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 400 words 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: AS well as any more recent modelling studies since the IPCC 1.5C report, the CCC should take into account the literature on positive feedbacks within the climate system. Some recent studies (see eg in Q6 below) indicate that some feedbacks may kick in with as little as 2C of warming and these may trigger runaway climate change. In addition, the CCC should take into account the range of climate sensitivities, and make recommendations based both on the most precautionary assessments of these, and the ways in which the risks of the feedbacks can be minimized.

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 extent of climate heating and of resulting climatic impacts is a function of the cumulative emissions, so the budgets consistent with a high probability of remaining at or below 1.5ºC of warming are important considerations in defining the UK's carbon budgets consistent with the 1.5ºC goal. As the global budgets are not disaggregated, the UK's share of them, as reflected in the CCC's advice should reflect the UNFCCC's principles of common but differentiated responsibility and respective capability and equity.

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: The IPCC 1.5ºC report found that global emissions need to be reduced by around 45% by 2030, but the underlying scenarios retained an unacceptably high probability of overshooting the 1.5ºC goal. Ideally far greater reductions would be achieved

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by 2030. As a developed country, the UK has a duty to take the lead in achieving deep domestic decarbonization as fast as possible, not only for its own reductions, but to buy down costs of technology, where relevant, for others. Spain and Germany's roll out of RES technologies helped to spur the rapid reductions in the cost curves of these technologies facilitating others to adopt them.

The CCC should therefore recommend tightening of the UK's 5th, and perhaps also the 4th, carbon budgets, to reflect a precautionary approach to 1.5ºC and the UK's fair share of global action. It should also make its recommendations based on frontloading of action (rather than a linear reduction to a net zero target) to avoid lock in to high carbon infrastructure and to minimize the area under the emissions curve of the UK's emissions through time.

As a wealthy, major historic emitter the UK has a responsibility to support a global transformation to a net zero carbon world.

As well as domestic mitigation, the UK has international obligations to provide means of implementation to developing countries, including transfers of technology, especially renewable energy technologies, climate finance for clean development and resilience building, and capacity building support to enable countries to plan and implement climate action appropriate to their national circumstances. New an additional sources of climate finance will be needed for loss and damage in developing countries.

The UNFCCC has political limitations as a consensus based body. The UK should therefore additionally work with coalitions of the willing, such as the powering past coal alliance, to work with like-minded countries to move ahead and show real climate leadership. As well as being potentially useful initiatives in their own right, they can leverage greater action through sending strong signals to the markets on shifting investments.

The UK needs to avoid 'outsourcing' its carbon emissions by importing high carbon goods. The new post-BREXIT trade deals and promotion of UK investments around the world need to maintain the highest standards to reduce embedded carbon in out imports and overall consumption. In addition, the UK should stop all public funding for fossil fuels but rather promote low or zero carbon energy options. The UK's total carbon footprint on the world counts to what the environment experiences.

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: The UK will have no credibility as COP president unless it is able to demonstrate leadership from the front, especially on its mitigation ambition and implementation through the 2020s through to 2030. This means not only ambitious targets/ budgets, but also detailed plans for implementation in the immediate/ near term. The UK will have no moral leverage on other major emitters to reduce their emissions to the extent necessary, unless the can demonstrate its own intentions and practice in this regard.

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?

The only times when there have been breakthroughs in the UNFCCC process, such as at Paris, have been when the EU (as was, including the UK) have been able to form alliances with developing country groups, including the LDCs, AOSIS, Africa Group and AILAC. These alliances rely on mutual trust and good faith that climate action by the powerful EU will be forthcoming and will reflect the concerns of these vulnerable nations. If the UK does not have a credible package of domestic ambition on the table well before COP, this alliance building will also be compromised.

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: Consumer behaviour, if aggregated in sufficient quantities, can make a difference. More importantly though is for greener choices to leverage action in the market eg by consumers letting companies know why they are divesting from certain goods or services. Assessment of impact on the market scale may be more measurable than individual actions.

As to incentives, these will vary on the behavior/ action being targeted. For those involving capital expenditure, such as retrofitting housing for insulation, heating and renewable electricity, government schemes will be needed to effect the changes needed on the scale needed eg through street by street improvements and also support those unable to meet the costs.

For other changes more subject to individual choice, such as meat consumption, there are a variety of measures the government could use to encourage or incentivize these. Education in schools is one area to change behaviour before it has hardened into habit, eg drawing out the links of beef and soy for beef consumption to Amazon rainforest destruction. Labelling goods that are supplied by such harmful chains could also be required. Pricing measures may be appropriate. Psychological ‘nudges’ of other kinds may be appropriate, depending on the desired behavior change.

For this to be effective there has to be accurate and accountable information from the companies with vested interest in maintaining high carbon lifestyles. Recent advertising and initiatives falsely implying that fossil fuels, high carbon transport including flying, and other high carbon activities can be made ‘green’ should be scrutinised and stopped, as they provide mis-information to the consumer.

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 most important uncertainties the government needs to consider are the non-linearities inherent in the climate system. Studies, such as:

Chadburn SE, EJ Burke, PM Cox, P Friedlinstein, G Hugelius and S Westermann, 2017, "An observation-based constraint on permafrost loss as a function of global warming" Nature Climate Change,7, 340-344

Steffan W, J Rockström, K Richardson, TM Lenton, C Folke, D Liverman, CP Summerhayes, AD Barnosky, SE Cornall, M Crucifix, JF Donges, I Fetzer, SJ Lade, M Scheffer, R Winkelmann, HJ Schellnhuber, 2018, "Trajectories of the Earth System in the Anthropocene" PNAS, 115, 33, 8252- 8259

have indicated that positive feedbacks in the climate system may be triggered by 2ºC. If these feedbacks start, they may trigger further feedbacks that lead to runaway climate change, with more and more carbon stores releasing their carbon to the atmosphere.

The government's best approach to addressing these critical uncertainties would be a) to put in place precautionary and ambitious near term and long term climate targets and the legislation/ policies to implement them and b) use the full potential of its diplomatic corps to work with others both to increase their ambition, and to make sure other developed countries are putting forth the levels of 'means of implementation', especially new and additional climate finance, needed to allow clean climate-friendly development in developing countries.

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: Absolutely, unequivocally, yes. The current levels of ambitions are inadequate for net zero, and also fail to front load action to the near term (next decade): both carbon budgets should be improved to reflect both of these considerations.

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: The co-benefits depend on the emissions type being targeted.

For reducing fossil fuels, and managing the rapid decline of the industry as a whole, the co-benefits include reduced climate change (both directly from combustion of the fossil fuels, and indirectly through the decline in fugitive emissions). Combustion of coal in particular is associated with release of toxics, such as mercury, which affects brain development of children. It would benefit air quality as combustion of fossil fuels also causes a lot of radical tropospheric chemistry involving ozone, NOx and volatile organic compounds. The plastics crisis of the seas is also a fossil-fuelled crisis.

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?

In the housing sector, then homes will be warmer and higher efficiency, so lower bills. New and efficient industries will emerge for new jobs will emerge. Integrated efficient transport across the country, with less congestion. The UK could become the zero-carbon investment hub, financing future net zero futures globally. These co-benefits need to be planned in through a just transition of people and their economic context so that the benefits are shared, and any potentially negative impact such as job losses in the fossil fuel sector planned for with decent work alternatives put in place.

Climate change will not be solved without the near-term end of the fossil era. Atmospheric loading of greenhouse gases is now such that negative emissions will be needed. There are few proven options for this: CO_2 is near-perfect from a thermodynamic perspective (strong bonds, is a gas) and so chemically removing it at scale would require considerable energy inputs. Even plants, which have had millennia to perfect using CO_2 have only come up with one of the less efficient enzymes in biology to break up CO_2 as part of photosynthesis. Fossil carbon has remained reliably stored for 300-360 million years and if left alone will remain so. While there is a huge need for ecosystem conservation and restoration, not least for resilience building, the extent to which biological carbon should be conceived of as a means to store fossil carbon should be minimized as far as possible. The Moana Loa CO_2 concentration graphs, as well as the recent Amazon and Australian fires, demonstrate the rapidity of possible fluxes of biological carbon back to the atmosphere.

Ecosystem restoration and conservation have important co-benefits for climate resilience, for biodiversity, for the livelihoods of the poorest. **It is imperative that we restore much of what we have destroyed, but it should be seen as an 'as well as', not an 'instead of' to ending the fossil era in the near future.** Fossil and biological carbon operate on different carbon cycles, with radically differing timescales in their natural fluxes: they should not be treated as fundamentally fungible. Fossil emissions must be reduced radically – reducing emissions is the only precautionary approach to the climate crisis. Biological sinks have a role in mopping up the rump of emissions, but this should be conceptualized as a mechanism only when fossil emissions have been reduced as far as is at all possible. We will need negative emissions in the second half of the century and should not use up all suitable land for biological sinks without having made every effort to tackle the main root of the problem – fossil emissions.

To achieve net zero, it is imperative, on precautionary grounds, to minimize emissions as far as is possible, with a particular focus on ending the use of fossil fuels. We need to reduce consumption, consume efficiently and consume sustainably. Conceptually, only when emissions have been minimized, should negative emissions should employed. Nature based solutions cannot be used to allow industrial business as usual.

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: Ending all UK direct and indirect use of public finance to support the fossil fuel industry in any way. The managed phase out of the UK's own fossil production in a way that ensures a just transition is also needed.

We need to ensure all new buildings are at least net zero in their build and use and undertake a massive program of retrofitting of existing building stock.

We need to make our electricity supplies 100% renewable and enact energy efficiency measures to minimize energy use, at the same time as electrifying sectors, such as transport so that they can effectively decarbonize.

We need to either clean high emitting industries through new processes, or replace their products with ones that are low emission eg a switch from steel to wood in construction.

We need to reduce our consumption and create a far more circular economy.

We need to change our agricultural system from one based on fossil fuel-based chemicals, such as insecticides that have devastated our native biodiversity to one that is itself more biodiverse and that produces less emissions-producing meat. A 2014 study found there may only be 60 years of harvests in the soils, caused by factors including "chemical-heavy farming techniques, deforestation which increases erosion, and global warming". https://www.scientificamerican.com/article/only-60-years-of-farming-left-if-soil-degradation-continues/ The fossil fuel petrochemical industry is a cause of another life-threatening source of environmental destruction.

We need to match the domestic action by championing global zero-carbon trade, consumption, and investment. We need to lead the race to the top, and not just out source our climate impact through accepting high carbon, low quality imports. The UK action will be negated if we continue to encourage business as usual globally through out footprint on the world.

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: Our impression is that these sub-national pledges were made in the best of faith, but that there may be knowledge and resources constraints that may limit implementation. The government should be encouraged to create means to support sub-national governments to act, but the extent to which the CCC should rely on these pledges in its 6th carbon budget should be based on a realistic assessment of what might actually be implemented under different scenarios of action by the sub-national bodies and support provided from the UK government.

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: Fuel poverty can be best addressed through a program of making houses energy efficient, which can also lead to cost reductions under other budget lines eg reduced costs for the NHS from not having to dealing with people suffering respiratory problems as a result of living in damp and mouldy homes. Any strategy addressing heating (eg through a strategic roll out of heat pumps), should expressly consider the needs of the fuel poor in policy design.

Security of energy supply becomes less of a problem when increasing amounts of indigenous renewable energy are on the grid coupled with higher efficiency homes and businesses. The UK already has, or has planned, a number of interconnectors with other European countries, including Ireland, France, Iceland. Good cooperation and maintaining good relationships with the EU post-Brexit will be important for maintaining the flexibility of supply from these countries. Investment in battery and other energy storage should also be prioritized to protect security of domestic supply.

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: In order to reduce emissions as far and fast as possible, the UK needs a strategic plan for how it intends to do so. The UNFCCC calls on countries to produce low-carbon development strategies. The UK should fulfil this by developing, with public consultation, the direction of travel towards meeting its long term net zero goal, including which industries and sectors will face major overhauls, and on what timescales. There should be considerable detail on implementation of climate action for the 5 and 10 year time horizons. Such planning will provide an overview of where impacts are likely to fall and when, to allow for education and training programs, targeted investments for job creation and to take into consideration opportunities provided by changing technologies eg through remote working. The transition needs to consider those who would be left behind and make explicit reasonable provisions to address their needs.

The solutions need to be progressive. There needs to be recognition that the wealthiest in the country are the highest emitters, but also have the wealth to make personal changes to their lifestyles, their homes and and their businesses. This group has the wealth to make these changes but will require incentives and regulation to encourage change. Often those on a lower income have few choices on their impact as they live in rented accommodation, use public transport and have not influence in their work places, therefore greater focus on providing resources should be targeted here to ensure the majority of people can be part of the overall solution.

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: Scotland is already considerably further down the path, so has something of a head start on other parts of the UK in terms of an achievable decarbonization pathway. Scotland also has some notable relative advantages in terms of renewables potential, scope for using peatland, forestry and so on, as part of the policy portfolio. Scotland also has potential for CCS, if we wanted to go down that route. All of these make a steeper pathway possible in Scotland.

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

ANSWER: Scotland has legislated a 75% emissions reduction target for 2030. Because of the need to minimize the atmospheric loading of greenhouse gases, a high level of ambition is needed – the question should be 'how to achieve what is necessary for the climate' and to work to achieve it.

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: On a political level, there are now four different parties leading each of the four countries of the United Kingdom, which is not without its challenges, but our view is that climate change is an issue in which cross-party and cross-government collaboration is desirable and necessary. For example, the Joint Ministerial Committee is perhaps an obvious mechanism through which this kind of collaboration could work well. A greater shared spirit of the need to collaborate to overcome the climate crisis would be helpful.

On a more technical level, some policy areas can well be addressed at the national level, but there are some where an all-UK approach is needed, especially involving transboundary infrastructure, including in the energy and transport sectors. There is a sense that policy collaborations between the countries are functioning better at the official level than political.

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: b) Public transport should be better provided for and better integrated. Trains should have few 1st class carriages and more 2nd class to allow for greater numbers of passengers on existing capacity. Lines removed in the Beeching era should be reinstated where appropriate, and other lines considered to reflect more recent growth patterns. Local councils, especially around conurbations, should be required to cooperate to create regionally coherent public transport. Instead of subsidizing private companies to run the railways, government money would be better used to subsidize passengers to protect them against significant ticket prices and fare increases.

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: c) The government should stop using any public finance to support any part of the fossil fuel industry, including upstream, midstream and downstream, and for coal, oil and gas. This would include finance aimed overseas, including ODA, export credits and indirect financing, eg through the CDC. We are currently working on analysis for why oil and gas are not needed for development and that there are better, cleaner and more sustainable ways for countries to develop, both in supplying energy to their people and to build their economies. For its domestic fossil industry, the UK needs to plan and start to implement its just transition to end extraction and use of fossil fuels.

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: The UK needs to look across its fossil fuel related supply chains and analyse where jobs can easily be shifted into other sectors, and to place education and training as appropriate, and also to actively seek to bring jobs into affected areas – or support the creation of appropriate jobs that can be done remotely.

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?

ANSWER: The absolute aim must be to reduce emissions as fast as possible. We are in a climate crisis and already the dawn of the Anthropocene is causing untold misery through wide ranging, severe climate related impacts. While cost minimization is a vital consideration, it should not be an overriding imperative. Decisions now must have zero-carbon electricity in its sight, so natural gas power investment now will have a long life span which could be contrary to the zero-carbon electric future we need. Also decarbonization of other sectors such as business, homes and industry are dependent on rapid zero-carbon power transition, making this the rapid transition priority.

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: The Imperial modelling seems *prima facie* sensible. It will be interesting to see what progress is made on non-weather dependent RES, such as wave and tidal, but these of course need to be developed in ways that don't adverse effect oceanic biota, or otherwise have notably negative unintended consequences.

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: A concern about the use of hydrogen is in the political economy. A technology with infrastructural needs that are consistent with continued use of fossil gas makes it harder, without strong political will, to end the use of fossil gas.

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: CORSIA discussions started earlier in the decade with a ridiculously weak target (no net increase of emissions from 2020 levels). The negotiations of the mechanism give no succour that it will be an effective mechanism – one offset company invited to present to the ICAO expert group, defining what offsets should be allowed, peddled EOR CCS credits. In 2015, ICAO members set excessively future targets for technological improvements in aircraft design slowing the rate of new more efficient technologies becoming the market norm. Measures at the national level (are domestic flights really needed – especially when rail alternatives exist) and in collaboration with the EU – are important and should be pursued.

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: It is important to emphasize the need to realize biodiversity co-benefits in land use planning. The UK has suffered precipitous declines in its biodiversity related to poor land use practices, including through spraying the land with fossil-fuel based agrochemicals killing insects generally and bees

It is not just a question of the areas being covered, but also maximizing their resilience to current and future climate impacts. There is extensive literature on the 'diversity-stability' hypothesis on biodiversity, which implies that more biodiverse ecosystems and managed systems are inherently more resilient to climate impacts. Increasing resilience of biological systems is therefore important to reduce the risks of carbon stores being reversed into sources.

In 2020, nature based solutions will be an important part of the climate discourse as the Convention on Biological Diversity sets its new targets to 2030. Integrating implementation of climate and biodiversity measures in the land sector has the potential for many co-benefits, including for increasing the resilience of human systems eg reducing flood risks through conserving and expanding woodlands.

The CCC's advice should draw out both the importance of biodiverse systems for stabilizing biological carbon stores, but also the importance of restoring natural systems for human resilience.

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: Many negative emissions technologies seem very nascent. It does not seem precautionary to rely on these to any great extent, not least as any DACs involving chemical transformation of the CO_2 face the challenges of its fundamental thermodynamic properties, which would require high energy inputs to overcome enthalpic and entropic considerations.

BECCS is highly questionable in the extent of land needed for significant penetration of the energy market. It is also questionable for the intensive inputs (including fertilizers that are energy intensive to produce) to drive rapid plant growth, with their ecological side effects and impacts on the soils. There are also issues in the way that biomass is accounted for, which makes it less climatically beneficial than is sometimes assumed.

The primary focus needs to be on reducing emissions as negative emissions approaches are either not proven (engineered GHG removals) or potentially subject to climate impacts (nature based solutions).

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: