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.

Questions:

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?
    - Yes.
    - And we should bear in mind that some sectors (e.g. electricity) are easier to decarbonise than others (e.g. aviation) and so should decarbonise earlier.
2. How relevant are estimates of the remaining global cumulative CO_2 budgets (consistent with the Paris Agreement long-term temperature goal[1]) for constraining UK cumulative emissions on the pathway to reaching net-zero GHGs by 2050?
    - Very relevant: we should do better than the 1.5oC targets because such a large proportion of historical emissions are British. For the same reason (as well as our comparative wealth) we have a moral duty to help other countries.
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?
    - We should realise that each country sets its targets to flatter itself, meaning that the 1.5oc (or even 2oC) temperature rise will not be achieved unless we change. The UK is probably the worst for this, because we omit imported CO2. If we close a cement factory and import the cement, that makes the global situation worse (adding shipping-related emissions, and getting its energy from dirtier sources) rather than better (as shown in our current methodology). I have read that the difference would add ~40% to our claimed current emissions. See, for example, https://www.carbonbrief.org/mapped-worlds-largest-co2-importers-exporters
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?
    - Enormous, particularly our taking responsibility for (a) historical emissions, (b) helping others and (c) imported emissions.

A. The path to the 2050 target

Carbon budgets need to be set on a path that is achievable from today, on the way to the 2050 target. The Committee has previously set out a cost-effective path to the

[1] Remaining CO_2 budgets incorporate the effect of future emissions of non-CO_2 greenhouse gases and other climate pollutants such as aerosols.

previous long-term target (for a reduction of at least 80% in GHG emissions between 1990 and 2050) that balances effort before 2030 with potential opportunities from 2030 to 2050. The path includes ways of reducing emissions that are likely to be relatively low-cost and actions that will develop options that may need to be deployed at scale by 2050.

The new net-zero target means that:

- The current cost-effective path for decarbonisation to 2035 is unlikely to be sufficiently steep, as it was set on the basis of the previous 2050 target. The path will need to be reassessed in the light of the net-zero target.
- Near-full decarbonisation will be needed across every sector to reach net-zero emissions. This leaves less flexibility on which emissions sources need to be abated and the loss of optionality could increase risks that the legislated 2050 target will not be met. Therefore, although cost-effectiveness will continue to be an important criterion in informing abatement opportunities, measures which keep future options open and increase potential to achieve targets will be of increased value.

Given long lead-times for many abatement measures (e.g. large-scale new infrastructure build out, tree planting) many critical abatement options will have to be in place or well advanced by the sixth carbon budget period, if Net Zero is to be achieved in 2050.

Questions:

5. How big a role can consumer, individual or household behaviour play in delivering emissions reductions? How can this be credibly assessed and incentivised?
    - Large, but maybe only 1/4 of the total influence, with 1/2 being government and 1/4 being infrastructure, utilities and businesses). If people aren't given the right opportunities, then they can't take advantage of them. If they see free-loaders getting away with it, then they'll rebel.
6. What are the most important uncertainties that policy needs to take into account in thinking about achieving Net Zero? How can government develop a strategy that helps to retain robustness to those uncertainties, for example low-regrets options and approaches that maintain optionality?
    - The biggest single issue is lack of long-term thinking. Every sector is focused on achieving 2025 and 2030 targets, not on 2050. Thus, for example, the electricity sector wanted to build lots of gas-fired power stations to achieve 2030 targets, which would have become stranded assets very fast owing to dropping emissions ceilings, thereby wasting the country billions.
    - It is well recognised that the first reductions are the easiest and the last the hardest. Many of the last ones are only achievable with substantial investment TODAY, e.g. in sufficient storage to enable renewables to power the grid, because of lead times in (a) development [though this is not needed for electricity storage] and (b) roll-out.
    - The biggest single hurdle that these new technologies face is first-of-a-kind commercial-scale plants, which private money won't finance if they

cost more than ~£1m. Therefore the government MUST devote a lot of attention, commitment and money to them. For example,

- Treasury should halve tax incentives if there's little or no innovation involved, and double them if there is;
- Treasury should give a tax break to funds that devote 10% of total fund value to investments with technical risk (and half-sized tax break for 5%) – which can be sold to investors as keeping 90 / 95% of the fund in "safe" investments while providing enormous up-side potential;
- Ministries should award long-term contracts to first-of-a-kind plants (more than one, if they are more than a factor of 5 or 10 different in size, as scale has its own challenges) to buy an optimised revenue stack of their services at the prices that apply at the time and under the contracts that apply at that time (i.e. zero subsidy), starting when the plant can deliver (i.e. accommodating long-lead-time developments) – probably with safeguards such as no more than 10% of the total value of any contract type (to prevent market distortions). There will not be excessive takers as there is no subsidy, though if innovation funding is granted then that would be provided independently of the contracts and therefore additional to them. Legally binding letters of intent to award such contracts, written at early-stage development, would give private investors the confidence to fund early work such as applying for planning permission and detailed design.

  - All major developments MUST be compliant with 2050 objectives.
  - Pressure should be put on ministries to structure their regulatory systems such that appropriate investment and innovation is intrinsic to the system rather than needing special incentives like (in the electricity industry) CfDs, CATOs, ROCs, OFTOs, Capacity Market, cap-and-floor etc. Please see A 21st Century Electricity System (sent as a separate PDF with this document) as an example regulatory structure.

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?
   - Yes. Faster early reductions are essential to delivering total targets.
   - But that should not absolve ministries' obligations to think long-term and to instigate NOW the work needed to achieve 2050 targets.
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 options should be prioritised and why?
   - In the electricity industry, investing now in large-scale long-duration electricity storage (such as Storelectric's CAES) would not only provide the balancing services needed to enable renewables to power the grid,

but also the ancillary services such as inertia, (see the associated one-page PDF, Inertia and Stability) and the national sufficiency so we don't depend on imports during times of system stress – as all our neighbours are planning to do concurrently (see the associated one-page PDF, Imports and Interconnectors – if wanted, I can supply much more detailed analysis on the matter).

- There is recent ill-informed opinion that the German energy transition can happen without needing baseload or inertia. Please see the associated Word document "De-Bunking Fictions Citing Germany", which also refers to the same two PDFs mentioned above.

B. Delivering carbon budgets

The UK's statutory 2050 target requires actions across the economy to reduce emissions. Many of these actions will be driven by (UK and devolved) Government policy and implemented by businesses and individuals. There will also be an important role for Local Authorities and cities in successful delivery, with a requirement for local targets and action to be a cost-effective part of meeting the UK-wide target.

Although the carbon budgets do not mandate specific actions, they indicate the overall direction that policy will take in future. Once set, carbon budgets can only be changed if there has been a significant change in the relevant circumstances set out in the Climate Change Act. Feedback from businesses as part of the Committee's 2019 Call for Evidence to inform the Net Zero advice was that stability is an important and valuable characteristic of carbon budgets.

Questions:

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?
    - The 6th Carbon Budget should go beyond previous ones inasmuch as nobody is responsible for achieving previous targets. People, companies and government departments (including Treasury, as so much of what it does makes achieving the budgets almost impossible) must be made legally and financially accountable. Of these, the most important is people – individuals who are therefore incentivised to do the right thing rather than the expedient thing.
10. How should the Committee take into account targets/ambitions of UK local areas, cities, etc. in its advice on the sixth carbon budget?
    - Where they wish to advance beyond the country as a whole, that should be applauded.
    - Where their ambition is behind the country as a whole, that should be offset against areas where they are in advance, but the region as a whole must not be behind.
    - Where a region as a whole is ahead of the country as a whole, then this "surplus" should be "banked" against failures by other regions –

without relaxing the obligations of the other regions, or the country as a whole will fail.

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?
    - Yes, they are policy decisions independent of emissions.
    - Where investment is being made to achieve emissions, combining it with investment to reduce fuel poverty etc. would reduce the costs of the two actions combined. Provision should be made to share the benefits proportionately between budgets.
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?
    - For the most part, the two topics are distinct.
    - Where investment is being made to achieve emissions, combining it with investment to reduce fuel poverty etc. would reduce the costs of the two actions combined. Provision should be made to share the benefits proportionately between budgets.
    - Most people, not just the poor, will need help investing in (for example) lower-emissions homes and vehicles.
    - Tax policies should penalise private vehicle use and encourage public transport use, associated with massive investment in public transport, especially rail-based services (e.g. bringing Beeching-cut lines back into service for light rail) and separate cycle lanes / roads.

C. Wales, Scotland and Northern Ireland

The Climate Change Act states that differences in circumstances between England, Wales, Scotland and Northern Ireland must be taken into account when setting the level of carbon budgets. We consider as part of this:

- Relevant legislation in the devolved administrations (e.g. the Environment (Wales) Act 2016, the Climate Change (Scotland) Act 2009) and any associated GHG reduction targets (e.g. Welsh carbon budgets, Scottish interim targets).
- A fair contribution from each of Wales, Scotland and Northern Ireland towards global decarbonisation efforts and towards the UK long-term target, based on their ability to reach net-zero GHG emissions (which relies on the proportion of economic activity in hard-to-decarbonise sectors, existing infrastructure that will impact decarbonisation in the long-term, the way land is used, opportunities for engineered GHG removals and potential to deliver more speculative abatement options).

Alongside the UK target to reach net-zero GHG emissions by 2050, our Net Zero advice also recommended a net-zero target for 2045 for Scotland and a 95% emissions reduction target against 1990 levels for Wales by 2050. These different

targets reflect the opportunities for emissions reduction in different parts of the UK, rather than different levels of ambition.

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. As such, the questions below are mainly focused on Wales.

Questions:

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?
    - Where they wish to advance beyond the country as a whole, that should be applauded.
    - Where their ambition is behind the country as a whole, that should be offset against areas where they are in advance, but the region as a whole must not be behind.
    - Where a region as a whole is ahead of the country as a whole, then this “surplus” should be “banked” against failures by other regions – without relaxing the obligations of the other regions, or the country as a whole will fail.
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?

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

D. Sector-specific questions

In developing our analysis and evidence base for past reports (including, most recently, our advice on Net Zero) the Committee has identified a number of evidence gaps in specific emitting sectors of the economy, which are set out as questions below.

Many of the questions below refer specifically to CCC scenarios and analysis developed for the Net Zero advice. Please see the Net Zero Advice Report and Technical Report for further details. Chapters and page references are provided in the relevant questions where necessary.

When answering these questions please bear in mind the factors the Committee must consider in our advice on carbon budgets – i.e. the path to the UK's long-term target objective, international commitments and considerations such as social circumstances (including fuel poverty), competitiveness, energy security and the Government's fiscal position.

You do not need to answer all the questions. Please answer only those questions where you have specific expertise and evidence to share.

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

Questions:

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?
        - That depends entirely on the policies (below).
    b) What policies, measures or investment could incentivise this transition?
    - Penalising the use (not ownership) of private transport while simultaneously investing massively in public transport (especially rail services) and separated cycle paths / lanes.
19. **Surface transport:** What could the potential impact of autonomous vehicles be on transport demand?

- A huge increase in mileage, while decreasing the number of vehicles on the road: if people A, B and C wish to get to work, currently that's 3 journeys. In shared transport it's 6 (A to work, then to B, B to work, then to C, C to work, then to the next point).
- We cannot assume lift sharing because it ignores many unconsidered hazards, e.g.
  - Would you wish to be a co-passenger with someone antisocial or dangerous? What of public safety? Liability?
  - If not, then do you create an underclass who is excluded from the main transportation system and therefore can't easily find employment etc., creating some of the really dystopian societies such as in the film Demolition Man?

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?
    - Two barriers: cost and technology.
    - Cost: renewable vehicles are too expensive. This needs bringing down by (a) taxing non-renewable vehicles and (b) helping with prices of renewable ones.
    - Technology: there isn't enough lithium in the earth's crust for all the vehicles of this world, even without considering aircraft, electricity systems and portable devices. Cobalt is scarcer.
    - https://www.economist.com/news/briefing/21726069-no-need-subsidies-higher-volumes-and-better-chemistry-are-causing-costs-plummet-after -
      - Vehicles, 2016 25 GWh 750,000 vehicles
      - Mid-range: 2040 Bloomberg 15,500 GWh 465,000,000 vehicles
      - 2040 OPEC 5,000 GWh 150,000,000 vehicles
      - 2040 ExxonMobil 3,000 GWh 90,000,000 vehicles
      -
      - Total lithium, 2016 180,000 tonnes in one year
      - 2040 Bloomberg 111,600,000 tonnes in one year, just for vehicles
      - 2040 OPEC 36,000,000 tonnes in one year, just for vehicles
      - 2040 ExxonMobil 21,600,000 tonnes in one year, just for vehicles
      -
      - Total available lithium in planet 210,000,000 tonnes
      - Years' output:2040 Bloomberg 1.9 years, just for vehicles
    - Therefore a rational transportation system would involve 1/3 batteries (for short journeys in small vehicles) and 2/3 fuel cells (for the rest) – the country needs to work fast on developing:

        - Fuel cells;
        - Bulk means of producing hydrogen by electrolysis (not PEM, too dear, or SMR, too many emissions) – there are some promising technologies around but they're not being supported;
        - Hydrogen infrastructure.

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?
    - Overhead wires on motorways are unlikely ever to happen (changing lanes; joining and leaving motorways; contending with bad drivers).
    - Batteries are wrong for HGVs, as per my response to Q20.
    - Hydrogen is the appropriate fuel for HGVs.
        - Need to incentivise development and production in the UK.
        - Need to make them cheap enough.
    - And more rail transport.
        - Need more and better road/rail hubs, railways, freight vehicles, load/vehicle/route management, speed and ease of decoupling and recoupling vehicles.

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[2]
        a. Tax emissions. If imported, ensure that a similar level of emissions tax is levied on (a) the product and (b) the transportation, with an equalising duty if not (and corresponding credits for export to match the receiving country's system)
    b) Manufacturing sectors not at risk of carbon leakage
        a. CCS clusters for polluting industries.
    c) Fossil fuel production sectors
        a. These should just die; tax them on the fossil fuels that they produce / extract / use.
    d) Off-road mobile machinery
        a. Hydrogen.

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

[2] Carbon leakage occurs if costs of climate policies result in offshoring of production to other countries.

created economic opportunities (e.g. increased market shares, job creation) for the manufacturing and fossil fuel supply sectors?

- Re-injection (rather than flaring) of gases; on-site CCS

24. **Industry:** How can the UK achieve a just transition in the fossil fuel supply sectors?
    - These should just die; tax them on the fossil fuels that they produce / extract / use.
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)?
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:[3]
    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?
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?
    - No we don't – I know architects who depend on foreigners who learned their skills in Germany for some skills, e.g. thin-mortar thermal block laying.
    - We need to train not only all builders but also engineers, architects, facilities managers etc.
    - And we should tax the less efficient materials and buildings.
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?
    - All new buildings should be carbon positive.
    - The Pasivhaus system is not the be-all and end-all: there are other systems/standards that are at least as good.
    - The UK should create a legally enforceable standard for new buildings of all types.

[3] For further discussion please see Element Energy and UCL for the CCC (2019) *Analysis on abating direct emissions from 'hard-to-decarbonise' homes, with a view to informing the UK's long term targets*, p88.

- Every single big roof (e.g. stations, warehouses, factories) should be a solar farm: we shouldn't have to take a single new field out of production for solar.
- Tidal barrages should be facilitated – much more cost-effective than lagoons, storing much more energy with much shorter dams. Standards need to be developed to minimise environmental damage.

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?
    - See A 21st Century Electricity System, PDF associated with this document. Easy to implement in stages within the current system, it's a very simple way to:
        - Eliminate subsidies;
        - Incentivise cleanness of energy technologies;
        - Incentivise adoption of new technologies.
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?
        a. Greater: large-scale long-duration storage such as www.storelectric.com – the technology exists and is already sufficiently cost-effective to roll out nation-wide, provided that the first-of-a-kind plant is financed and built.
        b. This enables CCS generation (far too expensive and inefficient) to be abandoned except where it piggy-backs on CCS infrastructure built for industrial hubs.
        c. Batteries are greatly over-emphasised: they are small-size, short-duration and have no inertia.
            i. Since there isn't enough lithium on the planet for all the vehicles of the world, and since lithium's Unique Selling Propositions are energy density per weight and per volume, it makes strategic sense not to implement lithium solutions where we'd bolt them to the ground.
            ii. And equally it makes sense to stop trying to make lithium larger-scale or longer-duration: there are already other technologies that can do it much more effectively, but are suffering greatly from governmental ignorance.
    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?

- Seasonal storage is not required.
  - The monthly output graphs of solar and wind are the mirror image of each other.
  - Therefore a suitable proportion of each would enable us to supply appropriate energy in all seasons.
  - This reduces the maximum duration of storage required to two weeks, the *kalte dunkel Flaute*.
- Interconnectors cannot be relied upon for energy needs. By 2049 nearly all European countries will depend on imports during largely-concurrent times of system stress (see the associated one-page PDF, Imports and Interconnectors – if wanted, I can supply much more detailed analysis on the matter). If all seek to import, who's exporting? And with Brexit our neighbours will find it impossible to tell their governments that the black-outs in their country were because they could earn millions exporting to us, so they just won't.

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?
    - Feeding into the gas grid. Percentages cannot be ramped up gradually as flame characteristics would change with each stage, requiring modifications of a similar order to the Town Gas to North Sea Gas conversion at each stage. Instead, distinct areas need to switch to 100% hydrogen, with these areas growing/merging over time, to make the transition a much cheaper once-off conversion.
    - Fuel cells for vehicles.
    - Feedstock for industry.
    - NOT for combusting in electricity generation: much too inefficient (though more efficient and beneficial in conjunction with CAES).
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?

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?
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?
35. **Greenhouse gas removals:** What relevant evidence exists regarding constraints on the rate at which the deployment of engineered[4] GHG removals in the UK (such as bioenergy with carbon capture and storage or direct air capture) could scale-up by 2035?
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?
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?
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?

[4] We consider land-based removals, such as afforestation and peatland restoration, separately in the agriculture and land-use sector.

- CCS will only be cost-effective and manageable in industrial clusters for industries that cannot otherwise decarbonise. Some generation may piggy-back on such clusters.
- CCS doesn't capture all emissions, and the 95% being bandied about appears to be a hugely expensive pipe dream. 3 years ago an 85% capture rate imposed a 30% inefficiency on power stations as well as being hugely costly – even where pipelines exist already, into suitable hydrocarbon fields. Every American CCS project has been cancelled prior to build because they're unaffordable – so what hope do we have of affording it?
- Where industrial CCS is stored, the insurance risk needs to be addressed (I have ideas): it would remain until the tectonic plate is subducted in millions of years, until when if there's a burp the CO2 would asphyxiate everyone above.

Question and answer form

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

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

a. My answers are all written above.