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 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: In addition to these reports, CCC should also base its recommendations for the sixth carbon budget on the UN Environment Programme 2019 Emissions Gap Report, which highlights the gap between emissions reductions offered by current nationally determined contributions (NDCs) under the Paris Agreement and the yearly emissions reductions that have to be delivered to remain within a 1.5°C scenario.

The UNEP report highlights the urgent need for action in achieving deep emissions cuts. If governments around the world had acted on the available climate science ten years ago, they would have had to reduce emissions by 3.3% each year. Given the window of inaction, governments now need to cut emissions by 7.6% each year if we are to limit warming to 1.5°C, which falls short of any national climate action plan of any country.(UN Environnent Programme 2019 Emissions Gap Report)

In setting the level of the sixth carbon budget, it is essential to show that inadequate action to reduce emissions now will have a cumulative effect on the level of cuts we need to achieve in the future and can severely undermine the UK's ability to contribute towards limiting warming to 1.5°C.

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: n/a

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: Most nations are expected to strengthen their NDCs in 2020 and ramp up their efforts to reduce emissions. As a developed country, the UK is responsible for a larger historical share of emissions, with the G20 countries being collectively responsible for 78% of all GHG emissions (UNEP 2019 Emissions Gap Report). This is why it is key that the

UK accelerates domestic emission reductions as part of the sixth carbon budget, whilst encouraging the rest of the world to follow suit through an ambitious climate diplomacy and trade strategy.

With a net zero emissions target passed into legislation, the UK is already faring better than some of its G20 counterparts. However, current policies and regulations do not set the UK on a credible track to meet even its fourth and fifth carbon budgets, which were set in the context of an 80% emissions reductions target. The UK must now urgently set meaningful targets to tackle the largest emitting sectors (e.g. transport, buildings, aviation, shipping, industry etc), supported by robust policy packages that can put the UK on a credible and cost-effective pathway towards net zero emissions by 2050. By taking convincing measures at home, the UK will have more leverage in international discussions.

As host of COP26 and president of the G7 in 2021, there is ample scope for the UK to use climate diplomacy and its network of climate attachés to increase other countries' commitments to reducing emissions. As the UK is set to develop its trade policy, government needs to ensure that it supports the delivery of domestic climate and environmental targets, whilst encouraging other countries to adopt high environmental standards.

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: As the UK leaves the EU, it is crucial that it sends the right signal to its partners across the world. A revised and strengthened UK NDC will show that the UK intends to remain a world leader in driving for action to address climate change, and not withdraw from climate leadership following its departure from the EU. From its world-leading Climate Change Act in 2008 and top performance in growing the economy while cutting emissions to its adoption of the net zero emissions target by 2050, the UK must continue the trend and demonstrate leadership in this area. As the UK prepares to host COP26 at the end of the year and become G7 president in 2021, it should demonstrate commitment through a strengthened NDC supported by an ambitious sixth carbon budget and comprehensive net zero delivery plan so that it can make the most of these opportunities and encourage other countries to take action.

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: n/a

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: Whilst the pathway for getting to net zero is widely accepted for certain sectors (e.g. transport, power, buildings), other sectors face more uncertain pathways to

decarbonisation. For heavy industry, agriculture, heat or long-distance transport, many of the technologies and business models needed to cut emissions further have not yet been trialled at scale and therefore the policy framework to drive decarbonisation is not yet in place.

Policy can play a role in tackling these uncertainties through adequate funding for innovation and a more ambitious innovation policy. It is clear from Aldersgate Group engagement with a wide range of sectors that innovation funds in the UK have often been too small and lacking in long-term strategy and stability, negatively impacting investment and undermining the development of ambitious, large projects.

A robust innovation policy should move beyond the fear of failure, increase ambition and recognise that successful and unsuccessful trials offer equally important lessons for good policy making. Both can improve our understanding of best practice and develop governance principles to roll out new technologies, when accompanied by strong evaluation methodologies enabling government and innovators to draw the right conclusions from what has and has not worked during technology trials.

The UK's innovation policy will need to be closely co-ordinated with the development of market creation policies to support the rapid deployment of these technologies and new business models. Updates to public procurement rules, a clear carbon pricing trajectory and standards regulating the embodied carbon of industrial products such as buildings materials are examples of measures that could play a key role in stimulating the market and accelerating the roll-out of ultra low carbon solutions, products and infrastructure. Achieving a successful transition also requires securing an adequate provision of skills to deliver against these changes. Government policy will play a significant role in guaranteeing an adequate provision of skills for the economy. Government should develop a national low carbon skills strategy, integrating sustainability at all levels of the educational system in the national curriculum – apprenticeship programmes, higher education and lifelong learning. This will ensure the UK has an attractive pipeline of skilled workers for new and growing industries in the long run.

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 need to revisit the level of the fourth and fifth carbon budgets will depend on the probability of it influencing a faster and cheaper transition to a net zero economic model. If increasing the ambition of the fourth and fifth carbon budgets in light of the net zero target will increase the feasibility of getting to net zero and/or reduce the overall cost of getting there, then the level of ambition should be revised.

Evidence is available which suggests that added action on curbing emissions during the period covered by these two carbon budgets will reduce the cost added action later. Research shows that delaying any mitigation actions even to 2030 will increase their medium term costs (2030 – 2050) by 50% and their long term costs (2050 – 2100) by 40%. (World Bank 2015Decarbonising development) and that delayed action means that deeper cuts will have to be achieved each year, which again increases the cost of the transition (UNEP 2019 Emissions Gap Report). However, with the UK not currently on track to meet the fourth and fifth carbon budgets at their current levels, a quick uplift in policy work is

needed to show that revising these carbon budgets will demonstrably impact the UK's likelihood of meeting the net zero target.

Another aspect that needs to be considered in revising the level of ambition for the fourth and fifth carbon budgets is readiness of supply chains. In industries that are essential for getting to net zero, such as building insulation, low carbon heating, wind turbine manufacturing or EVs, supply chains have been growing but are not always sufficiently mature to support a sudden and significant increase in the pace of decarbonisation. As an example, based on engagement with some of our members, it is clear that rolling out low carbon heating at scale by 2030, albeit necessary, is a challenge given the readiness of supply chains at present. Revising the ambition of the fourth and fifth carbon budgets should strike a careful balance between pushing for early action and allowing sufficient time for supply chains and markets to mature and deliver the required emission cuts in key sectors.

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: Decarbonising industry and supporting low carbon businesses offers a range of economic benefits for the UK, boosting industrial competitiveness and supporting job creation. Long-term policy certainty, well-developed regulations, investment and market mechanisms can provide a good framework for this. Low carbon businesses have a direct and indirect combined turnover of £79.6bn, directly employing 396,200 people. The low carbon and renewable energy sector grew by 6.8% to £44.5bn in 2017 (ONS January 2019). Climate-driven policy could also generate over 65 million new low carbon jobs in 2030, equivalent to the UK and Egypt's workforces combined.

The offshore wind sector is a good example of this, with the latest CfD auction generating historically low prices and jobs created in industrial clusters. At its Hull facility, Siemens Gamesa has created over 750 ongoing jobs in blade manufacturing, assembly and servicing facilities. Significant investments have also been made in education and training facilities, such as half a million pounds invested in the Hull College Group for a new facility to train the wind turbine blade factory workforce and further investment in new University Technical Colleges in the region. In 2016, Siemens Gamesa made 14 four-year advanced apprenticeships available and other co-benefits of decarbonisation relate to healthcare. Decarbonising surface transport and encouraging alternative modes of transportation, especially active travel, could deliver significant benefits. Lower levels of emissions from diesel cars could improve air quality in cities and reduce the incidence of respiratory diseases. The impact of air pollution on health and social care was estimated at £43.88m in 2017 and the costs are predicted to reach £5.3b by 2035 in England. (Public Health England May 2018).

Conversely, better cycling and walking infrastructure and encouragement of active travel could help tackle obesity, anxiety and depression and manage chronic health conditions. Sustrans, a transport charity, has estimated that between 2017 and 2040, cycling could avert 34,000 long term health conditions, saving the NHS £319m (Sustrans January 2019). Given this data, a phaseout of ICE vehicles and investment in alternative modes of transportation, including active travel should represent a priority for government given the co-benefits it can deliver.

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: Aldersgate Group agrees with these priorities. Rapid progress on decarbonising key sectors through no regret policy options (e.g. for housing, power, transport) will be essential for 2030-2035, as well as clear plans for cutting emissions in hard to treat sectors, including industry, heat, agriculture, shipping and aviation.
Efforts to decarbonise these sectors should be supplemented by:

• Policy certainty for the long term, through a clear commitment to delivering the carbon budget and a net zero target delivery plan for the next decade, backed by cross-departmental support.

• Update the UK's innovation policy to support ambitious innovation for technologies through at scale trials and deployment, which will be essential for cutting emissions, especially in hard to treat sectors. Priority technologies include CCS in both industrial clusters and non-clusters, testing the potential use of hydrogen for heating provision and long-distance transport, the development of sustainable waste-based biofuels for aviation and shipping and next generation of offshore wind turbine designs, as well as negative emission technologies. (Vivid Economics & UKERC April 2019 Accelerating innovation towards net zero emissions)

Provide adequate funding to support innovation up to the commercialisation stage. It is clear from Aldersgate Group engagement with a wide range of sectors that innovation funds in the UK have often been too small and lacking in long-term strategy and stability, negatively impacting investment and undermining the development of ambitious, large projects. To look at an example from CCS, energy companies such as ScottishPower, Eon, Royal Dutch Shell and Drax have sought to build full-scale carbon capture and storage projects in the UK since the mid-2000s but two government subsidy bidding competitions, in 2007 and 2012, were later cancelled over cost concerns (Financial Times 1 July 2019 "Carbon capture schemes urged to be more ambitious).

• Design market mechanisms that grow the demand for ultra low carbon goods and services. This could include incentives aimed at accelerating the take-up of technologies like CCS, by for example providing incentives for industry to capture and store carbon emissions. Clarity on the development of long-term market creation measures, such as power-CCS CfD, regulated asset base financing, or revenue for stored carbon for industrial CCS, is essential to increase private sector appetite for investment.

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: n/a

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: These impacts can be managed regardless the level of a carbon budget, provided that there is clarity on the direction of travel for the long term (e.g. detailed sectoral decarbonisation pathways or instruments such as a carbon price escalator) so that businesses and investors can plan accordingly. However, the level of a carbon budget needs to take into account supply chain readiness and the ability of industries to scale up to the required levels to deliver emissions reductions mandated in the budget (e.g. supply of EVs or the use of CCS for industrial processes).

Increased levels of investment required to align businesses to the net zero emissions target could impact their competitiveness through increases in product prices or lower levels of production. This can be addressed through the adoption of product standards driving down embodied carbon in building materials such as steel and cement, growing the market for ultra-low carbon industrial goods and protecting UK businesses from high carbon imports. Government should update its procurement rules with mandates for investing in infrastructure to buy low carbon steel or cement from plants using CCS, thereby attracting more investment in this technology from the private sector. In addition, with public procurement market valued at £284bn in 2017/18 there is real scope for government to drive demand in this sector. (IfG & Gowling WLG December 2018) Mitigating adverse impacts on fuel poverty and security of supply will require substantial investment in energy efficiency for buildings and industrial processes. Whilst some forms of low carbon heating and energy generation are well developed, their roll out needs to be supplemented by energy efficiency measures. For instance, the roll out of heat pumps for decarbonising heating needs to be accompanied by significant investments in retrofits for energy efficiency to guarantee an adequate level of comfort for households at reasonable costs. Similarly, electrifying industrial processes is a necessary step towards cutting emissions, but investing in energy efficiency will also ensure that the demand on the grid is managed and businesses are not burdened with excessively high costs for electricity. Investment in energy efficiency measures should be encouraged through robust and well-enforced energy efficiency standards, non-bureaucratic access to funds (e.g. IETF, CCAs), the creation of competitive markets for energy efficiency (e.g. ESCOs).

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 sectors which are most likely to elicit high transition costs government needs to prioritise the availability of subsidies or schemes that protect vulnerable consumers form high transition costs. The transition to a net zero economy will place significant costs on those living in poorly insulated houses with high energy costs, who are unlikely to be able to afford the upfront cost of retrofits, with house-by-house retrofits for a small semi-detached home being around £600 for cavity wall insulation or around £7,000 for internal wall insulation. (Aldersgate Group March 2018)

Similarly, a switch to EVs will impact dwellers in rural areas who are more dependent on cars in the absence of good public transport links and less likely to afford one given that a budget of £5,000 at a minimum is necessary for an EV purchase.

Examples of schemes that alleviate the impact on consumers include, in the case of buildings, incentives such as VAT and stamp duty rebates for homes and businesses adopting energy efficiency measures. Tax breaks for businesses investing in energy efficiency should have the same effect, such as through exemptions from the Climate Change Levy and CCAs.

Distributing the cost of retrofits for domestic buildings is necessary, as the level of investment needed to improve energy efficiency is substantial for individuals, but too small to attract capital from major investors. These projects need to be aggregated into larger portfolios through Energy Service Companies, which then allows capital to be invested at scale. The continuation of such intermediary schemes will be essential to ensure that retrofit costs do not have to be supported exclusively by consumers.

To mitigate the impact of transition costs in the transport sectors, government should guarantee the availability of plug-in vehicle grants maintained at October 2018 levels (House of Commons BEIS Committee October 2018) until upfront cost parity with diesel vehicles is reached. At the same time, sustained investment in integrated transport links will be essential, with bus and rail services that are reliable, accessible and reasonably priced.

Looking at the whole economy, to ensure that costs are shared government should also establish a national body along the lines of the Scottish Just Transition Commission that develops strategies to maximise the opportunities brought by the transition in terms of fair work and tackling inequalities.

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: n/a

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: n/a

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: n/a

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

ANSWER: n/a

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: n/a

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: Improving the overall efficiency of the transport system will be key in managing this transition, as will the development of an integrated transport strategy, bringing together road, rail and bus, with investment towards infrastructure choices to deliver the most efficient economic, passenger travel and emissions outcomes.

The government's strategy for cutting emissions from surface transport as set out in its Road to Zero Strategy does not place enough emphasis on influencing consumer

behaviour away from car dependency. For instance, while fuel duty was frozen each ear from 2010/2011, rail fares have risen by 42% over the same period, incentivising consumers to rely more on cars than public transport. Government should set incentives that accelerate transport decarbonisation and ensure that pricing does not discourage people from using public transport when it is available.

Alternatives to car travel must be more readily available. Many car journeys can be avoided by making reliable alternatives available: it is estimated that in urban areas 72% of journeys are under five miles, which should be shifted to public transport. (DfT July 2018 Future of Mobility: a call for evidence)

Closer collaboration with local authorities and adequate levels of funding will be essential. Aside from Manchester and London, few other cities or regions across the UK have so far developed integrated transport strategies, because they lack the power and resources to implement them. Lack of stable and appropriate funding prevents local councils from investing in sustainable and efficient transport systems, and projects remain focused on the short term and subject to ad-hoc funding competitions (Urban Transport Group September 2018). Long-term capital funding for local bodies will enable regions to develop the most appropriate transport links and the infrastructure appropriate to local needs to shift as many car miles to cycling, walking or public transport.

A strategy for active travel strategy should be developed to increase the uptake of cycling and walking in urban areas through investment in a high-quality cycling and walking network and investing in a national public health communications campaign that highlights the co-benefits of active travelling, including tackling obesity, depression and preventing chronic health conditions. It is estimated that between 2017 and 2040, cycling could avert 34,000 long term health conditions, saving the NHS £319m. (Sustrans Jan2019)

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

ANSWER: n/a

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: Aldersgate Group agrees that the phase out of conventional car sales should occur by 2030 at the latest, taking into account the readiness of supply chains and the availability of affordable and feasible alternatives.

Currently, overreliance on diesel vehicles is due to cost, inadequate charging infrastructure, especially in rural areas and consumer reticence towards the new technology. Government should guarantee the availability of plug-in vehicle grants maintained at October 2018 levels (House of Commons BEIS Committee October 2018) until upfront cost parity is reached. In the meantime, introducing gradually tighter vehicle emission standards throughout the 2020s, while continuing initiatives that grow business and consumer confidence in the new technology (e.g. through providing better information

to consumers, clarifying the fiscal incentives and taxation regimes that early buyers can expect and through clarity of policy) will be essential. This could be combined with measures to mandate minimum sales of zero emissions vehicles as has been done in California and China. This set of incentives combined with long-term policy certainty will prepare supply chains to scale up in time.

One adverse effect of an earlier diesel phaseout is the loss of revenue from fuel tax earlier than predicted. Government raised about £27.9bn from fuel duties in 2016-17, according to the Office for Budget Responsibility, 4% of the total tax take (BBC 19 October 2019). Impacts could be mitigated by consulting on a new system of road taxation (https://www.ifs.org.uk/publications/14407) , including a single levy for road usage and transport emissions, charges based on distances travelled and trips taken during rush hour. As the take-up of EVs increases, a taxation mechanism to cover all vehicles becomes more urgent.

Another adverse effect could be decreased mobility, especially for sections of the population that cannot afford a switch to EVs or for those living in remote areas where the use of EVs is currently less practical given inadequate charging infrastructure. This can be addressed through better investment in charging infrastructure across the country, focusing public funding where market conditions are more difficult such as in rural areas or residential areas without off-street parking, to ensure equitable access to charging facilities. The development of an integrated transport strategy as per the response above will support these efforts.

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: n/a

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: Manufacturing sectors at risk of carbon leakage represent a key decarbonisation challenge for the UK. In the last few years, UK demand for industrial products has increased considerably, with the net value of imports more than doubling for manufactured products, pointing to an increase in consumption emissions, but a decrease in territorial industrial emissions (Committee on Climate Change June 2018 Reducing UK emissions: progress report to Parliament)

An effective way to decarbonise domestic industry and prevent the risk of carbon leakage is through the introduction and gradual tightening of product standards driving down

embodied carbon in building materials such as steel and cement. Such standards could help grow the market for ultra-low carbon industrial goods whilst also protecting UK businesses from high carbon imports or an offshoring of carbon intensive manufacturing practices.

To support this, government should update its procurement rules with mandates for investing in infrastructure to buy steel or cement with low levels of embedded carbon, thereby attracting more investment in this technology from the private sector. In addition, with public procurement market valued at £284bn in 2017/18 there is real scope for government to drive demand in this sector. Establishing a robust carbon price escalator will also help improve the investment signal for industrial decarbonisation.

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: The Swedish government launched a Fossil Free Sweden initiative ahead of COP21 with the aim of becoming one of the world's first fossil free nations.
Over 350 companies, municipalities, regions and organisations are taking part in the initiative and so far 11 industries have set out their own roadmaps towards "fossil freedom and increased competitiveness" (Fossil Free Sweden February 2018 Roadmap for fossil free competitiveness: a summary of roadmaps from Swedish business sectors). The roadmaps set out when and how the industries will become fossil free, what technological solutions need to be developed, what investments need to be made and what policy or regulatory obstacles need to be removed.

For example:
• the construction and civil engineering industry believes that it can halve emissions by 2030 using existing technologies, and reach net zero by 2045 using technologies currently under development;
• the concrete industry intends to halve its climate impact in 5 years, with climate neutral concrete available by 2030 and all concrete in Sweden becoming climate neutral by 2045;
• the aviation industry intends to use biofuels to achieve fossil free domestic aviation by 2030 and all flights departing from Swedish airports are to be fossil free by 2045.

The process adopted by Sweden in realising its net zero commitment provides a positive precedent for how the UK could develop an industry-led and evidence-based strategy to deliver net zero. Engaging industries to set their own roadmaps in partnership with their value chains demonstrates a good model for public-private collaboration, anchored in business growth and innovation. However, to be effective and ensure cross-industry buy in, industry engagement needs to be matched by government action in the shape of regulatory drivers and supportive market creation policies, including product standards, change in public procurement rules, guaranteed revenue mechanisms).

Another example comes from the EU's ecodesign and energy label requirements, which have empowered customers to choose the most energy efficient products, reduced emissions from power generation and supported industrial competitiveness by removing less efficient products from the market. It is estimated that these policies will have saved 15% of energy by 2020, while reducing the energy bills of European households by almost €500 each year (Euractiv 1 March 2019)

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

ANSWER: Achieving a just transition in the fossil fuel supply sectors will depend on adequate provisions for reskilling the workforce and transitioning them into similar level jobs in the green economy. In the longer term, as some industries become increasingly specialised, the focus should be on skills provision at all educational levels to secure an adequate pipeline of workers to meet demand across the sectors.

A key priority should be developing a national low carbon skills strategy, which integrates sustainability at all levels of the educational system in the national curriculum – apprenticeship programmes, higher education and particularly through lifelong learning. This will ensure the UK has an attractive pipeline of skilled workers for new and growing industries in the long run. More widely, everyone entering the workforce, irrespective of their sector, should be equipped with skills for the low carbon economy and basic net zero literacy, as all job roles will require this knowledge to ensure the step change needed by employers to get to net zero.

In the immediate term, taking a strategic approach to direct low carbon investment to regions in need of opportunities and with transferrable skill sets will be essential. This will require identifying parts of the low carbon economy where the UK is particularly well placed to grow its supply chains, and in which geographic areas these jobs are likely to be created. This should be mapped against how sectoral transition pathways are likely to impact on employment, with plans made accordingly to support the growth of new industries with similar skill sets as declining industries in the same parts of the country. There are already successful examples of this transition, with over one third of marine engineers working in offshore renewables transitioning from the oil and gas sector (The Telegraph 11 September 2016).

Government should facilitate better dialogue with local government and Local Enterprise Partnerships (LEPs), who have a significant role to play in engaging businesses, particularly SMEs on the net zero agenda and ensuring that they understand and can identify potential supply chain opportunities in the net zero transition. Where adequately funded and working in close co-ordination with national government, LEPs can support local businesses to successfully bid for supply chain contracts in low carbon sectors, as has been seen for example with offshore wind in the Humber and Solent regions.

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: In 2013, the Aldersgate Group became a partner on the REBus project, an EU LIFE+ funded partnership project that pioneered and tested a methodology enabling companies to transform their strategies to be more profitable, resilient and resource efficient. REBus worked with businesses across the UK and the Netherlands in a range of market sectors, worth an estimated €350bn across the EU. Across its pilot projects, REBus had already delivered by the end of 2016 a total of €5.62m in financial benefit, whilst reducing materials consumption by 62,619 tonnes and reducing emissions by 1,953 tonnes. These results are significant when one considers that many of the business pilots were run by SMEs and have continued to grow since.

Under an ambitious transformational change scenario, WRAP, one of the lead partners in the REBus project, estimated that if the resource efficiency models tested by these pilot projects were replicated throughout their respective economic sectors, they could deliver an increase in gross value added to the EU economy of up to €324bn by 2030, whilst also reducing material demand by up to 184 million tonnes, avoiding an additional 172 million tonnes of material use and reducing emissions of 154 million tonnes CO2 equivalent by that same date.

Examples of companies embracing such resource efficient business models and deriving gains from it include: in the ICT sector, Sky launched a new mobile phone. To improve the resource efficiency of its new offer, Sky included a mobile "take-back" option for its consumers with technical assistance provided by REBus around market research and the selection of recycling and refurbishment partners. It is expected that this take-back option will provide environmental and financial benefits in the form of better value for consumers, material savings and Sky retaining the asset value of returned products. In the furniture sector, the SME, Naturalmat worked with the REBus team to adapt its mattress manufacturing processes to make them easier to disassemble at the end of their lives. By adopting an ecodesign approach, Naturalmat now uses 50% less adhesives which means more materials can be reused, recycled or upcycled. Naturalmat also developed a market-based incentive for customers to return old mattresses to their stores. More examples and policy recommendations can be found in Aldersgate Group (January 2019) Beyond the 2019 elections: maintaining momentum on resource efficiency.

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: Replacing traditional oil or gas boilers can be done through: injecting clean hydrogen into the grid, direct electric heating, district heat networks and the use of heat pumps.

Clean hydrogen is still an emerging technology which has not been rolled out at scale so far, so it is difficult at present to be clear about the potential of hydrogen to decarbonise heating until concrete lessons can be learnt from high scale trials. This is why the use of hydrogen must be an urgent R&D priority for government.

Direct electric heating should only be used for highly energy efficient homes due to cost concerns.

Given these constraints, heat pumps and the use of heat networks are the most readily available options for decarbonising heat more quickly..

Heat networks are estimated to deliver savings of roughly £100 per year on bills for customers when compared to gas. They are low maintenance, with no boiler repairs needed, and less specific expertise required for installation. 5,000,000 customers in the UK are already connected to one of the 14,000 heat networks existing in the UK, with 91%

of them located in England. Given that some of the infrastructure is already in place and use of heat networks is already widespread in certain areas, they represent a viable option for achieving quick emission cuts in heating, although the heat they distribute needs to come from a low carbon source. However, they are mainly used at present in urban and high-density areas, and their use in rural, more isolated areas makes less economic sense.

Heat pumps are a low regret option for providing low carbon heating to around half of the four million homes currently not connected to the gas grid, delivering considerable savings to customers. However, only about 20,000 are installed each year in the UK though the technology has been in common use for more than a decade. One of the reasons is that there are not enough trained installers for heat pumps, so more emphasis on reskilling engineers to deliver low carbon heating alternatives should be a priority.

However, the use of these two options needs to go hand in hand with decarbonising the power sector and an uplift in energy efficiency standards in buildings. To overcome cost concerns, it is key that government continues its Renewable Heating Incentive scheme beyond 2021 to subsidise retrofitting costs and encourage wider take-up of these two options until technologies like hydrogen mature and costs come down.

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: The construction sector is already experiencing significant skills shortages. In the quarterly RICS UK Construction and Infrastructure Market Survey for Q1 2018, 60% of respondents cited labour shortages as a serious constraint on growth (The Edge Foundation April 2018) The adoption of a net zero target amplifies these shortages, given additional demand for skills on energy efficiency improvements, low carbon heating installation or net zero building design. In addition, the transition to a net zero emissions economy in the construction sector will require adding a sustainability dimension to all roles, from engineers to project managers.

Government should develop a national low carbon skills strategy, integrating sustainability at all levels of the educational system in the national curriculum – apprenticeship programmes, higher education and particularly through lifelong learning. This will ensure the UK has an attractive pipeline of skilled workers for new and growing industries in the long run. More widely, everyone entering the workforce should be equipped with skills for the low carbon economy and basic net zero literacy, as all job roles will require this knowledge to deliver the step change needed by employers to get to net zero.

Government should develop regulation that facilitates the net zero transition while at the same time giving businesses the confidence to invest in skills. A success story in this area comes from the waste and automotive sectors where regulations have changed the ways these sectors operate. For example, mandating certain standards via product regulations, building regulations (such as through demanding energy efficiency retrofitting standards and net zero construction standards for new builds) and / or public procurement contracts will help drive demand for requisite training in the construction sector.

Central government should also collaborate more closely with local authorities and Local Enterprise Partnerships (LEPs) to identify areas where the UK is well placed to grow its low carbon supply chains or support the growth of new industries owing to similar skill sets

as declining industries in the same parts of the country should help direct investment to these areas. A good example comes from the offshore wind industry, which has grown in areas associated with high emitting industrial sectors, with over one third of marine engineers working in offshore renewables transitioning from oil and gas

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: n/a

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: As the cost of renewable technologies continues to fall and in order to maintain clear investment signals in line with the UK's net zero target, we would encourage the government to facilitate the development of a long-term market for zero carbon and tradeable electricity contracts. This suggestion, based on research commissioned by the Aldersgate Group from UCL, would have the advantage of providing industry with access to low-cost, unsubsidised renewable electricity sources in a way that would reduce industrial electricity prices, help them avoid the carbon price and send a clear market signal to renewable energy developers. Industrial consumers would also be able to trade these contracts (or a part of them) subject to their demand needs. (UCL 2018 UK Industrial Electricity Prices: Competitiveness in a low carbon world, UCL)

In the absence of government backed CfD auctions, the resumption of a carbon price escalator is another key measure that needs to be adopted to continue the decarbonisation of the power sector. As coal is phased out, a carbon price escalator will offer a clear direction of travel for businesses and offer long-term incentives for investment in low carbon alternatives. This is important because the move from coal to gas as the main wholesale price setter would more than halve the impact of the carbon price on the electricity price. With coal coming off the system in the very near future, government needs to ensure that the price of carbon does not reach an artificially low level and continues to send an important investment signal.

In addition, the UK should maintain good access to the EU Internal Energy Market after EU exit and support continued investment in interconnection, so that the UK remains plugged into the much larger EU market, thereby ensuring price competitiveness.

Interconnectedness allows excessive domestic generation from intermittent renewables to be exported to neighbouring markets, reducing the risk of negative prices and curtailment costs, and vice versa, reducing the need for additional domestic 'backup' generation capacity. In addition to being cost-effective, investment in interconnectedness will boost the UK's capacity to import renewable, low-cost electricity from Western Europe.

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: A priority for decarbonising the power sector in 2030/35 is to secure a route to market for mature forms of renewable energy such as onshore wind or solar, through a continuation of Pot 1 CfD auctions in the short term and the establishment of a market of zero carbon tradeable electricity contracts in the medium term as referenced above. Greater access to mature renewables is an essential part of delivering competitive industrial electricity prices whilst completing the decarbonisation of the power sector. Whilst gas power stations play an important back-up role today, a key focus of UK's innovation policy and policy measures such as the capacity market must be to incentivise a greater role for storage, demand side response, and interconnection as part of a low carbon back-up mix from the mid 2020s.

Investment in storage is already underway, with planning permission applications to install energy storage facilities in the UK having quadrupled since 2016 (Edie 6 November 2018 "UK's energy storage revolution happening faster than expected, study finds"). Investment in interconnectedness is also increasing: currently, there are already almost 4,000 MW of interconnectors joining the UK to France, the Netherlands, and the Republic of Ireland, and a pipeline of approximately 12,000MW of projects are proposed or are already under construction by 2025, with increased interconnection being an essential part of National Grid's strategy (The Engineer 21 October 2019 "Power sharing: building the world's longest subsea electricity interconnector")

With better access to renewables as more technologies mature and improved capacity to balance the grid through better storage , technologies like gas with CCS or new nuclear can play a lesser role in the energy mix in the run up to 2050. In addition, with electricity prices from mature renewables going down, increased reliance on these forms of generation are highly likely to be more cost effective than other options including new nuclear or BECCS.

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: The current cost of producing clean hydrogen is very high, which means that priorities for government should include:

1. Delivering at scale trials testing the potential applications in key areas, with a particular focus on hard to treat sectors (industry, heating or long distance transport).

Steel manufacturing in Sweden has already reduced emissions through the use of hydrogen produced by electricity from fossil fuel free sources instead of coke in blast furnaces. This will give the Swedish company a clear competitive advantage, becoming the world's first fossil fuel free steel making technology with virtually no carbon footprint. (http://www.hybritdevelopment.com/)

2. Developing commercialisation strategies and market creation mechanisms to support the roll out of hydrogen at scale, for example through regulations mandating the installation of low carbon heating in existing and new buildings.

With complex technologies like hydrogen, government must not wait to have the definitive 'right' answer on a number of difficult areas before acting. Rather, it must start trialling different solutions at scale, using already existing pre-commercial technologies to gather evidence, improve understanding of best practice, skill up the supply chain, spread consumer understanding and develop governance principles around new technologies. While early pilot projects may not deliver the ideal desired outcome, well-designed and managed pilots have inherent value in generating lessons learned, through both technical and operational successes and failures.

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 main domestic measures that can be taken to reduce emissions from aviation and shipping are around innovation and support for the application of innovative solutions from other sectors to slash emissions in aviation and shipping.

Capitalising on fuel efficiency and electrification gains from the transport sector will be essential. For example, the Driving the Electric Revolution Challenge supported by the Industrial Strategy Challenge Fund is predicted to deliver spillover benefits for other sectors such as the development of hybrid aircrafts. Government should facilitate cross-industry collaboration and encourage companies in this space to share R&D gains without fear of losing their competitive advantage. A successful model of such collaboration is National Industry Symbiosis Programme, which generated cost-effective ways of reducing waste and emissions from waste through knowledge-sharing, mediated by government.

Investing in innovation for alternative fuels and exploring the applicability of technologies like hydrogen to power ships and planes will be another way of capitalising on research already underway in the automotive or industrial sectors to cut emissions for aviation and shipping.

The UK will need to act fast to secure a first mover advantage in sustainable fuels, the production and use of hydrogen, batteries or other technologies essential for sustainable shipping and aviation. It is already investing in R&D to develop superior technologies through schemes such as The Faraday Challenge or the Industrial Strategy Challenge Fund. As more countries adopt net zero targets and impose similar targets for the shipping

and aviation sectors, the UK needs to be well-placed to capture a large share of this growing market. For example, a growing number of shipping companies are already adopting technological and operational measures to become more sustainable, including NYK (Nippon Yusen Kaisha), RCCL (Royal Caribbean Cruises), Carnival, Maersk and Wilhelmsen and spanning markets that are crucial for UK trade after Brexit. This shows the need for urgent action if the UK is to stay ahead of its competitors (https://blogs.dnvgl.com/sustainability/2018/12/sustainable-shipping-why-does-it-matter/)

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: n/a

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: Aldersgate Group agrees with the key measures proposed and suggests developing these alongside market mechanisms to support emissions reductions in this sector.

Firstly, government must consider how best to kickstart a private investment market in natural capital and nature-based GHG removal solutions, working with farmers to develop collaborative solutions. Ramping up investment in these methods will reduce emissions and deliver co-benefits, such as increased crop productivity, biodiversity enhancement, improved soil carbon sequestration and habitat restoration. At the same time, government needs to ensure that subsidies to the sector are focused on the delivery of positive environmental and social outcomes such as clean air and water, enhanced landscapes, thriving plants and wildlife and benefits to the rural economy. This approach will help meet the net zero target whilst also delivering against environmental improvement targets under the Environment Bill.

The creation of a carbon trading scheme could deliver further reductions, by encouraging investment in nature-based solutions through better land management practices and technology, such as GHG credits for avoided emissions and GHG removals through soil and peatland restoration, tree planting and technologies such as bioenergy with carbon capture and storage and other processes. Through the introduction of a robust carbon price, a Bioenergy Strategy and demonstration projects, the agriculture sector could deliver emissions savings of up to 22 MtCO2e/year (NFU September 2019)

In addition, government should direct businesses to invest in practices enabling sustainable land management, by introducing obligations of due diligence to ensure that the impact of supply chains on soil quality through unsustainable farming practices is publicly reported and that genuine steps are taken to mitigate this. Improper use of soil through excessive farming and inadequate agricultural practices is the top direct driver in the decline of nature, followed by climate change, pollution and invasive alien species (Earthwatch Institute 2019). In this way, a plan for getting the agriculture sector to net zero would guard against the possibility that land use is only valued for its carbon storage potential, and that co-benefits such as improved resilience to climate and water stress, improved food security and protection of biodiversity are all reflected in business practices

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 GHG removal technologies have not yet been commercialised and deployed at scale, and scaling them by 2035 will depend on the acceleration of innovation cycles for these emerging technologies. This is why government should focus on developing an ambitious innovation policy which includes at scale trials and then creating new markets to support their deployment.

Firstly, government should facilitate at scale trials for Negative Emissions Technologies (NETs) and adopt a learning by doing approach, in order to better understand how to deploy complex NETs and what their spillover benefits might be. Government should ensure that pots of funding are available for these new technologies at all stages of their development until they are commercialised.

To ensure success, the innovation trials should be linked up with a viable commercialisation strategy. In encouraging their adoption, creating new markets is equally important in making these technologies competitive. A clear view on the future demand for carbon negative technologies and availability of future revenue streams gives a concrete indication to NET developers and consortiums that their investments would be rewarded if they succeeded in bringing the technology to market at scale (Vivid Economics & UKERC April 2019 Accelerating innovation towards net zero emission)

A final constraint is the public acceptability of these largely unknown technologies. Government should create a strategy to communicate and encourage acceptability and rapid adoption NETs. The rapid roll out of unfamiliar forms of technology may elicit public concern and government should therefore devise an appropriate communications strategy that addresses this from the get-go. A successful example of this is the management of communications during the UK's transition from town gas to natural gas, where time and resources were dedicated to address consumer concerns through initiatives including the Conversion Strategy handbook and the 'Guaranteed Warmth' campaign. Rapidly moving

towards achieving net zero gives government an important role to play in gaining public acceptability for these technologies and ensure there are as few impediments as possible to their wide adoption.

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: n/a

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: As covered under the heating decarbonisation question under the building section, investment in heat networks and grid reinforcements will be key to cut emissions from heating. However, the most effective options will vary from region to region, which is why close collaboration with local authorities will be essential to identify the least disruptive and most cost-effective options available.

Investment in the gas grid may be needed to support low carbon hydrogen roll out, but this will depend on whether large scale trials indicate that it will be a cost-effective and scalable solution to decarbonise heat.

Investment in heat networks will be economical for decarbonising heating in buildings in dense and urban areas, but less so in rural or isolated communities. However, it is important to note that existing heat networks do not currently distribute low carbon heat: in many cases existing district heating is served by gas CHP (combined heat and power) and has higher carbon emissions, introduces additional capital and billing costs, removes the consumer's ability to switch suppliers and is less efficient due to network losses. Infrastructure investments to minimise losses alongside a review of decarbonisation of heat sources will be key to make heat networks a viable solution. These heat networks are of utmost strategic importance as they provide an extremely flexible and future proofed approach that enables upgrades to primary energy delivery as technology develops, with minimal change within the consumer's property.

Cutting heating emissions by reinforcing the electricity grid will be essential for homes switching to heat pumps, which are seen as a viable option in buildings with higher levels of energy efficiency and buildings off the gas grid and a low regret option for cutting heating emissions given low cost of installation and potential savings for consumers. However, given the slow take-up of heat pumps so far (only about 20,000 are installed each year in the UK though the technology has been widely available for more than a decade), government should invest in communications campaigns and renewal of the Renewable Heat Incentive scheme to encourage faster take up of heat pumps. Power grid reinforcements should be happening simultaneously to support increased electrification in sectors including heating and surface transport.

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: n/a