Achieving Carbon Neutrality or Net Zero Greenhouse Gas Emissions

Somerset West and Taunton Shadow Council in February 2019 resolved with partners across the district and region, to start working towards making Somerset West and Taunton carbon neutral by 2030, taking into account emissions from both production and consumption*. See annex 1 for full resolution.

The UK Government set a target in June 2019 to require the UK to bring all greenhouse gas emissions to net zero by 2050 (see: first major economy to pass net zero emissions law).

This paper summarises what it is expected will be required to achieve carbon neutrality or net zero greenhouse gas emissions in the UK, based on a report by the Committee on Climate Change. This is an independent, statutory body established under the Climate Change Act 2008 to provide advice to government on building a low-carbon economy and preparing for climate change.

Introduction

To stop on-going global warming and climate change, we need to stop the accumulation of greenhouses gases in the atmosphere, which have several sources, including the burning of fossil fuels. This will require many changes to our economy and lifestyles. Two good guides are:

- Committee on Climate Change, 2019: Net Zero – The UK's contribution to stopping global warming
- Centre for Alternative Technology, 2013: Zero Carbon Britain – Rethinking the Future

The Energy Systems Catapult have published Living Carbon Free to explore the role of households in a net-zero emissions society, which was produced to accompany the CCC's Net Zero report. See annex 2 for CCC's list of actions that people can take to reduce their greenhouse gas emissions.

Zero Carbon Britain is currently being updated by the Centre for Alternative Technology to take account of developments in knowledge and technology. A new Hub and Innovation Lab is being launched at CAT later this year to help communities, local authorities and policymakers to create Zero Carbon Action Plans, and to provide support for the development of innovative solutions.

The following paper consists of referenced extracts from CCC's Net Zero report to outline what will be required to move to a future with net zero carbon emissions by 2050. The Zero Carbon Britain research and reports by the Centre for Alternative Technology provide a scenario for net zero emissions by 2030, with similar policies to CCC but with greater ambition.

Summary

COMMITTEE ON CLIMATE CHANGE - NET ZERO

Key elements of the contribution to be made by the UK in the Net Zero report are:

- Major improvements to the energy efficiency of buildings and low-carbon heating throughout the building stock. Heat pumps in new builds (not connected to gas grid from 2025) and retrofit hybrid heat pumps to existing housing. Also support use of biomethane gas, hydrogen

* This includes scope 1, 2 and 3 greenhouse gas emissions, which are explained at: www.carbontrust.com/resources/faqs/services/scope-3-indirect-carbon-emissions

and networked low-carbon heat (district heating). 40% of houses and flats built with a timber frame (up from under 30% today). Industry must also be largely decarbonised.

- Encourage walking, cycling and the use of public transport in preference to car usage. Phase-out of petrol and diesel cars and vans by 2030-35, so all cars and vans can be fully electric (not hybrid) by 2050. The vast majority of HGVs to be either electric or hydrogen powered. Roll out rail electrification and trials of hydrogen trains. Restrict growth in demand for flying and reduce net emissions from aviation and shipping.
- Extend electrification across surface transport, buildings and some industrial processes. Quadruple renewables and low-carbon power to meet higher demand and to increase its share from around 50% today to around 95%. The other 5% from decarbonised gas, by using carbon capture and storage (CCS) and converting natural gas to hydrogen.
- Shift to healthier diets with 20-50% reduction in consumption of beef, lamb, and dairy, replaced by an increase in consumption of pork, poultry, and plant-based products. Improve arable yields and grazing intensity.
- By 2025 stop sending biodegradable waste to landfill and increase recycling rates to 70% across the UK.
- An early and sustained increase in tree-planting. A fifth of our agricultural land must shift to alternative uses that support emissions reduction: afforestation, biomass production and peatland restoration. Embed emissions reduction and removal in agriculture and land use policy.
- Where there are remaining emissions, these must be fully offset by removing CO_2 from the atmosphere and permanently sequestering it, for example by using sustainable bioenergy in combination with carbon capture and storage. CCS will be needed for hydrogen and electricity production where these involve greenhouse gas emissions.
- Phase-out fluorinated gases used in medical inhalers, refrigeration, air conditioning and heat pumps.

NOTE: not all of the policies are government policy yet. SOURCE: The UK's contribution to stopping global warming (detailed extracts from report recommendations below, after next section)

CENTRE FOR ALTERNATIVE TECHNOLOGY - ZERO CARBON BRITAIN

Key elements of solutions in CAT's Zero Carbon Britain (2013) are:

- High Passivhaus standards for all new builds, retrofitting all existing buildings, and improving internal temperature control could reduce heating demand by around 50%.
- Reducing how much we travel and changing how we travel could reduce energy demand for transport by 78%.
- Invest in joined-up affordable public transport, and in better infrastructure for walking and cycling. Cut flights through a frequent flyer levy – and scrap the third runway at Heathrow.
- It is possible to meet 100% of the reduced energy demand with renewable and carbon neutral energy sources, without fossil fuels and without new nuclear.
- Many different renewable energy sources are in the mix, with wind (both on-shore and off-shore) providing around half of the energy supply.
- Most of the energy in our scenario (around 60%) is produced in the form of electricity.

- We can balance supply and demand – hourly modelling of the renewables mix in our scenario over a ten-year period shows that we would produce a surplus of energy 82% of the time. Smart appliances and energy storage solutions (batteries, pumped storage, heat storage, hydrogen, carbon neutral synthetic natural gas) could be used to cover the remaining periods.
- Diets and land-use are an essential part of the mix. Dietary changes, mainly reducing meat and dairy, combined with food waste reduction and improved agricultural processes could cut greenhouse gas emissions from agriculture by 75%.
- This could also improve our health and free up land for other purposes, including a doubling of forest cover, restoring peatlands and providing more 'wild spaces' for biodiversity to thrive.

SOURCE: www.cat.org.uk/can-we-reach-zero-carbon-by-2025

Committee on Climate Change Recommendations

CCC define (Box 1.2, page 45) net-zero emissions as follows:

> "Long-lived greenhouse gases like carbon dioxide accumulate in the atmosphere. Therefore, their emissions must be reduced to zero in order to stop their cumulative warming effect from increasing and to stabilise global temperatures.
>
> Some activities, such as afforestation, actively remove CO_2 from the atmosphere. 'Net-zero' emissions means that the total of active removals from the atmosphere offsets any remaining emissions from the rest of the economy. The removals are expected to be important given the difficulty in entirely eliminating emissions from some sectors.
>
> Sometimes 'net-zero' is used to refer to CO_2 only, and sometimes it refers to all GHGs. There are some merits in each … . Our recommendation in this report is that the UK should set a net-zero target to cover all GHGs and all sectors, including international aviation and shipping."

The following (pages 11-12) are key points from the summary of CCC's net-zero report:

- "**The foundations are in place**. Policy development has begun for many of the components needed to reach net-zero GHG emissions: low-carbon electricity (which must quadruple its supply by 2050), efficient buildings and low-carbon heating (needed throughout the building stock), electric vehicles, carbon capture and storage (CCS), diversion of biodegradable waste from landfill, phase-out of fluorinated gases, increased afforestation and measures to reduce emissions on farms. These policies must be strengthened and they must deliver action.
- **"A net-zero GHG target is not credible unless policy is ramped up significantly.** Most sectors will need to reduce emissions close to zero without offsetting …
  - **Delivery must progress with far greater urgency**. Many current plans are insufficiently ambitious; others are proceeding too slowly …:
    - 2040 is too late for the phase-out of petrol and diesel cars and vans, and current plans for delivering this are too vague.
    - Over ten years after the Climate Change Act was passed, there is still no serious plan for decarbonising UK heating systems and no large-scale trials have begun for either heat pumps or hydrogen.
    - Carbon capture (usage) and storage, which is crucial to the delivery of zero GHG emissions and strategically important to the UK economy, is yet to get started. …

        - Afforestation targets for 20,000 hectares/year across the UK nations (due to increase to 27,000 by 2025), are not being delivered, with less than 10,000 hectares planted on average over the last five years. The voluntary approach that has been pursued so far for agriculture is not delivering reductions in emissions.

    – Challenges that have not yet been confronted must now be addressed by government. Industry must be largely decarbonised, heavy goods vehicles must also switch to low-carbon fuel sources, emissions from international aviation and shipping cannot be ignored, and a fifth of our agricultural land must shift to alternative uses that support emissions reduction: afforestation, biomass production and peatland restoration. Where there are remaining emissions these must be fully offset by removing CO_2 from the atmosphere and permanently sequestering it, for example by using sustainable bioenergy in combination with CCS.

    – Clear leadership is needed, right across Government, with delivery in partnership with businesses and communities. … It must be vital to the whole of government and to every level of government in the UK. Policies must be fully funded and implemented coherently across all sectors of the economy to drive the necessary innovation, market development and consumer take-up of low-carbon technologies, and to positively influence societal change."

- **"Overall costs are manageable but must be fairly distributed.**

    – There have been rapid cost reductions during mass deployment for key technologies (e.g. offshore wind and batteries for electric vehicles). As a result, we now expect that a net-zero GHG target can be met at an annual resource cost of up to 1-2% of GDP to 2050 … .

    – The transition, including for workers and energy bill payers, must be fair, and perceived to be fair. Government should develop the necessary frameworks to ensure this. An early priority must be to review the plan for funding and the distribution of costs for businesses, households and the Exchequer."

"The background (page 12) … is one of increased awareness of climate risks and falling low-carbon technology costs, but where global emissions continue to rise:

- Global average temperature has already risen 1°C from pre-industrial levels and climate risks are increasingly apparent. The Special Report of the Intergovernmental Panel on Climate Change (IPCC) in October 2018 emphasised the critical importance of limiting further warming to as low a level as possible and the need for deep and rapid reductions in emissions to do so.
- Current pledges of effort from countries across the world would lead to warming of around 3°C by the end of the century. This … is well short of the Paris Agreement's long-term goal to limit the rise to well below 2°C and to pursue efforts to 1.5°C.
- While the UK has demonstrated that it is possible to cut emissions while growing the economy, global emissions continue to rise.
- However, falling costs for key technologies mean that the future will be different from the past: renewable power (e.g. solar, wind) is now as cheap as or cheaper than fossil fuels in most parts of the world."

CCC (page 13) "do not start from an assumption that the world will meet the Paris Agreement's temperature goal. Instead, we have sought to identify a UK target that is within reach and best supports an increase in global effort, consistent with bringing the expected temperature rise down

from the current trajectory. Success will bring huge benefits for the world and for the UK by limiting some of the worst climate risks.

“In developing our advice we have consulted widely, issued a public Call for Evidence, and compiled an extensive evidence base. Our new emissions scenarios draw on ten new research projects, three expert advisory groups, and reviews of the work of the IPCC and others.”

To be compatible with the Paris Agreement temperature goal, CCC report that greenhouse gas (GHG) emissions of -0.4 – 1.7 tCO_2e/year (tonnes of carbon dioxide equivalent per year) would be required in 2050. For the UK, this is a reduction from 1990 levels of 85-104% (pages 20 & 111).

CCC (page 21) “scenarios demonstrate that some sectors (e.g. the power sector) could reach net-zero emissions by 2045, for most sectors 2050 currently appears to be the earliest credible date. An earlier date would also give less time to develop currently speculative options as alternatives to make up for any shortfall from other measures. That could lead to a need for punitive policies and early capital scrappage to stay on track to the target.”

SCENARIOS FOR UK NET-ZERO GREENHOUSE GASES IN 2050

CCC observe (page 23) “it is impossible to predict the exact mix of technologies and behaviours that will best meet the challenge of reaching net-zero GHG emissions”, but their analysis “gives an improved understanding of what a sensible mix might look like”. CCC scenarios include (page 23):

• “**Resource and energy efficiency**, that reduce demand for energy across the economy. Without these measures the required amounts of low-carbon power, hydrogen and carbon capture and storage (CCS) would be much higher. In many, though not all, cases they reduce overall costs.

• “Some **societal choices** that lead to a lower demand for carbon-intensive activities, for example an acceleration in the shift towards healthier diets with reduced consumption of beef, lamb and dairy products.

• “Extensive **electrification**, particularly of transport and heating, supported by a major expansion of renewable and other low-carbon power generation. The scenarios involve around a doubling of electricity demand, with all power produced from low-carbon sources (compared to 50% today). That could for example require 75 GW of offshore wind in 2050, compared to 8 GW today and 30 GW targeted by the Government's sector deal by 2030. 75 GW of offshore wind would require up to 7,500 turbines and could fit within 1-2% of the UK seabed, comparable to the area of sites already leased for wind projects by the Crown Estate.

• Development of a **hydrogen** economy to service demands for some industrial processes, for energy-dense applications in long-distance HGVs and ships, and for electricity and heating in peak periods. By 2050, a new low-carbon industry is needed with UK hydrogen production capacity of comparable size to the UK's current fleet of gas-fired power stations.

• **Carbon capture and storage** (CCS) in industry, with bioenergy (for GHG removal from the atmosphere), and very likely for hydrogen and electricity production. CCS is a necessity not an option. The scenarios involve aggregate annual capture and storage of 75-175 $MtCO_2$ in 2050, which would require a major CO_2 transport and storage infrastructure servicing at least five clusters and with some CO_2 transported by ships or heavy goods vehicles.

• Changes in the way we farm and use our **land** to put much more emphasis on carbon sequestration and biomass production. Enabled by healthier diets and reductions in food waste, our scenarios involve a fifth of UK agricultural land shifting to tree planting, energy crops and peatland restoration.”

“Taken together, these measures would reduce UK emissions by 95-96% from 1990 to 2050. Tackling the remaining 4-5% would require some use of options that currently appear more speculative. That could involve greater shifts in diet and land use alongside more limited aviation demand growth, a large contribution from emerging technologies to remove CO_2 from the atmosphere (e.g. 'direct air capture'), or successful development of a major supply of carbon-neutral synthetic fuels (e.g. produced from algae or renewable power).

“The scenarios involve additional reductions in the UK's consumption emissions as they include measures like resource efficiency that cut emissions from production overseas as well as in the UK. However, consumption emissions will only reach net-zero once the rest of the world's territorial emissions are also reduced to net-zero. At this point the UK can expect to pay slightly more to cover the costs of low-carbon production of the goods we import.”

COSTS

“Many of the changes required involve no or only limited additional costs (page 27). For example:

• “Contracts for renewable power can be signed at prices below recent wholesale electricity prices (and below the costs of building and running a new gas-fired plant).

• “Electric cars are expected to be cheaper to purchase than conventional cars by 2030 and yield considerable savings in their running costs (without existing subsidies or advantageous tax treatment).

• “Costs for these options have fallen far more quickly than the Committee assumed to be possible when we first advised in 2008 on the UK's long-term emissions targets. …

• “Efficiency improvements have barriers to uptake and upfront costs but often recoup these costs through fuel savings. That is true for many sources of emissions: buildings, agriculture, aviation and industry. Similarly, costs can be reduced through improved resource efficiency and shifting consumer choices towards healthier diets, reduced waste and reduced flying.

“Some other changes have higher costs, such as switching from natural gas to hydrogen, applying Carbon Capture and Storage (CCS}, installing heat pumps to replace gas boilers across the existing housing stock and GHG removals. Many of the options required to get from an 80% to a 100% target currently appear relatively expensive (e.g. with costs of around £200/tCO_2e).”

INVESTMENT

“Capital cost increases in our scenarios are highest for the power and buildings sectors. (page 28)

The “increase in investment emphasises the importance of ensuring that policies are designed with investors in mind. They should be clear and stable and avoid exposure to unnecessary risks. The long-term contracts offered under the Government's Electricity Market Reform are a good example of an effective policy and have been vital to reducing costs for renewable power.

“It also suggests that wider policies that encourage investors to prioritise low-carbon investments are valuable, for example: mandatory disclosure of exposure to climate risks and assessment by investors of how their portfolios are consistent with a transition to net-zero emissions across the economy.” …

“Switching homes to low-carbon heating remains a major challenge. It is currently funded by

Exchequer spending, but roll-out is limited and less than £100 million was spent in 2018. Our estimates imply an annual cost, reflecting higher upfront costs, for switching to low- carbon heating of the order of £15 billion. Large-scale deployment must begin before 2030. It would be regressive, and probably restrict progress, to pass the cost on fully to households." (page 29)

"The annual costs of removing emissions from the atmosphere are potentially large in our scenarios (e.g. of the order of £10 billion in 2050, possibly as high as £20 billion). These could be paid by industries, like aviation, that have not reduced their own emissions to zero. That would imply increasing costs (e.g. for flights) from 2035, as emission removals scale up in our scenarios." (page 29)

CO-BENEFITS

"Set against the costs, there will be significant benefits, including avoided costs (page 30):

• "**Improved quality of life**:
  - Benefits to human health (and savings to the NHS) from better air quality, less noise, more active travel and a shift to healthier diets.
  - Improved air and water quality, enhanced biodiversity, increased resilience to climate change, and recreational benefits from changes to land use.
  - Monetising benefits is not straightforward. However, estimates using HM Treasury's Green Book guidance suggest that these would partially or possibly even fully offset the resource costs we have estimated (i.e. up to 1-2% of GDP in 2050).

• "**Lower risks from climate change**. These include direct benefits (e.g. lower risk of flooding in the UK) and indirect benefits (e.g. reduced exposure to rising food prices and disaster-induced migration and conflict). We have not attempted to monetise these benefits.

• "**There could be industrial opportunities**. With appropriate policy and support there could be an industrial boost to the UK from being one of the early movers in some key sectors (e.g. specialised supporting services like finance and engineering for low-carbon technologies, carbon capture and storage), with potential benefits for exports, productivity and employment. The shift in resources from imported fossil fuels to UK investment could also stimulate further economic activity. However, we do not factor these into our cost estimates.

"Overall, a well-managed transition can be achieved and lives can be improved. People can benefit from better physical and mental health, an improved environment and, crucially, a reduced exposure to climate risks."

NEXT STEPS

CCC advice on the next steps for government is provided on pages 30-35 of their net-zero report and include:

- Strengthening policy-making.
- Ensuring businesses respond.
- Engaging the public to act.
- Determining who pays.
- Providing the skills.
- Ensuring a just transition.
- Developing the infrastructure.

CONSUMPTION EMISSIONS

“The UK imports additional GHG emissions through our consumption of goods and services. These emissions do not appear in the UK GHG inventory, which in line with emissions accounting across the world is conducted on a territorial basis (i.e. it only counts emissions that directly arise from activity within the UK) to prevent any double counting of emissions at the global level. This also more closely maps to levers available to the UK to reduce emissions. (Page 104)

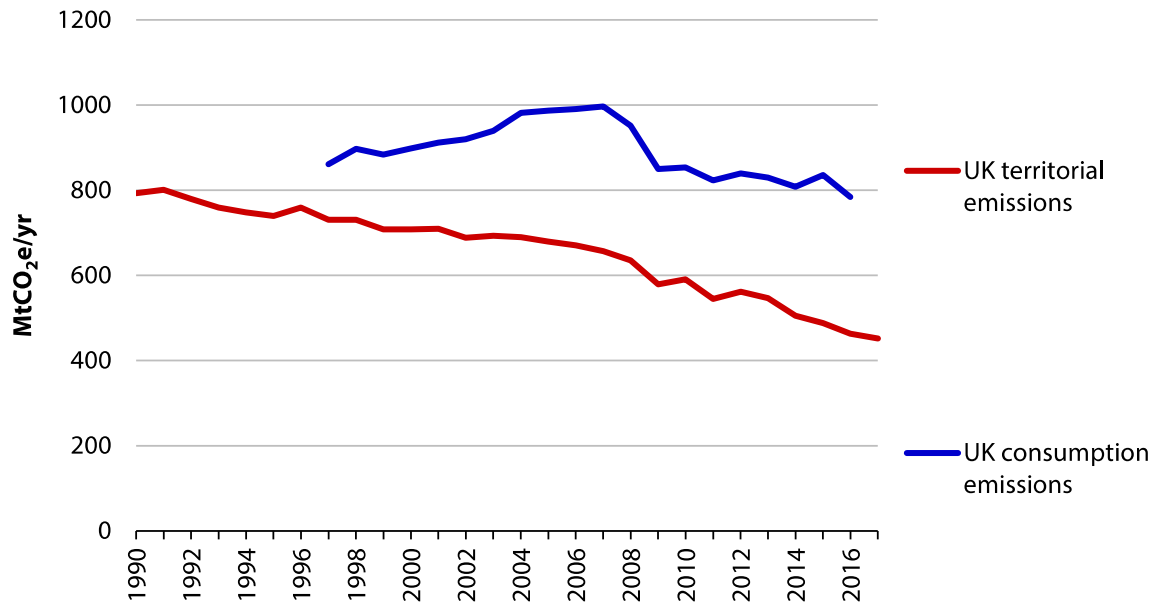
“Estimates published by Defra (the Department for Environment, Food and Rural Affairs) indicate that UK consumption emissions were significantly higher (69%) than comparable territorial emissions reported in the UK GHG inventory. That reflects the high carbon intensity of our imports, which are more likely to be industrial products, than our exports, which are more likely to be services.” (Page 104)

“Even if the UK reduces its own territorial emissions to net-zero, consumption emissions will only reach net-zero once the rest of the world's territorial emissions are also reduced to net-zero. At that point the UK can expect to pay slightly more to cover the costs of low-carbon production of the goods it imports. (Page 105)

“High consumption emissions in the UK could be seen as a reason for the UK to go further on emissions reduction, since it has a larger impact on global emissions than its territorial emissions suggest.” (Page 105) …

“In pursuing a net-zero emissions target, it is important that the actions to reduce UK territorial emissions do not simply off-shore these emissions to other parts of the world. Furthermore, actions that the UK can take to reduce its consumption emissions could be as effective in tackling climate change as actions to reduce territorial emissions.” (Page 105)

Figure B3.3. Historical consumption emissions in the UK



RESTRICTED PROGRESS (2018 REPORT)

UK "reductions in GHG emissions seen so far have largely been in the power, waste, and industry sectors. Emissions in other sectors (e.g. transport) have not shown significant reductions or have increased" (pages 139-140):

"**Power**. Emissions from electricity generation have fallen by 50% since 2013 and 64% since 1990. The very large recent reduction reflects a decrease in coal use for electricity generation, as electricity demand has fallen and the supply from renewables has increased.

"**Waste**. Emissions from waste have fallen by 69% since 1990, due to the UK's landfill tax, which has reduced the amount of biodegradable waste going to landfill, and due to an increase in methane captured at landfill sites.

"**Buildings**. Emissions from buildings have fallen by 13% since 2013 and are around 20% below 1990 levels. There has been low uptake of energy efficiency measures, and limited deployment of low-carbon heating options (e.g. heat pumps).

"**Transport**. Emissions from transport have increased by 6% since 2013 and are now 4% higher than in 1990. Although vehicles have become more fuel efficient, this has been offset by increasing travel demand."

UK OPTIONS FOR DEEP DECARBONISATION

CCC identify a range of technologies and behaviour changes that can help reduce emissions, which are split into the following 'Core', 'Further Ambition', and 'Speculative' options (page 141):

- "**Core options** are those low-cost low-regret options that broadly reflect the Government's current level of ambition (but not necessarily policy commitment or action).

- **Further Ambition options** are more challenging and on current estimates are generally more expensive than the Core options.

- **Speculative options** currently have very low levels of technology readiness, very high costs, or significant barriers to public acceptability. It is very unlikely they would all become available. Some of these options would be required alongside the Core and Further Ambition options to reach net-zero GHG emissions by 2050."

Core scenario options involve "lower-cost energy efficiency and extensive decarbonisation of the power and transport sectors", including: (pp.141-142)

- **Buildings** - "Make as many homes as possible EPC band C by 2035 and stop the installation of gas heating in new homes from 2025". These commitments need "strengthening and extending".

- **Industry** - Decarbonise "through improved energy efficiency and low-carbon technologies", which includes the Industrial Clusters Mission, the ambition to improve business energy efficiency by at least 20% by 2030, and the Carbon Capture Usage and Storage (CCUS) Action Plan.

- **Power** - Continue and expand "current commitments to contract low-carbon power and to deliver on the Government's CCUS Action Plan".

- **Transport** – "Current Government commitment to phase-out sales of conventional petrol and diesel cars and vans by 2040".

- **Aviation and shipping** – "Government objective to keep 2050 aviation emissions at or below 2005 levels". Internationally agreed target "to reduce global international shipping emissions by at least 50% below 2008 levels by 2050".

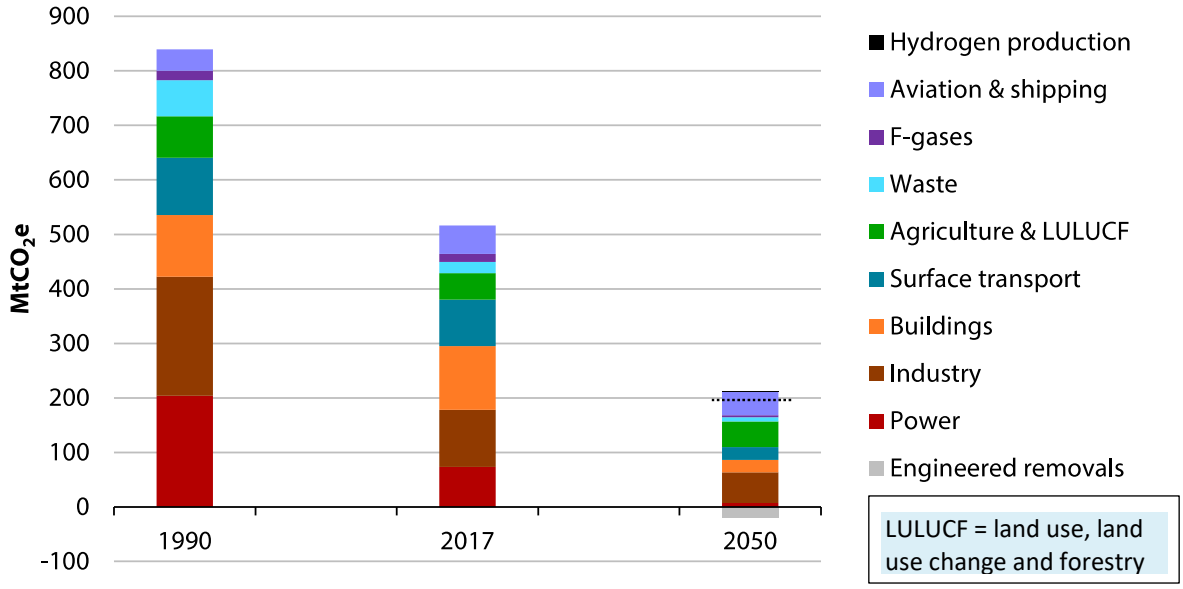
- **Agriculture and land use** – "Some emissions reduction from livestock, soils, and waste manure management" and afforestation of "an additional 27,000 hectares per year from 2025".

- **Waste** - Stop "sending five key biodegradable waste streams to landfill by 2030 or earlier". "Increase recycling rates in line with current ambition" (e.g. from around 45% "to 65% in England by 2035").

- **Fluorinated gases** – "Reduce F-gas emissions by two-thirds by 2030 compared to 2014 levels".

- **Greenhouse gas removals** (GGRs) – "Developing a strategic approach" with "an increase compared to today in the use of wood as a construction material, together with inclusion of bioenergy with carbon capture and storage (BECCS)".

Figure 5.3. 2050 GHG emissions in the Core scenario compared to 1990 and 2017



Further ambition options include: (pages 144-145, page 163)

- **Electricity generation**. "Fully decarbonising electricity supply … achieved through increasing the share of renewables and firm low-carbon power from around 50% today to around 95% in 2050, whilst meeting additional demand for electricity from electric vehicles and heat pumps. Decarbonised gas – via CCS and hydrogen – will be required for the remaining 5%. Renewable generation could be four times today's levels, requiring a sustained and increased build out between now and 2050, complemented by firm low-carbon power options such as nuclear power and CCS (applied to biomass or gas-fired plants)."

- **Heating in buildings**. "This requires roll-out of technologies such as heat pumps, hybrid heat pumps and district heating in conjunction with hydrogen, and new smart storage heating, combined with high levels of energy efficiency. New homes should not be connected to the gas grid from 2025. By 2035 almost all replacement heating systems for existing homes must be low-carbon or ready for hydrogen, such that the share of low-carbon heating increases from 4.5% today to 90% in 2050. ... Remaining emissions in 2050 largely come from a small proportion of homes which could be very expensive to treat (e.g. due to space constraints and the costs of the heating systems they require)."

- **Surface transport**. "This will need all cars and vans to be electric by 2050, and for the vast majority of HGVs to be either electric or hydrogen powered. These changes are likely to be cost saving overall. Remaining emissions in 2050 are largely from a small level of conventionally powered HGVs and rail freight.
  - "Getting all cars and vans to be electric by 2050 will require all sales to be pure battery electric by 2035 at the latest. ... It would require 3,500 rapid and ultra-rapid chargers near motorways to enable long journeys and 210,000 public chargers in towns and cities. Today in total there are 21,000 public chargers of all speeds.
  - "HGVs are harder to decarbonise. … new research suggests that it is possible to get to very-low emissions by 2050 by switching most of these vehicles to hydrogen power or electrification. A hydrogen-based switchover would require 800 refuelling stations to be built by 2050 and electrification would need 90,000 depot-based chargers for overnight charging."

- **Industry**. … "a combination of wider deployment of CCS, hydrogen, and electrification. … also potential for additional savings through resource efficiency. The remaining emissions … mostly come from smaller non-combustion processes and uncaptured emissions where CCS is deployed."

- **Waste**. … "additional emissions reduction from treatment of waste water, and by 2025 stopping sending biodegradable waste to landfill and increasing recycling rates to 70% across the UK. … Some remaining emissions in 2050 are likely to be unavoidable from continuing waste degradation at legacy landfill sites."

- **F-gases**. … "additional emissions reduction from a transition to lower-emission medical inhalers and tighter standards in the refrigeration, air conditioning and heat pump sector (e.g. through a switch to low-GWP refrigerants and measures to reduce leakage)."

- **Shipping**. … "same as the Core scenario (i.e. improved energy efficiency and ship operations, and use of alternative fuels) … deployed significantly further and faster. … it would require a globally coordinated transition to support a new fuelling infrastructure."

"Our Further Ambition measures would not reduce emissions completely to zero in any of these areas. However, if they were applied none of these sectors would remain as a significant source of emissions." …

"Our Further Ambition options include a number of demand reduction measures, such as resource efficiency and dietary change, which target goods and services whose production may be more difficult to decarbonise. These include: fossil fuels, industrial products (steel, cement, and lime) and foods such as red meat and dairy products. This approach is taken primarily because these measures are a relatively low-cost way for the UK to achieve net-zero territorial emissions."

Hard-to-treat sectors – agriculture and aviation (pp.147-148)

"Agriculture and aviation stand out … as sectors where there are limited options currently available to reduce emissions. For agriculture that reflects some of the fundamental biological processes involved. For aviation it reflects the high energy-density required for aviation fuel.

CCC "have identified some potential to reduce emissions from agriculture and aviation further beyond the Core scenario, but these sectors are likely still to be significant emitters in 2050.

- **Agriculture**. … "more ambitious uptake of the measures included in the Core scenario. … additional potential from on-farm measures targeting livestock emissions (e.g. improved breeding and diets)."
- **Land use and forestry**. "This includes a 20% reduction in consumption of beef, lamb, and dairy which is replaced by an increase in consumption of pork, poultry, and plant-based products. In combination with an improvement in arable yields and grazing intensity this would release land for increased afforestation (e.g. of 30,000 hectares per year), peatland restoration (e.g. to 55% of land area restored compared to 25% today), and the growing of energy crops (e.g. to 700,000 hectares by 2050 from very low levels today). Emissions from land use also include those from the cultivation of biomass used for GHG removal."
- **Aviation**. … "technical potential for additional emissions reduction beyond the Core scenario, including through more ambitious uptake of the Core options plus some use of hybrid-electric aircraft from the 2040s, and from reductions in design speeds of aircraft. … a fully zero-carbon plane is not anticipated to be available by 2050, particularly for long-haul flights which account for the majority of emissions."

Removal of CO_2 from the atmosphere (pp.148-149)

CCC's "further Ambition scenario includes established natural ways of removing CO_2 and less-established options":

- **Established 'land-based' removals**. "Afforestation and other land-management practices (e.g. peatland restoration) are well-established ways of using land in a way that achieves an overall absorption of CO_2 from the atmosphere which then remains in the land over the long-term."
- **Wood in construction**. "Wood-based products and timber frame construction … provides a store of carbon on the timescale of decades to centuries in the built environment. … The Further Ambition option assumes that 40% of houses and flats are built with a timber frame (up from under 30% today)."
- **Bioenergy with Carbon Capture and Storage (BECCS)**. "The level to which sustainable low-carbon biomass production can be increased is finite, given land constraints and competition from other uses (e.g. food production). It is therefore important to pursue ways of using this finite resource that maximise its contribution to emissions reduction. This means combining bioenergy with CCS, whether for power generation, hydrogen production or production of biofuels for areas that cannot move away from hydrocarbon fuels (e.g. aviation). Bioenergy is already used in the energy system, while CCS has been proven in a number of other countries. However, to date they have not been combined at scale.
  - We have assumed overall bio resource available to the UK of around 200 TWh (of which only 17% is imported and the rest is produced in the UK). This is equivalent to around 10% of UK primary energy consumption in 2050.

  - Of this, 173 TWh goes into BECCS in 2050, providing 51 $MtCO_2$ of removals. The energy generated provides 6% of power generation, as well as 21 TWh of biofuels for aviation and buildings off the gas grid, saving a further 5 $MtCO_2e$ in those end-use sectors.
  - A small amount of biogas (14 TWh) is assumed to be available after reductions in food waste, of which half is assumed to be used in gas-fired CCS power generation and the other half is used to displace natural gas in industry (79%) and buildings (21%)."

- **Direct Air Capture of Carbon with Storage (DACCS)**. "CO_2 can also be removed from the atmosphere by stripping it from the air and sequestering it using CCS. Capturing CO_2 from the air is challenging, requiring significant energy input given the low atmospheric concentration of CO_2.
  - Different approaches are being pursued, and the technology is generally at the pilot scale.
  - In the Further Ambition scenario we assume some, but very limited, deployment of DACCS at a scale sufficient to drive learning-by-doing. … If breakthroughs can be made it could make the overall net-zero challenge materially easier."

"CCS plays a vital role in many Greenhouse Gas Removal (GGR) approaches. Although the UK has not yet made progress in deploying CCS at scale, it is well placed to do so and this should be a policy priority."

Figure 5.6. Role of societal and behavioural changes in the Further Ambition scenario

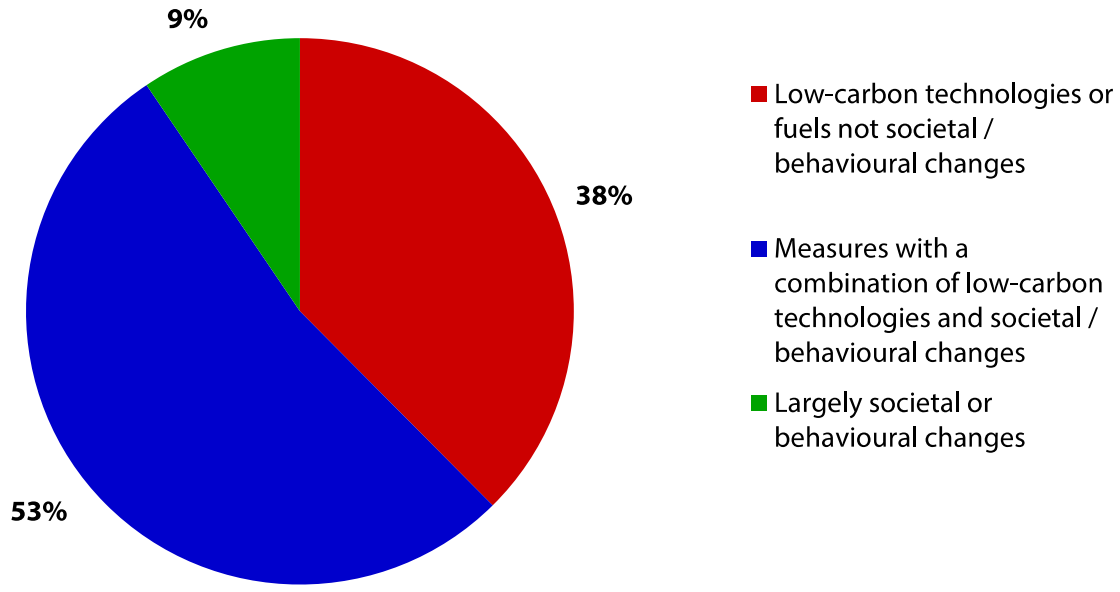


Table 5.1. Measures required under the Core and Further Ambition scenarios in 2050				
Sector	**Measure**	**2017**	**2050 scenario**	
			Core	**Further Ambition**
Power	Share of low-carbon generation	50%	97%	100%
	Low-carbon generation (TWh)	155	540	645
Buildings (Share of low-carbon heat*)	Low-carbon heat in existing homes	4.5%	80%	90%
	Low-carbon heat in non-residential buildings		100%	100%
Industry	CCS**	0%	50%	100%
	Low-carbon heat***	<5%	10%	85%
Surface transport (Share of fleet)	Battery electric cars and vans	0.2%	80%	100%
	Electric and hydrogen HGVs	0%	13%	91%
Aviation	gCO_2 per passenger-km	110	70	55
	Sustainable biofuel uptake	0%	5%	10%
Shipping	Ammonia uptake	0%	75%	~100%
Land use and forestry	Afforestation (% of UK land area)	13%	15%	17%
	Peatland restoration (% area in good condition)	25%	n/a	55%
Engineered removals ($MtCO_2$)	BECCS	0	20	51
	Direct air capture	0	n/a	1

Source: CCC analysis.
Notes: *2017 represents share of heat from low-carbon sources, 2050 represents the number of existing homes with low-carbon heat. **In manufacturing sectors with process emissions or internal fuel use (fuels produced using the industries' feedstock). ***Excluding in sectors with process emissions or internal fuel use (2017 and 2050 Core scenario exclude existing electricity use).

Speculative Options (pp.156-158)

"Speculative options currently have very low levels of technology readiness, very high costs, and/or significant barriers to public acceptability. It is very unlikely they would all become available by 2050 but some contribution from Speculative options is likely and will be required in

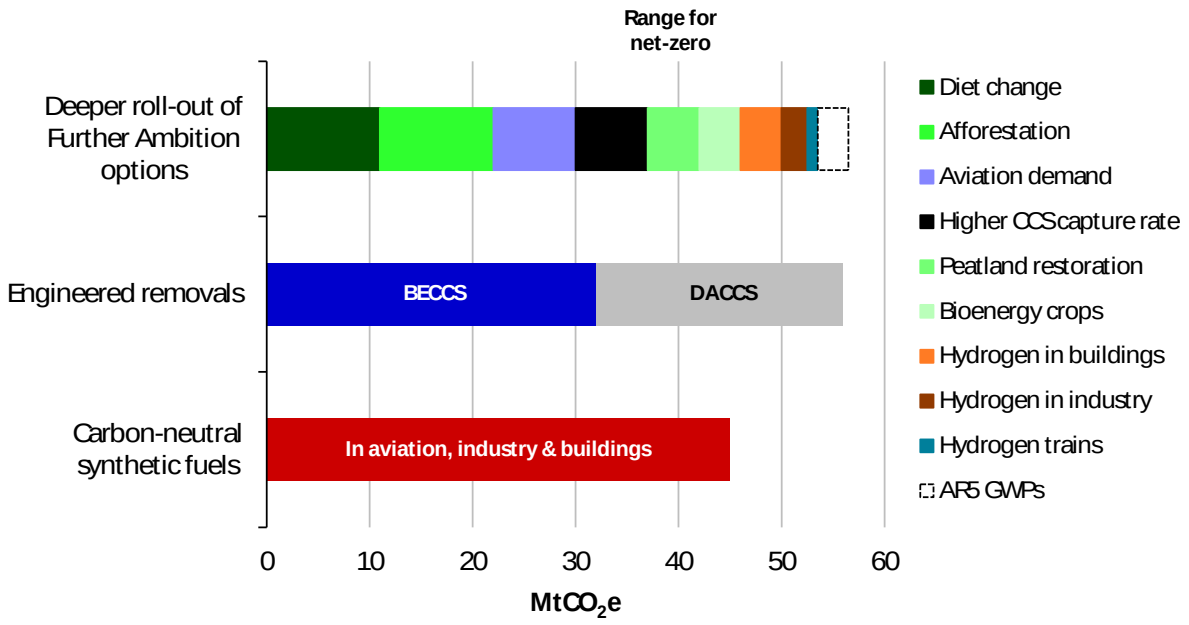
order to reach net-zero GHG emissions domestically." These include:

- **Further societal and behavioural changes**. "There is potential for larger changes in consumer choice, particularly in sectors where there are significant remaining emissions in 2050 (i.e. agriculture and aviation)."
  - **Agriculture**. "There is potential for further changes in diets beyond the Further Ambition scenario, by further reducing meat consumption. The Speculative option reflects reductions in livestock farming in line with a 50% reduction in beef, lamb, and dairy consumption compared to current levels. This would be closer to, but still not meet, the Government's current healthy eating guidelines. If consumption levels remain higher, this scenario could still be met with a role for alternative sources of protein grown off- farm (e.g. synthetic meat)."
  - **Aviation**. "The Further Ambition scenario allows a 60% increase in passenger demand above 2005 levels by 2050 (demand is currently around 30% higher). An additional reduction in emissions could be possible if demand were to be lower than this level (e.g. as an illustration, 20-40% above 2005 levels would imply a further saving in emissions of 4-8 $MtCO_2e$). This could, for example, reflect a future change in consumer preferences and social norms, or more ambitious policy to limit growth in demand."
- **More extensive changes to land**. "The diet changes under the Further Ambition scenario release land which can be used to increase afforestation rates. … Additional peatland restoration may also be possible. … Additional emissions reduction from peatland that does not require land to be released out of agricultural production is possible … through better use of lowland agricultural peatland (e.g. seasonal management of the water table)."
- **BECCS**. "More ambitious deployment of BECCS may be possible, if available biomass resource turns out to be higher than our assumed level of around 200 TWh."
- **DACCS** "does not have a particular limit that constrains its potential scale of deployment. The scale of its deployment therefore depends on its costs relative to alternatives and the pace at which the industry can scale up. The 2018 Royal Society and Royal Academy of Engineering report on greenhouse gas removal included 25 $MtCO_2$ of DACCS in the UK. That would require energy input of around 50 TWh (equivalent to the output of up to 10 GW of offshore wind), an increase of around 14% in use of CCS compared to our Further Ambition scenario and an extra annual investment of around £4 billion per year through the 2040s to pay for DAC facilities with a land footprint of the order of 50 km^2."
- **Enhanced weathering** "is a process that entails finely crushing up rocks and spreading them on land so that the fragments of rock react with CO_2 in the air, removing it from the atmosphere. This option has not yet reached a stage that provides confidence that it can be done effectively without significant adverse impacts, but further research should be pursued to determine whether it can be. We do not include it even as a Speculative option in this report."
- **Biochar** "entails treating biomass in a way that enables it to store bio-carbon in a stable form that is resistant to decomposition when mixed with soil. While this option is more developed than enhanced weathering, it is not yet mature and also competes for finite sustainable biomass resources with other options (e.g. BECCS) that are expected to be more effective in permanently sequestering the carbon in biomass. We therefore do not include a specific estimate of biochar potential as a Speculative option."

- **Synthetic fuels**. "These may be technically possible but will be thermodynamically and economically challenging, and therefore currently appear likely to be significantly more expensive than other Speculative options. If these challenges could be resolved and scaled-up globally then synthetic fuels could potentially have a large role."
- **Higher CCS capture rates**. "The Further Ambition scenario assumes that 95% of CO_2 is captured when CCS is applied in electricity generation, industry, and for hydrogen production. The Speculative option assumes a higher capture rate (99%), which would save an additional 7 $MtCO_2e$. Though uncertain, higher capture rates are potentially possible without increasing costs significantly."
- **Wider hydrogen roll-out**. "Hydrogen is rolled out extensively in the Further Ambition scenario. It could be rolled out further, and faster, across industry, to replace residual gas use in buildings, and for use in trains. These currently appear relatively challenging so we only include them as a Speculative option."

"It is possible that other currently unknown opportunities could arise even beyond these Speculative options. However, given timeframes required to commercialise and deploy options, it is unlikely they would be able to make a major contribution to reducing emissions by 2050."

Figure 5.7. Additional abatement potential from Speculative options in 2050



DELIVERY

"Reaching net-zero GHG emissions requires extensive changes across the economy, with complete switchovers of several parts of the UK capital stock to low-carbon technologies and development of new industries for carbon capture and storage and low-carbon hydrogen production. Major infrastructure decisions need to be made in the near future and quickly implemented. The public will need to be engaged in making the required changes." (page 175)

"Delivering this will require concerted policy action over the next three decades across every emitting sector of the economy. It is essential that this includes stronger actions in the near term to put the UK on track towards net-zero emissions by 2050." (page 176)

Limiting Factors

"There are various constraints on how quickly a transition to net-zero emissions can occur without major disruption. The time needed for development of markets, supply chains and infrastructure, as well as innovation and turnover of the capital stock limit the rate of decarbonisation that can be achieved as a smooth transition and without the need to write off substantial parts of the capital stock (e.g. vehicles, heating systems, industrial plants)". (page 176)

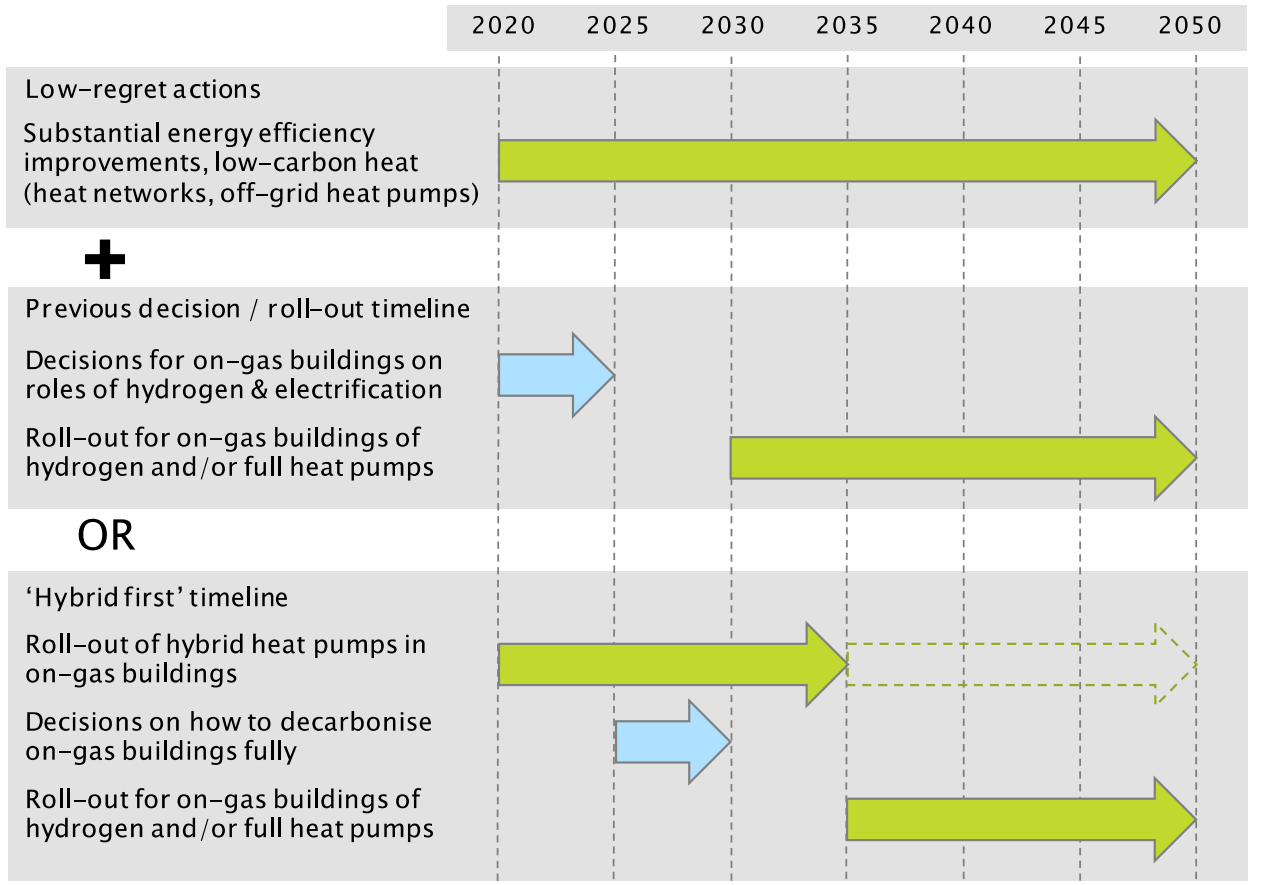
Key Near-Term Actions

"There is a set of required near-term actions that are on the 'critical path' towards achieving net-zero emissions by 2050 (pages 177- 178):

- **Afforestation**. "Reaching the necessary level of CO2 removal through afforestation by 2050 requires an early and sustained increase in tree-planting rates. These must increase from current rates below 10,000 hectares per year to at least 30,000 hectares per year.

- **Buildings**. "Major improvements are required to the energy efficiency of buildings, in order to improve comfort levels, lower energy bills and prepare the building stock for a switch to low-carbon heating. Retrofit of hybrid heat pumps, enabling continued use of existing boilers and radiators, could sensibly be done alongside energy efficiency improvements in many cases."

Figure 6.2. Timing of key decisions and changes to deliver the net-zero scenarios for buildings



- **Public engagement**.
  - **Healthy lifestyle choices**. “People can take action immediately to improve their diet and increase the amount of walking and cycling they do. The Government must engage with people over why and how they can make these improvements, and take supporting actions (e.g. ensuring that road infrastructure encourages people to view cycling as a safe option).”
  - **Future of heating**. “Currently the general public has a low awareness of the need to move away from natural gas heating and what the alternatives might be. There is a limited window to engage with people over future heating choices, to understand their preferences and to factor these into strategic decisions on energy infrastructure. This is especially important if solutions to heat decarbonisation could differ in different parts of the UK.”
- **Market development**. “Accelerated take-up of technologies is needed in the 2020s, for example rapid electrification of transport and heating accompanied by the growth of charging infrastructure for electric vehicles and strengthening of electricity networks:
  - **Electric vehicles**. The need to switch the entire fleet of light-duty vehicles to ultra-low-emission vehicles (ULEVs) by 2050 means that by 2035, at the very latest, all sales of new cars and vans will need to be ULEVs. If possible, an earlier end to sales of petrol and diesel vehicles would be preferable (e.g. by 2030 if feasible), as this will have lower financial costs, lower cumulative CO2 emissions and lead to better air quality. This means a rapid ramping up of the market share of EVs, from around 2% today, during the 2020s.
  - **Heat pumps** are an established solution in many other countries, but not yet in the UK. Establishing them as a mass-market solution will take some time, with strong progress required during the 2020s. There are particular opportunities in new-build properties, homes off the gas grid, non-residential buildings and hybrid heat pump systems retrofitted around existing gas boilers.”
- **Power sector decarbonisation**. “More rapid electrification must be accompanied with greater build rates of low-carbon generation capacity, accompanied by measures to enhance the flexibility of the electricity system to accommodate high proportions of inflexible generation (e.g. wind).”
- **Hydrogen and CCS**. “In order to develop the hydrogen option, which is vital in our scenarios, significant volumes of low-carbon hydrogen must be produced at one or more CCS clusters by 2030, for use in industry and in applications that would not require initially major infrastructure changes (e.g. power generation, injection into the gas network and depot-based transport). More broadly, plans for early deployment of CCS must be delivered with urgency - CCS is a necessity not an option for reaching net-zero GHG emissions.”
- **Infrastructure**. “Development of new infrastructure will be important in opening up new avenues for decarbonisation, for example CCS and hydrogen. Expansion of electric vehicle charging networks and electricity grid capacity will be important in facilitating strong growth in electric vehicles. Decisions will be required on the future pathways for heating buildings and decarbonisation of heavy goods vehicles during the 2020s, with important implications for infrastructure roll-out.”
- **Bioenergy with CCS**. “Deployment of sustainable bioenergy with CCS (BECCS) will need to start sufficiently early (e.g. by 2030) to build up to a potentially large contribution from BECCS in the longer term.”

Policy pre-conditions

CCC identify "policy pre-conditions" which provide further guidance on policies needed to those outlined in the key near-term actions above. These include:

- "Encourage walking, cycling and the use of public transport in preference to car usage wherever possible". (page 199)
- "Rail electrification should be planned on a rolling basis to keep costs low, and trials of hydrogen trains on UK rail should be supported where necessary". (page 199)
- "Energy efficiency retrofit of the 29 million existing homes across the UK should now be a national infrastructure priority. … Energy efficiency is the key precursor to low-carbon heat and delivers most benefits when deployed early." (page 200)
- Support for "heat pumps, biomethane, and networked low-carbon heat" so "that by 2035 at the latest, all new heating system installations are low-carbon". (page 200)
- "An overall framework to support long-term industrial decarbonisation" which "does not drive industry overseas" and involves "reshoring industry to the UK", which "will ultimately improve the global effort to tackle climate change". (page 202).
- Scale-up decarbonised electricity supply and extend electrification "across surface transport, buildings and some industrial processes". (page 203)
- Embed emissions reduction and removal in agriculture and land policy by (pages 204-205):
  - Improved "farming practices such as better soil and livestock management".
  - Release agricultural land for "increasing forest cover from 13% of all UK land today to up to 19% by 2050", "restoring over half of peatlands, catchment-sensitive farming and agricultural diversification".
  - It is important that future land use decisions "both reduce emissions and improve resilience of land to climate impacts".
  - "Changes in farming practices and dietary preferences will drive the release of land".
  - Land use "measures should be rewarded if they go beyond a minimum standard that land-owners should already be delivering".
- "Reducing emissions from aviation will require a combination of international and domestic polices, and these should be implemented in ways that avoid perverse outcomes (e.g. carbon leakage). … New UK policies will need measures "to manage growth in demand. These could include carbon pricing, reforms to Air Passenger Duty, or policies to manage the use of airport capacity". (pages 205-206)

Investment

"Delivering net-zero emissions will involve increased investments, generally offset by reduced fuel costs. For example, wind and solar farms are costly to build, but avoid the need to pay for gas and coal; energy efficiency involves an upfront cost followed by reduced energy use. CCS and hydrogen are clear exceptions, requiring both increased upfront spend and higher fuel costs." (page 179) …

"Some of this investment will come from Government funds, but the volume of additional investment required means that the private sector will need to contribute a significant proportion. Investable propositions (i.e. with suitable risk-return criteria to appeal to the private sector) will be needed to bring in the required volume of capital at a relatively low cost." (page 180) …

"Government success in providing clear and stable mechanisms that attract sufficient volumes of

low-cost capital will be key to the overall success in reaching a net-zero GHG target, given the importance of capital-intensive options. It will also be key to minimising costs for consumers and tax-payers and to making the most of the business opportunities that the transition can bring." (page 180)

Table 7.3. Average abatement costs by sector and measures (2050)

Sector or measure	**Abatement cost (£/tCO_2e)**	**Sector or measure**	**Abatement cost (£/tCO_2e)**
Power	**20**	**Agriculture**	**-55**
Variable renewables	-5	Agricultural soils	-80
Firm low carbon power	50	**Land use**	**85**
CCS for mid-merit generation	80 – 120	Tree planting	10
Residential buildings	**155**	Forestry management	-50
New homes	70	Peatland restoration	See note
Heat in space constrained homes	310	**Waste**	**10**
Heating in homes off the gas grid	-20	**Transport**	**-35**
Non-residential buildings	**95**	Cars	-40
Industry	**120**	Buses	200
Iron and steel	100	HGVs	-35
Cement	95	**Aviation**	**-10**
Stationary combustion	120	Fuel efficiency	-50
Engineered removals	**-**	Biofuels	125
Bioenergy with CCS	125 – 300	**Shipping**	**200**
Direct air capture with CCS	300	**F-gases**	**-10**

Source: CCC analysis.
Notes: Costs correspond to the Further Ambition scenario and are rounded to the nearest £5/tCO_2e. Not all sectoral emissions sources are included. Costs of demand measures (aviation demand, diet shift and transport modal shift) are assumed to be zero. CCS cost range reflects different uses of CCS (lower bound is cost of CCS for firm power and upper bound for peak power).
Peatland restoration costs vary significantly, between £75 – 5,885/tCO_2e (depending on e.g. type of peatland restored, ease of access to the location), but these estimates ignore significant co-benefits resulting from restoration. Lower bound BECCS costs correspond to costs using domestically produced bioenergy, while upper bound corresponds to imported bioenergy.

Innovation

"The dramatic reductions in offshore wind costs during this decade, due to deployment led by the UK, highlight the value of 'learning by doing' in achieving cost reductions via deployment, including the importance of good policy design, rather than relying only on research and development. As well as reducing future costs of UK decarbonisation, UK deployment of less-mature technologies also reduces the costs for other countries, making global action to tackle climate change more tractable." (pages 183-184) …

"The limited amount of time available to develop new technologies means that not all potential innovations will be able to make a significant difference by 2050, given the multi-decadal timescale for commercialisation of new technologies. However, the example of offshore wind development shows that these timeframes can be compressed in some cases, which does provide scope for well-designed policy to pull through known but undeveloped solutions in the time available." (pages 184)

Public Engagement

"It will not be possible to get close to meeting a net-zero target without engaging with people or by pursuing an approach that focuses only on supply-side changes (page 193):

- At the moment, while the public are generally supportive of action to tackle climate change [see Box 6.3 on page 194], people who wish to reduce their impact on emissions are not provided sufficient support to make decisions that achieve this. People will need help to make low-carbon choices, both in terms of avoiding high-carbon activities and in adopting low-carbon technologies. This will require making low-carbon choices more available, provision of information, trials to see what works and policy that learns by doing (see Box 6.4 on pages 194-195).
- Some of the difficult decisions that will be required, (e.g. on the balance of electrification and hydrogen that replaces natural gas heating), will only be possible if people are engaged in a societal effort to reach net-zero emissions and understand the choices and constraints.
- The transition will necessitate a shift in employment, away from some inherently high-emitting activities (e.g. fossil fuel supply) to highly-skilled jobs to deliver the emissions reductions required. A strategy will be needed to ensure a just transition across society, with vulnerable workers and consumers protected."

A true cross-Government effort is required

"Emissions reduction must be embedded meaningfully in the objectives of the key Ministerial departments - and at each level of government in the UK, so policy decisions can have the greatest impact. It must also be integrated with businesses and society at large." (page 195) …

"Cities and local authorities are well placed to understand the needs and opportunities in their local area, although there are questions over [whether] they have sufficient resources to contribute strongly to reducing emissions. They have important roles on transport planning, including providing high-quality infrastructure for walking and cycling, provision of charging infrastructure for electric vehicles, and ensuring that new housing developments are designed for access to public transport. They can improve health outcomes for people who live and work in the area by implementing clean-air zones that discourage use of polluting vehicles and other technologies." (page 196)

Cllr Dave Mansell, August 2019

ANNEX 1 – Somerset West and Taunton Climate Emergency Motion

On 21st February 2019, Somerset West and Taunton Shadow Council unanimously resolved:

(1) To declare a climate emergency.

(2) With partners across the district and region, to start working towards making Somerset West and Taunton carbon neutral by 2030, taking into account emissions from both production and consumption (7).

(3) To call on the UK Government to provide guidance and the powers and resources to make carbon neutrality possible by writing to local MPs, the Secretaries of State for Business Energy & Industrial Strategy, Transport, Environment, Food & Rural Affairs and Housing, Communities & Local Government.

(4) To develop a Carbon Neutrality and Climate Resilience Plan, starting from July 2019, with a cross party working group and the necessary officer support to assist with investigative work, drafting the plan and the delivery of early projects.

(5) To report to Full Council before the end of 2019 with costed proposals for projects for the Council to effectively start addressing the climate emergency, which could include:

- Enabling more cycling, walking and use of shared and public transport.
- Providing electric car charging points in car parks and other suitable locations, including for use by council tenants and council vehicles.
- Adopting high energy efficiency standards and providing for the effective use of recycling services in new buildings through the planning system.
- Demonstrating and developing a programme for retrofitting high standards of energy saving and insulation in existing council buildings, including housing, and assets; initially focusing on where the greatest benefits could be gained.
- Promoting waste reduction, reuse and recycling on the go, and supporting community projects.
- Sourcing electricity used by the council from renewable energy suppliers and providing support for smart energy infrastructure, including demand management and storage.
- Supporting green businesses and social enterprises.
- Review of planning policies and investment opportunities for local renewable energy and infrastructure and environmental markets, as well as divestment from fossil fuels.
- Adaptation for flooding, coastal erosion and other impacts of climate change.
- The appointment of a specialist officer to develop and champion the delivery of the Carbon Neutrality and Climate Resilience Plan.

(6) To provide an annual review and update of the plan thereafter; and

(7) To allocate a provisional budget of £25,000 to allow this work, including early projects agreed by the working group, to be undertaken either through resources already available or through commissioning. This sum to include £15,000 as a supplementary budget allocation from the General Fund in 2019/20, to be taken from general reserves and returned if able to be undertaken from already available resources, and £10,000 to be prioritised from the proposed Housing Revenue Account Maintenance Budget in 2019/20.

ANNEX 2 – Actions that people can take to reduce their emissions

Committee on Climate Change "scenarios to reduce UK greenhouse gas (GHG) emissions to net-zero point to actions that individuals and households can take to reduce their carbon footprints and contribute to the UK and global goals:

- "The way you travel:
  - Choose to walk and cycle or take public transport in preference to a car.
  - Make your next car an electric one, and then charge it 'smartly'.
  - Minimise flying, especially long-haul, where possible.
- "In your home:
  - Improve the energy efficiency of your home (or ask your landlord to) through draught-proofing, improved insulation, choosing LED light-bulbs and appliances with high efficiency ratings.
  - Set thermostats no higher than 19°C and the water temperature in heating systems no higher than 55°C.
  - Consider switching to a low-carbon heating system such as a heat pump, especially if you live off the gas grid; if you are on the gas grid consider a hybrid system.
- "What you eat and buy:
  - Eat a healthy diet, for example with less beef, lamb and dairy.
  - Eliminate food waste as far as possible and make sure that you use separate food waste collections if available. Reduce, reuse and recycle your other waste too.
  - Use only peat-free compost.
  - Choose good quality products that will last, use them for longer and try to repair before you replace.
  - Share rather than buy items like power tools that you don't use frequently. If you don't/won't use your car regularly then consider joining a car club instead.
- "Look for changes that you can make in your workplace or school to reduce emissions and support your colleagues to make changes too.
- "Talk about your experiences and help to raise awareness of the need to act. Consider the wider impacts of your actions (e.g. through your pension or ISA and via the companies you buy from)."

SOURCE: Box 4, page 25 of Committee on Climate Change, 2019: Net Zero – The UK's contribution to stopping global warming. Further information on pages 187-188 of CCC's Net Zero report and in The Energy Systems Catapult Living Carbon Free.