, Online CO2 Storage Site Atlas. Accessed January 2020. Available at: http://www.co2stored.co.uk/

[7] Pale Blue Dot, 2016. Progressing Development of the UK's Strategic Carbon Dioxide Storage Resource. A Summary of Results from the Strategic UK CO2 Storage Appraisal Project. Available at: https://www.eti.co.uk/programmes/carbon-capture-storage/strategic-uk-ccs-storage-appraisal

Development over the period to 2030

To achieve the scale of CCUS required by the UK and international community, CCUS projects and infrastructure will need to be developed in the 2020s. In the UK there are several areas of development to focus on in the near term:

Annual increases in CO_2 injection rate

For the UK to reach 75-175Mt, the amount of CO_2 injected per year will have to increase at an approximate rate of 3-7MtCO_2 injection p.a. (assuming injection starts in 2025 and a linear rate of deployment). This will result in an increased CO_2 injection rate of approximately 15-35MtCO_2 p.a. in 2030.

Therefore, the CCC recommendation of 10MtCO_2 p.a. by 2030 should be viewed as an absolute floor that provides the minimum level of deployment. While the 10MtCO_2 in 2030 is lower than the 15 – 35MtCO_2 identified above it is expected that deployment rates can be increased over time.

Nonetheless, the 10MtCO_2p.a. target implies a backloading of effort in 2040-2050, as such, a discussion should be initiated to understand what an appropriate 2030 target could be which balances an achievable and credible ambition which can be endorsed by Government.

Infrastructure access to all storage regions

By 2030 all UK clusters should have access to CO_2 transport and storage, this will be most effectively achieved by the development of CO_2 transport and storage infrastructure in each of the UK CO_2 storage regions (Central North Sea, Southern North Sea and the East Irish Sea).

This geographical distribution of infrastructure is required so that;

- All of the UK's major industrial sites have access to the CO_2 infrastructure so that they can contribute to emission reductions in the 2030s and 2040s. Failure to do this will either mean industry are unable to continue to operate in those locations or that industry will be allowed to continue to emit and greater emissions reductions will be required in other sectors (which may well be more technically challenging and expensive).
- Developing infrastructure in multiple regions will provide additional resilience to the infrastructure by offering the potential of alternative storage facilities, and giving storage site confidence to industrial emitters.

Ability to 'scaleup' deployment from 2030

Significant scale up of CCS will be required in the 2030s and 2040s in order to realise the levels of CCS deployment consistent with reaching 75 – 175MtCO_2 storage per year by 2050. If assuming a minimum of 10MtCO_2 storage per year is online in 2030, the 20 year period to 2050 could require 65 – 165MtCO_2 of additional capacity being brought online.

The initial infrastructure established by 2030 must therefore be designed to enable the early CCUS projects and be appropriately sized to handle the initial phase of the 'at scale' rapid increase CO_2 volumes from 2030. It is expected that as the 'at scale' deployment in the 2030s progresses additional infrastructure will come online.

To be able to facilitate the rate of growth of CCUS infrastructure, the UK must progress a pipeline of projects in the 2020s so that CCUS deployment in the 2030s can be realised. Doing so will build robust domestic supply chains and create skilled jobs. Early mobilisation of supply chain actors in the early 2020s will be vital if infrastructure targets in the 2030s and 2040s are to be met.

Ability of CCUS projects to reach 2030 targets

Since the announcement of the Clean Growth Strategy in 2017, industrial momentum for CCUS in the UK has increased. There are now a number of projects which intend to be operational by 2030. Many of those projects will be approaching Final Investment Decision in the early 2020s and operating from the mid-2020s.

There are currently at least five major industrial decarbonisation projects including CCUS which are aiming to be operational in the 2020s. Current ambition from these projects clearly shows that the proposed 2030 10MtCO_2 p.a. target is achievable and could be surpassed. Indeed, all clusters have scenarios which show that with the right level of Government ambition multiple 10sMtCO_2p.a. could be stored by 2030.

CCUS ambition in industrial clusters highlights that a 10MtCO_2 p.a. target is therefore constrained by policy. Nonetheless, the initial infrastructure will most likely have operational lifetimes to 2050 and beyond. Transport and storage assets developed in the 2020s would not be considered a stranded asset risk as the combined capacity if fully utilised would still be under the 2050 CO_2 storage volumes targets.

Importance of sustainable CCUS business models

The ability to scale will also require substantial scale up of CO_2 capture from the CCUS suitable industrial sectors . By 2030 it will therefore also be necessary to have commercially proven business models for each part of the CO_2 value chain (industrial capture, power generation, hydrogen production and transport and storage). As projects develop in the 2020s early learning by doing will help refine with the business models and establish a firm platform that can underpin further deployment and deep decarbonisation from 2030.

Support through policy, business models and funding from Government will provide confidence which can unlock sources of financing and enable the at scale delivery of vital infrastructure. This infrastructure, and subsequent expansions, are expected to be operational into the 2040s and 2050s, continuing to support the UK meet its' 2050 net zero target and be a place for industry and innovation.

New Clean Growth opportunities

The UK is well positioned internationally to offer CO_2 storage services, importing captured CO_2 for storage in its' ample offshore storage reservoirs. The concept of international CO_2 import and storage as a business model is currently most advanced by the Norther Lights Project in Norway, which has signed 14 MoU with coastal CO_2 emitters around the Baltic and North Sea coastline[8].

Depending on the growth of the CCUS market, and the decarbonisation pathway of European and international coastal nations, the UK could be importing material amounts of CO_2 for geologic storage. For fossil fuel dependant and industry intensive countries with limited access to storage (either through policy or geography), international CO_2 export options may be the one of few routes to decarbonise industry, power and hydrogen production.

As exemplified by the Norwegian Northern Lights, and Dutch CCUS projects (in Rotterdam[9] and Amsterdam[10]), CO_2 storage sites in Europe are developing on a similar timeline to, or slightly advanced of, UK projects. Early deployment of UK projects can not only achieve UK climate targets,

[8] Northern Lights Project. More information at: https://northernlightsccs.com/en/about
[9] PORTHOS. More information at: https://www.rotterdamccus.nl/en/the-project/
[10] ATHOS. More information at: https://www.portofamsterdam.com/en/request-athos

but also show leadership across borders, unlock international value in the UK Continental Shelf, and contribute to European and Global climate commitments.