December 2020

Policies for the Sixth Carbon Budget and Net Zero



Climate Change Committee

Committee on Climate Change
December 2020

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The Committee



The Rt. Hon John Gummer, Lord Deben,
Chairman

Lord Deben was the UK's longest-serving Secretary of State for the Environment (1993 to 1997). He has held several other high-level ministerial posts, including Secretary of State for Agriculture, Fisheries and Food (1989 to 1993). Lord Deben also runs Sancroft, a corporate responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues.



Baroness Brown of Cambridge DBE FRS
Deputy Chair

Baroness Brown of Cambridge DBE FREng FRS (Julia King) is an engineer, with a career spanning senior engineering and leadership roles in industry and academia. She currently serves as Chair of the CCC's Adaptation Committee; non-executive director of the Offshore Renewable Energy Catapult; and Chair of the Carbon Trust.



Professor Keith Bell

Keith Bell is a co-Director of the UK Energy Research Centre (UKERC), a Chartered Engineer and a Fellow of the Royal Society of Edinburgh. He has been at the University of Strathclyde since 2005, was appointed to the Scottish Power Chair in Smart Grids in 2013 and has been involved in energy system research in collaboration with many academic and industrial partners.



Professor Nick Chater

Nick Chater is Professor of Behavioural Science at Warwick Business School. He has particular interests in the cognitive and social foundations of rationality, and applying behavioural insights to public policy and business. Nick is Co-founder and Director of Decision Technology Ltd, a research consultancy.



Professor Piers Forster

Piers Forster is Director of the Priestley International Centre for Climate and Professor of Physical Climate Change at the University of Leeds. He has played a significant role authoring Intergovernmental Panel on Climate Change (IPCC) reports, and has a coordinating lead author role for the IPCC's sixth assessment report.



Dr Rebecca Heaton FICFor

Rebecca Heaton is responsible for Drax Group's efforts to mitigate climate change, ensuring that sound science underpins climate change polices and business strategy. She is also responsible for developing sustainability and climate change research programmes. Rebecca has a 20-year global career working at the interface between business, science and policy.



Paul Johnson CBE

Paul Johnson is Director of the Institute for Fiscal Studies and a visiting professor at University College London (UCL). He is widely published on the economics of public policy, and he co-wrote the 'Mirrlees review' of tax system design. He was previously Chief Economist at the Department for Education (2000 to 2004).



Professor Corinne Le Quéré CBE FRS

Corinne Le Quéré is Royal Society Research Professor of Climate Change Science at the University of East Anglia (UEA), where she conducts research on the interactions between climate change and the carbon cycle. Corinne is currently the Chair of the French Haut Conseil pour le Climat.

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Policies for the Sixth Carbon Budget and Net Zero

We have proposed an ambitious Sixth Carbon Budget for the UK on the path to Net Zero 2050.

The Committee is advising that the UK set its Sixth Carbon Budget (i.e. the legal limit for UK net emissions of greenhouse gases over the years 2033-37) to require a reduction in UK emissions of 78% by 2035 relative to 1990, a 63% reduction from 2019. This will be a world-leading commitment, placing the UK decisively on the path to Net Zero by 2050 at the latest, with a trajectory that is consistent with the Paris Agreement.

Delivering the Sixth Carbon Budget and 2050 Net Zero target requires major policy strengthening across the economy:

- Meeting our recommended budget will require **a major nationwide investment programme**, led by Government, but largely funded and delivered by private companies and individuals. Low-carbon markets and supply chains must scale up so that almost all new purchases and investments are in zero-carbon solutions by 2030 or soon after. Investments should be made resilient to the expected impacts of climate change. Reduced operating costs in later years will pay back on the initial investment.
- More than ever before, future emissions reductions will require **people** to be actively involved. This need not entail sacrifices. Many people can make low-carbon choices, about how they travel, how they heat their homes, what they buy and what they eat. The experience of the UK Climate Assembly shows that if people understand what is needed and why, if they have options and can be involved in decision-making processes, they will support the transition to Net Zero.
- **Fairness** is also fundamental to public support and must be embedded throughout policy. Only a transition that is perceived as fair, and where people, places and communities are well-supported, will succeed. UK Government policy, including on skills and jobs, must join up with local, regional and devolved policy on the just transition. Vulnerable people must be protected from the costs of the transition.

A major strengthening of UK policies is required.

- Recent UK emissions reductions have come from the transition away from coal-fired power, which is almost complete. Future reductions must come from transport, industry, buildings and agriculture, as well as phasing out gas-fired power. There are positive lessons from power sector decarbonisation but each of these sectors raises **different policy challenges**. Policies must provide a clear direction to millions of people and businesses in the UK, shifting incentives to favour low-carbon options and tackling barriers to action.

The Government has recognised the need for significant policy strengthening and is developing plans in all areas of UK emissions. Now plans must translate to action and Government must organise for the major delivery challenge of Net Zero.

This Policy report accompanies our advice on the Sixth Carbon Budget, by setting out the broad policy changes that could deliver the budget and the UK's 2050 Net Zero target. We set these out for two reasons. First, to demonstrate that our recommended pathway is feasible, not just technically and economically but also practically.

This report is one of three reports we are producing for the Sixth Carbon Budget.

Second, to support the Governments of the UK, Scotland, Wales and Northern Ireland in developing their plans. Policies must be well executed and developed at pace; our analysis brings various insights that we expect to be useful.
In addition to this Policy Report we have also published:

- **An Advice report**: *The Sixth Carbon Budget – The UK's path to Net Zero*, setting out our recommendations on the Sixth Carbon Budget (2033-37) and the UK's Nationally Determined Contribution (NDC) under the Paris Agreement. This report also presents the overall emissions pathways for the UK and the Devolved Administrations and for each sector of emissions, as well as analysis of the costs, benefits and wider impacts of our recommended pathway, and considerations relating to climate science and international progress towards the Paris Agreement.*
- **A Methodology Report:** *The Sixth Carbon Budget – Methodology Report*, setting out the approach and assumptions used to inform our advice.†
- **A dataset** for the Sixth Carbon Budget scenarios, which sets out more details and data on the pathways than can be included in this report.
- **Supporting evidence** including our public Call for Evidence, 10 new research projects, three expert advisory groups, and deep dives into the roles of local authorities and businesses.

For ease, the relevant sections from the three reports for each sector (covering pathways, method and policy advice) are collated into self-standing documents for each sector (e.g. for Buildings, Surface Transport). A full dataset including key charts is also available alongside this document.

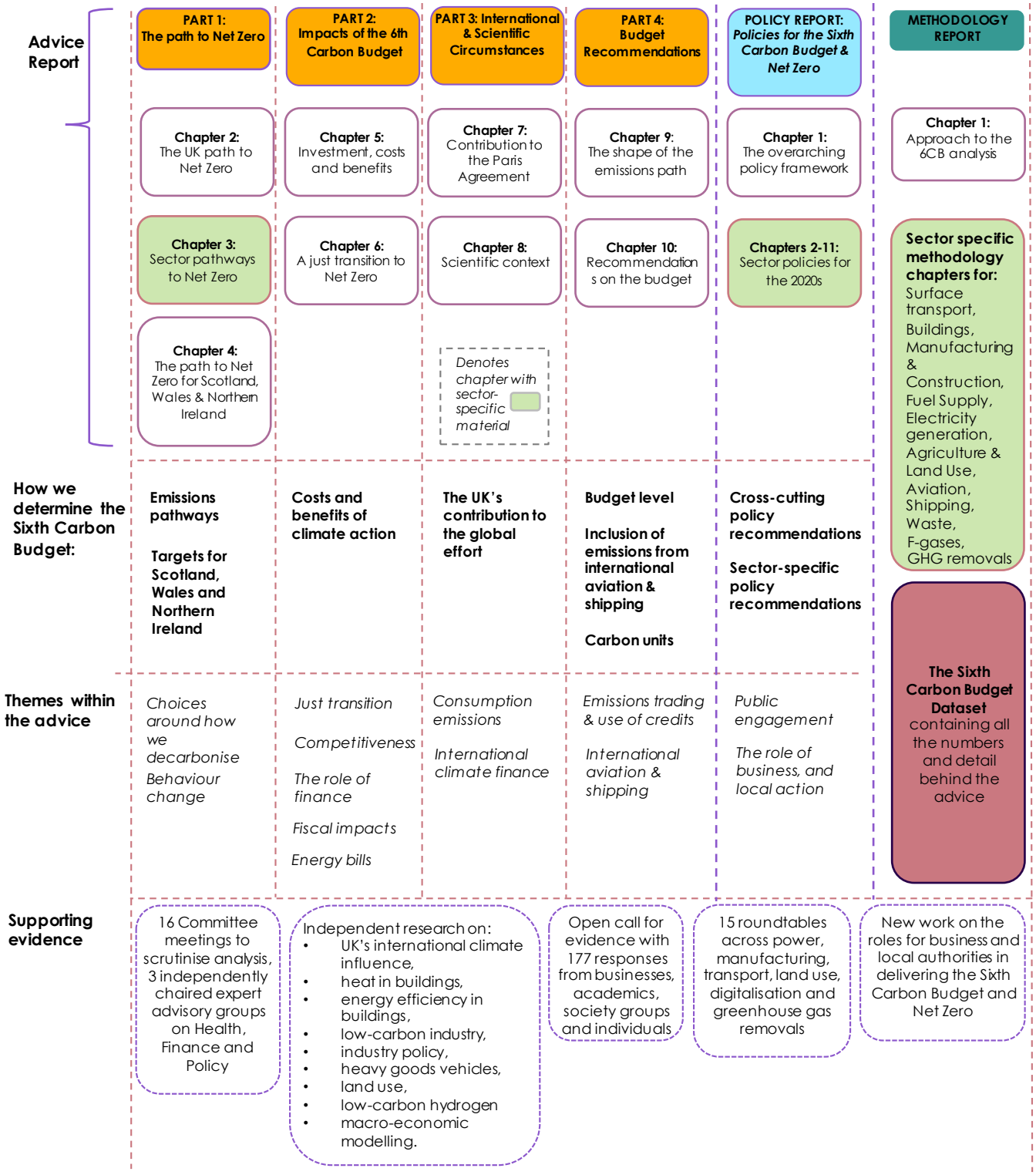
All outputs are published on our website (www.theccc.org.uk). The Report Map on the next page lays out the coverage of the various parts. In this report we first set out our cross-cutting policy advice, and then step through on a sector-by-sector basis across the following 11 Chapters:

1) The overarching policy framework for the 2020s
2) Surface transport
3) Buildings
4) Manufacturing and construction
5) Electricity generation
6) Fuel supply
7) Agriculture and land use, land-use change and forestry (LULUCF)
8) Aviation & Shipping
9) Waste
10) F-gases
11) Greenhouse gas removals

* CCC (2020) The Sixth Carbon Budget – The UK's path to Net Zero.

† CCC (2020) Policies for the Sixth Carbon Budget and Net Zero.

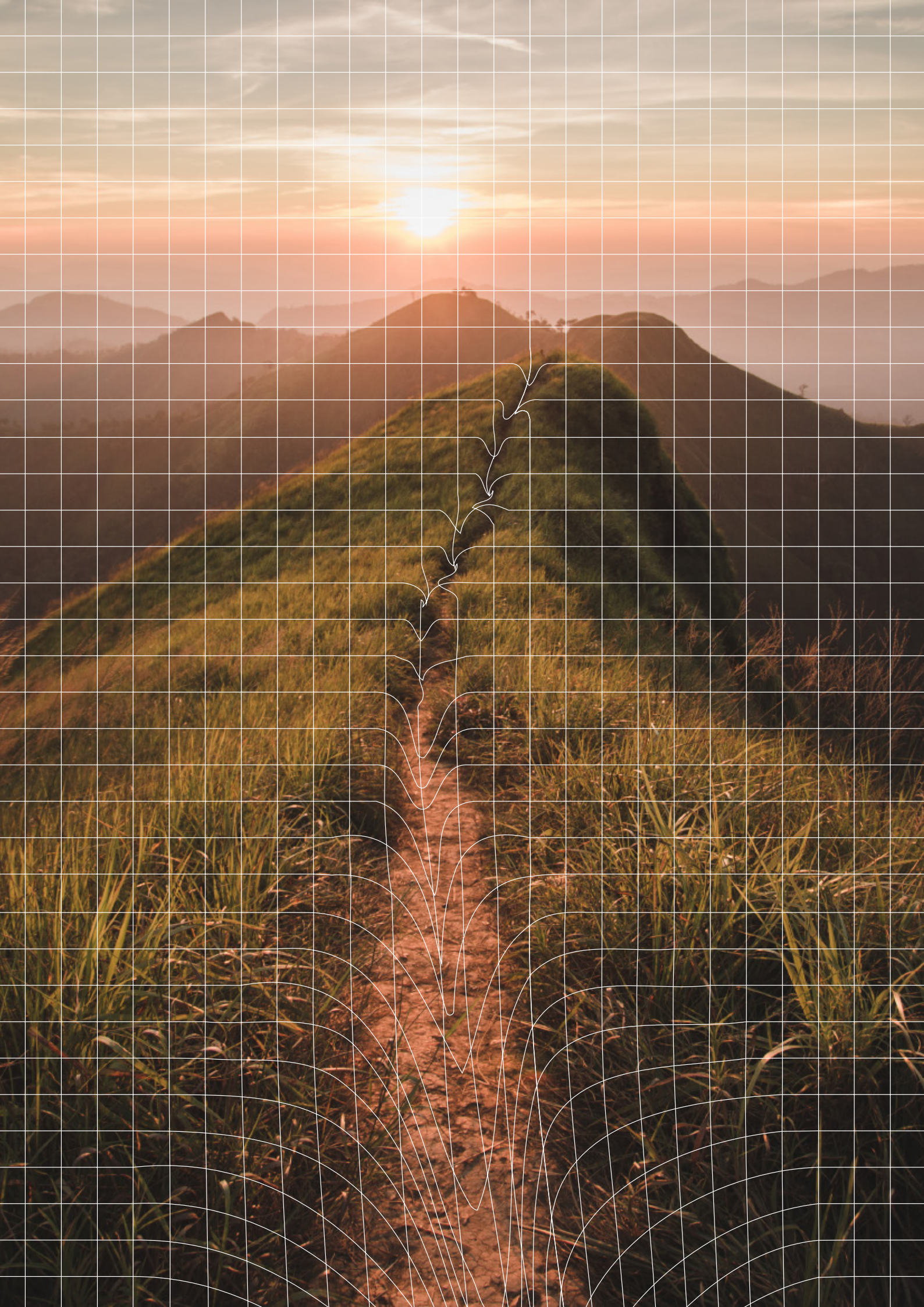
Figure 1 Sixth Carbon Budget: Report map



Chapter 1

The overarching policy framework for the 2020s

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Introduction and key messages

Delivering Net Zero will require overarching challenges to be addressed, such as public engagement, and a just transition.

Delivering the Sixth Carbon Budget will require an immediate scale up in action across the economy, building an annual investment programme reaching around £50 billion per year by 2030, up from around £10 billion per year today. This must be accompanied by significant changes in people's choices and behaviours alongside major changes in the UK's land use. The required transformation presents a major policy challenge for Government and a delivery challenge for UK business. Both Government and businesses have signalled their commitment to meeting these challenges, but much remains to be done.

This chapter sets out the key cross-cutting policy challenges, with a particular focus on the crucial coming decade, which will ultimately determine whether or not the UK Net Zero target can be met. The Government must adopt decisive policies across all emitting parts of the economy and ensure that they join up as a cohesive whole that engages the public, supports businesses to invest in low-carbon options at low risk, and enables a just transition for the economy with a fair sharing of the costs. All parts of society have a role to play, and this chapter ends by considering the roles of the public, businesses and local government. The next chapters set out the policy priorities for each emitting sector of the economy.

The goal for Government should be to set out its approach and policy proposals for delivering the Sixth Carbon Budget and 2050 Net Zero target well before the UN talks in November 2021.

Our key messages in this chapter are:

The green stimulus measures put in place in response to the COVID-19 pandemic can form the foundations of a decade of climate action.

- **Build climate policy into the recovery from the pandemic.** The Government has taken positive early steps to bring forward green investment to support the recovery including launching – and subsequently extending – a Green Homes Grant, a Green Recovery Challenge Fund for nature, and pledging to double the amount of capacity contracted in next year's renewable electricity auction. These steps can provide the foundation for a comprehensive scale up of low-carbon investment over the next decade. Furthermore, the Government should use this as an opportunity to accelerate a shift towards low-carbon behaviours such as walking, cycling, and increased working-from-home.
- **The 2020s will be crucial in mainstreaming Net Zero solutions.** Scale up of low-carbon technologies and behaviours will be needed in all areas to set the conditions for mass rollout from the 2030s onwards. By the 2030s choices in all areas should default to the low-carbon, rather than high-carbon, option.
- **The early foundations for a decade of delivery are being put into place.** The Government has demonstrated it is taking the Net Zero challenge seriously. It has set up climate action committees in Cabinet on strategy and delivery, is publishing an interim Net Zero Review from HM Treasury into the fair allocation of costs during the transition, has promised a comprehensive Net Zero Strategy in the Spring, and is developing Net Zero policies across the economy to build on The Ten Point Plan for a Green Industrial Revolution that it recently published.

- **However a major delivery challenge remains** to extend action to reduce emissions into all areas of the economy (see subsequent chapters), within a portfolio of cross-economy policy that accelerates a fair and just transition to Net Zero. This will need:
  - Consistent low-carbon policy packages for all sectors, developed within a systems approach, including a clear long-term direction, investable incentives, removal of non-financial barriers and investment in innovation and skills.
  - Regulation, acting to phase out high-carbon technologies and behaviours, supported by a rebalancing of carbon pricing to favour low-carbon options in all applications.
  - Public engagement around the need for climate action, information about how to reduce emissions and involvement in decisions on how best to achieve a transition.
  - A plan for achieving a just transition for people, workers, consumers and regions, building on the Treasury's Net Zero Review.
  - Encouragement and enabling of businesses and local authorities to deliver ambitious climate objectives, through workable business models, removal of barriers to action, and a strategy for how sub-national action can complement action at the national level.

This chapter is set out in four sections:

1. Climate policy as part of the economic recovery
2. The importance of the 2020s in mainstreaming Net Zero solutions
3. Cross-economy climate policy priorities
4. Roles of a wider set of actors – local government, businesses, regulators, people

1. Climate policy as part of the economic recovery

Just two years ago the UK was aiming to reduce emissions to at least 80% below 1990 levels, by 2050, from 41% today. As of 2019, the goal for 2050 is now at least 100% ('Net Zero'), and our advice on the Sixth Carbon Budget (2033-2037) recommends the Government legislate for a reduction in UK emissions of 78% by 2035. This shift in the objectives is necessary to meet the demands of the Paris Agreement and it is possible given the rapid progress in low-carbon technologies and the increasing levels of ambition around the world. Government policy needs to ramp up to match.

The COVID-19 pandemic, and the UK's exit from the EU present a unique context for Government policy.

The background conditions for policy have also changed dramatically. The COVID-19 pandemic is a public health crisis and has had a profound economic impact. The long-term effects of the pandemic on the economy remain highly uncertain – optimistic estimates suggest the UK economy could bounce back to pre-crisis levels as early as 2022, while pessimistic estimates suggest it could be the middle of the decade or later.[1] Government policy will be a key determinant, along with the rollout of an effective protection from the virus through a vaccine and developments in household and business confidence.

The end of the transitional period with the European Union and the nature of future trading relations represent a further large uncertainty to redefine policy in key areas, and prioritise climate action.

Given these large uncertainties, and the risk of an ongoing demand shortage in the economy, the large investment programme in our paths to Net Zero offers some welcome certainty and a chance to boost demand. As we stated in our June progress report, Net Zero must be 'integral to the COVID-19 recovery'. That recovery will potentially continue for several years.

Tackling climate change is also a vital step in avoiding future public health crises. The World Health Organisation has described climate change as the greatest threat to global health in the 21st century.[2] As we noted in our June progress report, the pandemic itself will do little to slow climate change (Box 1.1).

a) Building a resilient recovery from the pandemic

The months ahead have huge significance. The steps that the world and the UK take to rebuild from the COVID-19 pandemic and its economic damage can accelerate the transition to low-carbon activities and improve our climate resilience. Short-term choices that lock-in emissions or climate risks must be avoided.

There is strong evidence, set out in our 2020 Progress Report to Parliament, to support a range of low-carbon and climate adaptation 'green stimulus' measures. Many can be delivered quickly and have high multipliers, high numbers of jobs created, and boost spending in the UK. In the long term, a transition to a low-carbon, efficient and resilient economy will bring productivity benefits throughout the economy.

The Committee previously set out six principles to help guide the recovery:

The Committee has set out six principles to guide an economic recovery from the COVID-19 pandemic.

1. Use climate investments to support the economic recovery and jobs.
There is a detailed set of investments needed to reduce emissions and manage the social, environmental and economic impacts of climate change. Many are labour-intensive, shovel ready, spread geographically across the UK and will have high multiplier effects. Government can act to bring these investments forward, often without direct public funding or by co- financing to accelerate private investment, as part of a targeted and timely stimulus package with lasting, positive impacts.

2. Lead a shift towards positive long-term behaviours.
There is an opportunity to embed the new social norms, especially for travel, that benefit wellbeing, improve productivity, and reduce emissions. Government can lead the way through its own operations (e.g. encouraging home working and remote medical consultations), through public communications and through infrastructure provision (e.g. prioritising resilient broadband investments over the road network, improving safety for cyclists), and investing in measures to facilitate social distancing on public transport.

3. Tackle the wider 'resilience deficit' on climate change.
This crisis has emphasised the importance of evidence-led preparations for the key risks facing the country. Comprehensive plans to reduce emissions and to prepare for climate change are not yet in place. Strong policies from across government are needed to reduce our vulnerability to the destructive risks of climate change and to avoid a disorderly transition to Net Zero. Business must also play its part, including through full disclosure of climate risks. Plans must be implemented alongside the medium-term response to COVID-19 and will bring benefits to health, well-being and national security.

Issues of fairness have been evident throughout the pandemic, and will be a key issue to address for a just transition to Net Zero.

4. Embed fairness as a core principle.
The crisis has exacerbated existing inequalities and created new risks to employment in many sectors and regions, placing even greater priority on the fair distribution of policy costs and benefits. The response to the pandemic has disproportionately affected the same lower-income groups and younger people who face the largest long-term impacts of climate change and will be most affected by the transition to a Net Zero economy. The benefits of acting on climate change must be shared widely, and the costs must not burden those who are least able to pay or whose livelihoods are most at risk as the economy changes. It is important that the lost or threatened jobs of today should be replaced by those created by the new, climate-resilient economy.

5. Ensure the recovery does not 'lock-in' greenhouse gas emissions or increased climate risk.
It is right that actions are taken to protect jobs and industries in this immediate crisis, but the Government must avoid 'lock-in' to higher emissions or increased vulnerability and exposure to climate change impacts over the long term. Support for carbon-intensive sectors should be contingent on them taking real and lasting action on climate change, and new investments should be resilient to climate change.

6. Strengthen incentives to reduce emissions when considering fiscal changes.
Changes in tax policy can aid the transition to Net Zero emissions. Many sectors of the UK economy do not currently bear the full costs of emitting greenhouse gases. Revenue could be raised by setting or raising carbon prices for these sectors, and low global oil prices provide an opportunity to offset changes in relative prices without hurting consumers. The UK's future carbon pricing mechanism should be designed to ensure that an appropriate price for carbon is maintained even in times of external shocks, for example through a well-designed floor price.

Since our June advice, Governments around the world have taken the first steps towards a green recovery, including over €30 billion for building renovations, transport, agriculture and energy in France,[3] almost €40 billion in Germany, including support for hybrid and electric vehicles and low-carbon hydrogen in Germany[4] and up to 30% of the EU's recovery package earmarked for climate action.[5] The opportunity to use climate investments to support the recovery was also a key focus of recent announcements of new Net Zero ambitions in South Korea and Japan.

b) Continuing support for the recovery

The UK has taken strong steps to build the foundations of a green recovery in the UK.

The UK has taken its own steps. The key immediate step has been to introduce (and subsequently extend) the Green Homes Grant scheme, which provides grants to support investments in greening residential and public buildings. Further big announcements include doubling the capacity to be contracted in next year's Contract-for-Difference (CfD) auction for renewable electricity, funding for new cycling and walking infrastructure, and for nature-based investments such as tree-planting and peatland restoration (via the Green Recovery Challenge Fund).

The arguments in favour of the Green Homes Grant will continue to apply beyond 2021, and we recommend a continuation of funding until a successor scheme is in place:

- Demand is likely to remain suppressed across the economy, with high numbers seeking new employment. Retrofitting buildings to improve efficiency and potentially to shift to low-carbon heating offers high multipliers and local employment.
- Decarbonising the building stock remains a major delivery challenge, and the enduring policy regime will not yet be fully in place until completion and implementation of the Heat and Buildings Strategy.
- Without an extension of funding, any jobs that have been created so far could be lost again.

Further steps can be taken and can act as a launching point for further climate action over the next decade.

The other principles that the Committee has set out also continue to apply and require further attention:

- Infrastructure to support increased walking and cycling has already started to be rolled out in response to the pandemic, and the Government has pledged £2 billion of investment to increase this further, as part of a wider programme of funding for cycling and buses.6 Similarly businesses have accommodated a rapid shift to home-working. Government should ensure that the development of the UK's digital infrastructure continues to support these changes.

- Government has extended support to a wide range of industries across the economy in order to avoid closure as a result of the pandemic. This support should be targeted to avoid lock-in to high carbon industries and behaviours wherever possible.
- The Government will have to make difficult fiscal choices to address the debt and deficit increases resulting from the pandemic response. Carbon taxes offer a possible route to increasing Exchequer revenues while strengthening incentives to reduce emissions.

It remains the case that Net Zero policy must be integral to the UK's recovery, and offers opportunities to support jobs and boost the recovery (see also Chapters 5 and 6). We welcome the Government's *Ten Point Plan for a Green Industrial Revolution.*[7]

Box 1.1
Emissions impacts of the pandemic

Global emissions impacts
Reduced energy demands during the lockdown are expected to cause a record fall in global emissions in 2020. These impacts are likely to be transient, reversing as the global economy reopens. The impact of this year's reduction in emissions on global warming will be negligible.

- **Short-term evidence** indicates very substantial reductions in energy use and emissions. An early comprehensive estimate suggests that global emissions declined by over 5% in the first three months of 2020 compared to the same period in 2019, with daily emissions in early April around 17% (11% - 25%) lower than in 2019. Estimates since then have suggested emissions are expected to be around 7-8% lower over the whole of 2020.
- **Medium-term impacts** will be, in a large part, driven by the carbon intensity of any economic stimulus efforts in countries with large emissions today and longer-lasting structural impacts of the crisis. Investments in new long-life high-carbon infrastructure could lock in high global emissions for years to come.
- **Longer-term** the prospects for addressing global climate change will be affected by the as yet unknowable impacts of COVID-19 on investment actions and attitudes to global collaboration.

Global temperature will continue to rise and climate impacts will continue to mount. CO_2 emissions largely accumulate in the atmosphere meaning that human-induced warming will only stop once global emissions of CO_2 (and other long-lived GHGs) are brought to Net Zero and emissions of shorter-lived GHGs have been stabilised.

UK emissions impacts
The full impact on UK greenhouse gas emissions is also unclear at this stage - and will depend on the rate at which the economy is able to fully reopen safely. It is already clear, however, that lockdowns have caused a substantial fall in UK emissions in 2020. In a mid-case estimate, daily CO_2 emissions were around 30% lower than mean 2019 levels in the UK during the peak of the lockdown in April and May 2020. They are expected to be around 16% lower over the course of 2020 (including the UK contribution to IAS, which is a sector that is very affected by the crisis). Most changes observed in 2020 are likely to be transient, as they do not reflect structural changes in the underlying economic, energy, transport or land systems. Emissions are likely to rebound in the coming years, though some changes could be more permanent (e.g. working from home, business travel).

Source: Le Quéré, C. et al. (2020) Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement; Lui, Z. et al. (2020) COVID-19 causes record decline in global CO_2 emissions; IEA (2020) Global Energy Review 2020.

a) Mainstreaming Net Zero solutions

The scenarios we set out in Chapters 2 and 3 of our *Advice Report* demonstrate that action is needed across the economy for the entire period from now through to 2050. The scale-up over the coming decade will arguably be the most challenging part of the programme, and the most fundamental to delivering the Net Zero 2050 target. Delivering that scale up will depend on effective policy being developed in the coming year and rolled out over the rest of this Parliamentary term (to 2024) (Figure 1.1, Table 1.1). This Government must be the one to shift the UK decisively onto the path towards ending its contribution to global warming.

The pathways to Net Zero laid out in this report broadly involve two distinct phases for UK climate policy, with the next decade being vital:

Progress across every sector in the 2020s can ensure the conditions are set for a mass rollout of low-carbon technologies over the 2030s.

- **The 2020s: scale-up.** The UK must build supply chains and new markets for low-carbon consumer offerings (e.g. electric cars and heat pumps) so that these can scale from being niche offerings to dominate the market and fully push out high-carbon alternatives by 2030 or soon after. Alongside, we must develop and scale up new options for industrial decarbonisation such as carbon capture and storage (CCS), low-carbon hydrogen and engineered emissions removals. Tree planting rates must increase from 13,000 hectares per year today to 30,000 hectares per year by 2025 in line with the Government's commitment and continue to grow to 50,000 hectares per year by 2035.

By 2030, the low-carbon option should be the default option in all areas.

- **From the early 2030s to 2050: roll-out.** Having scaled up the required markets, these will then take around 15 years to flow through the stock of vehicles and houses. Instruments driving implementation in industry and land use should be well developed and continue to drive roll-out at similar rates. But policy will be less about aiming to scale up markets, instead focusing on continuing achieved rates of roll-out, tackling emerging barriers and systems challenges and ensuring fairness across society.

Our scenarios have been developed with a particular attention to the pace at which change is feasible, allowing time for supply chains to scale up and for consumer choices to change. They move in step with the natural turnover of long-lived assets like vehicles and boilers, avoiding increases in embedded emissions or emissions leakage.

Having made more progress to date, the electricity sector is moving to the second phase already. Costs of renewables have plummeted so that subsidies are no longer required, and annual roll-out rates have already ramped up close to levels that will be needed through to 2050. Policy must continue roll-out (e.g. by continuing regular auctions of long-term contracts), unblock barriers (e.g. by better coordinating the onshoring of transmission lines to offshore wind farms) and deal with the system challenges (e.g. through strengthening flexibility markets to accommodate intermittency).

The next year will be key to setting the foundations of a decade of delivery for climate action, ahead of COP 26.

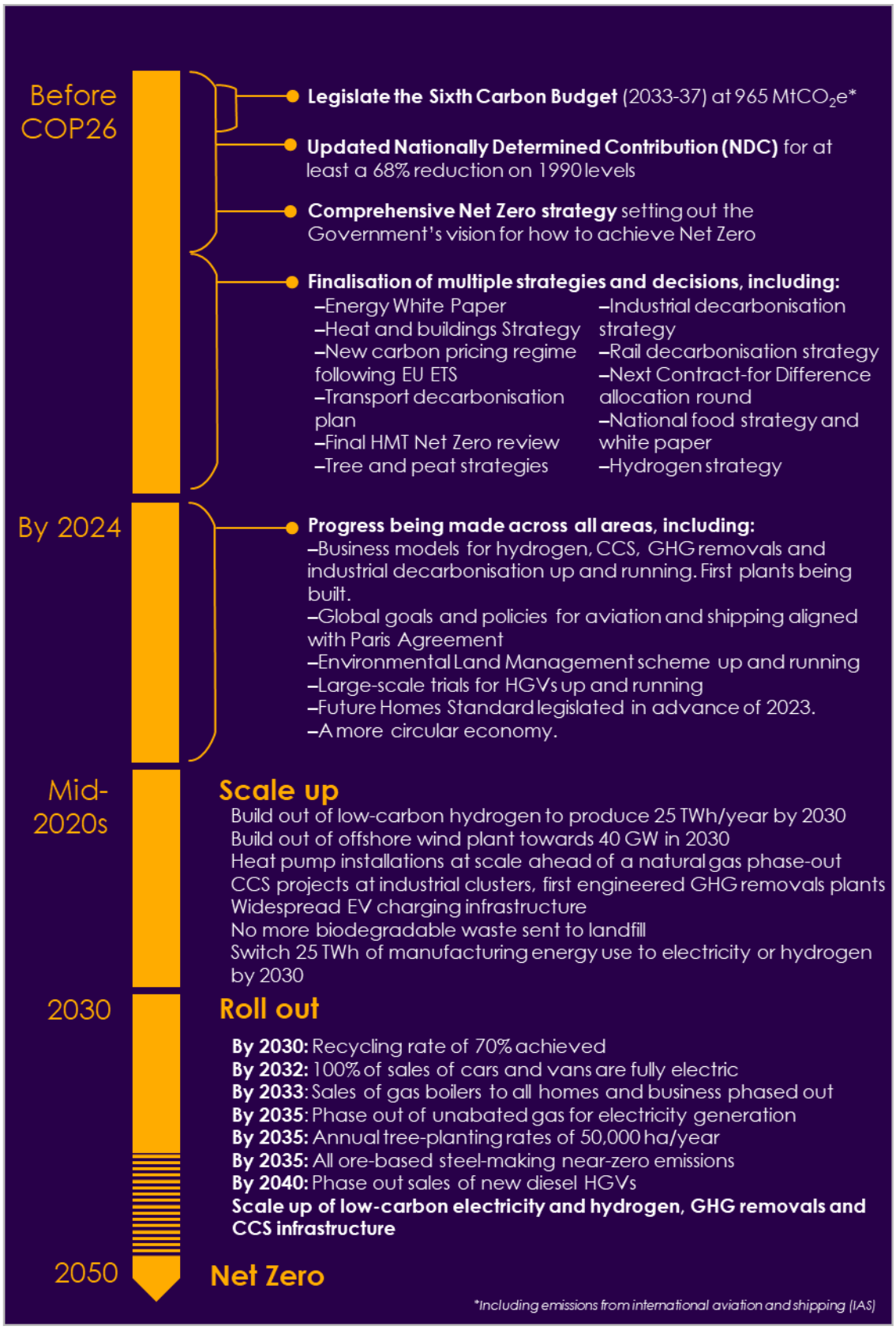
Delivering the changes required to meet the Sixth Carbon Budget will only be possible if comprehensive programmes of infrastructure and skills are developed over the same period. Policy must be designed to support business models that will work in the growing markets for low-carbon solutions.
Alongside this, focus should be placed on supporting innovation, and bringing forward policy that lowers the cost of finance.

The precise policy challenge of course differs for each sector, and we explore those details in the subsequent sector Chapters in this document.

If the required scale-up over the coming decade is to be a success, the key building blocks of policy must be introduced in the coming months. That takes on added significance as the UK hosts the UN climate talks in Glasgow in November 2021 – setting out a strong and credible policy package to deliver the scale up over the next decade would put the UK firmly on track to Net Zero, greatly strengthening its credibility as a climate leader.

Key milestones for policy to deliver on are set out in Table 1.1 and Figure 1.1.

Figure 1.1 Timeline for the decade of delivery, and beyond



Source: CCC analysis based on the Sixth Carbon Budget and HMG (2020) *The Government Response to the Committee on Climate Change's 2020 Progress Report to Parliament*.
Notes: Table 1.1 has a complete list of the milestones and targets to be reached on the path to 2050.

Table 1.1
Key outcomes to target over the next few years, and milestones towards 2050

Date	Outcomes and Milestones	
Before COP 26	• Legislate the Sixth Carbon Budget at 965 $MtCO_2e$, including emissions from International Aviation and Shipping (IAS) • Net Zero strategy • Energy White Paper • Heat and Buildings Strategy • New carbon pricing regime following EU ETS • Transport decarbonisation plan • Final HMT Net Zero review • England Tree Strategy • Peatland strategy, including an immediate end to rotational burning of peat • Hydrogen strategy, and consultation on hydrogen business models • Rail decarbonisation strategy • Industrial decarbonisation strategy • Net Zero carbon hospital standard, and further commitments towards delivering a Net Zero NHS • Publication of Greening Government Commitments • Ofgem's final business model approvals for the RIIO-ED2 period should accommodate network upgrades for EVs and heat pumps • Next Contract-for Difference allocation round, targeting large volumes of renewables, towards 40 GW offshore wind by 2030	• Updated Nationally Determined Contribution (NDC) for at least a 68% reduction on 1990 levels (excl. IAS) • Build on the UK's NDC to increase global climate ambition in the run up to COP26 • Strengthened UK Adaptation Plans • Updated Green Book guidance on climate change • Decision on funding model for CCS infrastructure • MOD review of climate change and defence • Call for evidence on policy for GHG Removals (GGRs) • Consultation on mandatory food waste reporting • Consultation on including maritime in the Road Transport Fuel Obligation (RTFO) • Scottish Government to publish updated Climate Change plan • Conclusion of Green Jobs Taskforce • Environmental Land Management pilots • Implementation of minimum device standards for EV chargers • National food strategy and white paper • Welsh Government to publish an 'All Wales Plan' for the second carbon budget • Aviation decarbonisation strategy
By the end of 2022	• CCUS business models decided for power, hydrogen and manufacturing and construction • 3rd Climate Change Risk Assessment published by Government • Cross-Government bioenergy strategy • Establish business models for both electrification and hydrogen-use in manufacturing.	• Defra to publish a Nature strategy for England • ICAO negotiations to set long-term Paris-compatible target for global aviation (align & strengthen CORSIA in 2023) • Strategies for aviation and shipping (including IAS) that reflect UK Net Zero
By 2024	• Business models for hydrogen, CCS, GHG removals and industrial decarbonisation up and running. First plants being built. • Environmental Land Management (ELM) scheme up and running • Large-scale trials for HGVs in place • Universal waste collections and recycling facilities in place across England	• IMO negotiations revise 2050 target for global shipping in 2023, set new policies • Coal phased out of the power system • Future Homes Standard in place for new build homes (from 2023) • Implement a trading or auctioning system to deliver private sector investment in tree planting

Mid-2020s	• Construction of low-carbon hydrogen plant to demonstrate low-carbon hydrogen at scale via 1 GW of hydrogen production capacity by 2025 • Strategic decisions on the future of the gas grid, including the extent of zoning for heat networks, electrification and any planned conversions of the gas grid to hydrogen; plans for delivery and a governance framework. • All new boilers 'hydrogen-ready' from 2025	• CO_2 transport and storage infrastructure operational • Annual tree-planting rates of at least 30 kha/year • First UK sustainable aviation plants operational, policy support in force • No more biodegradable municipal and non-municipal waste sent to landfill from 2025 • From 2025, flaring and venting on platforms only permitted for safety reasons • No direct emissions from operational energy use on new oil and gas platforms by 2027
By 2030	• Nearly 100% of cars and van sales are battery electric (or other zero emission) vehicles • Heat pump installations at scale (1m annually) ahead of a natural gas phase out date pre-2035 All buildings except owner-occupied non-fuel poor homes achieve EPC C • Sales of oil and coal heating in homes phased out (2028) • Rented homes achieve EPC C and homes for sale achieve EPC C (2028) • Phase-out of the most harmful F-gases and restricting the use of all F-gases by 80%	• CCS and low-carbon hydrogen across 5 industrial clusters, capturing and storing at least 10 $MtCO_2$ per year and producing 30 TWh/year of low-carbon hydrogen • 40 GW of offshore wind installed in UK waters, reducing emissions from electricity generation to less than 50 gCO2/kWh • Commercial roll-out of low-carbon ammonia and hydrogen starts in shipping, with at least one cluster (>2 TWh/year) • Recycling rate of at least 70% achieved across the UK, food waste 50% reduction • Commercial scale engineered GHG removals plants operational • Switch 25 TWh of manufacturing energy to electricity or hydrogen
Over the 2030s	• Sales of gas boilers to all homes and business phased out (by 2033) • Phase-out of sales of new diesel HGVs (by 2040) • By 2030: All ore-based steel-making near-zero emissions • By 2040: All cement production near-zero emissions	• Phase-out of unabated combustion of fossil gas for electricity generation (by 2035) • Widespread rollout of CCS, including on energy-from-waste plants • Annual tree planting rates of at least 50 kha/year
By 2050	Any residual sources of emissions are offset through emissions removals in the UK. Low-carbon electricity, hydrogen and bioenergy provide all the UK's energy, in combination with CCS. Low-carbon technologies and behaviours continue to roll out at scale and all asset replacements continue to be low-carbon.	

Source: CCC analysis based on the milestones to delivering the Sixth Carbon Budget pathway, and HMG (2020) *The Government Response to the Committee on Climate Change's 2020 Progress Report to Parliament*, Policy Exchange (2020) *UK Energy & environment policy timeline*.

3. Cross-economy climate policy priorities

This section sets out eight cross-cutting policy priorities that need to be addressed, in addition to sector-specific policy packages.

Since the passing of the Climate Change Act in 2008, strong policy action from Government has been a key driver of emissions reductions in the UK, particularly in the power and waste sectors. Such reductions have been delivered through a combination of stable regulation, price incentives and technology support.* To achieve the emissions reductions required for the Sixth Carbon Budget, policy will need to build on these successes and extend to all sectors of the economy. Importantly, policy will need to look beyond individual policy objectives to deliver a systems approach to decarbonisation, with strong co-ordination required throughout Government.

No single policy can deliver cross-economy decarbonisation, but a combination of sector-specific interventions in the early 2020s, combined with co-ordinated regulation and standards that favour the low-carbon option, over the high-carbon option, can enable the emissions reductions required to achieve the Balanced Pathway towards the Sixth Carbon Budget.

This section sets out our advice on the priorities for cross-economy climate policy. It draws heavily on the advice from an expert group that we convened on Net Zero policy (Box 1.2, Figure 1.2), as well as our own analysis, the advice of our advisory groups on health and finance (see Chapter 5 of the Advice Report), assessments we commissioned on the role of business and local government, and the proposals from other independent organisations.

In our annual Progress Reports to Parliament we will assess the Government's progress not just on a sectoral basis, but also on tackling the overall Net Zero challenge, with a particular focus on *fairness* and the *just transition*, as well as success in engaging and involving *people* across the UK, *regional* implementation and the Government's approach to *delivery*.

This section is in eight parts:

- Sectoral policy and the foundations of a Net Zero strategy
- Institutions and organising government for the challenge
- Public engagement
- Business engagement
- Who pays and the Just Transition
- Delivering Net Zero at the local level
- International policy and trade
- Policy advice from other groups

* See CCC (2020) *Progress Report to Parliament*, for further detail on how policy delivered the UK's emissions reductions in the last decade.

Box 1.2
Summary of the Expert Advisory Group report on policy for Net Zero

Alongside our work on the Sixth Carbon Budget we convened an export policy advisory group to provide input on how cross-sectoral policy can complement the CCC's existing approach to policy advice. The group was chaired by Professor Cameron Hepburn, and consisted of Tera Allas, Laura Cozzi, Michael Liebreich, Jim Skea, Lorraine Whitmarsh, Giles Wilkes and Bryony Worthington.

The remit of the advisory group was to think beyond sectoral targets and to suggest cross-cutting, top-down views of how policy could accelerate progress towards achieving Net Zero emissions by 2050. The group had three meetings between July and September 2020. Their report is published alongside our advice on the Sixth Carbon Budget.

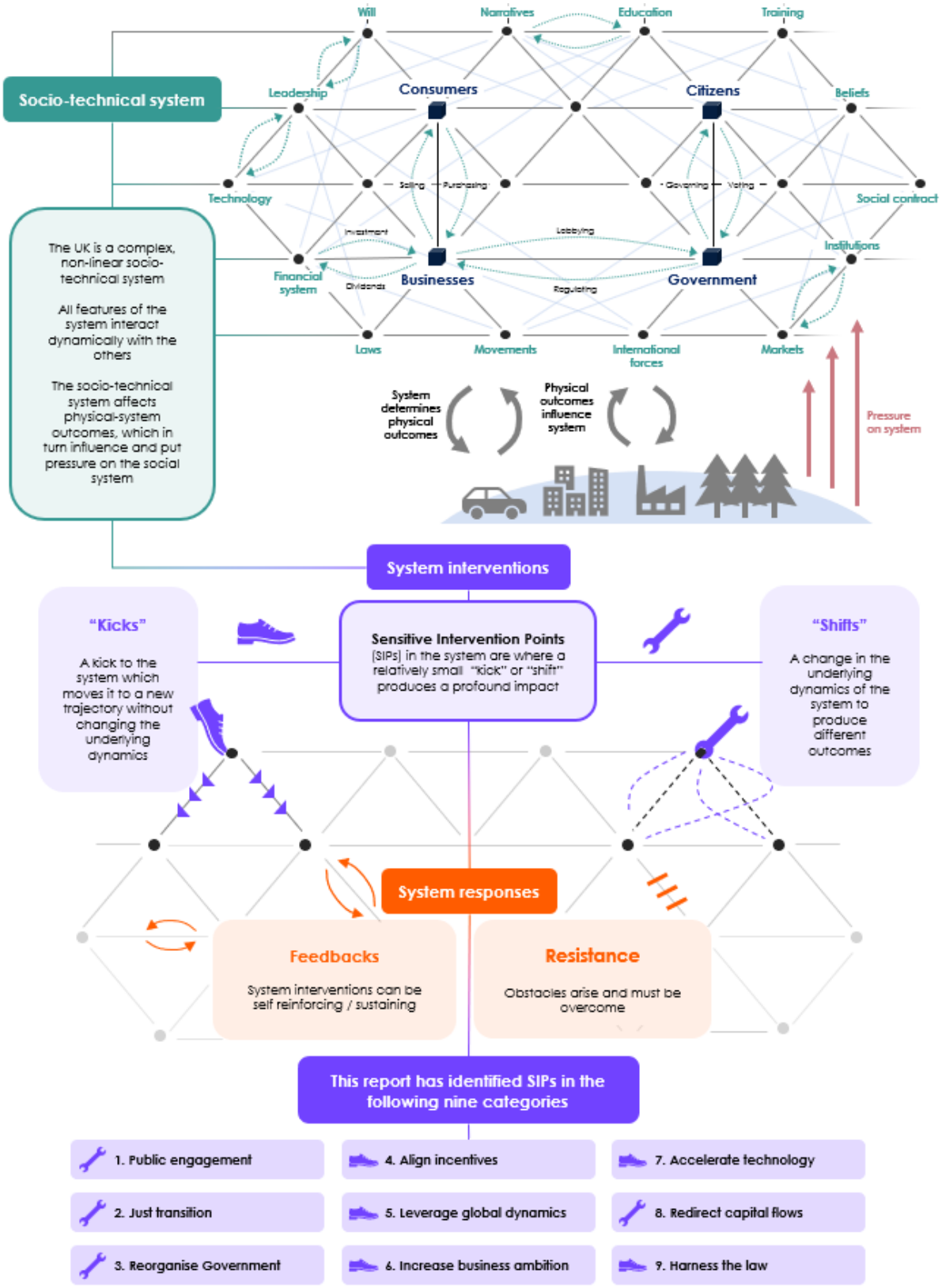
The group concluded that the transition to Net Zero can and will occur, and will leave a positive legacy for future generations. They examined the UK as a complex adaptive system and identified recommendations for accelerating progress and reducing the risks of failure (Figure 1.2). The Group recognised an opportunity for Sensitive Intervention Points (SIPs) coinciding with these recommendations, pointing to opportunities to accelerate a transition towards Net Zero by exploiting socio-economic tipping points.

These included:

- **Deepening public engagement** through investments to support measures to lower 'thresholds' to behavioural change, such as energy efficiency or dietary alternatives. This can form part of a public engagement strategy for Net Zero that educates the public, involves people in decision-making and provides trusted information at key decision points
- **Delivering social justice** via a clear long-term vision for specific regions coupled with mechanisms that reward the private sector for building industries in otherwise deprived areas, starting now
- **Government leading on Net Zero** by requiring any company meeting with ministers and secretaries of state to have a plan to reach net zero emissions
- **Leveraging global dynamics** by introducing a border carbon adjustment, and consider forming bilateral and multilateral preferential trading arrangements for environmental goods and services
- **Penalising emissions** by committing in the UK's NDC to sequester 10% of CO2 emissions generated by fossil fuels and industry by 2030
- **Increasing business ambition** by identifying businesses that shape industries – celebrate and elevate them
- **Accelerating technology** via Pathfinder cities that can deliver comprehensive steps towards Net Zero, and demonstrate the interactions required across complex systems of low-carbon electricity, heat and transport
- **Redirecting capital flows** by introducing Net zero aligned and transparent accounting and auditing
- **Harnessing legal avenues** by legislating all regulators to regard the Paris Agreement, Sixth Carbon Budget and 2050 Net Zero target in their duties.

Source: Advisory group on cross-cutting policy for the CCC (2020) *Sensitive intervention points to achieve net-zero emissions.*

Figure 1.2 A complexity economics framework for the transition to net-zero emissions



Source: Advisory group on cross-cutting policy for the CCC (2020) *Sensitive intervention points to achieve net-zero emissions.*

a) Sectoral policy and the foundations of a Net Zero strategy

The core parts of a comprehensive Net Zero strategy are being put into place.

Historically, emissions reduction in the UK has been targeted to specific sectors such as low-carbon electricity generation, and waste, though, as noted in section b) this is now being complemented by a programme of policy development that covers most areas of decarbonisation. Some cross-economy policy instruments do exist, such as the EU's Emissions Trading Scheme and the carbon price support scheme, though they only cover emissions from the power sector, parts of manufacturing, fuel supply and domestic and intra-EU aviation.

Government has successfully identified priority areas for policy intervention over the coming years, and Departmental priorities are rightly focused on delivering key strategies across hydrogen, industrial decarbonisation, buildings heat, land use as well as development of removals policy and delivering the energy white paper. We set out our advice on what should be included in these strategies in the sector specific chapters of this report. The challenge for the Government's forthcoming Net Zero strategy will be to co-ordinate these strategies within a cross-economy policy package that adds up to a programme of delivery towards the Sixth Carbon Budget. This should include consistent principles for sectoral policy, support for innovation, removing barriers to progress and cross-economy carbon pricing.

Climate adaptation and resilience is also a priority across multiple areas. In particular on buildings and land use, there are benefits to thinking holistically about how policy can reduce emissions, while ensuring it improves resilience to the UK's changing climate. Like Net Zero, climate adaptation will also need to be integrated into core Government policy in both cross-cutting and sectoral policy development.

Key components of sectoral policy

Government policy can enable the private sector to provide the bulk of investments for the transition.

Driving down emissions in specific sectors is likely to require a combination of consistent direction, investable incentives, enabling measures, preparing for the future and fairness.

- Clear long-term **direction** will be required. For example, the Government's ambition of 40 GW by 2030 for the offshore wind sector for the industry to plan for increased scale.
- Businesses and consumers will need **investable incentives** that favour the low-carbon option, such as up-front grants for EVs and heat pumps, as well as longer-term instruments, such as contracts-for-difference, which provide a consistent return for investors over the course of the investment.
- Removing **non-financial barriers** to deployment, such as enabling infrastructure for EV charging and offshore wind networks, or building up new skills in home retrofit.
- Preparing for **future challenges** as well as current ones, such as continuing to invest in future technologies such as floating wind alongside support for more established renewables.
- Focusing on the **particular issues** for that sector, for example heat policy in residential buildings will need to address fuel poverty, and a strategy for low-carbon manufacturing will need to address competitiveness.

Support for innovation and option creation

Government should provide support and create options, rather than prescribe a pathway that others have to follow.

Innovation has played a critical role in driving down the costs and improving the efficiencies of the low-carbon technologies we use today. Continued support for innovation can ensure costs and efficiencies continue to improve in the future, while discovering and commercialising the next generation of low-carbon technologies. Support will be required across all stages of the technology lifecycle, from research and development, through to demonstration, commercialisation and deployment.

Government should provide support and create options, rather than prescribe a pathway that others have to follow.

- A transition to Net Zero will need to be led by Government, **though all parts of society need to play their part**, including people, businesses and local, regional and devolved governments (section d). Increasingly, businesses, local governments and parts of society are leading the way in a low-carbon transition. Government's role should be to co-ordinate, support and guide these bodies as part of a national transition, encouraging them to work together.
- **Option creation.** Government policy should work to create and encourage multiple technologies and pathways, by developing market mechanisms that work towards technology-neutrality (e.g. auctions for renewables, enabling both hydrogen and electrification to compete in industrial decarbonisation). In some cases Government will need to work to level the playing field amongst technologies. For example, support for early-stage technologies (e.g. floating wind), can enable them to compete against established technologies in the future. Where innovation support doesn't lead to results, Government should be willing to change direction, or withdraw support as required.
- **The importance of infrastructure development.** Scaling up low-carbon technologies will rely on new infrastructure, such as electric vehicle charging points, electricity network upgrades and new hydrogen and CO_2 networks. These must be reflected in infrastructure decisions in the 2020s and be resilient to a changing climate. In most cases, such as in distribution networks for electricity, where upgrades may be required for both EVs and heat pumps, planning for scale is likely to lower long-run costs.* These systems are increasingly interlinked, therefore planning for the next 30 years of low-carbon infrastructure will need to be cognisant of the impact of decisions in one area (e.g. electrification) on another (e.g. gas grids).

* For example, upgrading electricity distribution networks to allow sufficient capacity for both EVs and heat pumps has been estimated to save over £30 billion compared to upgrading these networks separately. See Vivid Economics (2019) *Accelerated electrification*.

Carbon pricing

Carbon taxes could be expanded, but without careful management this could raise issues around the equitable distribution of these costs.

To incentivise the transition to Net Zero, relative prices will need to reflect carbon content sufficiently to favour low-carbon options over high-carbon options. That can be achieved through explicit carbon pricing or other levers. In principle, all sectors of the economy can be exposed to carbon pricing. In the UK at present, carbon pricing is applied inconsistently:

- Electricity prices currently carry most climate policy costs. That increases electricity prices relative to natural gas and discourages a switch to lower-carbon electric heating. These costs must be a priority area for reform.
- Other sectors face less explicit carbon prices but can be judged indirectly to reflect a carbon price. For example, road fuel duty in the surface transport sector and the landfill tax in the waste sector.[8]
- However, some sectors do not face a carbon price at all, or face reduced tax rates that are judged by some to be, in effect, negative carbon prices or fossil fuel subsidies.[9]
  - For example, home heating (often using natural gas) faces a reduced rate of VAT.* Red diesel fuel for tractors is another example. These examples demonstrate the importance of wider considerations, including equity and fairness, given the regressive nature of charges on energy bills and the wider policy package to support farmers.
  - Similarly, aviation fuel faces no taxes at all, meaning that international flights that go beyond EU borders (where they are covered by the EU Emissions Trading System) do not face a carbon price or fuel taxation. Equity arguments are less relevant for this sector, although as set out above, the Climate Assembly favoured a frequent flyer levy on account of fairness concerns.
  - Energy-from-waste plants also face very little carbon taxation.

Carbon pricing could help rebalance stretched public finances, while strengthening incentives to reduce emissions.

Greater use of carbon taxes can also support the public finances while strengthening incentives to reduce emissions. They are particularly attractive when global oil prices, and therefore consumers' energy costs, are low, as they are now. The Zero Carbon Commission (ZCC) estimate that carbon pricing could raise up to £27 billion per year by 2030, though this could increase costs to households, raising a further need for an equitable redistribution of costs.†[10] Recognising this need, the ZCC suggests that some carbon pricing revenue could be redirected towards the most affected households. Any expansion in carbon pricing could be applied upstream or downstream:

- **Upstream:** Carbon could be taxed on fuels (at the point of production or import), and on direct sources of emissions from industry, waste and agriculture (alongside complementary measures to stimulate efficiency and investment). Fuels are currently taxed this way in the power and industrial sectors under the Climate Change Levy (and Carbon Price Support).

* A Green Gas Levy has been proposed, paid through gas bills, that will fund the injection of biomethane into the natural gas grid. It is expected to come into place in 2021.

† The Zero Carbon Commission estimate that £27bn/year could be raised via a £75/tCO_2 charge across most domestic sectors, revenue from a Border Carbon Adjustment for industry, energy and agriculture, and removal of the Red Diesel subsidy for agriculture and shipping. This is an increase on carbon revenues of over £3 billion/year today.

- **Downstream:** Applying a carbon tax on goods and services at the point of consumption, maximising consumer-visibility (through carbon labelling) and taking account of full lifecycle emissions for both imported and domestic production.

As an alternative to taxing carbon and spending on low-carbon solutions some mechanisms would close that loop directly.

- For example a carbon obligation on fossil fuel suppliers – where oil and gas companies are required to put back in the ground a proportion of the carbon they extract – could be used to fund carbon capture and storage (CCS) in the UK.* The obligation could scale up over time until it covers 100% of the emissions associated with fossil fuel extraction, supply and use.
- Emissions removals, whether from afforestation or engineered removals such as bioenergy with CCS (BECCS) will need financial support, which could be provided by including them within an emissions trading system (and setting a commensurately lower cap for the scheme).

In the long term, an economy-wide trading scheme with a cap of zero emissions would be a plausible way of balancing emissions and removals across the economy.

In the long term, an economy-wide trading scheme with a cap set to zero emissions would be a plausible way of sustaining Net Zero emissions across the economy by balancing emissions and removals (or for certain sectors, like aviation). During the transition, other levers will be vital alongside carbon pricing and instruments must be designed to give sufficient confidence and visibility to investors. We note that carbon prices (either as taxes or from trading schemes) have tended to turn out at different levels to those expected or promised, while long-term contracts for low-carbon power have been very successful in bringing forward considerable investment at low cost.

The value of regulation

Where appropriate, regulation can be used to give a strong and investable signal to businesses and consumers that the highest carbon technologies and behaviours will be phased out in the future. It will usually need support from additional policies to enable low-carbon solutions to scale up and replace the old high-carbon options.

Bodies such as the Confederation of British Industry (CBI) and Energy UK note their support for long-term regulation in giving clarity in a transition to Net Zero, even if it affects the operations of their members' businesses. [11] The UK Climate Assembly showed strong support for regulation in specific areas, such as a mandated phase-out of gas boilers.

Our scenarios have a clear expectation of using regulation to shift away from high-carbon technologies and behaviours by a specific date, including a phase-out of fossil fuelled vehicles and boilers, the phase out of unabated gas generation and avoiding biodegradable waste being sent to landfill (Table 1.2). Where possible, regulation should be used to phase out the sale of high carbon technologies, allowing the low-carbon option to then flow through the asset stock. Backstop dates can also be used to ensure that old, high-carbon assets don't continue to operate beyond certain dates.

* See, for example, Oxburgh et al. (2016) *Lowest cost decarbonisation for the UK: The critical role of CCS*.

The sale and construction of new high-carbon assets should be phased out by specific dates to ensure that they are removed from the economy before 2050.

The dynamics of each sector, and the principle of minimising early scrappage, point to common timings on the phase-out of high-carbon assets on the path to Net Zero, regardless of what low-carbon solution replaces them (Table 1.2):

- **Boiler lifetimes of 15 years imply a phase-out date for the installation of fossil fuel boilers in advance of 2035**, in order for uptake of low-carbon heat to be sufficient to decarbonise buildings by 2050. Our scenarios involve sales of oil boilers phased out by 2028, and gas boilers by 2033 in residential homes, with the exception of hydrogen-ready gas boilers in areas where the gas grid is set to convert to low-carbon hydrogen.
- **Sales of new fossil fuel cars, vans and motorbikes** phased out by 2032 at the latest.

Where possible, new equipment should be designed to allow retrofit of low-carbon technologies like CCS or hydrogen.

- **Building on the phase-out of coal-fired power generation by 2024, no new unabated gas plants should be built after 2030**, and the burning of unabated natural gas for electricity generation should be phased out entirely by 2035. Any gas plant built before 2030 should be made ready for a switch to CCS or hydrogen (i.e. this should be both technically feasible and the plant should be located in a part of the country that will be served by the necessary infrastructure).
- **Emissions from the UK's growing fleet of energy-from-waste** plants will need to be captured in order for energy-from-waste to be sufficiently low-carbon by 2050. Waste should be minimised, and any new plants should be built with CCS or CCS ready.

Rather than simply announcing these phase-out dates, Government must work closely with industry to deliver all the enabling conditions to achieve them, such as on skills, infrastructure and public engagement.

Table 1.2
Phase-out dates of high-carbon activities under the Balanced Pathway

Technology/behaviour	Phase out date (sales)	Backstop date (operation)
New fossil-fuelled cars and vans	2032	2050
Gas boilers	2033 (in residential homes) 2030-33 (in commercial properties)	2050
Oil boilers	2028 (in residential homes) 2025-26 (in commercial properties)	2050
Gas power generation (unabated)	2030 (no new build of unabated gas plants)	2035
HGVs	2040	Beyond 2050
Biodegradable waste sent to landfill	N/A	2025 ban on all municipal & non-municipal biodegradable waste going to landfill
Energy-from-waste plants (unabated)	From today, new plants and extensions should be built with CCS or CCS ready	2050
Cement	From today, new conventional plants should be built with CCS or CCS ready	By 2040: All cement production near-zero emissions.

b) Institutions and organising government for the challenge

There are now two Cabinet level Committees for Climate Action.

Net Zero is a major delivery challenge across the economy and across government. In our June *Progress Report to Parliament* we emphasised the importance of leadership from the Prime Minister and the role of the Cabinet Committee on Climate Change.

We are pleased that the Government has now clarified that there are two Cabinet Committees for Climate Action – a Strategy Committee chaired by the Prime Minister and an Implementation Committee chaired by the BEIS Secretary of State. These are important first steps in ensuring that action to deliver Net Zero is sufficiently prioritised at the heart of Government. We welcome the further announcement of a Task Force Net Zero to put a systems approach at the heart of the Government's thinking.

The Committee does not see its role as being prescriptive on how Government should be organised to deliver the transition. We note the work of others in this area:

- The external Policy Advisory Group that we convened suggested the need for the Cabinet Office to play the leading role in delivering the UK's climate change mitigation and adaptation objectives, as well as the importance of the Net Zero objective being consistently championed by the Prime Minister. They also noted the importance in ensuring that HM Treasury sufficiently balance the need to reduce emissions with fiscal objectives.
- Others have noted the need for an arms-length 'Net Zero delivery body' to co-ordinate and ensure action across multiple Government departments, either for the entire Net Zero challenge, or for particularly complex areas such as heat decarbonisation.

Reaching the UK's climate objectives will require all departments to review how their policies interact with the UK's Net Zero target. Similarly, climate adaptation will need to be integrated into policies to ensure that objectives can be met in a changing climate. Policy teams across departments must be sufficiently resourced to develop and implement the changes required.

c) Public engagement

As we set out in section (4) below, people will have a crucial role in delivering the Sixth Carbon Budget and Net Zero. An effective policy approach must inform, engage and involve people.

Though BEIS leads regular monitoring of public attitudes to energy and emissions, and the public are engaged in some policy development, there is currently no Government strategy to engage the public in the transition to a low-carbon and climate resilient economy. This will need to change. People should understand why and what changes are needed, see a benefit from making low-carbon choices and have access to the information and resources required to make the change happen. The engagement strategy should recognise the importance of co-benefits such as improved air quality, comfort and health and the need to adapt to the impacts of climate change, alongside reducing emissions.

The public should be engaged around the need for climate action, provided with information about how to reduce emissions and involved in decisions on how best to achieve a transition.

A successful public engagement strategy for Net Zero is likely to require the following:

- **Involvement of people in decision-making**, not just persuading them to change, as part of a national conversation on the options available for achieving Net Zero. This should be done in a way that allows people to understand and deliberate over the options available, at a point where people's input is most useful in policy-making – which is likely to differ according to the policy being developed - and in a way that is transparent about how people's decisions will influence the course of action taken.
- **Trusted information** available about the choices being made in the UK's transition towards Net Zero, the reasoning behind and impact of these choices as well as the provision of information available at critical decision points, such as buying a new car or home, delivered using trusted messengers and intermediaries. Tools like the Mackay Carbon Calculator have been used in promoting an understanding of choices available in the UK, and globally. Further tools, such as a carbon footprint calculator, should also be considered.
- Educating the public on the need for climate action to reduce emissions and to adapt to climate change, on the options available for reducing emissions, and on the challenges and opportunities likely to arise during the transition.

An effective Net Zero Strategy will need to include a public engagement strategy that should build on the findings of the UK Climate Assembly.

d) Business engagement

Businesses will also have a crucial role, not least in delivering the bulk of the £50 billion annual investment programme for Net Zero. The Government must put in place policy rules that encourage businesses to make these investments and give them the confidence to do so at low cost. Real economy policy will be key to making low-carbon investments attractive and to overcoming barriers, including on skills and the just transition. However, softer levers and financial rules will also have a role in a complete policy package.

- **Market development and business models.** Government will have an important role to play in creating and scaling up markets for low-carbon technologies, by providing consistent policy signals and supporting financeable business models. Government should look to replicate the success of the Contracts-for-Difference model (CfD) in electricity, for other sectors, which has lowered the costs of the UK's renewable electricity programme, by delivering a risk-sharing model that balances risks across consumers and the private sector.

Government policy can lower the cost of borrowing the money to finance the investments required for the Sixth Carbon Budget.

- **Keeping the cost of finance low.** As noted in chapter 5 of the Advice Report, scaling low-carbon finance, while keep the cost of borrowing low, will be critical in delivering a transition to Net Zero at lowest cost. Government policy is a key determinant of risk, and therefore the cost of borrowing. Government and regulators should aim to deliver consistent, long-term policy that allocates risks to those best placed to manage them. Alongside this, reforms to the UK's financial system can continue to direct money towards low-carbon investments (Box 1.3).

Clear messaging from Government can ensure that the UK's businesses play an effective role in the transition and maximise the opportunities associated with it. The following are likely to be important:

- **Clear messaging from Government** has an immediate impact on big business. Since the UK's Net Zero objective became law, more than 45% of FTSE 100 companies have signed up to the same level of ambition, or higher. Clear signals on the growth of low-carbon markets, and the phase-out of the most carbon-intensive ones can steer businesses towards the UK's objectives.

Businesses' accounts could be audited to ensure they are aligned to goals of the Paris Agreement.

- **Encourage Paris-aligned decisions, driven by Paris-aligned accounts**, audits and disclosure which go beyond the foundations set by the Taskforce for Climate-related Financial Disclosure (TCFD).* This can encourage business leaders to confirm that they have accounted for material climate risk or explain why they have not.

  Accounting and auditing in accordance with Net Zero targets can then be promoted, which should provide additional transparency as to the climate risks sitting in a portfolio of assets, and ultimately redirect capital away from high-carbon assets, towards lower-carbon alternatives (see Box 5.3 in Chapter 5 of Advice Report).

- **Review existing regulation** to identify barriers to businesses looking to delivery the UK's low-carbon objectives.

Our advisory groups made further recommendations on how Government could further enhance the contribution of UK businesses:

- The Government could identify the top 100 businesses that are critical to success on Net Zero and engage with them directly to influence their approach.
- For particular leaders, innovators or blockers the Government could elevate, support or circumvent their efforts to amplify successes and overcome resistance.
- Our Finance advisory group made a number of recommendations for changes to financial regulations and rules to encourage more capital to flow to low-carbon solutions at lower cost (Box 1.3).

For the first time, the Committee has provided detailed guidance on how businesses can aid the delivery of the UK's Net Zero ambition (section 4).

Box 1.3:
The Expert Advisory Group's recommendations on Net Zero finance

Over the course of 2020, the CCC convened an expert advisory group on Net Zero finance, chaired by Professor Nick Robins of the London School of Economics, to advise on the question: What is the role for finance in delivering the Sixth Carbon Budget and how can Government support it at least cost?

* The Government introduced reporting standards under the Taskforce for Climate-related Financial Disclosures (TCFD) in 2019. The TCFD sets out guidelines for the management and disclosure of material climate risk, but not financial statements themselves. From 2023, all publicly listed UK companies with a premium listing will be required to comply with the TCFD's requirements.

Our Expert Advisory Group on Net Zero finance concluded that the large investment programme required for the Sixth Carbon Budget was deliverable.

The group's summary report, concluded the that investment programme required for the Sixth Carbon Budget was deliverable, but that delivering this at the lowest overall cost was dependent on policy in both the 'real' and financial economies, suggesting 15 recommendations where the Government can build on the UK's existing green finance infrastructure to accelerate a transition to Net Zero (Figure B1.3).

Figure B1.3 The finance Expert Advisory Group's recommendations

A. Strategic

1. The UK should commit to be the world's first net-zero financial system

2. Make net-zero projects and plans investable, by increasing the predictability of cash flows & reducing risks through sector pathways, carbon pricing & de-risking

3. Design net-zero policies so that investments are resilient, fair & enable local action, for example, by introducing a just transition strategy

B. Private finance

4. Ensure that market innovation responds to the scale of the net-zero financing challenge through both sector-specific strategies & system-wide instruments

5. Deepen the skills and capacity of the UK's financial professionals to support their customers and clients in the transition

6. Build the literacy, expertise and confidence of the users of UK financial services to understand and demand climate-aligned product

C. Financial regulation

7. Fully integrate climate risk and net-zero into financial regulation and monetary policy (including assessing legacy rules for alignment)

8. Make net-zero targets and plans mandatory for financial institutions

9. Extend investor stewardship to incorporate the achievement of net-zero

10. Set clear metrics for the net-zero transition at the institutional and product levels

D. Public finance

11. Use the post-COVID recovery plans as an opportunity to fast-track climate investment, reset fiscal incentives & connect public debt with climate goals (including through a green sovereign bond programme)

12. Set net-zero and sustainability goals for existing public financial institutions

13. Establish a National Investment Bank with a clear sustainability mandate

E. International frameworks

14. Build the international frameworks that can accelerate the financing of net-zero, resilience and a just transition, using 2021 as a key milestone with COP26 and the G7 presidency (for example, through the establishment of an International Platform for Climate Finance).

F. Tracking progress

15. Establish a regular assessment of investment needs and financial flows for climate action in the UK, including net-zero, resilience and a just transition.

Source: Advisory group report for the CCC (2020) *The Road to Net Zero Finance*.

e) Who pays and the Just Transition

Fairness is fundamental to public support and must be embedded throughout policy. Only a transition that is perceived as fair, and where people, places and communities are well-supported, will succeed. UK Government policy, including on skills and jobs, must join up with local, regional and devolved policy on the just transition. Vulnerable people must be protected from the costs of the transition and benefits should be shared broadly.

Net Zero will also have (largely positive) implications for public health. The central message of the health advisory group that the Committee convened for our Sixth Carbon Budget advice is that a strategy to achieve Net Zero emissions should have health equity—the fair distribution of health—as an explicit policy goal, and that a 'health equity in all policies' approach be adopted. Action to improve health equity can be consistent with measures to reduce greenhouse gas emissions and adapt to climate change, but it is evident that this requires careful consideration of who benefits from and who pays for different policy measures.

A strategy for a just transition is required, addressing key issues of fairness, including jobs.

More broadly, a strategy for a just transition is required. Across many areas, including energy bills and regional employment, fairness is already an issue. For example, deployment of low-carbon technologies at scale will require skilled low-carbon workers. Our scenarios suggest a need for over 200,000 skilled energy efficiency and heat pump installers in the 2020s, as well as many more in other sectors, such as EV manufacturing, renewables, hydrogen, CCS, peatland restoration and tree-planting. Skills policy will need to recognise the need for these skills, and deliver education and training that begins in schools and continues throughout workers' careers. In some places skills programmes will be needed to encourage a shift away from high-carbon industries (see Chapter 6 of the Advice Report). Navigating this transition must start now and will require effective plans, widespread public involvement and an embedding of the principle of fairness throughout climate policy. Regional and local considerations are vital.

Scotland's Just Transition Commission was appointed to advise on a Net Zero economy that is fair for all. It has identified four priorities for achieving a just transition:

- **1) Planning ahead** –clear transition plans need to be developed down to the sectoral level so that surprises are minimised. Unplanned transitions tend to be unjust transitions.
- **2) Engagement** – people need to be brought into the decision-making process and derive a sense of ownership of the Net Zero project.
- **3) Bringing equity** to the heart of climate change policies. Climate policies need to be systematically screened for their impact on vulnerable and excluded groups and for the opportunity to address existing inequalities.
- **4) Start now.** The transition is already underway both in the UK and around the world. A strategy that recognises this can put the UK at the forefront of addressing fairness in a transition to Net Zero.

The transition to Net Zero is already underway, so a strategy for a just transition is needed now.

For the UK, the Treasury's Net Zero Review will be the first comprehensive look at elements of the just transition to Net Zero. It will consider how the transition to Net Zero will be funded, and where the costs will fall.

The Review should deliver a plan for funding decarbonisation that is fair.

The Treasury's final report of their Net Zero Review, due in Spring 2021 should:

- **Develop a plan for funding decarbonisation and review the distribution of costs for businesses, households and the Exchequer.** This should set out the main areas where action and funding will be required, the principles on which the distribution of costs should be determined and clarity over how costs will be allocated.
- **Consider near-term as well as long-term decarbonisation funding needs and policy implications.** The Government cannot make funding commitments that bind future governments, but the review can set out principles to inform the scale and nature of long-term government funding and make concrete proposals for action and funding over the next five to ten years, or at least be accompanied by a spending review or budget which does the same.
- **Give due weight to issues of fairness, including assessing:**
  - Where the costs of policies are likely to fall and how they can be mitigated where vulnerable groups or industries are likely to be affected. This should include adverse distributional impacts of current policies.
  - Impacts on jobs and job quality and how to manage them, including consideration of reskilling and retraining.
  - Plans to monitor and to report publicly on progress towards achieving a fair transition and protecting vulnerable groups.
  - The benefits of Net Zero and where they fall, which will have implications for individuals, specific regions and the Exchequer.

We will review the Treasury's final publication as part of our 2021 progress report to Parliament. Managing the just transition will be an ongoing process and must continue beyond the report's publication. A full strategy is needed.

f) Delivering Net Zero at the local level

Over 300 local authorities have declared Climate Emergencies and a third have developed strategies and action plans to deliver carbon neutrality or zero carbon between 2030 and 2050. More than half of these have a target date of 2030. Local authorities are making policy and contract decisions now, that will remain in place during the 2020s and beyond, but with limited guidance as to how these decisions feed into a national strategy for meeting the UK's Net Zero objectives. With effective coordination and support, the high levels of engagement could be leveraged to make a significant contribution towards Net Zero.

Government should support local and regional authorities to deliver climate action, as part of the national strategy to deliver Net Zero.

Government should support local and regional authorities to deliver climate action, as part of the national strategy to deliver Net Zero, and without mandating how local areas should achieve their climate goals. This is likely to require additional funding for staffing and resources for local delivery plans, alongside a 'duty to collaborate' to encourage authorities to work with local, regional and national partners to deliver their climate ambitions. Without additional support, and some level of coordination there is a risk that local plans fragment a national Net Zero strategy.

- Building on local climate ambition, **Government should consider introducing a Duty to act for local authorities, in accordance with Net Zero** and to develop climate action plans within a common reporting system* that can devolve climate accountability to the local level, and empower local authorities to take action.
- **Local authorities will need to be properly resourced and supported** to develop the skills and capacity needed to plan and implement climate action across both emissions reduction and climate adaptation in their local areas.
- **Local areas should work together** as part of a broader dialogue around how local and national action can coordinate action towards the UK's Net Zero objectives. Local area energy plans can be used to increase understanding of how individual areas can achieve Net Zero, and Government should consider introducing a 'duty to collaborate' for local authorities and regional partners and national agencies, so that the plans of neighbouring areas and regions are taken into account in local decarbonisation strategies.

A lack of coordination of sub-national climate strategies, risks missed opportunities.

- **The Government's Net Zero Strategy should** align and clarify the roles of national, sub-national, regional government, public bodies and local authorities in delivering the UK's climate objectives. This should provide a clear direction to reduce uncertainty, and additional powers where needed. The recent NAO review on how the Government is coordinating for Net Zero notes that local authorities are currently absent from the Government's coordination strategy.[12] A lack of coordination risks missing opportunities and synergies across local and national plans that could increase costs and slow down the pace of the transition.

We consider the roles of local authorities and other regional authorities further in section (4).

g) International policy, global dynamics and trade

COP 26 presents an opportunity the UK showcase its climate ambitions.

The UK was the first major economy to set a Net Zero target in legislation, but since then many others have followed, including recently China, Japan and South Korea. This points to a shift in global dynamics towards Net Zero, creating large low-carbon industries. Countries that ignore these dynamics could miss out on the benefits of the transition. The international dynamics are particularly important for the UK currently as President of the next UN climate talks (COP26) and in 2021 as President of the G7.

As host of COP 26 the UK should:

- Ensure UK trade policy and future trade deals protect against risks of **carbon leakage leading to increases in the UK consumption emissions footprint**, particularly from trade in agricultural and industrial products. Options to address this include standards for lower-carbon products and border-carbon adjustments (see Chapter 6 of the Advice Report, and Chapter 4 of this report).

* Local authorities in Scotland already use a common reporting system. See CCC (2020) *Local Authorities and the Sixth Carbon Budget*.

- **Aim to ensure the UK's consumption emissions fall** in line with pathways consistent with the Paris Agreement, and look to use trade policy to ensure this (see recommendations in Chapter 10 of the Advice Report.)
- **Build on the commitment to end funding of overseas coal projects through the UK's export credit agency (UK Export Finance)** to direct finance towards low-carbon technologies and away from fossil fuels.
- **Use its diplomatic influence to** accelerate decarbonisation efforts around the world through formal and informal diplomatic channels, including multilaterally (e.g. through the UNFCCC) and bilaterally.
- **Provide financial support and capacity building as part of a programme of targeted international action.** The UK already supports climate action abroad and has recently doubled its climate finance commitment to £11.6 billion in aggregate over 2021/22-2025/26. Building on the mechanisms that are already in place the UK should ensure financial transfers are directly funding the deployment of low-carbon and Net Zero technology elsewhere in the world, alongside technical assistance to other countries to help develop their capacity and capability in introducing climate mitigation solutions.

Chapter 7 of our Advice Report contains an assessment of the international transition towards meeting the Paris Agreement, and how the UK can accelerate progress as host of COP26.

h) Policy advice from other groups

Our policy advice builds on a growing body of evidence on how policy should shape the next decade of climate delivery.

Our advice above draws on and echoes advice given by other groups since the UK Net Zero target was set:

- The **Council for Science and Technology** wrote to the Prime Minister to identify the need to deliver Net Zero from the heart of Government in order to allow for a systems approach* to achieving Net Zero which recognises actions in one area of the economy are likely to have impacts in other areas, and the need for delivery to take place across multiple levels of Government and society.[13]
- The Energy Systems Catapult recommended a sector-led approach to climate policy, complemented by a cross-economy policy package of innovation support and access to funding that's targeted towards addressing barriers to change in specific sectors. It notes the opportunity to link sectoral policy together into a integrated economy-wide framework, via carbon trading.14
- The **Climate Assembly UK** produced a set of principles to guide a transition to Net Zero, including detailed perspectives and recommendations on decarbonising buildings, transport, electricity generation and the UK's land. Key principles included a need for public engagement, the need for a fair transition, maintaining freedom and choice, consistent leadership from Government and restoring the natural world.[15]

* The CST define a 'systems approach' as combining structured approaches to understanding and managing physical factors (such as infrastructure and novel/advanced technologies) with broader perspectives on economic, behavioural and other issues, taking into account complex interactions. See CST (2020) *A systems approach to delivering Net Zero*.

- The **Just Transition Commission (JTC)** identified the key elements of an effective just transition strategy for Scotland, including developing transition plans across the economy, widespread public engagement, fair sharing of costs and support for the vulnerable, starting from today.[16]
- The **National Infrastructure Commission** noted how its existing recommendations support the delivery of the UK's Net Zero objective, and pointed to the importance of the forthcoming National Infrastructure Strategy progressing these recommendations. It also noted several areas where the Commission hasn't yet carried out work related to decarbonisation, such as decarbonisation of heavy industry, which may be given consideration in the future.[17]

Others note how Government can organise itself for the Net Zero delivery challenge.

- The **Institute for Government** assessed how Government is set up to deliver the UK's climate targets, identifying some missing pieces. These include a coherent plan and consistent policy development towards Net Zero that recognises decisions will need to be made under uncertainty, and co-ordinated across the whole of Government and beyond.[18]
- The **National Audit Office (NAO)** recently reviewed how Government is set up to deliver the UK's Net Zero target, recognising it as a cross-Government delivery challenge, and noting that the Government needs to identify how it relates to other Government priorities. The review noted the need for effective co-ordination between departments, led by BEIS, the Cabinet Office and HMT, the need for Net Zero to be built into all departmental plans and suggested that regular review points be set up that consider the effectiveness of the working arrangements. Additionally, it noted that Government has yet to include other public bodies, such as local authorities, it its coordination arrangements.[19]

Together these reports demonstrate considerable consensus around the core principles for effective policy design and show the wealth of expertise available to support the UK Government in its challenge.

Many other respected groups have also expressed their support for an ambitious package of measures and/or ambitious UK NDC, consistent with the recommendations in this report, such as 'The Elders',[20] a coalition of global leaders, the Confederation of Business and Industry (CBI),[21] the Aldersgate Group of business leaders,[22] the Trade Unions Congress (TUC)[23] and Energy UK[24].

Local government, businesses, regulators, people

The UK Government must establish and guide a successful transition to Net Zero. Successful delivery is contingent on everyone playing a role, including people, consumers, businesses, suppliers, financiers, workers, local and regional government. In all cases national policy will have to work closely with an array of sub-national actors to ensure an effective and fair transition towards Net Zero. This section consists of three sub-sections, which consider:

a) The role of people

b) The role of businesses

c) The role of local government

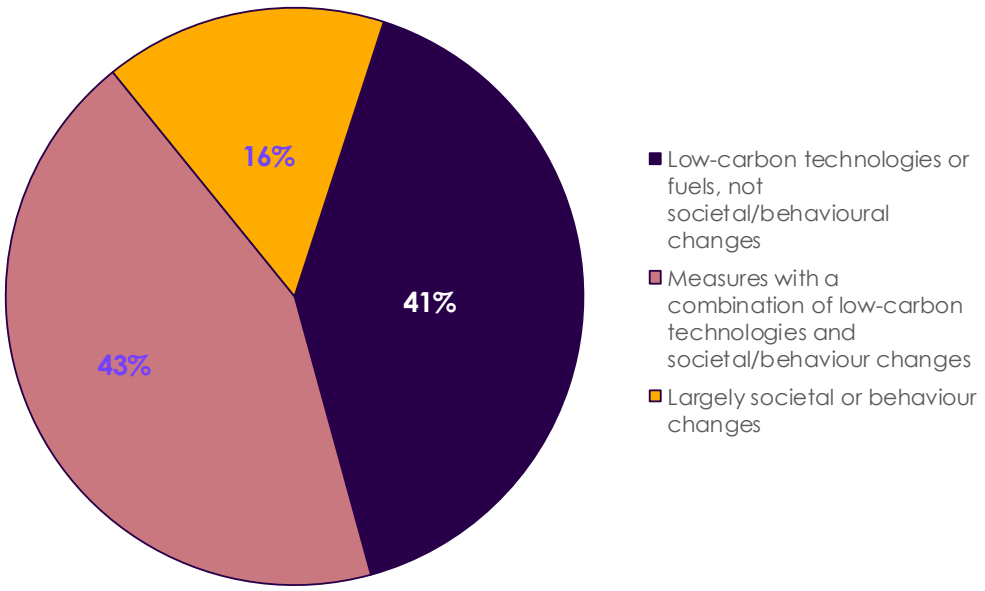
a) The role of people

Over half the emissions reductions in our scenarios requires some level of behaviour change.

To date, much of the success in reducing UK emissions has been invisible to the public. Government policy has enabled emissions reductions to proceed in a way that has not required mass engagement, by reducing the 'supply' of emissions into the economy. For example, low-carbon power now provides over 50% of the UK's electricity supply, with no change to the service that electricity provides. Reaching Net Zero emissions will require more involvement from people in engaging with the emissions reductions required, and reducing or adapting demand for energy intensive services:

- Over 40% of the abatement in our scenarios to 2035 involves some from consumers as they adopt new low-carbon technologies (e.g. driving an electric car, or installing a heat pump instead of a gas boiler) (Figure 1.3).
- Over 15% of the abatement requires consumer choices – both to reduce demand and improve efficiency. Shifting quickly towards healthier diets, reducing growth in aviation demand and choosing products that last longer and therefore improve resource efficiency are all key. In the Widespread Engagement scenario this is even higher, at 19%.

Figure 1.3 Role of societal and behavioural way changes in the Balanced pathway (2035)



Source: CCC analysis.

There are many reasons to think that these changes, and potentially much larger changes, are feasible given suitable policy leadership. The Committee are publishing a supporting note from one of our Members, Professor Nick Chater, on the behavioural principles underpinning this view (Box 1.4).

Reaching Net Zero will not be possible without involving people in the transition.

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:

- At the moment, the public are generally supportive of action to tackle climate change. 80% of the public are concerned about climate change and 66% of people are now aware of 'Net Zero' specifically, up from around half of people earlier this year,[25] however only half of people are aware that their gas boiler produces emissions.[26] 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 behaviours and in adopting low-carbon technologies. This will require making low-carbon choices more available and easier to use, provision of information, trials to see what works and policy that learns by doing. 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 Climate Assembly that was convened by Parliament has been a welcome step towards understanding public attitudes to achieving Net Zero. Similar processes have taken place or are underway in Scotland and Wales and at local levels. Efforts to consult and inform the public must continue, and together these examples offer a model for involving the public more in policy design.

There is significant overlap between the conclusions of the Assembly, and the actions in our scenarios (Table 2.1 of the Advice Report) and policy priorities set out in this report. By acting on its findings the Government can recognise the importance of this process, and look to integrate it further into policy development. One next step could be to consider public attitudes to climate adaptation through a similar mechanism. We plan to expand our monitoring on public engagement, for example by monitoring progress indicators that build on BEIS's regular tracking of public attitudes, in our annual progress reports to Parliament.

COVID-19 has changed behaviours. Three behavioural principles outline how the UK can Build Back Better from the pandemic.

Box 1.4:
Behavioural Principles and Building Back Better from the COVID-19 pandemic

The COVID-19 pandemic has led to large and highly disruptive changes for individuals, businesses and governments. Alongside our Sixth Carbon Budget Advice, we are publishing a paper from Professor Nick Chater, the Committee's behavioural science specialist. This paper considers three behavioural principles that explain how people have adapted so rapidly, and how we might "build back better" as we emerge from the pandemic, with a particular focus on meeting the challenge of dramatically reducing greenhouse gas (GHG) emissions over the coming decades. The principles are:

- **The power law of practice**: People, organizations and whole industries learn to adapt to new ways of working following a surprisingly predictable pattern. This can help predict where adaptation to new ways of living and working is likely to succeed or fail.
- **The status quo effect**: People and organizations tend to prefer the current status quo, but can often adjust rapidly to prefer a new status quo. However we tend to systematically underestimate such effects, and therefore can sometimes resist changes that, in retrospect, we may ultimately prefer.
- **Unwritten rules:** Our social behaviour is guided by implicit guidelines about what is "appropriate," which can be somewhat independent of our personal values. Changing these implicit rules, alongside changes in regulation and the law, is crucial to adapting to new circumstances---and the pandemic has shown that rapid change is possible, though sometimes resisted (e.g. new norms about mask wearing, and social distancing).

These principles of behaviour explain sources of "friction" in moving from one pattern of living and working to another. But if those frictions can be overcome, these principles also indicate that people and organizations can often adapt surprisingly quickly. In the light of the enforced changes in response to the COVID-19 pandemic, there may be significant opportunities to lock in, and build on, positive developments, especially, though not exclusively, regarding levels of demand for transport. Moreover, actively promoting these, and further positive shifts, provides an opportunity to contribute to meeting climate objectives, such as the U.K.'s commitment to Net Zero emissions by 2050. These changes, while beneficial for society, will happen more slowly, if at all, without a clear policy framework and financial support. Priority areas for policy development include:

- **Consolidating the digital transformation and shift to flexible working**, including prioritizing fast broadband, and measures to bridge the "digital divide."
- **Government and business "leading by example" on digital-by-default** meetings where appropriate.
- **Enhancing town and city infrastructure and regulation**, for walking and cycling, e-bikes and e-scooters, while introducing low/zero emissions zones.
- **Active measures may be required to encourage people back on to public transport**, where there has been a shift to car travel.
- **Tracking levels of use, efficiency, and liking for, new patterns of living and working**, to help guide future policy, and reduce negative impacts.
- **Developing a shared and positive vision of the opportunities and benefits of a transition to Net Zero by 2050** future through public engagement and debate.

Source: Chater (2020) Net Zero after Covid: Behavioural Principles for Building Back Better

b) The role of businesses

Recognising the critical role of the private sector, the Committee is publishing a dedicated briefing note on the actions leading businesses can take to reduce emissions.

While the UK government must set the frameworks for the transition, and citizens must make low-carbon choices, the private sector must invest and transform their business models. This will often be driven and supported by the third sector. Recognising the critical role of the private sector, the Committee is publishing a dedicated briefing note to make the Sixth Carbon Budget recommendations relevant to business in the UK.*

Companies within the UK and around the world are increasingly setting ambitious carbon reduction and Net Zero strategies, often aligned with major frameworks and commitments, and driven by policy as well as other factors such as investor and customer pressure. With the requisite conditions set by Government, the role of the private sector is to act across its sphere of influence:

- **Decarbonising operations.** Looking across their operations, businesses can reduce their own direct emissions and indirect emissions by switching to low or zero carbon alternatives, such as converting vehicles to pure electric, electrifying and making buildings more energy efficient, and converting electricity use to renewable.
- **Fostering innovation.** The UK (and international) private sector has the ability to develop and deliver innovative technological and business models. That includes transforming wider supply chains and in some cases completely overhauling traditional and established business, including for example circular economy principles which reduce overall consumption through reuse.
- **Leveraging procurement.** Companies can leverage individual and collective buying power to create the demand for low-carbon products and processes.
- **Manufacturing and Production.** UK businesses will be responsible for shifting manufacturing and production technologies and practices to create the goods and processes needed to reach Net Zero.
- **Nudging employees and customers to make Net Zero decisions.** Companies can empower these groups with information, alternatives and the support to guide lifestyle choices towards zero carbon. Where companies hold portfolios of investments, financial managers can ensure these are invested in low-carbon, rather than high-carbon, assets.
- **Building support for bold policy.** The private sector can demonstrate that ambitious policy is possible and desirable by proving the business case, technological possibilities, and willingness to embrace change.
- **Setting international leadership.** UK companies and global companies operating within the UK can support raised ambitions around the globe by setting ambitious strategies and targets, decarbonising international operations and supply chains, and contributing to wider systemic change around the world.

The Committee's recommendations for the UK, can be applied to businesses.

Our policy advisory group noted that the approach of some businesses (e.g. oil and gas companies) is likely to influence how others see a transition to Net Zero.[27]

* See CCC (2020) *The role of business in delivering the UK's Net Zero ambition*.

The recommendations that the Committee has made to the UK government reflect key principles that are also relevant for corporations considering their climate contributions:

- **Do the basics well – measure, disclose, target, act, adjust.**
  - While the UK's Net Zero target is for 2050, the Committee emphasises the need for immediate action and on-going monitoring. Effective corporate action requires a similar approach, with regular measurement that is disclosed and used to set targets, action plans that are developed and implemented, and adjustments based on progress tracked.
  - UK companies should be doing all of the above: measuring all emissions across Scopes 1-3, disclosing publicly these emissions, targeting carbon reduction, and setting then achieving phased action plans. Companies should also disclose climate risk through the Taskforce for Climate-related Financial Disclosure (TCFD), and measure, target and adjust for adaptation as well as mitigation.
  - In a recent survey of FTSE100 companies, 99% of companies are measuring and reporting their carbon emissions, 67% have set carbon reduction targets (45% Net Zero targets), and 73% are on track to meeting these targets.[28]

Leading businesses are likely to be able their Net Zero objectives ahead of the UK's 2050 goal.

- **Adopt the highest possible ambition.** The Paris Agreement requires all parties to adopt and communicate their highest possible ambition. For the UK this means Net Zero for all greenhouse gases from all sectors by 2050 at the latest. However, the UK target will only be met once the latest movers in the hardest sectors have reduced emissions to Net Zero. Ambitious companies should look at significantly earlier targets – a recent study in the UK showed that of the 36% of UK businesses which have or are planning to have a Net Zero strategy, almost 80% expect to reach Net Zero by 2029, 48% by 2025, and 10% by the end of 2020. Companies across the UK should strive for the highest ambition – the earliest Net Zero date – possible.

Business leadership means understanding the impact of all actions, and actively seeking opportunities to go further.

- **Address all emissions including Scope 3 - and go beyond.**
  - The Committee monitors progress and recommends action to reduce both territorial and consumption emissions. For businesses the equivalent approach is to consider and reduce all emissions including Scope 3, which includes indirect emissions from wider supply chains (often reaching international jurisdictions), emissions from the use of their products, and investments.
  - Corporations should increase their focus on Scope 3, and even go beyond these measured emissions by addressing actions within Scopes 1-3 that can impact wider systemic changes in the UK and abroad even if there is no measured impact on the corporation's own accounted emissions. An example would include embracing corporate renewables procurement that pays for new low-carbon electricity to be installed, rather than just purchasing existing renewables. Such approaches will involve embracing innovation in technologies and business models, increasing R&D, and persuading consumers and suppliers to change behaviours.

  - Investment portfolios should also be aligned to a transition to Net Zero, and accounts could be audited regularly to check their alignment to the goals of the Paris Agreement (see section c).

- **Ensure Climate Change is addressed at the highest levels of corporate leadership.** For companies to achieve the highest ambitions and make sure that targets are met and plans are achieved, climate change must be both a Board and CEO level responsibility. This requires following the key principles of frameworks such as the World Economic Forum's Corporate Governance Principles and ensuring there is overall climate accountability on Boards. In particular this could involve ensuring there is sufficient climate change knowledge and expertise at the Board level, updating executive incentive schemes to incorporate climate targets, and disclosing both transition and physical risks associated with both climate change mitigation and adaptation.

All companies should prioritise emissions reductions over the use of emissions offsets.

- **Minimise offsets, phase them out, and ensure only permanent emissions removals remain.** The Committee has recommended that the UK should aim to meet its Net Zero target and the Sixth Carbon Budget without use of carbon credits or 'offsets' (see Chapter 10 of the Advice Report). Longer term that should also be the goal for businesses, although there may be value in using carbon credits during the transition in addition to taking all possible actions to reduce emissions. All companies should prioritise emissions reductions over the use of emissions offsets so that by 2030, offsets should only be used for areas where emissions are not avoidable due to a lack of technical alternatives. Beyond 2030, offsets should transition to permanent removals, which must demonstrate additionality and promote sustainable development.

The Committee has no formal role in advising businesses, and decisions over the best approach to take must sit with businesses themselves. We hope that the principles set out above and scenarios set out in detail as part of this advice will be useful for businesses and other organisations in developing their own plans for cutting emissions.

As set out in the previous section there are opportunities for Government policy to do more to leverage the considerable enthusiasm for climate action from UK businesses.

c) The role of local and regional government

Plans by local authorities can represent 'locally determined contributions' towards meeting the UK's national objectives.

Local authorities and combined authorities are part of the wider system of national government, regional organisations, private sector and public and third sector policies, regulation, funding and action that works in systems and networks nationally to locally. Local authorities, combined authorities and regional agencies have a key role in delivering projects and strategies that reduce emissions and help the UK adapt to a changing climate, and their climate plans can be an effective means of delivering national objectives, but are currently under-resourced for these tasks.

- **Local authorities have direct control of a small proportion of a local area's emissions, but have strong potential influence** over a much larger proportion of emissions through land use and transport planning policies and decisions, housing and waste services and other activities).
- **Local authorities are proposing ambitious climate action at the local level**, which meets, or in some cases exceeds, the top-down climate objectives of the UK and devolved governments. These action plans can represent 'locally determined contributions' to deliver climate action across the UK.

  However there is significant uncertainty around how comprehensively these plans will be delivered, as well as how they fit into national, or indeed neighbouring local, strategies for achieving Net Zero.
- **In Scotland and Wales local councils and regional bodies are integrated into national climate strategies** through involvement in the delivery of Local Heat and Energy Efficiency Strategies in Scotland and as part of regional energy strategies in Wales. However in England and Northern Ireland, there is no overall plan on how local authorities fit into delivering Net Zero. This was recently recognised by the NAO in their review of how the UK Government I set up to achieve Net Zero.[29]
- **Local authorities have a range of levers at their disposal**, which can shape and deliver climate action in their local area (Box 1.5). However these levers alone are unlikely to result in sufficient action, without further policy and funding support from Government as part of a comprehensive Net Zero strategy that clarifies the role of local authorities in delivering Net Zero.
- **Local authorities are a cornerstone of climate change partnerships** across the country that link key delivery organisations to deliver Net Zero, resilient and well adapted places that foster nature recovery and support good jobs and skills.

Recognising the critical role of local authorities, the Committee is publishing a dedicated report on the how local authorities can deliver emissions reductions (and how Government should enable them to do so).

Alongside our work on the Sixth Carbon Budget, we are publishing an accompanying report on the role of local authorities in delivering climate action in the UK. This report summarises the key powers and levers available to Local Authorities, and provides recommendations to local and national governments on how local authorities can be empowered to deliver climate action, as part of a national strategy to achieve Net Zero (Box 1.5).

Box 1.5
The role of local and regional government in delivering the Sixth Carbon Budget

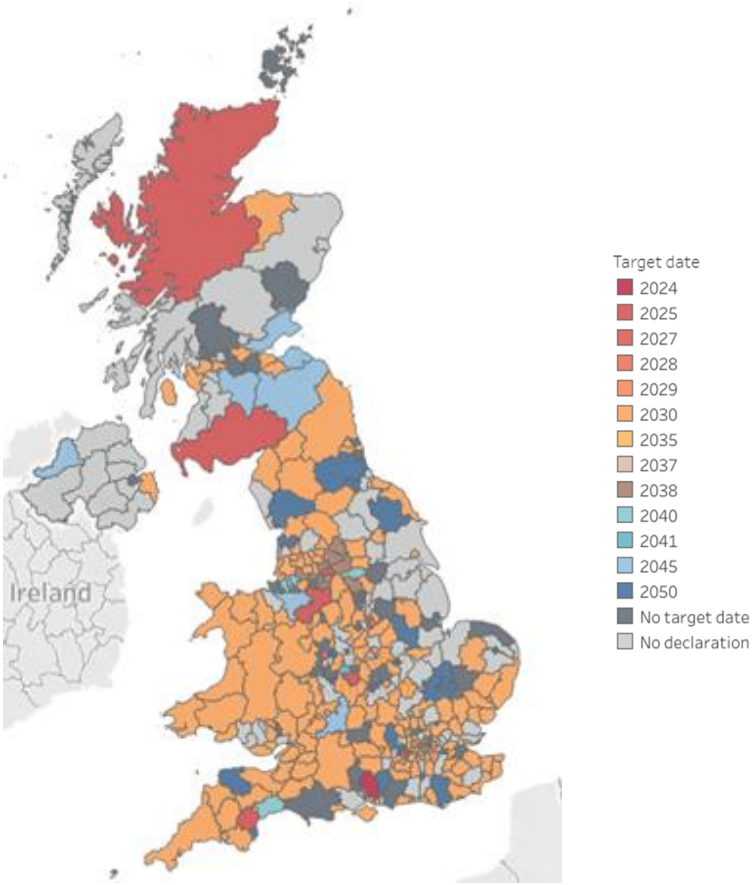
Local authorities are increasingly ambitious in their plans to tackle climate change. As of October 2020, over 300 local authorities had declared climate emergencies, and many are now in the process of developing plans to deliver against ambitious Net Zero targets (Figure B1.4). Local authorities have a range of existing levers that can be used to deliver local action that reduces emissions and prepares local areas to a changing climate. Key powers and duties include:

- A local leadership role to support the economic, health and social wellbeing of communities
- Planning powers over building and transport
- Duties to prevent homelessness and prevent hazards in housing
- Powers to ensure buildings meet basic energy efficiency standards
- Duties to manage risk including climate risks such as flooding
- Duties and powers to protect the environment, wildlife and heritage
- Duties to collect and dispose of waste
- Borrowing and investment powers

However these levers alone are unlikely to be sufficient to deliver local authorities' Net Zero ambitions, due to gaps in powers, policy and funding barriers, and a lack of capacity and skills at a local level. Additionally, without some level of coordination from Government, the UK risks pursuing a fragmented strategy towards Net Zero.

Alongside our work on the Sixth Carbon Budget, we are publishing an accompanying report on the role of local authorities in delivering the UK's Net Zero ambition.
The report aims to provide a framework for aligning climate action at the local level with the CCC's pathways for the UK, as well as recommendations for local, regional and national Governments aiming to remove barriers to delivering local climate action in the UK.

Figure B1.4 Local Authority climate emergency declarations



Source: Map by *Aether* (2020) *Progress towards UK local climate emergency targets* based on Climate Emergencies declared as at October 2020.
Notes: dates shown are earliest targets, some relate to council emissions rather than area-wide emissions.

Source: CCC (2020) Local Authorities and the Sixth Carbon Budget.

Endnotes

[1] IFS (2020) *UK economic outlook: the long road to recovery.*

[2] WHO (2019) *Climate change and human health.*

[3] French Government (2020) *France relance.*

[4] Bloomberg (2020) *Germany Just Unveiled the World's Greenest Stimulus Plan.*

[5] Carbon Brief (2020) *Coronavirus: Tracking how the world's 'green recovery' plans aim to cut emissions.*

[6] HMG (2020) *£2 billion package to create new era for cycling and walking.*

[7] HM Government (2020) *The Ten Point Plan for a Green Industrial Revolution.*

[8] ESC (2019) *Rethinking decarbonisation incentives.*

[9] Institute for Fiscal Studies (2013) *Energy use policies and carbon pricing in the UK*. Where reduced tax rates are applied to fossil fuels, this is sometimes referred to as fossil fuel subsidies.

[10] Zero Carbon Commission (2020) *How carbon pricing can help Britain achieve Net Zero by 2050*

[11] CBI (2020) *Principles for a low-carbon, sustainable and net-zero aligned economic recovery post COVID-19.*

[12] NAO (2020) *Achieving Net Zero.*

[13] CST (2020) *A systems approach to delivering Net Zero.*

[14] ESC (2020) *Accelerating to Net Zero.*

[15] Climate Assembly UK (2020) *The path to Net Zero.*

[16] Scottish Just Transition Commission (2020) *Interim Report.*

[17] National Infrastructure Commission (2020) *Net Zero - Commission recommendations and the net zero target.*

[18] See 17.

[19] NAO (2020) *Achieving Net Zero.*

[20] The Elders (2020) *Open letter to Prime Minister Boris Johnson.*

[21] CBI (2019) *The Low-Carbon 2020s – a decade of delivery.*

[22] The Aldersgate Group (2020) *Building a net-zero emissions economy: next steps for Government and business.*

[23] Trade Unions Congress (2020) *Voice and place: how to plan fair and successful paths to net zero emissions.*

[24] Energy UK (2019) *Energy in the UK 2019.*

[25] BEIS (2020) *Public Attitudes Tracker*

[26] BEIS (2020) *Public Attitudes Tracker;* Energy Systems Catapult (2020) *Net Zero: A Consumer Perspective.*

[27] See 16.

[28] Eco-Act (2020) *The 10th Annual Sustainability Reporting Performance of the FTSE 100.*

[29] NAO (2020) *Achieving Net Zero.*

Chapter 2

Surface transport

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3. Key changes needed 60



Table 2.1
Summary of policy recommendations in surface transport

Active travel and public transport	• **Strengthen schemes to support walking, cycling and public transport to reduce demand for higher-carbon travel.** This should include maintaining positive behaviour shifts and addressing risks resulting from the COVID-19 pandemic, provision of cycling infrastructure and investment in public transport. • The public sector should lead the shift to other positive behaviours that reduce travel demand, for example encouraging home-working, facilitated through prioritising broadband investments over road network expansion.
Cars and vans	**Develop a comprehensive policy package to deliver on the Government's commitment to phase out new petrol and diesel cars and vans by 2030.** This will require: • Strong consumer incentives to purchase zero-emission vehicles in the form of purchase subsidies, preferential company car tax, fuel duty exemption and lower vehicle excise duty should continue. These can be scaled back as costs of EVs fall. • Introducing a zero-emission vehicle mandate requiring car manufacturers to sell a rising proportion of zero-emission vehicles (excluding hybrids), reaching nearly 100% by 2030, with only a very small proportion of hybrids allowed alongside until 2035. • Continue to support EV charging infrastructure to ensure it can support high uptake levels. Project Rapid has the right ambition for the strategic road network and should be developed into a full strategy for the 2020s and beyond. Further investment is needed to support on-street and other urban charging solutions for those without off-street parking and destination charging. • Implement the recommendations of the EV Energy Taskforce to ensure that delivering additional power capacity and electricity demand required for EVs is efficient, cost-effective and fair for the consumer. Ensure that as many EV users as possible can access smart charging, so that EVs can provide a flexible demand resource to the wider power system and consumers can realise cost-savings. • Deliver plans to ensure investment in networks can accommodate future demand levels in coordination with Ofgem. • Set out ambitious UK regulations on new car and van CO_2 emissions to 2030, consistent with our Sixth Carbon Budget trajectory, with more regular intervals than the EU's five years, backed by rigorous real-world testing. • Government should deliver on its commitment to 100% of the central government car fleet being zero-emission by 2030 and extend this to include all Government vehicles. • Produce a clear assessment of how best to re-use and recycle EV batteries and fund development of competitive, large-scale battery recycling facilities in the UK.
Heavy-goods vehicles and the delivery sector	• Implement large-scale trials of zero-emission HGVs in the early-2020s to demonstrate the commercial feasibility of these technologies and establish the most suitable and cost-effective technology mix. • End new diesel HGV sales by 2040 at the latest to ensure the UK has a near zero-carbon freight industry by 2050. A comprehensive plan should be published in the early-2020s setting out how this will be delivered to give freight and vehicle operators time to plan for this transition. This should cover stronger purchase and other incentives, infrastructure plans and clean-air zones. • Evaluate schemes to reduce HGV and van use, particularly in urban areas (e.g. e-cargo bikes and use of urban consolidation centres), to reduce traffic and improve the safety of active travel. • Support freight operators to take advantage of opportunities to meet demand more efficiently, through logistics measures such as improved routing, better loading and reduced empty-running. Identify and address financial and non-financial barriers to improvements in this area.
Rail and buses	• Government should set out a clear vision to deliver Net Zero in rail and support Network Rail in delivering the target to remove all diesel trains by 2040. This is expected to cover a mix of zero-emission technologies (e.g. battery-electric, hydrogen and track electrification). The strategy should be published by 2021 as recommended by the National Infrastructure Commission. • End new diesel bus and coach sales by 2040 at the latest, with most operators encouraged to switch over much sooner. Empower Local Authorities to continue driving zero-emission bus take-up and to improve bus services.

Decarbonisation of surface transport has been slow over the past decade and surface transport remains the largest GHG-emitting sector. Policies have been implemented in some areas (e.g. new car and van CO_2 regulations and support for electric vehicles), but policies are off-track to contribute to the Net Zero target and need strengthening. Earlier this year, Government published a paper entitled 'Decarbonising Transport: Setting the Challenge', which set out the key decarbonisation challenges, and is currently developing a 'Transport Decarbonisation Plan' which aims to set out a comprehensive policy framework for surface transport.

Our recommendations are based on an assessment of existing policies, stakeholder engagement and a review of evidence. We also consider the Climate Assembly views, which recommend a future which minimises restrictions on travel and lifestyles, placing the emphasis on shifting to electric vehicles and improving public transport, and ensuring that solutions are accessible to all people. This chapter covers:

1) Challenges in decarbonising surface transport

2) Current Government policy commitments

3) Key changes needed

a) Cars and vans

i) Electric vehicles

Enabling the rapid take-up of electric vehicles (EVs) across society will be vital to delivering emissions reductions in the surface transport sector. There are several challenges that will need to be resolved in order to deliver this crucial transition:

Electric cars are currently more expensive to buy than comparable petrol and diesel vehicles. We expect upfront cost parity for a typical car to be reached by 2030, with savings over the vehicle lifetime realised before then.

- **EVs are currently more expensive** than equivalent petrol and diesel vehicles. For example, a VW e-Golf fully electric car is almost £7,000 more expensive than the standard petrol VW Golf (after the plug-in car grant) and electric vans can have a cost premium of around £10,000 over diesel vans. While running costs are much lower for EVs, consumers do not always factor in the benefit of fuel savings over the vehicle lifetime when making purchase decisions.
- **The supply of zero-emission vehicles** will need to scale up rapidly across all consumer segments in the next few years to ensure it does not constrain demand. Manufacturers are already responding to this challenge, driven by EU CO_2 regulations for new cars, but further progress in developing supply chains will be needed.

Electric car availability has rapidly expanded, and waiting times have reduced, over the past few years.

  - There are 130 fully or part electric vehicle models available in the UK in 2020, compared with just 38 in mid-2018. Long waiting times for EVs and launch delays, experienced in the last few years, have been reduced. However, only 73,000 EVs were sold in the UK in 2019, compared with 2.2 million petrol and diesel vehicles, and there still needs to be a significant switch in investment from petrol and diesel vehicles to high-volume EV production.
  - While EVs are less complex to produce and assemble, new supply chains, skills and production methods will need to be developed and original equipment manufacturers (OEMs) will need time to adjust. Re-training and re-skilling across the sector could be needed.
  - Global battery capacity will need to accelerate to meet demand. There are sufficient global supplies of raw materials for current-generation batteries (e.g. lithium, graphite, cobalt, nickel and manganese), but supplies will need to scale up significantly, especially from the mid-2020s. New mining facilities, appropriate battery-sizing and re-use and recycling will be fundamental to meeting demand cost-effectively. While new battery chemistries are being developed, these will take time and it is uncertain when or if they will come to market.

Battery capacities are expected to get larger, enabling electric vehicles to offer sufficient driving range to allay range anxiety among consumers.

- **Battery range**. Range anxiety needs to be addressed to enable mass-market EV roll-out. The average real-world driving range* of a new battery-electric vehicle (BEV) today is around 180 miles, and this is expected to reach 220-250 miles by 2030. Research suggests that a driving range of 230 miles is sufficient to eliminate range anxiety among consumers, although the vast majority of trips are less than 25 miles.[1]

* The range of an electric vehicle is the distance it can travel on a full battery without needing to be recharged.

However, larger vehicles require larger batteries to offer comparable range figures, therefore, van ranges are likely to remain below those of cars. Real-world battery range is also an issue, particularly in cold weather where there are other demands for power.

Substantial roll-out of charging infrastructure across the UK will be a key enabler for electric vehicle take-up. This will need to include on-street chargers for households without off-street parking.

ii) Charging infrastructure

Widespread deployment of charge points is needed to enable reliable and accessible charging both during longer journeys and for those without access to off-street parking:

- **EV infrastructure**. A high take-up of BEVs will require significant charging infrastructure at homes, offices and on-street. We estimate there will be 14 million BEV cars and vans on the road by 2030, requiring 280,000 public chargers by 2030. Key challenges are:
  - A disproportionate share of public charging devices currently being rolled out are focused in London.[2] Charging infrastructure needs to be spread more evenly across the UK.
  - The need to provide on-street charge points for households without off-street parking is essential to enable the roll-out of EVs across society. This will give confidence that people will be able to charge when they need to. Technology is developing and options include lamp-post charging which could offer a convenient, low-cost solution.
  - There are currently 16 major public charging networks across the UK. Roaming agreements will be important to enable easy interoperability between these networks, so that EVs can be plugged in anywhere and paid for in a simple, transparent way for the consumer. Consumers will also need to be able to rely on each network's charge points to deliver high levels of reliability and availability.

Electric vehicle charging will significantly increase demand on the power system. Investment will be needed to ensure that the grid can support this additional load.

- **Networks.** Our scenarios have significant impacts on the power system, increasing electricity demand from today's very low levels to 104 TWh by 2050. Meeting this increased demand will require investment in system capacity and upgrades in the distribution network. The way consumers charge their EVs will be important in determining the cost of meeting this.
  - 'Smart charging', where EV charging is intelligently controlled (e.g. overnight when there is spare capacity), can help to ensure that charging of EVs is used as a flexible resource, responsive to the needs of the wider power system.
  - Building trust between EV owners and energy providers that any data provided are safe and will be used only as intended will be vital to enable this.
  - It is important that the benefits of smart charging should be available to as many consumers as possible. This includes exploring how its benefits can be extended to those without home chargers.

iii) Conventional vehicles

Conventional cars and vans that are purchased during the 2020s are likely to remain on the road well into the 2030s. Therefore, it is important that newly purchased vehicles continue to become more fuel-efficient and reverse recent trends towards increasing carbon emissions:

- **Fuel-efficiency**. Our analysis shows that there is scope for significant improvements in the fuel-efficiency of conventional cars and vans, with the real-world intensity of new vehicles expected to improve by 12% by 2030.
  - While EU new car CO_2 regulations have been successful in driving reductions in new car emissions, progress has reversed since 2017. This has been mainly due to the trend towards larger, heavier vehicles, particularly SUVs. This must be halted if our decarbonisation pathways are to be met. The Climate Assembly[3] highlighted this issue and advocated stopping selling the most polluting cars.

b) Heavy-goods vehicles

Despite comprising only 5% of UK road vehicles, heavy-goods vehicles (HGVs) produce 17% of GHG emissions from the surface transport sector. Therefore, it is important to enable this sector to transition to zero-carbon alternatives in a timely manner:

- **Zero-carbon HGV** technologies are currently at an early stage and it is too soon to say which will emerge as market-leaders. Manufacturers are developing battery-electric and hydrogen trucks and trucks suitable for use on electric road systems, as well as demonstrating infrastructure.
  - Many major HGV manufacturers now offer electric options for smaller, short-range models. DAF Trucks is aiming to offer electric versions of all its models by 2023 and Mercedes intends to offer a battery-electric truck with 300 miles of range by 2024.
  - Hydrogen fuel-cell trucks are expected to take slightly longer to reach the market but could offer longer range. Mercedes and Iveco are developing models that could offer up to 500-600 miles of range.
  - Scania currently offer the only commercial HGV suitable for use on an electric road system.
  - Electric road system demonstrations using overhead catenary are underway in Germany and Sweden, while a trial commercial hydrogen partnership has recently commenced in Switzerland.

c) Road demand, active travel and public transport

Reducing demand for car travel will require improvements to provision and reliability of public transport, along with investment in schemes to support active travel.

Reducing road travel and incentivising shifts to public transport or active modes of travel can bring both significant emissions reductions and a variety of important co-benefits to society:

- **Surface transport demand** is forecast to increase by 10-20% from today's level by 2050.[4] Reducing demand and switching to lower-carbon modes of travel is cost-effective and delivers significant co-benefits, but requires a range of barriers to be addressed:
  - Investment in walking and cycling infrastructure schemes, bicycle storage facilities and schemes to improve safety, security and accessibility.
  - Perceived comfort, cost and convenience of alternatives to car travel need to be improved, so that these options are viewed as similarly attractive as driving. Disincentives against driving designed to reduce congestion or improve urban environments (e.g. restricted or expensive parking and low-emissions zones) could also contribute.
  - Improvements in IT and network connectivity for people with options to work from home and to conduct business meetings online as a substitute for travel.
  - Barriers to ride-sharing include longer journey times, autonomy, control and comfort (e.g. social interactions may be perceived as difficult or unhygienic for some). This is a particular challenge following the COVID-19 pandemic.
- **Public transport**. Public transport must be well funded, frequent, reliable and safe to encourage more people to use it.
  - The number of journeys by local bus has reduced by 12% over the past decade[5], while rail travel has increased by 29%.[6]
  - Public transport needs to compete on cost, but improvements are also needed to link journey stages, address reliability and accessibility issues and make it easier to use travel time productively (e.g. providing free high-speed wi-fi to enable working).
  - Increased provision of bus lanes and high-occupancy vehicle lanes can incentivise switching to public transport and shared mobility by making these easier and quicker than individual transport.
  - Use of public transport has rebounded more slowly following the easing of COVID-19 lockdown restrictions than has car travel. Rebuilding public confidence in the safety of public transport will be crucial for increasing its use.

The Government's recent ten-point plan includes a number of welcome measures towards decarbonising the transport system. However, gaps remain.

There have been important advances in policy in many parts of this sector, including regulations on existing vehicles, support for EVs and infrastructure and a strategy for active travel. Some new measures were announced in Government's 'Ten-Point Plan for a Green Industrial Revolution'[7]:

- EU regulations on average CO_2 intensity have been in place for new cars since 2009 and new vans since 2011. Government has committed to be at least as ambitious as new EU regulations for 2025 and 2030 and plans to publish a Green Paper on the post-EU framework next year.
- Government's ten-point plan recently announced bringing forward the phase-out date for new fossil fuel cars and vans to 2030, setting a clear pathway to the transition to EVs.
- Plug-in car and van grants, providing up-front purchase subsidies for EVs, have been in place since 2011 and will continue until 2022-23. Additional support is provided through zero and lower rates of VED and company car tax for the lowest-emitting vehicles.
- Financial support for EV infrastructure is provided through home and workplace charge point installation grants and through financial support to Local Authorities to fund public charge points. Project Rapid commits £500 million to fund high-powered charge points on motorways and major roads.
- The Faraday Challenge provides funding for research and innovation in battery technology. Government has also committed £1 billion to develop Gigafactories in the UK to produce batteries needed for EVs at scale.
- The Road Transport Fuel Obligation (RTFO), the main policy to support biofuels in transport, has been in place since 2008. It has been extended to 2032.
- The Cycling and Walking Investment Strategy (CWIS) was introduced in April 2017. It has committed £2.4 billion to be invested to 2023 and sets out targets to increase active travel.
- Government intends to implement EU-wide CO_2 emission standards for heavy-duty vehicles, which set targets for reducing emissions from new lorries by 2025 and 2030.
- Government has also committed to investing £20 million in 2021 to fund zero-emission HGV freight trials and consulting on a phase-out date for new diesel HGVs.
- Government has set out an ambition to end diesel trains on UK railways by 2040.

However, gaps remain, and plans will be needed to tackle them.

a) Cars and vans

Our Balanced Pathway assumes that all sales of new petrol and diesel vehicles (including hybrids) end by 2032 at the latest. Policies should ensure that hybrids play a minimal role beyond 2030.

Our Balanced Net Zero Pathway has been determined on the basis of ending sales of all new petrol and diesel vehicles (including PHEVs and full hybrids) by 2032 at the latest. We also explore earlier and later dates in our exploratory scenarios:

- Government has recently announced that new sales of conventional petrol and diesel cars and vans will not be permitted beyond 2030, laying the foundation for a full transition to EVs. However, Government is proposing to continue to allow sales of hybrids with a minimum emissions-free range between 2030-35. Hybrids burn fossil fuels and are not zero-emission vehicles. In developing the precise details of its proposal, Government should ensure that the resulting emissions and miles driven are consistent with our Balanced Pathway (Table 2.2).
- Policies must ensure that hybrids play a declining role relative to pure electric vehicles, and minimal beyond 2030. This will benefit air quality and consumers, as we expect pure battery-electric models to be cheaper to buy and cheaper to run than hybrid models by 2030. Policy should be designed to ensure clear consumer benefit to buying full electric over hybrid models (including through provision of effective charging solutions) and to encourage manufacturers to supply them (e.g. by setting stringent CO_2 emissions targets for new vehicles or requiring a high minimum electric mileage for hybrid models).

Table 2.2
Proportion of car and van mileage driven by each powertrain among all new vehicles sold in each year, in our Balanced Net Zero Pathway

	2020	2022	2024	2026	2028	2030	2032 (and beyond)
Fossil fuel vehicles (including mild and full hybrids)	92%	77%	52%	27%	18%	2%	0%
Plug-in hybrid electric vehicles	3%	10%	17%	17%	8%	<1%	0%
Battery-electric vehicles	5%	12%	31%	56%	74%	97%	100%

Financial incentives for electric vehicle purchases will need to continue but will be able to be scaled back as costs reduce.

Delivering this transition in an effective and equitable manner will require sufficient funding, monitoring of market developments and timely investment in charging infrastructure:

- **Financial incentives for EV purchases** need to continue as long as purchase costs of EVs remain higher than for fossil fuel cars and vans. These can take the form of upfront grants, lower vehicle excise duty (VED), preferential company car tax and fuel duty exemptions. These can be scaled back as economies of scale and technological innovation reduce costs.

- **Disincentives to purchase the most polluting vehicles** should be increased. Stronger VED gradients between more and less polluting vehicles (including between BEVs and other electric vehicles such as PHEVs and full hybrids) can send a clear signal that high-carbon vehicles should be avoided, which could help reverse the recent trend towards larger, more polluting, cars.
- **A zero-emission vehicle mandate** should be introduced, requiring car and van manufacturers to sell a rising proportion of zero-emission vehicles, reaching nearly 100% by 2030, with only a very small proportion of hybrids allowed alongside until 2035. This should strengthen incentives to sell EVs in the UK market.
- **Government should deliver on its commitment** to 100% of the central Government car fleet being zero-emission by 2030 and extend this to include all Government vehicles.

Current investment in charging infrastructure is at an appropriate level. This will need to continue through the 2020s and beyond.

- **Support for EV infrastructure** should ensure it can support high uptake levels.
  - Project Rapid has the right ambition for the strategic road network and should be developed into a full strategy for the 2020s and beyond.
  - Government has committed to investing £1.3 billion to accelerate the roll-out of charging infrastructure, including on major roads and on-street near homes and workplaces. This is around the right level of investment at present, and investment, including through facilitation of private-sector investment, will need to continue throughout the 2020s and beyond to support widespread EV roll-out.
  - OLEV has allocated £20m of funding for Local Authorities to install on-street charging bays during 2020-21.[8] This should continue and be extended to provide on-street charging for all those without off-street parking as well as around towns and cities for top-up charging.
- **Networks and the wider energy system** will require investment to support increased demand from EV charging.
  - Government should deliver plans to ensure investment in networks can accommodate future demand levels in coordination with Ofgem (further details in Chapter 5 on policy for the electricity sector).

Common data and interoperability standards should be agreed to enable the electric vehicle and electricity sectors to work together effectively.

  - Implement the recommendations of the EV Energy Taskforce to ensure that delivering additional power capacity and electricity demand required for EVs is efficient, cost-effective and fair for the consumer:
    - Agree common standards to enable interoperability between the EV and electricity sectors and sharing of data. This should be an immediate priority.
    - Foster innovation in charging infrastructure in developing interoperability standards.
    - Developing national and local approaches to coordination of network and charge point infrastructure and future-proofing assets.
    - Enable as many EV owners as possible to realise the benefits of smart charging (e.g. charging their EV when electricity prices are low), to ensure EVs provide a flexible resource to the power sector.
    - Further, innovations such as vehicle-to-grid schemes should be supported.

- **Set ambitious UK regulations on new car and van CO_2 emissions** to 2030, to provide a strong incentive to manufacturers to continue to improve fuel-efficiency of petrol and diesel cars and vans consistent with the Sixth Carbon Budget trajectory.
  - There should be a coherent framework that incentivises greater fuel-efficiency of petrol and diesel vehicles and encourages a rapid transition to EVs. This should give OEMs the flexibility in meeting emissions targets in a way that works best for them.
  - They should be backed by a rigorous testing regime, with more regular intervals than the EU's five years.

Security of supply for raw materials should be enhanced by a clear assessment of how best to re-use and recycle batteries and developing UK-based recycling facilities.

- **Security of raw materials for batteries**. We welcome Government plans to develop Gigafactories in the UK to produce batteries needed for EVs at scale. Security of raw materials supply should be enhanced further by a clear assessment of how best to re-use and recycle batteries and through funding development of competitive, large-scale battery recycling facilities in the UK.

b) Heavy goods vehicles and deliveries

Large-scale trials of zero-carbon HGV options are needed in the early 2020s, to demonstrate technological feasibility and establish the most suitable technology mix.

While it is too early to decide what combination of zero-carbon technologies for HGVs will be optimal for the UK, action is needed now to support market development and put plans in place to enable the sector to deliver the transition to zero-emission vehicles:

- **Implement large-scale trials for zero-carbon HGVs**. We welcome Government's announcement of £20 million in 2021 to fund zero-emission trials for HGVs. Funding needs to continue in future so that commercial-scale trials can commence in the early-2020s and continue for up to five years, to demonstrate the feasibility of these technologies and establish which is the most suitable and cost-effective technology mix for the UK (Box 2.1).

Sales of new diesel HGVs should end by 2040 at the latest.

- **End sales of new diesel HGVs by 2040** at the latest, to be on track to nearly fully decarbonise this sector by 2050. This date should be moved earlier if information from the trials shows this to be feasible.
  - The Government is planning to consult on a date for phasing out the sale of new diesel HGVs, and a comprehensive plan should be published in the early-2020s setting out how this will be delivered to give freight and vehicle operators time to plan for this transition.
  - This plan should cover stronger purchase and other incentives, infrastructure plans and support (e.g. ultra-rapid chargers for battery-electric HGVs and hydrogen refuelling stations for hydrogen HGVs) and clean-air zones.
- **Set ambitious CO_2 emission standards for HGVs** that are at least as ambitious as those set by the EU requiring a 15% reduction in carbon-intensity by 2025 and 30% by 2030. This is achievable with options that are market-ready including hybridisation, improving aerodynamics and lighter-weight construction.

Schemes to reduce HGV and van use can deliver improved efficiency, reduced emissions and lower levels of congestion.

- **Support schemes to reduce HGV and van use**, particularly in urban areas.
  - Encourage, support and enable options for green last-mile deliveries (e.g. through e-cargo bikes and use of urban consolidation centres), to reduce traffic and improve the safety of active travel.
  - Support freight operators to take advantage of opportunities to reduce travel demand and increase efficiency through logistics measures such as improved routing, better loading and reduced empty-running.

Box 2.1
What is needed from low-carbon HGV trials

Government has recently committed £20m for trials of hydrogen and other zero-emission HGVs, to help position the sector to be able to phase out diesel trucks. This funding, alongside the stated intention to consult on a phase-out date, are welcome and timely.

Our research and stakeholder engagement have clearly shown that commercial-scale demonstrations of zero-emission HGVs are needed in the early-2020s, in order to test the deployment of the available technology options, demonstrate their commercial feasibility and stimulate further market development. Separate demonstrations should be conducted for hydrogen fuel-cell and pantograph-electric HGVs. These should involve:

- **Infrastructure deployment.** Supporting infrastructure, covering hydrogen refuelling stations and overhead line equipment (catenary), will need to be deployed. Concern as to the availability of infrastructure is frequently cited as a major barrier to adoption of zero-emission vehicles, so this will need effective planning and communication.
  - For hydrogen vehicles, refuelling stations will need to be distributed across the country to enable the demonstrator vehicles to refuel conveniently for travel across large portions of the road network.
  - For pantograph-electric vehicles, an electric road system of several tens of kilometres in length should be set-up along a corridor that is frequently travelled by a variety of freight operators.
- **Collaboration with business.** Planning of the demonstrations should be conducted in partnership with the freight industry, to ensure that the demonstrations will produce evidence that is of use to businesses. Collating vehicle orders and providing demand guarantees to OEMs and infrastructure providers, as in the H2 Energy/Hyundai partnership in Switzerland, could help to overcome initial barriers to involvement.
- **Commercial-scale participation.** Each demonstration should involve at least 50-150 zero-emission HGVs covering a range of sizes. This scale of participation will ensure reasonable minimum levels of demand for infrastructure and maintenance provision, helping to develop viable business-cases for these crucial supporting industries. Any smaller trials would not be in keeping with the scale of the Net Zero challenge.
- **Broad scope.** The demonstrations should also include a wide range of vehicles across multiple operators. This is important because the HGV industry is very diverse, with different operators using their vehicles in different ways. Ensuring a broad scope will allow the evidence and experience gathered through the demonstrations to be applicable across a larger proportion of the UK's HGV fleet.
- **Real-world operations.** The demonstrations should be located on major freight corridors, to enable the technologies to be implemented across a wide range of real-world haulage operations. This will ensure that the evidence gathered is widely applicable and showcases benefits and challenges associated with zero-emission technologies in practical use.
- **Sufficient duration.** All vehicles should be in operation for a minimum of 1-2- years. This will enable fleet operators to establish business models and demonstrate the effectiveness of the technology across all conditions. It will also enable issues regarding adaptability of operations, vehicle maintenance and infrastructure longevity to be better understood.

- **Strong communication.** The findings from the demonstrations should be disseminated widely across the UK HGV sector to help operators better understand the zero-emission options available to them. Data collected from the demonstrations could be used to provide this understanding through tailored advice or comparison tools.

For battery-electric HGVs, technological readiness may preclude a comprehensive trial at this stage, while read-across from the experience of battery development in the low-duty vehicle sector together with research and development by manufactures may be sufficient to stimulate this market and give operators purchasing confidence. However, this is uncertain, and development of the technology and levels of adoption should be closely monitored to inform whether a battery-electric HGV trial would also be beneficial.

The trials should collect data on costs, system performance and reliability and suitability to different HGV operations. They should aim to begin by 2023 with all vehicles fully operational by 2025, in order to provide evidence to support zero-emission uptake across the sector from the second half of the 2020s. This requires planning to begin immediately – the Connected Places Catapult's TranZET project has already produced Strategic Outline Business Cases for each potential trial[9], so these timelines are achievable.

For any technologies that are taken forward, there will need to be significant and timely roll-out of infrastructure to provide confidence to fleet operators that they will be able to refuel. Given the long lead-times associated with infrastructure deployment, a comprehensive plan for how this will be delivered will be needed in the early-2020s. The UK's approach will also need to integrate with that in mainland Europe, to ensure that fleets can operate across both territories without barriers. Emissions standards that apply to UK-registered vehicles should also apply to overseas vehicles operating on UK roads, in order to avoid placing UK fleets at a commercial disadvantage.

Source: Element Energy research for the CCC (2020).

c) Road demand, active travel and public transport

Recent initiatives, at both national and local levels, to support and encourage increased walking, cycling and public transport use are welcome. This should continue with increasing levels of ambition in order to realise the substantial opportunities for place-based and system-wide approaches to reduce road travel:

Schemes to reduce car usage should build on positive behaviour shifts and address risks in response to COVID-19.

- **Strengthen schemes to support a shift to active and public travel.** Measures should look to maintain and encourage positive behaviour shifts (e.g. increased home-working and shifts to cycling and walking) as well as address risks (e.g. reduced public transport use) in response to the COVID-19 pandemic. Provision of active travel infrastructure and other support schemes, including high-quality cycle lanes, secure bicycle parking facilities in city centres, places of work and train stations and park-and-ride schemes, as well as measures to make it less attractive to drive, are needed. Working across delivery bodies is critical:
  - Local Authorities play a key role in setting local transport policy and developing locally-based solutions that work for their communities (Box 2.2).
  - The public sector should lead the shift to other positive behaviours that reduce travel demand (e.g. encouraging homeworking), facilitated through prioritising broadband investments over road network expansion.

Zero-emission buses are already being deployed on many routes across the UK. Local Authorities should be empowered to continue driving this and to deliver improvements to services.

- **Incentivise the continued roll-out of zero-emission buses and coaches** to ensure that new sales of diesel vehicles end by 2040 at the latest. For the majority of routes, switchover to zero-emission options can and should occur considerably earlier than this. For instance, the Confederation of Passenger Transport has set a target for all new buses to be ultra-low or zero-emission by 2025. Local Authorities should be empowered to continue driving zero-emission bus take-up and to deliver improvements to bus services.
- **Set out a clear vision to deliver Net Zero in rail** and support Network Rail and other bodies in delivering the target to remove all diesel trains by 2040. This should cover a mix of zero-emission technologies (e.g. track electrification, battery-electric, hydrogen and hybrid trains). The strategy should be published by 2021 as recommended by the National Infrastructure Commission.

Box 2.2
The role of Local Authorities in local transport policies

Local Authorities (LAs) have a key role in reducing emissions and facilitating strategies to deliver decarbonisation, with leverage in several areas:

- They often have direct or strong control over local transport, housing and land-use policies, although the extent of this varies for each LA.
- They are part of the wider system of national Government, regional, private, public and third-sector organisations with a range of regulatory and financing powers.
- They have a critical role in coordinating partnerships across the country that link key climate change delivery organisations.

LAs have the potential to influence the transition to low-carbon transport across areas such as planning, investment in active travel networks, developing climate action and delivery plans and supporting local economic partnerships, as well as using parking powers to incentivise moves to sustainable transport:

- **Planning policy** can steer spatial and local planning that favours housing and commercial developments in the right places to reduce traffic and support efficient logistics.
- **Investment in walking and cycling networks** and development of Local Plans and Transport Plans to deliver modal shift from cars to active and public transport. These can also identify locations for consolidation centres near road links and urban micro-consolidation centres.
- Introduction of **low-emissions zones** that set minimum standards for carbon and other emissions.
- Planning and support for installation of **EV charging networks** across their jurisdictions.
- Supporting **Local Economic Partnerships** to invest in transport infrastructure including road junction improvements, link roads, park-and-ride schemes, cycling infrastructure and digital connectivity. For example, Sheffield City Region's £34 million 'Getting Building' funding includes support for active travel, digital infrastructure, construction skills training and a 12% increase in EV charge points in South Yorkshire.
- They can use **parking powers** under Traffic Regulation Orders to repurpose parking spaces for car clubs, cycle parking and EV charge points and use parking charges to discourage private car use and promote public transport. Nottingham City Council is a renowned example, where its Workplace Parking Levy – levied on private car-parking spaces – promoted modal shift to sustainable modes and raised funds for link buses and tram extensions in the city.
- LAs can **work jointly with bus operators** to provide a bus network that is rapid, reliable and affordable (e.g. through a bus strategy and bus quality partnership). However, improving bus services is more challenging because most LAs do not control routes, frequencies and fares.

d) Delivering the transition fairly

It is important to ensure that the transition to a zero-emission transport sector is fair and affordable across all sections of society, and that the benefits are available to everyone.

The Treasury's Net Zero Review[10] is considering how the transition to Net Zero it should be funded and where costs might fall. The Climate Assembly highlighted the importance of accessibility to avoid negative impacts on rural communities, those at risk of isolation and for those on low incomes. Delivering the transition in a way that is fair and affordable across all sections of society is challenging and will need careful policy design and implementation, including ensuring widespread EV charge points across the country, ensuring a strong second-hand market for EVs and improvements in the accessibility and reliability of public transport.

Endnotes

[1] Department for Transport (2019), *National travel survey*, Table 0308.
[2] Department for Transport (2020), *Electric vehicle charging device statistics*.
[3] Climate Assembly UK (2020), *The path to Net Zero: final report*.
[4] Department for Transport (2018), *Road traffic forecasts*.
[5] Department for Transport (2020), *Annual bus statistics*, Table BUS01.
[6] Office for Rail and Road (2020), *Passenger rail usage*, Table 1220.
[7] HM Government (2020), *The ten-point plan for a green industrial revolution*.
[8] Office for Low-Emission Vehicles (2018), *On-street residential charge point scheme*.
[9] Connected Places Catapult (2020), *Transitioning heavy-duty vehicles to zero-emission technology (TranZET)*.
[10] HM Treasury (2019), *HM Treasury's review into funding the transition to a Net Zero greenhouse gas economy: terms of reference*.

Chapter 3

Buildings

1. Current Government policy commitments 73
2. Key changes needed 75



This chapter sets out the Committee's recommendations in buildings for delivering the Sixth Carbon Budget, building on the recommendations put forward in the CCC's 2020 Progress Report to Parliament (Table 3.1). The pathways set out in our *Advice Report* see buildings emissions fall by just under 50% from 2019 to 2035, on the way to reaching near-zero by 2050. By 2033, all of the UK's buildings should be energy efficient and all boiler replacements should use low-carbon technologies such as heat pumps – or be designated as part of a zone for district heating, or possibly hydrogen.

Table 3.1
Summary of policy recommendations in buildings

Heat and buildings strategy	Produce a robust and ambitious heat strategy which sets the direction for the next decade, with clear signals on the phase out of fossil heating and commitments to funding. This must include a clear set of standards; plans to rebalance policy costs while making low-carbon more financially attractive; plans to introduce green building passports, and a role for area-based energy plans.
Standards for existing buildings	Bring forward the date to reach EPC C in social homes to 2028, in line with the Private Rented Sector (PRS) proposals, and finalise the delivery mechanism. Implement PRS proposals for homes and non-residential buildings in line with new proposals and implement improvements to the EPC framework, including ensuring they drive the energy efficiency measures needed. Develop options to cover the regulatory policy gap for owner-occupied homes, looking at trigger points at point of sale and through mortgages. Publish proposals for standards to phase out liquid and solid fossil fuels by 2028, and in-use standards in commercial buildings.
Newbuild standards	Implement a strong set of standards – with robust enforcement – that ensure buildings are designed for a changing climate and deliver high levels of energy efficiency, alongside low carbon heat. Publish a robust definition of the Future Homes Standard and legislate in advance of 2023.
Green recovery and supply chain development	Provide a stable long-term policy framework to support sustained growth at sufficient scale (i.e. 600,000 heat pumps per year in existing homes by 2028). Ensure continuing support for non-residential heat pump installations beyond 2022, including low-carbon heat sources for district heating schemes. Create a level-playing field for hybrid heat pumps by continuing to support new business models off the gas grid both financially and by ensuring hybrid heat pumps are an integral part of PAS2035 retrofit coordinator advice.
Hydrogen development	BEIS and Ofgem should undertake a programme of research to identify priority candidate areas for hydrogen, along with areas which are unlikely to be suitable, to inform development and network investments. Undertake one or more hydrogen trials at a representative scale in the early 2020s (e.g. 300-3000 homes), to inform decisions on low-carbon zoning from 2025. All new boilers to be hydrogen-ready by 2025 at the latest. Continue further pilots in the late 2020s, where valuable to inform large-scale take-up.

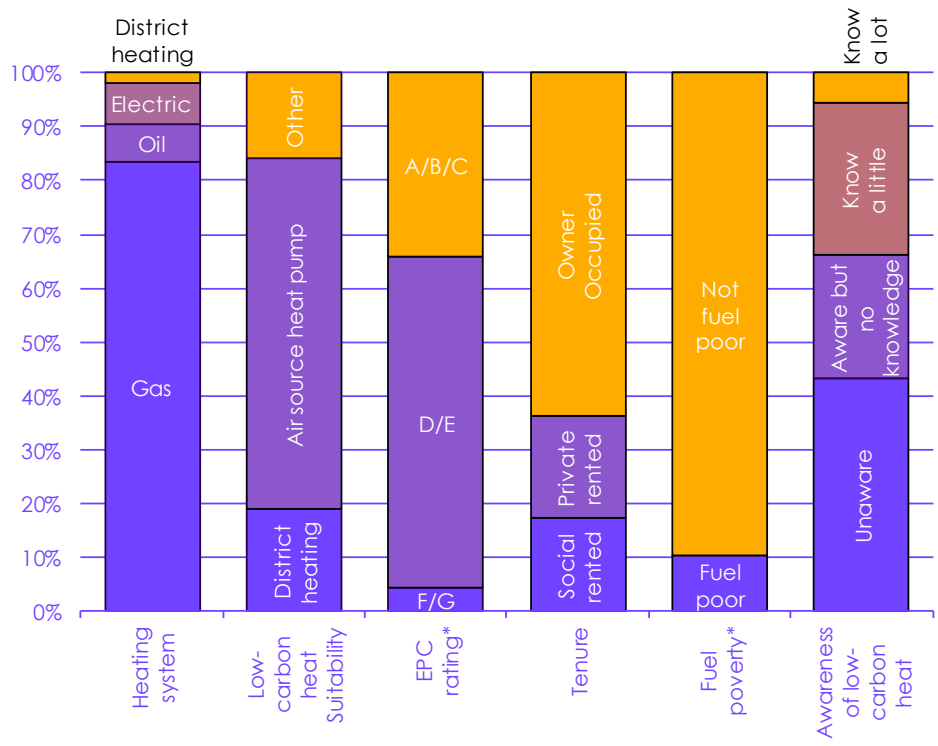
Low levels of public engagement and higher upfront costs of low-carbon heating make buildings particularly challenging to decarbonise.

Buildings is a particularly challenging sector to decarbonise.

- Progress has been slow to date, with emissions remaining flat or rising for the last five years.
- The implementation of key measures remains at very low levels, with weak supply chains for key measures such as insulation and heat pumps, and hydrogen use still in a development phase.
- Levels of public engagement are low - in particular, there is low awareness of the need to shift to low-carbon heating.
- This is compounded by the low cost of gas heating and balance of policy costs between electricity and gas, which make low-carbon options uncompetitive.

- Finally, the UK housing stock is both diverse and relatively inefficient, which means that a range of approaches is necessary (Figure 3.1). This includes a range of ownership – council, housing association, private-rented, owner occupiers with mortgages, owner occupiers without mortgages – as well as both freeholders and leaseholders.

Figure 3.1 Overview of the housing stock according to key metrics



Sources: Heating System: Element Energy (2020) for CCC; Low-carbon heat suitability: Element Energy and UCL for CCC (2019);[1] EPC Rating: MHCLG (2019);[2] Tenure: MHCLG (2020),[3] Scottish Government (2018),[4] Stats Wales (2020),[5] Department for Communities (2019)[6]; Fuel Poverty: BEIS (2020a);[7] Awareness of low-carbon heat: BEIS (2020b)[8]
Notes: *EPC and fuel poverty statistics shown for England only. Low-carbon heat suitability reflects assessment undertaken for Net Zero advice, and reflects the portion of the stock deemed suitable for air source heat pumps, net of those suitable for district heating.

However, our understanding of public support has developed, along with a growing consensus on the way forward. In particular, the UK Climate Assembly has shed new light on public support for different heating solutions and priorities for the transition, which can help shape Government's strategic approach:

- On low-carbon heating, Assembly Members back the use of hydrogen, heat pumps and heat networks, stressing that local areas should be able to choose the options best suited to their needs.
- On home retrofits, they emphasised the need to minimise disruption in the home, put in place support around costs and offer flexibility and choice to householders.

Government's Heat and Buildings Strategy aims to address these challenges and is due shortly. This advice supports that strategy development.

BEIS and MHCLG are currently developing a Heat and Buildings Strategy for imminent publication, following on from the 2018 evidence assessment.[9] This aims to address the challenges and set the policy direction through the next decade. We have worked up a set of policy recommendations based on evidence of what works,[10] insights from our pathways work and significant stakeholder input, to support the development of the strategy. This was presented at an Autumn Ministerial roundtable and is set out in the following section. Further detail on how we have developed our scenarios is set out in the Method report.

The following sections cover:

1. Current policy commitments
2. Key changes required

The Government plans to get all homes to EPC C over the next 10-15 years.

The UK Government has developed plans to improve the energy efficiency of all buildings over the next 10-15 years, and plans to phase-out the installation of new high-carbon fossil fuels in the 2020s:

- **Home efficiency**. In the 2017 *Clean Growth Strategy*, the Government committed to getting all fuel poor and rented homes to EPC C by 2030, and other owner-occupied homes by 2035. In September 2020 it published proposals to bring forward the date for private-rented homes to 2028.
- **Rented commercial and public buildings.** Existing regulations require all privately-rented properties in England and Wales to be at least EPC E by April 2023. In October 2019 the Government published proposals for all non-residential private-rented buildings in England and Wales to meet EPC B by April 2030 where cost-effective, based on meeting a seven-year payback test. BEIS estimate 64% of the stock will meet the EPC B target, 20% to fail but meet EPC C cost-effectively and 17% to be unable to meet EPC C cost-effectively.[11]
- **New buildings.** Under the proposed Future Homes Standard, no new buildings will be built with fossil fuel heating. UK Government is looking to introduce this in advance of 2025 in England and Wales, with the Scottish Government aiming for the same outcome from 2024.
- **Commercial efficiency**. In the Clean Growth Strategy, the Government set a goal to enable businesses and industry to improve energy efficiency by at least 20% by 2030.
- **Public buildings**. Government is aiming to reduce public sector emissions by 50% by 2032 against 2017 levels.

There are plans to phase out liquid and solid fossil fuels but no current proposals to phase out natural gas.

- **High-carbon fossil fuel phase out**. The commitment here is to phase out the installation of new coal and petroleum appliances in the 2020s, on which a consultation is due shortly. This covers 11% of the current energy consumption for heating and hot water[12].

Energy efficiency funding is targeted at the fuel poor, at social homes and public buildings at a UK level.

This regulatory timetable is supported by £9.2 billion of funding targeting public sector buildings, social homes and the fuel poor, on top of at least £4 billion committed under the ECO programme. An additional £2.0 billion of funding for homes has recently been announced through the Green Homes Grant, now extended until the end of the 2021/22 financial year.[13]

The UK Government's 2020 *Ten Point Plan* includes a number of further commitments. It is aiming to achieve sales of 600,000 heat pumps a year (across all homes) by 2028, and investing in hydrogen development, including a 300 home trial in Fife.[14]

The Scottish Government has a more ambitious programme in place in some areas. It has published proposals for point-of-sale standards to require all owner-occupied homes to meet EPC C, to be introduced from 2024, with a cap of £15,000 per home. This means that any homes which are below an EPC C efficiency rating will need to be upgraded before they can be sold. This is supported by £1.6 billion of funding to 2025 across buildings heat and efficiency. Smaller amounts of funding are available in Wales and Northern Ireland.

15.5 million 'owner-occupied' homes are not currently covered by proposed efficiency standards in England, Wales and Northern Ireland.

The main regulatory policy gaps are efficiency standards for 15.5 million owner-occupiers (of which over 65% are below EPC C), owner-occupied commercial buildings and plans for phasing out natural gas heating:

- There are currently about 29 million homes in the UK, of which 19 million are below EPC C. Of the 29 million, 18 million are owner-occupied, of which around 1.5m are fuel poor*. Accounting for the Scottish Government proposals, this means that there are 15.5 million potentially 'able-to-pay' properties not currently covered by proposed standards.
- Commercial buildings which are owned rather than leased are likewise not covered by current policy proposals.
- Around 85% of existing homes and 63% of public and commercial heating is met through natural gas which is not currently covered by regulatory proposals to phase out natural gas.

In the next section, we set out what more is required to address this regulatory policy gap as part of a broader policy package which creates employment and delivers a broad set of wider benefits in terms of comfort, health and ongoing energy bills savings.

* Calculated from percentage for England, in: BEIS (2020) 'Table 18: Fuel poverty detailed tables 2020', *Fuel poverty statistics report for 2020*. Department for Business, Energy & Industrial Strategy.

We have developed a four-point policy package in consultation with a broad set of stakeholders, covering: a clear direction; making low-carbon financially attractive; enabling measures such as green passports and skills strategy, and getting on with it - using planning and other tools.

We have developed a policy package in consultation with stakeholders which draws on the sixth carbon budget pathway analysis. In the following sections, we set out the four core components of the policy package along with the supporting evidence (Figure 3.2).

Figure 3.2 Buildings heat – high-level Sixth Carbon Budget policy package



Source: CCC

a) A clear direction

By the start of the Sixth Carbon Budget in 2033, all UK buildings should be energy efficient, the heat pump industry should have scaled up to be able to manage over a million installations a year in homes, heat networks should be fully low-carbon and being rolled out at scale and there should be a clear plan for the role of hydrogen in UK buildings.

Our pathways in this report factor in rapid progress in a set of low-regrets options for decarbonising buildings, including widespread energy efficiency, tackling newbuild, heat pumps in buildings off the gas grid, low-carbon heat networks and biomethane.*

* Further detail on the role of these is included in Chapter 3 of *The Sixth Carbon Budget - The UK's path to Net Zero* and the 2019 *Net Zero* report.

Government needs to give clear signals – electrification is of primary strategic importance; hydrogen provides flexibility and could play a role in regional grids, particularly in areas near industrial clusters.

i) The importance of electrification

Our Balanced Pathway is informed by the following judgements regarding the gas grid:

1. Efficiency is a fundamental first step, or the scale of the problem gets too big.
2. Low-carbon heat networks are a competitive and flexible solution in heat dense areas such as cities.
3. System costs are not a major differentiator between electrical and hydrogen heat for remaining homes on the gas grid,[15] so public support is likely to determine the shape of our decarbonised future. With coordination, solutions can vary by region, depending on local resources, infrastructure and consent.
4. Full hydrogen conversion is unwieldy due to the low system efficiency which poses a significant supply-side challenge (Chapter 2, Advice Report). As a worked example, 800 TWh of hydrogen would require 100-150 GW of gas reforming with CCS; or 300 GW offshore wind capacity if just using electrolysers. On this basis we do not recommend planning on a full hydrogen conversion. Full electrification would be challenging (though not impossible) as it requires considerable flexible supply and possibly an element of boiler scrappage if delays in building supply chains persist. This means it is sensible to plan for a range of solutions.

This implies electrification is of primary strategic importance for Net Zero; crucially, this strategic importance remains true even where hydrogen grid conversion is widespread (as illustrated in our Headwinds Pathway). Hydrogen is particularly valuable where it can provide flexibility – either at a system-level within the power sector, or at a buildings level through hybrid heat pumps. It could also play a supporting role through targeted regional gas grid conversion, where there is public support and an underlying technical case (for example, due to co-location with an industrial hydrogen cluster). Hybrid heat pumps offer a number of benefits and should be covered by the policy package (Box 3.1).

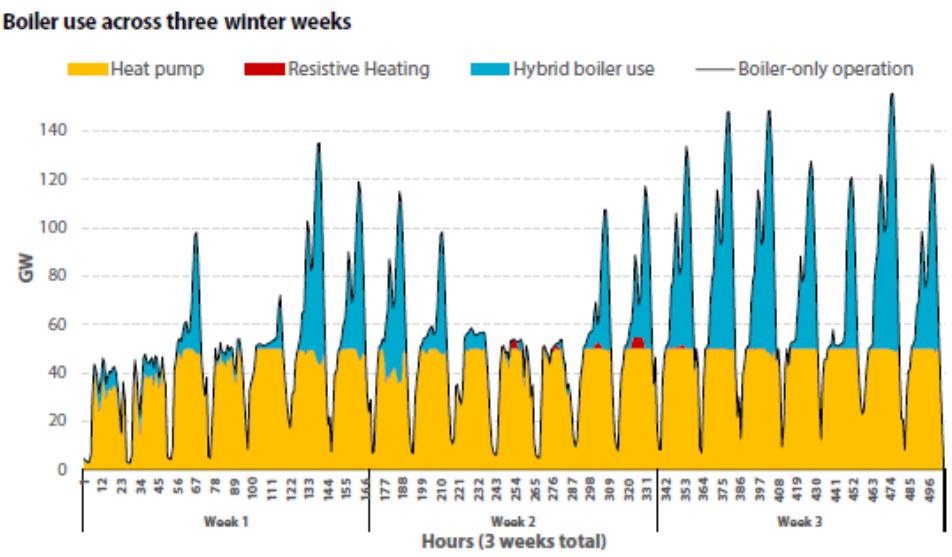
It is essential that the Government sets a clear commitment to electrification through the 2020s, including a stable and long-term support framework to build the heat pump supply chain to sufficient scale to deliver near term emissions reductions and keep full electrification on the table (1 million heat pumps a year in homes by 2030) (Box 3.2).

Box 3.1
Role of hybrid heat pumps

There is optionality over how hydrogen is used, including its role in the power system, the balance of use between heat pump-hydrogen boiler hybrids and hydrogen boilers at buildings level, and the extent of any regional conversion. In a system which uses high volumes of hydrogen, the use of hydrogen hybrid heat pumps can offer a number of benefits. These include:

- **A much lower reliance on CCS and imported natural gas**. Our net zero analysis suggested that very high amounts of CCS would be likely be required (>175 $MtCO_2$/year) even with constrained use of hydrogen alone in buildings. This constraint is potentially binding.
- **Lower residual GHG emissions**. Gas reforming with CCS is low-carbon rather than zero carbon, providing lifecycle emissions savings of 60-85% relative to natural gas use in boilers. If hydrogen from gas with CCS is deployed in very large quantities, the emissions savings may be insufficient to meet stretching long-term emissions targets.
- **Potentially competitive economics**. The evidence suggests that the majority of the costs involved with a full hydrogen scenario come from the cost of the hydrogen itself which remains considerably higher than the upfront costs of converting the gas grid and making changes inside the home. This remains true even given the higher capital costs of hybrid heat pump solutions.
- **System level flexibility benefits**. Hydrogen hybrid heat pumps would enable heating systems to respond to economic signals around the relative prices of fuels and to infrastructure constraints (e.g. ensuring electricity demand does not exceed local grid capacity).

Figure B3.1 Hybrid heat pumps and hydrogen can help deliver a flexible, low-cost solution



Source: CCC (2018) *Hydrogen in a low-carbon economy*, based on Imperial College (2018) *Analysis of alternative UK heat decarbonisation pathways*
Notes: Chart shows aggregate heat demand for both domestic and non-domestic premises. Pattern of use could be expected to be similar on individual premises. Chart is for heat output, rather than energy input. 'Boiler only operation' is shown as a comparator, and is not expected to be in addition to the boiler in a hybrid system.

Hybrid heat pumps have potential to offer a number of broader benefits in the near-term:

- **Advantages in public acceptability.** Unlike a shift straight to an electric heat pump, a switch to hybrid heat pumps would enable people to experience unchanged characteristics of the heating service they receive and avoid disruption (e.g. by replacing radiators), while increasing familiarity with the technology.

- **Scope for accelerated near term deployment and emissions reductions**. Hybrid heat pumps can be installed alongside existing systems such that distressed purchases need not be a barrier, and installation is more viable in advance of boiler end of life. It can also be installed alongside, rather than following improvements to the energy efficiency of buildings.
- **Suitability in hard-to-decarbonise properties, particularly in homes off the gas grid.** There are estimated to be around 1.3 million heritage homes, including 400,000 listed buildings. Homes off the gas grid are larger on average. For a portion of hard-to-decarbonise homes, hybrid solutions and cascading heat pumps will be more cost-effective than extensive efficiency upgrades with a large single heat pump.[16]
- **Reducing reliance on single set of government-led decisions in mid 2020s**. By taking the first part of the decision (i.e. on a move to hybrid heat pump-boiler systems) over how to decarbonise heat fully for on-gas properties now, the second part – on how to reduce emissions from the considerably lower residual natural gas use – could potentially follow in the second half of the 2020s.

In the context of the benefits that hybrid heat pumps have potential to provide, it remains that there are risks and uncertainties which would also need to be overcome. While hybrid heat pumps can offer a host of benefits, in order to achieve these it is important that hybrids are used effectively in homes. Based on work undertaken by Imperial College London our base assumption is that hybrid heat pumps can operate in heat pump mode up to 80% of the time.[17] Other trial data (e.g. from Passiv Systems, when combined with smart controls) supports the Imperial assumptions. However there is also evidence of homes using heat pump components of hybrids much less.* A sensitivity conducted on our scenarios suggests that hybrid heat pumps which only operate in heat pump mode 50% of the time (relative to 80% of the time in the baseline case) are significantly less cost effective.

In order to overcome challenges of this kind, standards on smart heating controls and operation, and rebalancing of gas and electricity prices, would be important parts of any policy package.

Sources: CCC analysis; Energy Systems Catapult for BEIS (2019); Element Energy and UCL for CCC (2019)[1]

Box. 3.2
Heat pump deployment in homes over the coming decade

Our Balanced Pathway includes deployment of 5.5 million heat pumps in homes to 2030, of which 2.2 million are in new build homes, with a large proportion of the remainder expected to be installed off the gas grid. This is consistent with deployment rates reaching just over 1 million a year in homes by 2030, compared to just 26,000 a year currently.

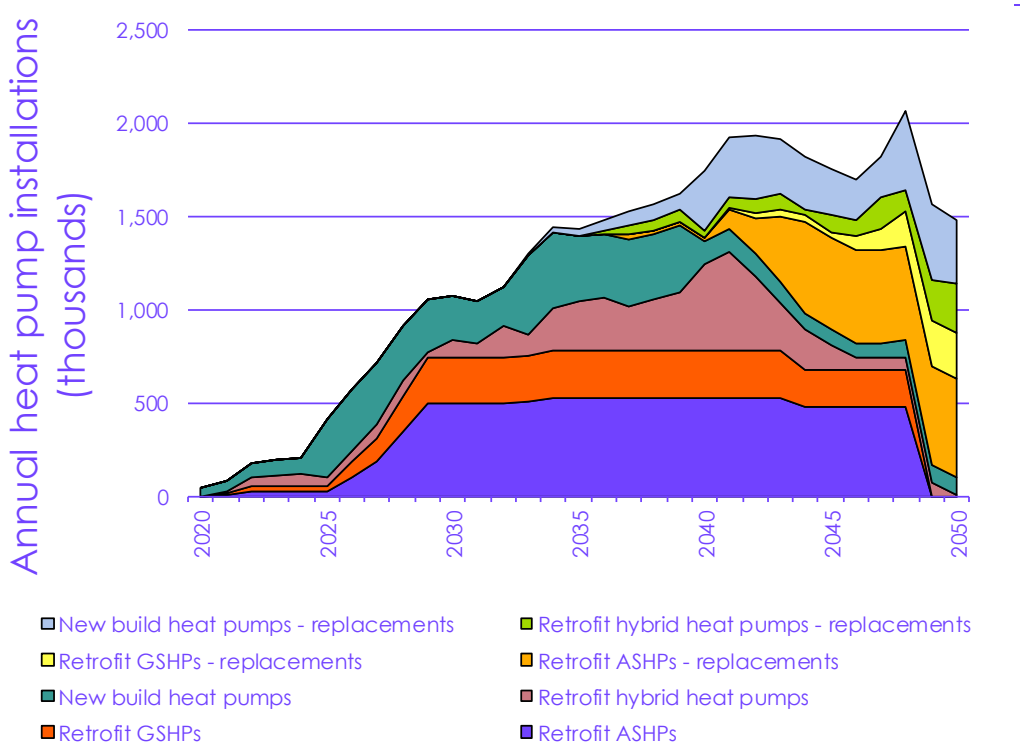
The deployment trajectory for heat pumps in our Balanced Pathway reflects our assessment that there remains a strong case for delivering growth of this scale, regardless of the heat mix chosen post-2030:

- **Clear market signals.** A commitment to strong near-term uptake provides the policy certainty necessary to support the levels of electrification across scenarios (with Headwinds also reaching deployment of 1 million heat pumps a year by the early 2030s).
- **Preparing supply chains to keep options open for full electrification.** For full electrification, boiler lifetimes imply a need to scale up markets and supply chains to cover all new installations by the mid-2030s at the latest, representing up to 1.8 million heat pumps a year in existing homes. Supply chains must grow steadily to accommodate not only first-time heat pump installations in existing homes, but also new build installations (including retrofits for those homes being built now with gas) and replacements (Figure B3.2).
- **Further benefits of early deployment.** These include driving down near-term emissions (reducing the scale of the challenge to 2050), increasing consumer familiarity ahead of further widespread adoption and driving down the costs through learning by doing.

Our analysis finds that deployment at this scale is achievable. The level of deployment remains well within the deployment constraints developed in discussion with stakeholders, assumed to reach around 1.3 million heat pumps by 2030. There is also evidence to suggest that this level of deployment may not be contingent on significant retrofit, with nearly 7 million homes in our scenarios receiving no or low energy efficiency packages. Where deployment comes in the form of hybrid heat pumps, early deployment is likely to be possible across a wider variety of homes.

* The Energy Systems Catapult conducted a trial where the performance of hybrid heat pumps was shown to be highly dependent on household heating behaviours, with heat pumps operating as part of hybrid heating systems delivering between 6% and 63% of the heating in different homes.

Figure B3.2 Annual heat pump deployment in homes



Source: CCC analysis, Element Energy for the CCC (2020) *Development of trajectories for residential heat decarbonisation to inform the Sixth Carbon Budget*

Source: CCC analysis; Element Energy for the CCC (2020) *Development of trajectories for residential heat decarbonisation to inform the Sixth Carbon Budget*.

A clear timetable is needed, backed by standards. We have set out an indicative timetable based on extending the current regulatory approach and working as much as possible with existing technology lifetimes to minimise costs and disruption.

ii) Phase-out dates and standards

The second element to setting direction is a clear timetable, backed by standards. We have set out an indicative timetable based on Government's existing commitments, and extending its current regulatory approach (Table 3.1). This is driven by the need to minimise costs and disruption, which means working as much as possible with existing technology lifetimes, while minimising scrappage. It would be possible to deliver a similar outcome through higher levels of subsidy and later regulation, but our modelling suggests that this is the minimum level of additional regulatory commitment required to deliver the programme of Net Zero buildings in the Sixth Carbon Budget pathway. Alternative regulatory approaches could also be possible, where they deliver similar levels of ambition.

Table 3.2
Critical dates and policy implications in the Balanced Pathway for buildings

	Indicative date	Policy implications
Efficiency		
All new buildings are zero-carbon	2025 at the latest	Implement a strong set of standards that ensure buildings are designed for a changing climate and deliver high levels of energy efficiency, alongside low-carbon heat. Commit to publishing a robust definition of the Future Homes Standard which is legislated in advance of 2023.
Rented homes achieve EPC C	2028	This means reforming EPCs to make them fit for purpose, aligning the timetable for social homes to private-rented sector (PRS) proposals, finalising a delivery mechanism for social homes, and legislating the PRS proposals.
Standards for lenders targeting EPC C across the housing portfolio	2025 - 2033	Government to pursue options set out in the Green Finance Strategy for mandatory disclosure by lenders of average efficiency across the mortgage portfolios, and introduce a progressive set of minimum standards.
All homes for sale EPC C	2028	No buildings can be sold unless they meet the minimum standard.* At the current housing turnover of once every ten years for mortgagors and once every 24 years for outright owners, regulations at point of sale would be expected to result in a further 15% of owner occupied homes meeting the required standard by 2035 (with further upgrades driven by the standards on lenders, totalling at least 60% of owner-occupiers overall).
All commercial efficiency renovations completed	2030	BEIS must accelerate plans for a new in-use performance standard for commercial properties along with plans for SMEs and legislate the private-rented proposals.
Heating		
All boilers are hydrogen-ready	2025	Based on projected additional costs of £100 or less per boiler, and with a view to minimising scrappage, we recommend appliance standards for hydrogen-ready boilers. Should costs prove higher or safety considerations materialise, this should be reviewed. Early commitments and widespread standards would be expected to drive costs down through competition and economies of scale.
Oil and coal phase out (outside of any zones designated for low carbon district heat)	2028	BEIS must now publish long-awaited proposals to phase out the installation of new high-carbon fossil heating. Further support is needed in the near-term to build critical supply chains and to channel investment in networks.
Natural gas phase out (outside of any zones designated for low-carbon district heat or hydrogen-conversion areas)	2033	A decision-making framework spanning national, regional and local levels, and informed by regional and local area planning, is needed to facilitate decisions on the future of heat. A programme of area-based energy planning can provide a locus for meaningful public engagement. In areas not designated as areas for hydrogen or heat networks, standards phasing out the installation of gas appliances will allow low-carbon heating to become widespread by 2050.
Gas CHP phase out for low-carbon heat networks	2025	Relative Gas Combined Heat and Power (CHP) carbon benefits reduce as the grid intensity continues to fall through the 2020s. On this basis, we assume that all new district heat network connections from 2025 are low-carbon, requiring emissions performance standards and funding for low-carbon heat sources. All heat networks supplied by legacy CHP schemes convert to low-carbon heat sources by 2040.

Setting a phase out date for natural gas (outside of designated hydrogen or district heat conversion zones) can build on the approach for high-carbon fossil fuels. The UK Citizens Assembly supported a ban on new gas boilers between 2030-2035, with 86% in favour.[18]

* In Scotland, these requirements are subject to spending caps. Our scenarios also implicitly assume spending limits form part of the minimum standards for all homes – for instance, we exclude measures from our economic potential where the costs are deemed too high, including for some hard-to-treat measures.

Boiler lifetimes of 15 years imply a phase out date for the installation of fossil fuel boilers in advance of 2035. Our Balanced Pathway picks a central date of 2033.* This in turn implies:

- The need to prepare the building stock for low-carbon heating in advance of this, through an approach which completes the majority of energy efficiency installations by the time the full-scale transition occurs. Our Balanced scenario assumes 76% of fabric energy efficiency measures in homes are deployed by 2033 and that 100% of public and commercial energy efficiency measures included in the scenario are complete. †
- The need to build low-carbon heat supply chains in the near term, such that they are able to service up to around 1.8 million homes by 2033 and 50% of the non-residential heating market.‡
- The need to designate areas for low carbon district heat networks and hydrogen conversion well in advance of 2033.
  - This would enable buildings in these areas to be given an exemption from a ban on fossil fuel boilers, such that they need only undergo one low-carbon heating transition and that infrastructure costs can be minimised.§
  - An exemption could take different forms and could still require new heating systems in these areas to meet certain conditions (such as hybrid heat pump configurations) even where some continued role for fossil fuels is permitted beyond 2033.

Moreover, keeping hydrogen in play means progressive steps building through the 2020s to develop an integrated approach across buildings, CCS, industry and transport (Figure 3.3).

- Where electrification remains the primary route to decarbonise buildings, it is expected that decisions on the future of the gas grid are most likely to comprise of a series of decisions on hydrogen zoning, informed by cross sectoral considerations.
- Decisions on those areas which will not be converted will be of equal importance, with early designation enabling effective targeting of electric heating and district heating, and associated infrastructure upgrades.
- This approach to decision-making can help minimise the risk of remaining uncertainties holding up progress on decarbonisation.
- It also implies the need for careful consideration of how the distributional implications of staggered low-carbon heat conversions might be managed.

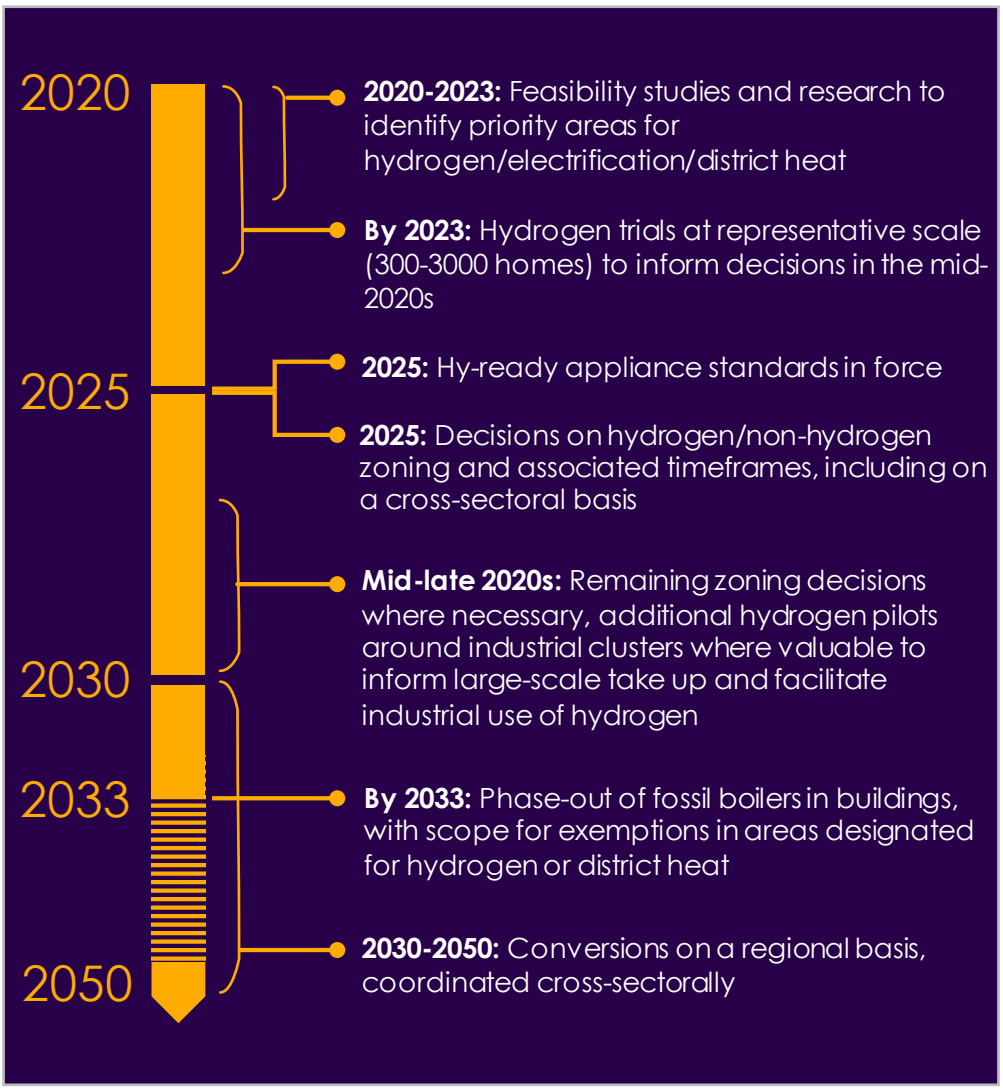
* Phase out regulations on the gas grid are envisaged to prevent the installation of new fossil fuel boilers in areas not designated for hydrogen or low carbon heat network conversion. An earlier date of 2030 is adopted for public buildings in order to achieve the targeted 50% cut in emissions by 2032.

† See Chapter 3 of the Methodology Report for details of what is included for public and commercial energy efficiency in our scenarios.

‡ 1.8 million homes based on current annual boiler sales. Some of these homes would be expected to switch onto district heat, with a small number potentially needing low-efficiency electrified solutions.

§ For instance, heat density is a key determinant of the costs of low carbon district heat provision. On this basis it is preferable to maximise the number of buildings using low carbon district heat where a heat network is in operation, This suggests the need to minimise alternative heating solutions.

Figure 3.3 Indicative hydrogen development Pathway for buildings



Policy must make low-carbon heat affordable and cost-competitive by targeting cost reduction, rebalancing policy costs and increasing funding for low-carbon heat.

b) Making low-carbon buildings financially attractive

Policy must make low-carbon heat affordable and cost-competitive by targeting cost reduction, rebalancing policy costs and increasing funding for low-carbon heat.

i) Cost reduction

The first step is to minimise costs through fabric efficiency measures, through learning by doing, and by enabling household-level flexibility:

- When installed in energy efficient homes, low-carbon heat can offer running cost savings relative to fossil fuel alternatives
- Innovation provides scope for cost savings over time in both energy efficiency and low-carbon heat, including through innovative roll-out models, modularisation and improved system design*,[19]
- Valuing and enabling flexible loads can cut costs and carbon. We estimate that pre-heating could save up to £2 billion per year.[20]

Government and Ofgem can enable household-level flexibility through implementing their Smart Systems and Flexibility Plan, including rolling out mandatory half-hourly settlement, and supporting cost-reflective charging and smart tariffs. Standards on smart heating could help maximise emissions reductions and minimise the system costs of electrifying heat.

ii) Rebalancing policy costs

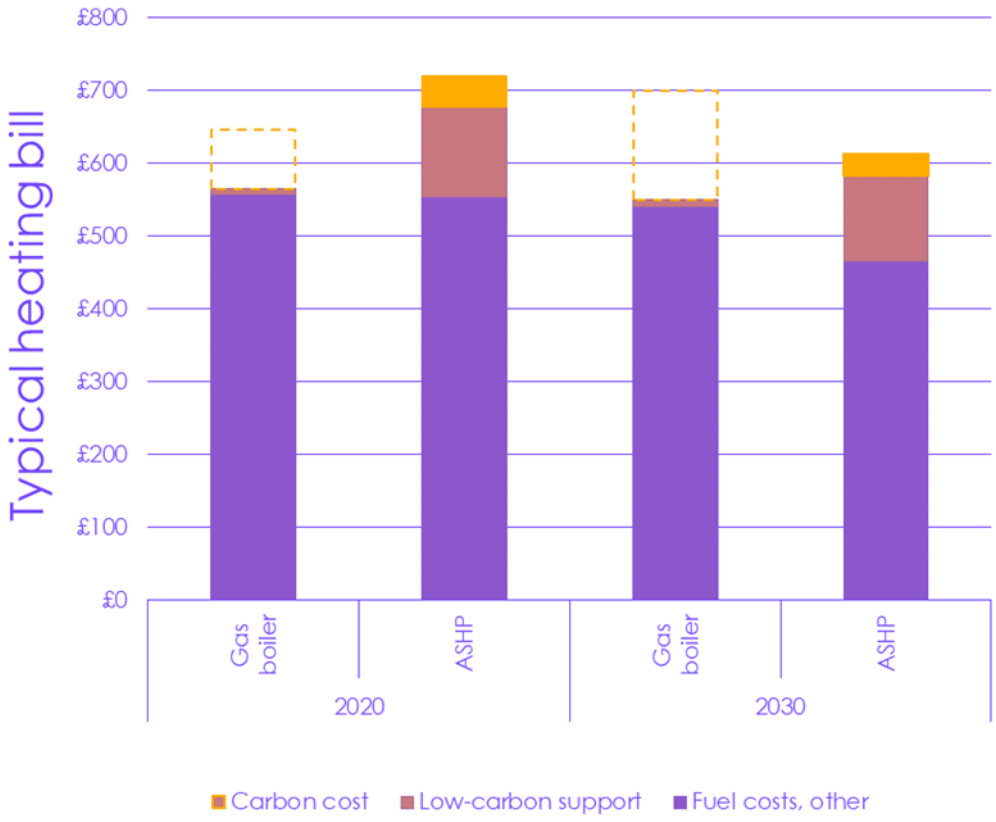
Rebalancing policy costs on electricity and gas is also a critical enabler, cutting running costs for electric heating where it is displacing fossil fuels (Figure 3.4).

A favourable VAT regime – including on the sale and installation low-carbon technology – can also support low-carbon solutions.

More broadly, it will be essential for Government to assess how the costs of all forms of heating – electric, hydrogen, hydrogen-hybrid and heat networks – can be made fair, and protect vulnerable and low-income households. This is particularly important with different solutions emerging in different parts of the country.

* This could include a role for area-based approaches to retrofit, making use of the 'mass customisation' model described in a recent report by the Connected Places Catapult and the Housing Innovation Programme. Energiesprong provides an excellent example of an approach which can deliver holistic deep retrofits for groups of homes whilst also offering guaranteed performance.

Figure 3.4 The uneven distribution of policy and carbon costs on electricity and gas penalises low-carbon electric solutions



Source: CCC analysis
Notes: Switching to heat pumps is made more costly by the fact that the carbon costs of gas are not reflected in its price and the distribution of the costs of low-carbon support across fuels. Electricity consumption is subject to a carbon price under the EU Emissions Trading System (ETS) and the Carbon Price Floor in the UK, whereas there is no carbon price on gas consumption. Both electricity and gas prices include a portion which is support for low-carbon and fuel poverty schemes, at 3.5p/kWh on electricity and 2.1p/kWh on gas. Low-carbon support costs are higher on electricity as they include the costs of decarbonising the power sector (through subsidies such as the Contracts for Difference).

iii) Increasing funding for low-carbon heat

The final step consists in addressing the remaining upfront cost barrier, through a combination of private (including 'green') finance and public funding targeted at low-income households and to support the vulnerable, along with other priority areas such as public buildings and social housing:

- The current policy approach aims to leverage private finance where possible, including through landlords and 'able-to-pay' owner-occupiers. For energy efficiency, householders can access low cost finance through mortgage finance, although there are still relatively few 'green mortgage' products on the market. The Green Finance Institute identified digital green passports based on accurate in-situ performance as a key solution to raising finance.

- Public spending should be prioritised for low income households and areas of the economy which do not have recourse to other funding. Additional

Exchequer-funding may facilitate the transition (see Chapter 6 of our accompanying Advice report).

- Public spend can also act as an economic stimulus as part of the Green Recovery. This has been recognised by the Government in the launch of the Green Homes Grant and Public Sector Decarbonisation scheme.

We have mapped current public commitments against investment projections, and identified three major funding gaps for existing homes: public sector buildings, along with bridge funding for heat pumps and low-carbon heat networks.

We have mapped current public commitments against investment projections for existing buildings. Our assessment is that, by and large, existing public funds are well targeted. However, we have identified three major funding gaps to 2030: public sector buildings, along with bridge funding for heat pumps and low-carbon heat networks (Table 3.3).

In our accompanying Advice report (Chapter 6), we set out an illustrative funding package in 2030 of £5-7 billion/year in 2030, including an additional £0.5 billion/year for low-income households; £0.5 billion/year for social homes and £1 billion/year for public sector buildings.

We also map current funding commitments against investment projections for public and commercial buildings, finding a shortfall in support for public buildings and negligible support for commercial buildings (Table 3.3):

- Funding for decarbonising the public sector currently stands at around £1 billion with a pledge to increase this to £3 billion, including grants under the Public Sector Decarbonisation Scheme in England, the Public Sector Low Carbon Skills Fund and additional funds in Scotland and Wales.[21],[22] We estimate costs of delivering public sector energy efficiency and heat pumps to 2030 of over £5 billion in our Balanced Pathway, suggesting a shortfall which will need to be met by central Government and/or supplemented by public bodies using interest free loans such as Salix or raising other funds.
- A substantial amount of investment in commercial energy efficiency is required in our scenarios, which may need to be largely met by the private sector. BEIS has a BASEE innovation fund to develop new business models that encourage take up of energy efficiency projects by small and medium businesses (SMEs).[23] Implementing in-use performance monitoring of commercial buildings could drive progress and low-cost finance will be needed to facilitate.

There is little planned financial support for low-carbon heat in the commercial sector. The Non-Domestic RHI closes to new applicants on 31 March 2021, with a year extension to submit full applications for accreditation due to COVID 19 disruption; and a new allocation of tariff guarantees to provide certainty to larger, better value for money installations. The proposed Clean Heat Grant for 2022-24 is set to include the smallest commercial businesses as well as homes.[24] With a capacity restriction of 45kW and limited funding, there will remain a significant gap in support to drive commercial low-carbon heat.

Table 3.3
Investment costs to 2030 in our Balanced Pathway alongside committed public expenditure

Segment	Estimated investment costs to 2030	Committed public expenditure to 2030 (estimated)	Comment and RAG rating
Fuel poor owner-occupied homes, energy efficiency	£4.5- 8.9 billion**	UK Govt: ~£5-6 billion across fuel poor homes (ECO, portion of the Home Upgrade Grant, portion of Green Homes Grant) Around £0.5 billion at Devolved Administration level Further funding possible from Scottish Government*	Funding in line with projected costs
Social housing, energy efficiency	£3.1-4.0 billion**	UK Govt: £3.8 billion Further funding from Scottish Government*	Funding in line with projected costs
Other owner-occupied homes, energy efficiency	£10.6 billion	UK Govt: £1-2 billion (a portion of the Green Homes Grant) Further funding from Scottish Government*	Current funding in place to 2022 with a focus on private finance for remainder
Private-rented homes, energy efficiency	£11.1-13.5 billion**	UK Govt: fuel poor funding (see top row) and Green Homes Grant Possible further funding from Scottish Government*	Regulatory approach designed to leverage private finance
Heat pump scale up to 2025, existing homes	Estimated £3.0 billion	UK Govt: Estimated £0.5-2 billion (Clean Heat Grant plus a portion of Green Homes Grant and Home Update Grant) Further funding from Scottish Government*	Additional funding is required to support the scale up of supply chains ahead of the introduction of standards
Heat pumps, 2025-2030, existing homes	£17.7 billion including £2.8 billion in social homes	Negligible	Current gap in social homes – extent of additional gap will depend on funding model
Heat networks (all buildings)	£17.5 billion in total, of which £~5.5 billion to leverage private investment	UK Govt: £0.6 billion, aiming to leverage ~£2 billion private finance Further funding from Scottish Government*	Further funding required, particularly for low-carbon heat sources post-2022
Public sector energy efficiency and heat pumps	£5.4 billion total cost to 2030.	UK Govt: £3 billion Further funding from Scottish Government*	Public funding will be required for the gap
Commercial energy efficiency	£21 billion	UK Govt: £6 million Further funding from Scottish Government*	Proposed standards to leverage private finance Possible gap for SMEs
Commercial heat pumps	£0.5 billion total cost to 2030. £80 million to 2025 if funding heat pumps at 80%.	UK Govt: <0.1bn under Clean Heat Grant for heat pumps <45kW Further funding from Scottish Government*	Additional bridge funding may be required until standards are introduced to build the supply chains

Sources: BEIS (2020),[21,22,23,24,25] The Conservative Party (2019),[26] Scottish Government (2020),[27] Welsh Government (2019),[28] HMG (2020)[13]
Notes: Estimates of committed policy spend are based on limited information and are subject to change. They are approximated based on current Government announcements and involve a number of judgements, particularly regarding how the Green Homes Grant, the Home Upgrade Grant and ECO will be apportioned between segments (reflected in ranges). Rows are not designed to be summed due to overlaps. *The Scottish Government has committed £1.4 billion of funding over the next Parliament, but it is not possible to disaggregate this currently. ** The top end of the range includes floor insulation in all fuel poor homes. This was implemented in Element's modelling by assigning high energy efficiency packages to these homes, and as such floor insulation was also included. In practice, it is likely that deployment of floor insulation may be more limited (particularly where this is more expensive solid floor insulation).

c) Enabling measures: information and skills

i) Information

High quality advice and information is a critical enabling measure.

High-quality advice and information is critical for guiding householders' decisions, and scored highly with the UK Climate Assembly.[29]

EPCs have been a useful source of basic comparable information but they have extensive issues (poor quality/low robustness; modelled rather than actual performance; they do not show benefits of decarbonising electricity or savings possible from smart tariffs; they do not always incentivise the measures needed to support decarbonisation).

There is an urgent need to reform EPCs to ensure they are fit to support near-term progress.

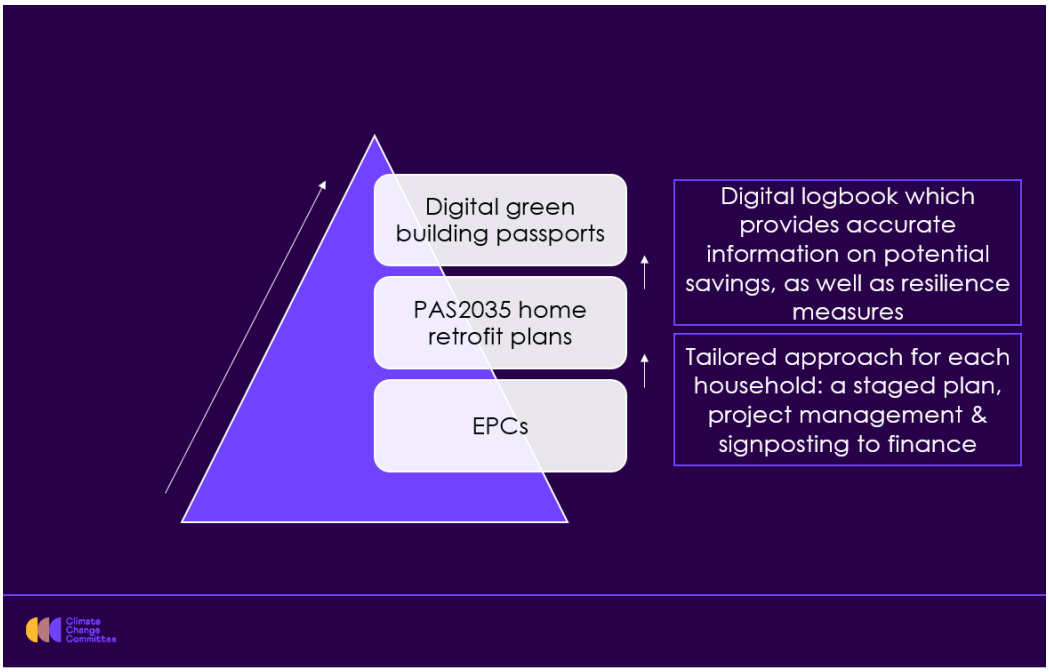
Government has recognised the urgent need to improve EPCs to ensure they are fit to support near-term progress, with a range of improvements proposed in the recent EPC action plan. It is important that alongside this, the methodology is designed to drive deployment of the necessary energy efficiency measures on a holistic basis,* and does not disincentivise low-carbon heat. Onsite generation is not a replacement for energy efficiency or low-carbon heat.

Green Building Passports could provide holistic guidance to householders and unlock green finance at scale.

As a next stage, home retrofit plans are a tailored approach which can bring in wider dimensions of comfort, aesthetics and affordability as well as adaptation needs (Figure 3.5). Combining these with the opportunity of smart meter data in a digital Green Building passport could unlock green finance at scale by providing a robust, quality source of information to raise finance against, track progress and help make standards enforceable. Approaches like this are required to scale up additional finance to the £~8 billion/year on home renovation by 2030 implied by our Balanced Pathway.

* Measures to address thermal efficiency, overheating, indoor air quality and moisture must be considered together when retrofitting or building new homes.

Figure 3.5 A high-quality source of information at Household-level



Source: CCC analysis

The Government is due to consult shortly on plans to introduce a mandatory in-use energy performance rating scheme for large commercial buildings, aiming to make it simpler for businesses to identify potential to save energy. Such schemes can be effective in driving change given business decisions around energy efficiency are shown to respond to reputation and risk.[30] Performance labelling for buildings allows tenants and owners to choose more efficient buildings, encouraging developers to compete for clients willing to pay a premium for efficient buildings. Well executed building labelling has created higher value for efficient buildings and attracted capital for low-carbon investment to go 'beyond code' (e.g. the Australian NABERS and the US Energy Star Buildings programmes).[31]

ii) Skills

Skills remain a further critical enabling measure. The CITB have identified pace of change as a key challenge, necessitating Government intervention. It is vital that the policy framework also scales up inspections and enforcement activity to ensure householders get what they have paid for.

The other critical element within the enabling measures is to prepare for new skills demand early, with enforcement of standards to drive up quality and drive down costs:

- The analysis of skills needs (Chapter 3, Advice report) shows the impact on activity levels from the major programme of building renovation over the next three decades, which is due to create over 200,000 jobs in home renovation and heating.
- The Construction Industry Training Board's (CITB) assessment of the skills challenges associated with our scenarios identifies the pace of change as a key challenge: current institutions are not equipping enough people with the required skills.

- It is unlikely that the market will develop the requisite skills in time, potentially resulting in poor quality installations (Box 3.3). Government intervention, working closely with installers and others in the private sector and with local government, is required to ensure that the skills that employers need are available at the required scale on a timely basis.

It is vital that the policy framework also prepares to scale up inspections and enforcement activity to ensure householders genuinely get what they have paid for, and see the savings realised through their energy bills.

Box 3.3
Current and future skills needs

There is an urgent need to upskill our workforce, both to meet current building standards, and to meet the immediate-term challenges ahead.

Skills issues exist for the standards and needs we have today. Deficits have been identified in areas such as repair and maintenance, and work on traditional buildings.[32] Skills deficits are expected to be a major contributor to the current performance gap.[33]

On top of this, the sector remains unequipped for the major and immediate-term challenges ahead. The chopping and changing of UK Government policy has inhibited skills development in design, construction and in the installation of new measures. An upcoming report by the CITB identifies low demand for skills and training linked to Net Zero, and finds the current training supply not yet 'Net Zero ready'. A survey undertaken for the CITB revealed that 78% of respondents considered there to be a skills gap in their occupation/profession for decarbonisation. [34]

This is a solvable issue. The same survey found that 90% of respondents would be willing to retrain, with a similar percentage willing to diversify their business offer or profession. External funding to cover some or all of the cost of training, and receiving an accredited qualification, were seen as the most important factors when undertaking decarbonisation retraining or upskilling.[35] Progress in standards has also been seen; a good case study is the PAS 2030 standard which addressed the need to look at ventilation alongside energy efficiency; PAS 2035 also represents a major step forward.

The CITB find that a rapid increase in skills capacity is needed, with large-scale re-skilling of the existing workforce and key structural issues addressed; including build quality, sector reputation and training readiness. All parties - Government, industry and the training sector – have responsibilities to deliver this. Actions for Government identified by the CITB include a clear decarbonisation policy framework; a planned approach to skills provision to balance immediate with future needs (with the recently launched Green Jobs Taskforce being a route to deliver this); requirements on the use of retrofit standards and a redesign building regulations around as-built performance; and support for SME innovation.

Sources: CITB (2020) Building Skills for Net Zero (draft report); CCC analysis.

d) Getting on with it

A mix of solutions displacing gas heating, and in particular any regional role for hydrogen in the gas grid, will not be achievable without a strategic, coordinated and planned approach to deliver heat decarbonisation.

A mix of solutions displacing gas heating, and in particular any regional role for hydrogen in the gas grid, will not be achievable without a strategic, coordinated and planned approach. Institutional frameworks will need to evolve, and national, regional and local decision-making frameworks will need to be determined in order to deliver this. Regional and local area energy planning and engagement can also minimise disruption and inform timely network investment.

While Area-based Energy Planning is not the whole solution, where underpinned by a robust methodology, it can provide better information to facilitate the process and is a hook to engage the public. A coordinated and planned rollout will also ensure that electricity network upgrades can be delivered in time and at reasonable cost (Box 3.4). This is particularly urgent in areas off the gas grid.

The Energy Systems Catapult estimates that the total cost for undertaking detailed-planning across Great Britain is £80-100 million – less than 0.5% of the costs of the transition in buildings.

In the immediate term, a better understanding at a national level of suitable candidate areas for hydrogen – together with areas which are clearly unsuitable – can help target investment in the gas grid better and enable targeted progress on electrification. BEIS and Ofgem would be well-placed to collaborate on a major study to identify prime candidate areas for hydrogen or full electrification, with input from networks on current capacity.[36]

Beyond this, there are a number of options for addressing the governance gap over the next decade and facilitating a set of decisions on the future of the gas grid in different parts of the UK, including Pathfinder Cities and other regional and local demonstrators, a new Heat Delivery and heat zoning:

- **Pathfinder Cities/areas.** Building on the approach signalled in the Ten Point Plan and existing demonstrators, these offer a route to scaling up, engaging the public and improving our understanding of system integration challenges. A BEIS/MHCLG-led process could identify up to three areas for demonstrators 2025-2030 plus pipeline for 2030s. 2025 local council elections are an opportunity to test with the public.
- **Heat Delivery Body.** The CBI and Birmingham University Heat Commission has recommended that a new heat delivery body be established to formalise governance structures and coordinate national, regional and local government.[37]
- **Next set of Local Area Energy Plan pilots, with full rollout after 2025**. Part of the focus will need to be in areas off the gas grid to inform network investment, given more rapid timelines.
- **Zoning for heat networks.** Given the spatial nature of heat networks and the importance of managing demand-risk, a zoning approach supported by policy such as licensing will help provide a robust framework for deployment at scale.

Government should aim to move forward with an equivalent set of proposals in its forthcoming strategy.

Box 3.4
The need for further strategic planning and local evidence to inform infrastructure investments

We surveyed UK Distribution Network Operators earlier this year to understand and gather views on preparedness of distribution networks for Net Zero delivery. All six respondents considered indicative electric vehicle and heat pump pathways to 2035 to be achievable 'if certain conditions are met' (particularly from a regulatory framework perspective) but levels of heat pump deployment in particular were more aggressive than a number have previously been planning for.

DNOs stressed the need for careful coordination and forward planning if this is to be achievable – and to control costs.
It was noted that significant cost savings could be achieved where EV and electric heat rollout is planned and coordinated such that streets only need to be dug once for cable upgrades, with one DNO quoting 85% of the costs of low voltage upgrades being excavations. This is supported by previous analysis from Vivid Economics and Imperial College London.[38] One suggested meeting net zero to be 'impossible' without planned and coordinated approach.

Policy recommendations included: the need for a ten-year strategy (including target heating fuels for different segments and timelines for transition); coordinated/regional rollout including taking a whole energy systems approach; valuing flexible loads; making charging cost reflective; and a focus on fairness/protecting the vulnerable. Network upgrade lead times were reported as ranging from a matter of weeks to up to eight years depending a wide range of factors relating to the specific upgrade needed.

Similar themes around the importance of co-ordination emerged from our Call for Evidence, where respondents argued that an uncoordinated approach to the decarbonisation of heat could put the net-zero target at risk if the different infrastructure requirements are not in place to support different solutions. A piecemeal approach was also seen to risk increasing costs (e.g. reducing economies of scale, and leading to unnecessary investment in multiple infrastructure networks).[39]

Source: CCC analysis

Endnotes

[1] Element Energy and UCL for CCC (2019) *Analysis on abating direct emission from hard-to-decarbonise homes*

[2] MHCLG (2019) Annex Table 1.2: Energy efficiency rating bands, by tenure, 2008, 2013 and 2018', *English Housing Survey: Energy efficiency, 2018-19*;

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[4] Scottish Government (2018) *Housing statistics: Stock by tenure*

[5] Stats Wales (2020) *Dwelling stock estimates by year and tenure*

[6] Department for Communities (2019) 'Northern Ireland Housing Statistics 2018-19 Section 1 Tables - Supply', *Northern Ireland Housing Statistics 2018-19*

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[8] BEIS (2020b) 'Cross-tabulation tables', BEIS Public Attitudes Tracker: Wave 32.

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[15] Imperial College (2018) *Analysis of alternative heat decarbonisation pathways*

[16] Element Energy and UCL for CCC (2019) *Analysis on abating direct emission from hard-to-decarbonise homes*

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[22] BEIS (2020e) 'Public Sector Low Carbon Skills Fund' https://www.gov.uk/government/publications/public-sector-low-carbon-skills-fund

[23] BEIS (2020f) 'Boosting access for SMEs to energy efficiency (BASEE) competition: winning projects' https://www.gov.uk/government/publications/boosting-access-for-smes-to-energy-efficiency-basee-competition-winning-projects

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[30] Dr Peter Mallaburn, UCL for the CCC (2016) *A new approach to non-domestic energy efficiency policy*

[31] CCC (2016) *Next steps for UK heat policy*

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Chapter 4

Manufacturing and construction

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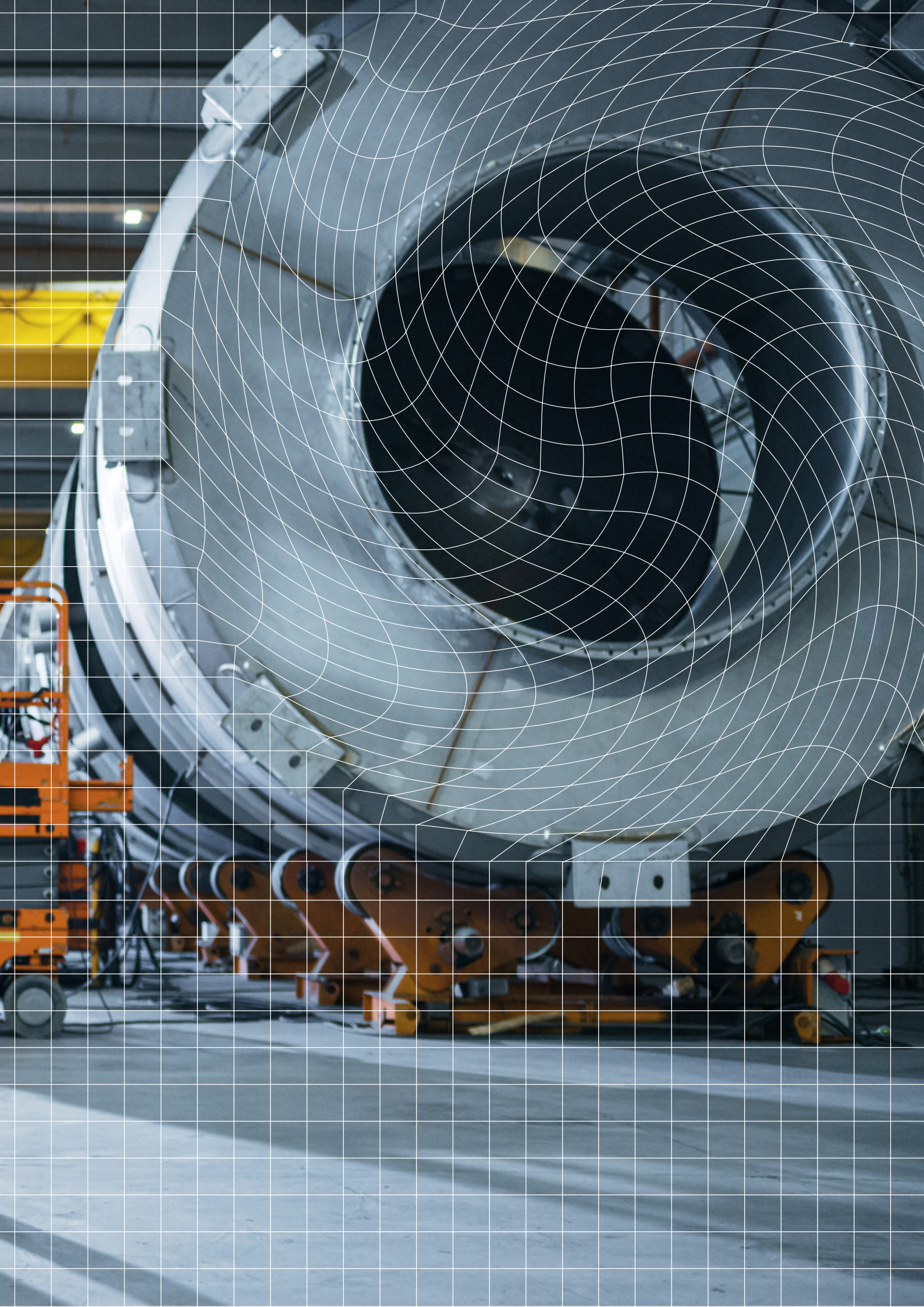


Table 4.1
Summary of policy recommendations for manufacturing and construction

Setting vision and ambition	Set out a comprehensive, ambitious vision for decarbonisation of manufacturing and construction. • The Government's Industrial Decarbonisation Strategy should provide a clear vision of the long-term policy mechanisms for industrial decarbonisation, including how policy will maintain the competitiveness of UK manufacturing on the path to Net Zero. • To indicate ambition, Government should set targets for ore-based steelmaking and cement production in the UK to reach near-zero emissions by 2035 and 2040, respectively. This is crucial to build momentum following the step-change in ambition necessitated by Net Zero. • Decarbonisation of off-road mobile machinery should not be omitted from the Government's set of plans and strategies.
Maintaining competitiveness	The design of policies to reduce UK manufacturing emissions must ensure that it does not damage UK manufacturers' competitiveness and drive manufacturing overseas. • In the near term, taxpayer funding should be used to support deep decarbonisation in manufacturing sectors at risk of carbon leakage. • Work should begin immediately to develop the longer-term options of applying either border carbon tariffs or minimum standards to imports of selected emissions-intense products. This should include developing carbon intensity measurement standards, mandating these are disclosed and fostering international consensus around trade policies through the G7 and COP presidencies.
Funding for fuel switching and CCS	• Establish funding mechanism(s) to support operational and capital costs of both electrification and hydrogen-use in manufacturing, to be awarded from 2022. • Finalise the Contract for Difference mechanism to support industrial CCS. • Continue to support innovation and demonstration of fuel switching and CCS technologies.
Resource and energy efficiency	• Extend consumer product standards to cover how a product is made. • Work towards introducing a mandatory minimum whole-life carbon standard for both buildings and infrastructure.
Strengthening market mechanisms	• Create a clear incentive for non-traded manufacturing sectors to switch to lower-carbon energy sources by reforming energy and carbon pricing. • Strengthen carbon prices and taxes on manufacturers. • Reform electricity pricing to reflect the much lower costs of supplying low-carbon electricity in the mid-2020s and beyond. • Address manufacturers' low appetite for risk, either though loans or grants.
Infrastructure development	• Establish at least two CCS clusters in the mid-2020s, at least four by the late 2020s, and further clusters around 2030. • Work with the minerals industries to develop a detailed joint plan for CO_2 transport from dispersed sites. • Prepare to make decisions about whether initial areas of the gas transmission and distribution networks should be converted to hydrogen. • Plan for a potential increase in large localised network reinforcements for manufacturers.
Jobs and skills	• Design industrial decarbonisation policies to support and create jobs, especially in regions with reliance on industrial jobs. Prompt award of existing funding can help the recovery. • Develop the capacity of skills and supply chains.

The adoption of the Net Zero target means a step-change in ambition for decarbonisation of UK manufacturing. Improvements in the evidence base also support going considerably further than the pathway in our Fifth Carbon Budget advice from 2015.

In order to drive the necessary changes in manufacturing and construction set out in Chapter 3 of our *Advice report*, it will be necessary to move from the current piecemeal set of policies, to a framework that drives ambitious decarbonisation across the sector, without undermining the competitiveness of UK industries (see Chapter 6 of the *Advice report*). Table 4.1 sets out a summary of our key recommendations for how to enable this transition.

Alongside this report we have published three pieces of supporting work on policies for industrial decarbonisation.[1,2,3]

In this chapter we set out:

1. The existing set of manufacturing and construction decarbonisation policies;
2. What policy is required to deliver our Balanced Pathway, in particular from the Industrial Decarbonisation Strategy.

There are several policies in place to support decarbonisation of manufacturing and construction. These can be broadly grouped into (a) capital funding, (b) ongoing decarbonisation incentives, (c) energy and resource efficiency policies, and (d) strategy development. However, the level of ambition is insufficient, the policies are frequently piecemeal, and recent progress on several existing policies has been slow.

a) Capital funding

Existing capital funding for manufacturing decarbonisation is worth around £800m.

The past three years have seen the launch of several capital funding schemes for innovation and deployment of established decarbonisation measures in the manufacturing and construction sector. Their total value is around £800m (Table 4.2), and around £35m has so far been awarded through these schemes. The Budget also suggested that the Energy Innovation Programme will support the development of near-zero GHG emission off-road mobile machinery.

In addition, there has been wider funding for carbon capture and storage (CCS), including a commitment to provide £1bn (increased from £800m previously) for CO_2 transport and storage infrastructure in the recent 10 Point Plan.[4] A further £20m was spent on carbon capture, use and storage (CCUS) innovation through the Energy Innovation Fund.

The Clean Heat Grant will also provide upfront support for the use of heat pumps at up to 45kW capacity, which is applicable to some space heating of manufacturers' buildings, a small fraction of overall manufacturing emissions.[5]

Table 4.2
Summary of capital funds for manufacturing decarbonisation

	Scope	Public funding	Awarded to date	Spending timeline
Industrial Energy Transformation Fund	Manufacturing decarbonisation	£315m	£0m	Announced 2018. To be spent by firms by 2024.
Clean Steel Fund	Steel decarbonisation	£250m	£0m	Announced August 2019. To be spent by Government from 2024.
Industrial Decarbonisation Challenge	CCS and fuel switching sites within clusters	£170m	£10m	Announced 2018. To be spent by firms by 2024.
Transforming Foundation Industries Challenge	Energy and resource efficiency	£66m	£5m	Announced 2018. To be spent by firms by 2024.
Industrial Fuel Switching (Energy Innovation Fund)	Fuel switching pilots	£20m	£20m	Announced 2018. Awarded.
Green Distilleries Fund[6]	Fuel switching in distilleries	£10m	£0m	Announced 2020. To be spent by firms by 2023.
Off-road mobile machinery (Energy Innovation Fund)	Machinery previously using red diesel	Unknown	£0m	Unknown, suggested in 2020 Budget.

b) Ongoing decarbonisation incentives

Government plans to bring forward a Contract for Difference to support the operational costs of industrial CCS.

There are several policies that provide or propose insufficient or piecemeal ongoing incentives for deep decarbonisation in the manufacturing sector:

- The EU ETS and its successor from January 2021 (either an UK ETS or emissions tax)* provides some ongoing incentive, although the carbon price has been too low to incentivise most deep decarbonisation measures. Free allowances are allocated to companies deemed to be at risk of carbon leakage.
- BEIS have committed to bring forward details of an industrial CCS Contract for Difference (CfD) in 2021 which would support the operational costs of manufacturing and refining CCUS. [7,8]
- The 2020 Budget's removal of red diesel tax relief for industrial off-road mobile machinery from 2022 will help to encourage deployment of low-carbon off-road mobile machinery.[9]
- The Non-Domestic Renewable Heat Incentive has provided some limited support for the use of low-carbon heat in manufacturing. This will close in March 2022.

c) Energy and resource efficiency policies

In addition to the proposed capital funding from the Industrial Energy Transformation Fund and Transforming Foundation Industries Fund (Table 4.2), there are several policies that help to improve energy and resource efficiency.

- The Climate Change Levy and Climate Change Agreements (CCA) provide an incentive for energy efficiency. The 2020 Budget confirmed plans for CCAs to run until March 2025.
- Other policies to improve energy efficiency include Streamlined Energy and Carbon Reporting, Ecodesign and Energy Information (labelling) regulations, Energy Savings Opportunities Scheme, Industrial Heat Recovery Scheme as well as Buildings Regulations.

The Environment Bill is creating new powers for Government to improve resource efficiency.

- The 2019-21 Environment Bill includes provisions to deliver the 2018 Resources and Waste Strategy.[10] It includes powers to extend producer responsibilities, to incentivise producers to prevent products or materials from becoming waste and promote reuse and recycling of products or materials. It also provides powers for Government to set product standards and extend the charge on single-use plastics beyond carrier bags. It builds on the Circular Economy Package which transposed several EU regulations focused on reducing waste and improving recycling into UK law.

d) Strategy development

The Government plans to set out its vision for a low-carbon UK industrial sector in spring 2021 in its Industrial Decarbonisation Strategy.

The Government is planning to publish an Industrial Decarbonisation Strategy in spring 2021, which will set out its vision for "a prosperous, low carbon UK industrial sector" in 2050, that can "support industrial competitiveness and the green recovery" and identify "opportunities for new markets and sectors to develop". The strategy's sectoral scope includes manufacturing and refining, but not off-road mobile machinery.

* Yet to be announced at the time of writing

2. What is needed from the Industrial Decarbonisation Strategy

The Industrial Decarbonisation Strategy and wider Government policy should be comprehensive, provide a clear vision and be integrated with wider policy.

Substantial gaps and weaknesses remain in the Government's set of policies for decarbonisation of manufacturing and construction. We have identified gaps, weaknesses, or areas for continued focus in the following areas:

a) **An overarching strategy**. Current policy on decarbonising manufacturing is piecemeal and needs an overarching strategy.

b) **Supporting green jobs and the recovery.** Government should support and create jobs through its industrial decarbonisation policies.

c) **A plan for competitiveness consistent with Net Zero**. Free allowance allocation may not be the most efficient way to achieve the combined goals of deep decarbonisation and avoiding carbon leakage, in future.

d) **Carbon and electricity pricing for decarbonisation.** Existing carbon pricing is too weak and not applied to non-traded manufacturers, and electricity prices do not reflect costs appropriately.

e) **Addressing manufacturers' appetite for risk**. UK manufacturers typically require investments to pay back within at least a few years.

f) **Funding mechanisms for deep decarbonisation.** Policy lacks support for electrification and is too limited to upfront rather than ongoing costs.

g) **Support for innovation and demonstration**. A range of key technologies still require development.

h) **Policy to improve resource efficiency, energy efficiency and material substitution**. There are gaps in policy to support more resource efficient products and construction.

i) **Off-road mobile machinery**. This area appears to have fallen through the gaps between Government Departments and planned strategies.

j) **Infrastructure development**. Electricity, hydrogen and CO_2 networks will all require development or upgrade.

k) **Target dates**. Current ambition on manufacturing decarbonisation is insufficient.

l) **Skills.** The capacity of skills and supply chain needs to be encouraged.

The Government's upcoming Industrial Decarbonisation Strategy, policies to improve resource efficiency and future policy on off-road mobile machinery should address the gaps and weaknesses. We set out below our recommendations in these twelve areas.

a) An overarching strategy

Current policy on decarbonising manufacturing and construction is piecemeal. An overarching strategy is necessary to drive the changes necessary for Net Zero.

Government should publish an Industrial Decarbonisation Strategy in early 2021 that is comprehensive, provides a clear vision and is integrated with wider policy.

- **Comprehensive**. The strategy should address the gaps, weaknesses and areas for continued focus that we have identified. It should clearly cover all manufacturing emissions within the scope – areas that have fallen out of scope (off-road mobile machinery) should be clearly covered elsewhere (see subsection (i)).
- **Clear vision**. It should provide a clear vision of the long-term policy mechanisms for industrial decarbonisation. This is crucial to shift expectations and build momentum for decarbonisation of manufacturing.
- **Integrated**. It should set out how industrial decarbonisation policy will integrate with other strategies including the Hydrogen Strategy, National Infrastructure Strategy, Heat and Buildings Strategy and Energy White Paper.

b) Policy to support jobs and the recovery

Government should design its industrial decarbonisation policies to support and create jobs, especially in regions with high reliance on industrial jobs.

In our Progress Report in June, we recommended that Government should design its industrial decarbonisation policies to support and create jobs, especially in regions with high reliance on industrial jobs. The Government's recent Ten Point Plan recognises this opportunity for "economic transformation of the UK's industrial regions".

Prompt award of existing funding can help the recovery.

Opportunities remain for the immediate future. Several funding schemes that have already launched (see Table 4.2) can both support jobs and urgent priorities, including demonstration of industrial fuel switching and CCS technologies, development of industrial decarbonisation projects and the creation of a skilled workforce and strong supply chain. Government should take this dual opportunity, by ensuring prompt award through these schemes and by increasing the ambition of the schemes.

Chapter 6, Section 1 of our *Advice report* talks further about the implications and opportunities for employment.

c) A plan for competitiveness consistent with Net Zero

The design of policies to reduce UK manufacturing emissions must ensure that it does not damage UK competitiveness, leading to 'carbon leakage'.

The design of policies to reduce UK manufacturing emissions must ensure that it does not damage UK manufacturers' competitiveness and drive manufacturing overseas ('carbon leakage'). This would not help to reduce global emissions and would be damaging to the UK economy. This is an important consideration for the Committee. Our *Advice report* (Chapter 6, Section 2) sets out details of three pieces of work, published alongside this report, that we have commissioned or collaborated on to improve our understanding of the policy options.[11,12,13] It also provides further details of the international context.

A key existing approach to decarbonise manufacturing without causing carbon leakage is to require large manufacturers to pay for emissions allowances from an Emissions Trading Scheme (ETS),* but to provide a free allowance allocation to manufacturers at risk of carbon leakage, which they may sell or use to cover their emissions.

* Currently the EU ETS. From January 2021, the EU ETS will be replaced in the UK by either an equivalent UK ETS or a UK emissions tax.

This combination of an ETS with free allowance allocation, *alone*, may not be the most efficient way to achieve the combined goals of deep decarbonisation and avoiding carbon leakage, in future.

An emissions trading scheme combined with free allowances, alone, is unlikely to provide a sufficient incentive to enable deep decarbonisation in the near term.

- **Free allowance allocation within an ETS** can protect competitiveness, but this combination alone is unlikely to provide a sufficient incentive to enable deep decarbonisation of manufacturing. In the longer term, there may be further issues, including relating to liquidity and consumption emissions.
  - The policy is unlikely to provide sufficient incentive to enable deep decarbonisation as a) costs for early manufacturing deep decarbonisation deployment will likely come at a premium above expected carbon prices b) the uncertainty of the carbon price level adds a further risk premium to costs. c) upfront capital support is likely to be required by manufacturers that seek very short payback periods (in addition to an ongoing carbon price incentive).
  - If a carbon tax combined with rebates or exemptions is implemented from January 2021 instead of a trading system, this is likely to reduce incentives for deep manufacturing decarbonisation further.*
  - The existing EU ETS (and potential subsequent UK ETS) plans to reduce free allowance allocation over the 2020s, which has left some companies concerned at the level of protection.
  - In the longer term, as the ETS cap falls, it may suffer from liquidity issues if a large proportion (or even 100%) of participants continue to be awarded free allowances.
  - This approach does not have the potential to reduce imported consumption emissions, which may be a longer-term consideration.

Taxpayer funding, border carbon tariffs and minimum standards offer alternative approaches.

Alternative approaches to enabling deep decarbonisation of manufacturing, while avoiding carbon leakage include taxpayer funding, carbon pricing combined with border carbon tariffs, and minimum standards. In the near term, taxpayer funding should be used to support deep decarbonisation in manufacturing sectors at risk of carbon leakage given the lead-times for other approaches and the need to make progress on decarbonisation over the 2020s.

Taxpayer funded policies should be used in the near term to enable deep decarbonisation and avoid carbon leakage.

- **Taxpayer funding** of manufacturing deep decarbonisation projects would maintain industrial competitiveness and bring down project cost of capital.
  - Government has consulted on a Contract for Difference scheme to support both some capital and operational costs of industrial CCS projects. This, or other funding approaches, should be rolled out more widely across deep industrial decarbonisation.
  - Given the estimated costs of our scenarios set out in Chapter 3 of our *Advice report*, and that only part of industry is at risk of carbon leakage, the required exchequer support to decarbonise manufacturers at risk of carbon leakage would be around £2-3 billion per year in the early 2030s, assuming manufacturers do not face legacy policy costs on their electricity bills (see subsection (d)).

* As companies would no longer be able to sell their free allowances if they decarbonise, which provides an incentive.

- **Border carbon tariffs*** would raise the price of high-carbon imported goods, by ensuring that they were subject to an equivalent carbon price to that faced by UK manufacturers.
  - Under this approach, manufacturers would pay for their emissions reductions, which could then be passed through to consumers in higher prices without competitiveness impacts. It would also send a signal to other manufacturing countries to decarbonise their production.
  - This approach, and minimum standards (below), have challenges associated with measuring the carbon intensity of imports and international trade tension.
  - The EU and the new US administration have both announced plans to introduce border carbon tariffs.
- **Minimum standards** applied to imported goods (in line with domestic standards) could also enable domestic production to decarbonise without threat of being undercut by high-carbon imports.
  - Standards could be applied on producers of goods or on purchasers, and applied at the primary, intermediary or tertiary product stage.† As with border carbon tariffs, this would lead to a premium price for low-carbon goods meaning that consumers would bear the cost.
  - Standards mandating near-zero-carbon intensity may need to be introduced later than the more flexible border carbon tariffs. Other formulations of standards may have an earlier role, either through partial reductions on carbon intensity of products or production, or indirectly through other requirements, such as resource efficiency requirements. Public procurement may also have a role.

Policies to protect competitiveness are likely to need to transition from being taxpayer-funded in the near-term towards applying border carbon tariffs or minimum standards.

Following initial taxpayer funding, the broad pathway is likely to need to involve a transition towards border carbon tariffs or minimum standards, or border carbon tariffs followed by minimum standards (Figure 4.1).

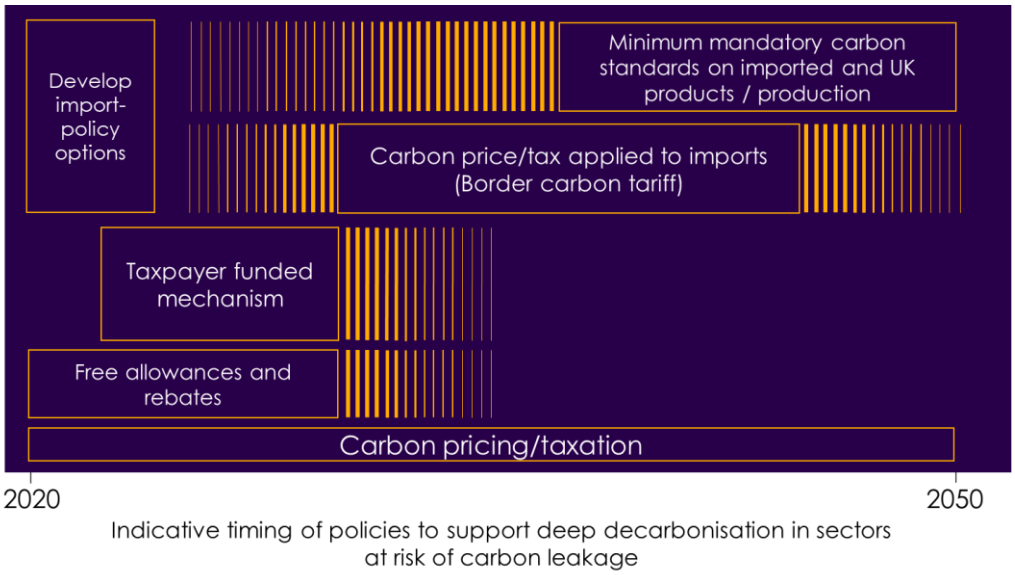
This transition reflects the likelihood that Government would seek to pass costs through to industry and subsequently consumers, once there is an alternative to subsidy mechanisms. The timing of this transition might be delayed in some areas where other benefits of subsidy approaches (such as reducing the risk from carbon pricing) make them desirable for longer. We estimate that providing support in this way would cost the exchequer around £2-3bn per year in the early 2030s, after which taxpayer support would fall.‡

* These are typically referred to as border carbon adjustments (BCA); however, some stakeholders also use the term BCAs to encompass the application of standards at the border, which we treat separately. Therefore, we use the border carbon tariff terminology for clarity.

† Primary product: This would be an unmanufactured product, consisting of a raw material. Intermediary product: A product that is manufactured or produced from a primary product intended for use in a secondary product. It can include steel or concrete, milk, or a car engine. Tertiary product: The final product for end use or consumption. In agriculture and food, this would include ice cream; in fashion a dress; in building and construction a building and in automotive manufacturing a vehicle.

‡ assuming manufacturers do not face legacy policy costs on their electricity bills (see subsection (d)).

Figure 4.1 Indicative timings of policies to achieve the combined goals of deep decarbonisation and avoiding carbon leakage



Source: CCC analysis
Notes: Dashed lines reflect uncertainty and complexity. For example, standards could represent standards of differing ambition. Policies would likely apply to different products/sectors at different times. Taxpayer funding range intended to indicate first year of support (for example, for a CfD contract, which may then last for several years).

Work should begin immediately to develop the longer-term options of applying either border carbon tariffs or minimum standards to imports of selected emissions-intense products

Work should begin immediately to develop the longer-term options of applying either border carbon tariffs or minimum standards to imports of selected emissions-intense products. This will provide Governments with the option to reduce the proportion of the cost of manufacturing decarbonisation that is borne by the taxpayer. With these options developed, Government will be able to decide on the appropriate mix of instruments, in consultation with the affected industrial sectors. It is particularly crucial to start work now, as many of the barriers could take substantial time to overcome.

This will require developing carbon intensity measurement standards, mandating that these are disclosed and fostering international consensus around trade policies.

To develop the longer-term options of applying either border carbon tariffs or minimum standards to imports Government should:

- **Develop carbon intensity (or broader) measurement standards** for selected industrial products and industrial processes, by working with industry and the international community.
- **Mandate disclosure** of the carbon intensity (as defined by the new measurement standards) for selected industrial products and industrial processes in the early to mid-2020s.
- **Foster international consensus** surrounding future carbon border/trade policy for products, using the UK 2021 G7 and COP presidencies. This will likely require engagement with the World Trade Organisation (WTO), to ensure future policy is developed to be WTO compliant.

While the assessment above focuses on traded* manufacturing, the principles are also applicable to non-traded manufacturing at risk of carbon leakage. However, for these sectors a basic incentive for decarbonisation, such as a carbon price is required first (see subsection (d) below).

* Those companies currently covered by the EU Emissions Trading Scheme

Policies that apply to the carbon intensity of imports would also likely reduce the imported element of our consumption emissions.

We note that some of the policies above are more obviously applied to imports to provide a level playing field for UK producers, but they could also be applied to UK exporters. For example, border tariffs could also involve rebates to exports from UK firms that have reduced emissions without full taxpayer support.

Policies that apply to the carbon intensity of imports would also likely reduce the imported element of our consumption emissions. Chapter 3, Section 3 of our *Advice report* sets out an indicative effect on consumptions emissions under our Balanced Pathway, taking into consideration two different levels of international climate action.

d) Carbon and electricity pricing for decarbonisation

There are several gaps or weaknesses in the existing and emerging set of incentives for decarbonising manufacturing.

- There is not a clear carbon price on manufacturers in the non-traded sector (i.e. those not in scope of the existing EU ETS).
- The strength of carbon prices applying to manufacturers is typically insufficient to drive action in line with our Balanced Pathway.
- Electricity prices are well in excess of costs that would reflect supplying extra low-carbon electricity.

i) Create a clear decarbonisation signal in the non-traded sector

There is not a clear carbon price on manufacturers in the non-traded sector. The closest policy is the Climate Change Levy (CCL), which is a tax on energy use that has been levied since 2001. The main CCL rate is currently 66% higher on electricity than gas, with a higher rebate applied on electricity (92%) than gas (83%) for Climate Change Agreement (CCA) holders.* While Government plans to equalise the tax on electricity and gas by 2025, this will still not provide an incentive for non-CCA holders to use electricity over gas.

Government should create a clear decarbonisation signal for the non-traded sector.

Government should reform overall energy and carbon pricing so that there is an incentive to switch to lower-carbon energy sources in the non-traded manufacturing sectors. Two options to achieve this are:

- Extend the future traded sector carbon pricing policy (either a UK ETS or emissions tax) to the existing non-traded sector.
- Reform the Climate Change Levy towards reflecting carbon content, so that electrification is clearly incentivised. If this approach is taken, there may be value in reviewing the role of Climate Change Agreements as the mechanism to incentivise electrical energy efficiency and protect sectors at risk of carbon leakage.

* Applies to 43% of 'industry' energy use - BEIS (2020) Evaluation of the second Climate Change Agreements scheme.

Carbon prices and taxes should be strengthened.

ii) Strengthen carbon pricing

Carbon prices and taxes on manufacturers are currently below the levels that we estimate are consistent with our Balanced Net Zero Pathway.

We recommend that carbon prices and taxes on manufacturers should be strengthened, while we recognise that this may not be the only policy mechanism to support decarbonisation.

- For the traded sector, if the UK has an ETS from January 2021, this strengthening can be achieved by using our Balanced Net Zero Pathway to set the cap for the UK ETS (see Chapter 10 of the *Advice report*).
- For the non-traded sector, a tax, or equivalent, should be set well above the existing levels from the EU ETS to enable our Balanced Net Zero Pathway. This will require the non-traded sector to be covered by some form of carbon pricing, as recommended above.

All carbon pricing should be designed to include measures that protect against carbon leakage, as set out in subsection (c).

iii) Ensure cost-reflective electricity pricing

Electricity pricing should be reformed to reflect the much lower costs of supplying low-carbon electricity in the mid-2020s and beyond.

At present, industrial electricity prices are well in excess of the costs that would reflect supplying extra low-carbon electricity (e.g. from additional inexpensive extra offshore wind). This difference is a barrier to electrification in manufacturing (and other sectors - see Chapter 6 of the *Advice Report*).

We recommend that electricity pricing is reformed to reflect the much lower costs of supplying low-carbon electricity in the mid-2020s and beyond, so that electrification can play a cost-effective contribution to decarbonisation.

e) Addressing manufacturers' appetite for risk

Government should establish policies that address manufacturers' low appetite for risk, either though loans or grants.

UK manufacturers typically require investments to pay back within at least few years, shorter than required by most other businesses. This reflects a lower appetite for risk and is a barrier to investment in measures to decarbonise manufacturing.

Government should establish policies that address this lower appetite for risk. There are two clear options:

- Government could seek to provide tailored loans for manufacturers, that reduce risk to manufacturers and enable them to invest. This could involve below-market-rate loans or be delivered through the new National Infrastructure Bank. This approach may also need to address the reluctance of some manufacturers to take loans onto their balance sheets. Chapter 1 contains further recommendations on financing.
- Government could provide capital grants, potentially embedded within policies. The draft Contract for Difference for industrial CCUS proposes to include an element of capital funding. The Industrial Energy Transformation Fund is considering grants to support energy efficiency measures that have longer payback periods.

Government should establish funding mechanism(s) to support upfront and operational costs for both electrification and hydrogen use in manufacturing – this is currently a clear policy gap.

f) Funding mechanisms for deep decarbonisation measures

Electrification, use of hydrogen and application of CCS all scale up from 2025 in our Balanced Pathway for the manufacturing sector. This will require a funding mechanism or business model to enable this early deployment. However, current policies and proposals do not consider a business model to support electrification* or the use of hydrogen and are too limited to supporting upfront costs rather than ongoing operational costs.

Government should establish funding mechanism(s) to enable both electrification and hydrogen-use in manufacturing.

- The mechanism(s) will need to support the operational costs of these measures, as well as some of the upfront costs.
- This could be achieved by extending the proposed industrial CCUS Contract for Difference, in a similar way to the Netherlands' Sustainable Energy Transition Scheme.
- The mechanism(s) should award to projects from 2022, to enable deployment from 2025.

Government should also finalise the Contract for Difference mechanism to support industrial CCS, to enable manufacturing CCS projects to be operating in 2025. Bioenergy with CCS and waste with CCS should also be considered within these mechanisms.

It is likely that funding mechanisms will be required across the different parts of manufacturing in the early stages of deployment: traded and non-traded, and sectors at (and not at) risk of carbon leakage. A transition away from initial funding should be a lot faster for sectors not at risk of carbon leakage.

The development of such mechanisms can help to drive investment in UK manufacturing, by reducing the policy risk that exists as a result of a lack of clear climate change policy for manufacturers.

g) Support for innovation and demonstration

Demonstration projects are needed to enhance industry confidence in novel technologies.

The manufacturing and construction sector is diverse, involving a wide variety of different industrial processes, which will require different low-carbon technologies. Analysis we commissioned from Element Energy sets out many of these technologies.[14] Several of these technologies required for Net Zero are still at earlier stages of development and require support for development. The Government has provided some initial support through its Energy Innovation Programme.

Government should provide further support for innovation and demonstration. These demonstration projects are needed to enhance industry confidence in novel technologies, enable a better understanding of costs and requirements of different options and keep options open for different future scenarios.

* Beyond the very limited industrial application of the Non-Domestic Renewable Heat Incentive.

h) Policy to improve resource efficiency, energy efficiency and enable material substitution

Our Balanced Net Zero Pathway includes a range of resource efficiency, energy efficiency and material substitution measures. The measures can broadly be split between the following groups.

- Consumer product related measures, including increasing product longevity; increasing product utilisation and sharing; optimising product design to reduce material inputs; and increasing recycling and reuse of products.
- Construction related measures, including optimising construction designs to reduce material inputs; increasing reuse and recycling of construction materials and material substitution.
- Manufacturing energy efficiency improvement measures.

Carbon and energy incentives (subsection (d)) and policy to address manufacturers' appetite for risk (subsection (e)) can help to encourage some of these measures, but in many cases non-financial policy is required. We set out policy recommendations to encourage the three groups of measures below.

i) Consumer products

Government should extend product standards to cover how a product is made.

The Government is taking steps to improve the resource efficiency associated with products, including through the Environment Bill's new provisions. However, the Government should go further. The Government should:

- Ensure continuous improvement to product standards, building on the success of the Ecodesign regulation. Coverage should expand to include major consumer goods and extend to consider how a product is made, through resource efficiency indicators such as the level of recycled content and critical material content, as well as how repairable, durable and upgradeable a product is.
- Consider whether the forthcoming plastics tax should be expanded to cover other single-use materials.
- Work with business to develop policies to facilitate more sustainable consumer behaviour such as incentivising the use of car clubs and 'libraries of things', discouraging 'disposable' business models such as fast fashion.

ii) Construction

Government should work towards introducing a mandatory minimum whole-life carbon standard for both buildings and infrastructure.

There are currently few policies in place to improve resource efficiency and incentivise material substitution within construction of assets such as buildings and infrastructure.[15] Standardised approaches to calculating embodied carbon at a building or infrastructure level are largely voluntary. To improve resource efficiency and incentivise material substitution within construction the Government should:

- Work with industry to agree a standard for the 'whole-life' carbon footprint of buildings and infrastructure.
- Introduce mandatory disclosure of whole-life carbon in buildings and infrastructure to facilitate benchmarking as soon as possible.

- Following this, introduce a mandatory minimum whole-life carbon standard for both buildings and infrastructure which strengthens over time, with differentiated targets by function and usage. For homes, this standard should be included within the Future Homes Standard.

This could also provide a driver for decarbonising construction materials such as steel and cement. However, we do not think this should be the primary measure to support the initial uptake of transformative measures such as fuel-switching and CCS in these sectors. This is because steel and cement plants typically have a diverse set of customers, for which coordination would be challenging for this demand-side policy. This standard may also provide a route to decarbonising off-road mobile machinery on construction sites (see subsection (i)).

iii) Manufacturers' energy efficiency

A range of schemes currently support energy efficiency. Ambition will need to be tightened to meet our Balanced Pathway, including by strengthening energy and carbon pricing (subsection (d)) and addressing manufacturers' low appetite for risk (subsection (e)).

There may be room for simplifying energy efficiency policy, for example by merging SECR and ESOS.

The Government could also consider strengthening enabling policies, such as mandating the use of Energy Management Systems. There may also be room for simplifying policy, for example by merging Streamlined Energy and Carbon Reporting (SECR) and the Energy Savings Opportunities Scheme (ESOS). Furthermore, Climate Change Agreements may require reform, after the upcoming round (see subsection(d)).

i) Off-road mobile machinery

Policy on off-road mobile machinery appears to have largely fallen through the gaps between Government Departments and planned strategies.

Policy on off-road mobile machinery appears to have largely fallen through the gaps between Government Departments and planned strategies. However, with emissions of around 12 $MtCO_2e$ in 2018 from off-road mobile machinery across sectors* (around half the emissions of Heavy Goods Vehicles), this area should not be ignored. This is emphasised by recent research suggesting that products of such low-carbon machinery may be an area of competitive advantage for the UK.[16]

We recommend that, failing its inclusion in either the Industrial Decarbonisation Strategy, Heat and Buildings Strategy or Transport Decarbonisation Strategy, it should be covered by the Net Zero Strategy.

This should set out a clear plan to develop near-zero emission off-road mobile machinery (ORMM) for applications where these are not yet available and increase deployment for ORMM applications where options are already available. The standard on embodied carbon in construction recommended in subsection (h) could be one way to increase deployment of low-carbon ORMM. The plan will also need to address the potential challenge of providing a distribution infrastructure for future fuels.

j) Infrastructure development

Electricity, hydrogen and CO_2 networks will all require development or upgrade in our Balanced Pathway. This will require actions on behalf of Government, regulators and network operators.

* 6 $MtCO_2e$/year from industrial off-road mobile machinery

i) CO_2 transport and storage infrastructure

CO_2 transport and storage networks need to be developed to enable CCS across manufacturing and other sectors. Government has recognised the need to do this and has consulted on a support mechanism. Network infrastructure is likely to be focussed around a series of CO_2 terminals and cluster points (Figure 4.2).

Government should establish at least two CCS clusters in the mid-2020s, at least four by the late 2020s, and further clusters around 2030.

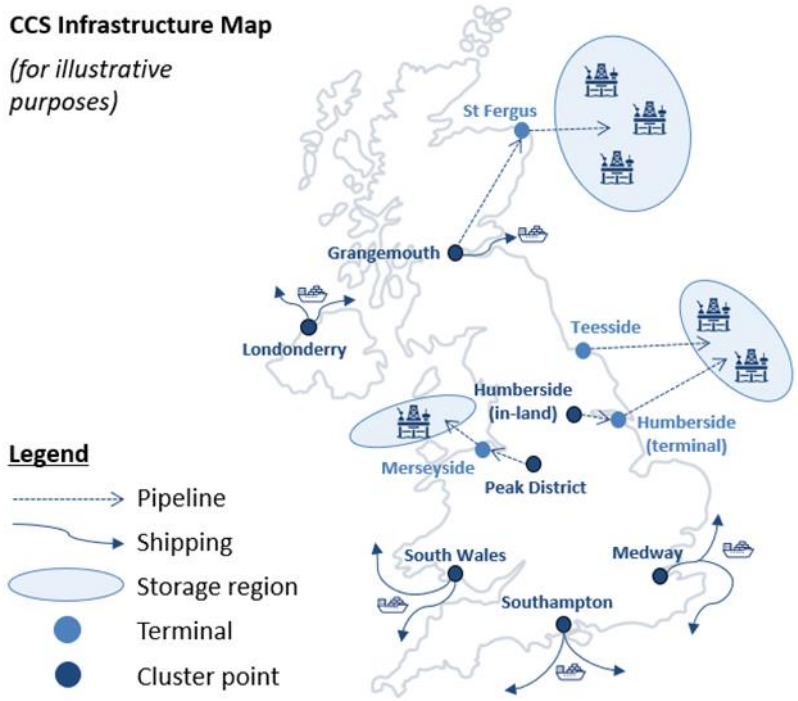
Government should establish at least two CCS clusters (terminals or cluster points) in the mid-2020s, at least four by the late 2020s, and further clusters around 2030, to ensure our Balanced Pathway can be met.

Our manufacturing Pathway also requires CCS to be fitted to a range of dispersed sites, particularly in the minerals sectors, such as cement and lime, with these sectors applying CCS (or potentially some CCU - Carbon Capture and Use) to all sites by 2040, with early projects starting in 2030. This may require substantial pre-planning as the transport of CO_2 will be more challenging than for sites located in clusters. It may involve trucking, shipping, trains or long pipelines, as identified by a study commissioned by BEIS.[17] Establishing options, such as pipelines, could have long lead-times.

Government should work with the minerals industries to develop a detailed joint plan for CO_2 transport from dispersed sites.

Given there is no likely alternative to CCUS for deep decarbonisation of these sectors and the possibility of long lead times, Government should work with the minerals industries to develop a detailed joint plan for CO_2 transport from dispersed sites.

Figure 4.2 Potential locations for cluster points and terminals for CO_2 transport and storage infrastructure



Source: Element Energy (2020) *Deep-decarbonisation pathways for UK Industry, report for the Climate Change Committee*

ii) Hydrogen distribution

Government and regulators should prepare to make decisions about whether initial areas of the gas transmission and distribution networks should be converted to hydrogen.

We anticipate that early hydrogen deployment in manufacturing in the second half of the 2020s will not be distributed through the existing gas networks (outside of trials), but rather via dedicated pipelines, or in some cases trucked. Hydrogen starts to be used via the existing gas networks (combined with dedicated new pipelines) from 2030 in our Balanced Pathway, starting near the industrial clusters.

Government and regulators should prepare to make decisions about whether initial areas of the gas transmission and distribution networks should be converted to hydrogen. These should be made on a cross-sectoral basis (see Chapter 3, Figure 3.3).

Future hydrogen (and alternative fuel) distribution plans should also consider the needs of off-road mobile machinery, which use around a fifth of the hydrogen consumed in manufacturing and construction in our Balanced Pathway. These are not typically located near clusters or with a grid connection.

iii) Electricity network upgrades

Ofgem and the network operators should make plans for a potential increase in large localised network reinforcements for manufacturers.

If a manufacturer decides to electrify its processes that currently use fossil fuels, it may require localised electricity network reinforcements. With widespread manufacturing this could necessitate a lot of localised network reinforcements. Ofgem and the network operators should prepare for this eventuality, which provides a different challenge to the larger but more evenly spread uptake of electrification of buildings and transport.

k) Target Dates

Government should set targets for UK ore-based steelmaking and cement production to reach near-zero emissions by 2035 and 2040, respectively.

Meeting the Sixth Carbon Budget will require decarbonisation actions to ramp up across the economy. In manufacturing, it will be particularly important to develop the momentum behind change. To achieve this, we recommend that the government set the following targets to indicate ambition.

- Government should target near-zero emissions from ore-based steelmaking* in the UK by 2035. This could include CCS applied with high capture and application rates.
- Government should target near-zero direct emissions from the cement sector by 2040.†

l) Skills

The capacity of skills and supply chains needs to be increased, which will require supply chains and skills gaps to be mapped.

As a key constraint for the pace of the Balanced Pathway, the capacity of skills and supply chains needs to be increased. While this can be partially achieved through demonstration projects, additional work on mapping supply chains and future skills gaps is likely to be needed.

As part of this, engineering, procurement and construction organisations and training institutions need to be engaged and consulted on new training courses for the required upskilling. This should involve a role for the Engineering Construction Industry Training Board (ECITB) and the Government's new Green Jobs Taskforce.

* This is typically based on using coke – a refined form of coal - in blast furnaces.

† This excludes the negative emissions from BECCS, which would take the sector net negative.

Endnotes

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[16] Vivid Economics (2019) *Energy Innovation Needs Assessment (Sub-theme report Road transport)*

[17] BEIS (2020) *CCS deployment at dispersed industrial sites. Element Energy for the Department for Business Energy and Industrial Strategy (BEIS)*.

Chapter 5

Electricity generation

1. Current policy and gaps to be addressed 117
2. A policy framework for the Sixth Carbon Budget & Net Zero 119



Table 5.1
Summary of policy recommendations for electricity generation

Deploying low-carbon capacity	**Fully decarbonise electricity generation by 2035, while meeting a 50% increase in demand, through:** • Delivering 485 TWh of generation by 2035, which should all be low-carbon. That will require 400 TWh of new low-carbon generation. • Deploying variable renewables at scale, including 40 GW of installed offshore wind capacity by 2030 and sustaining that build rate to support deployment of up to 140 GW by 2050. • Deploying at least 50 TWh of dispatchable and flexible generation (e.g. gas CCS, hydrogen) by 2035 that can balance a system driven by renewables at low emissions. • An increasingly flexible system, including from demand-side response (with 20% of demand being flexible in 2035), storage, hydrogen production, and interconnection. **Develop and implement plans to overcome barriers to deployment, including through:** • Developing a holistic deployment strategy and planning and consenting regime for offshore wind as soon as possible to improve coordination, taking into account wildlife concerns, commercial activities, and radar interference. • Contracting models for nuclear, gas CCS, and BECCS that provide predictable revenue streams. • Demonstrating the viability of burning low-carbon fuels such as hydrogen or ammonia in gas turbines and then incentivising their deployment at commercial scale in the 2020s. **Ensure networks are ready to accommodate new generation technologies and new demands, by:** • Delivering plans to ensure investment in networks can accommodate future demand levels in coordination with Ofgem. • Developing a strategy to coordinate interconnectors and offshore networks for wind farms and their connections to the onshore network, bringing forward legislation necessary to enable that.
Phasing-out use of unabated gas	**By the end of 2021 the Government should:** • Commit to phasing-out unabated gas generation by 2035, subject to ensuring security of supply. • Publish a comprehensive long-term strategy for unabated gas phase-out. • Ensure new gas plant are properly CCS- and/or hydrogen-ready as soon as possible and by 2025 at the latest. **In the 2020s the Government should ensure unabated gas generation faces a carbon price consistent with it being phased-out by 2035, and incentivise initial deployment of low-carbon alternatives.** **From 2030, once further progress has been made and more information is available on the relative economics of different options, the Government should:** • Regulate for a firm pathway to zero unabated gas by 2035, subject to ensuring security of supply. • Not allow new unabated gas capacity to be built.
Electricity market design	**The Government should develop a coherent vision for a Net Zero electricity system by:** • Developing a clear long-term strategy as soon as possible, and certainly before 2025, on market design for a fully decarbonised electricity system. • Continuing the use of long-term contracts as an appropriate investment mechanism. • Focusing on developing the market for gas CCS and hydrogen, strongly deploying low-carbon generation, and phasing-out unabated gas.

This chapter sets out the policy implications of the Committee's scenarios for decarbonising electricity generation that underpin the Sixth Carbon Budget.

The scenario results of our costed pathways are set out in the accompanying Advice and Methodology Reports. For ease, sections covering pathways, method and policy advice for electricity generation are collated in the Sixth Carbon Budget – Electricity Generation. A full dataset including key charts is also available alongside this document.

The key messages for electricity generation are:

Electricity generation should be fully decarbonised by 2035. This will require phasing-out the use of unabated gas, and has implications for market design.

- **Electricity generation should be fully decarbonised by 2035.** That will need to happen while meeting a 50% increase in demand, and will require:
  - **Deployment of 400 TWh of new low-carbon generation,** including 50 TWh of dispatchable low-carbon generation to ensure security of supply.
  - **An increasingly flexible electricity system,** including from demand-side response (with 20% of demand being flexible in 2035), storage, hydrogen production, and interconnection.
  - **A coordinated strategic approach** to ensure all elements of the 2035 low-carbon transition are developed as a coherent package.
- **Phasing-out unabated gas by 2035.** The Government should commit to phasing-out unabated gas generation by 2035, subject to ensuring security of supply. This will require developing the markets for dispatchable low-carbon generation in the 2020s, to be in a position to regulate for a phase-out from 2030. No new unabated gas plant should be built from 2030, and those built prior to this should be suitable for retrofit.

Given lead-times for policy development and investment, Government should begin immediately planning market design for Net Zero.

- **Market design for Net Zero.** Renewables are likely to play a dominant role in the future electricity system (e.g. 70% of generation in 2035, and up to 90% in 2050). This will bring new challenges for the electricity market.
  - An evolutionary approach is appropriate over the short-to-medium term. But planning for running a fully decarbonised system should begin immediately, given lead-times for policy development and investment.
  - The Government should develop a clear long-term strategy as soon as possible, and certainly before 2025, on market design for a fully decarbonised electricity system.

We set out our assessment in two sections:

1. Current policy and gaps to be addressed
2. A policy framework for the Sixth Carbon Budget & Net Zero

1. Current policy and gaps to be addressed

Policies have been built up incrementally.

This section sets out the existing policies that have contributed to reducing emissions by 64% since 2012, in addition to the policy gaps that need to be addressed to deliver new low-carbon generation in the 2020s.

Policies for reducing emissions from electricity generation have been built up incrementally over the last several decades. They reflect a range of different regulatory and market-driven approaches:

- **Long-term contracts for electricity generation.** Contracts for Difference (CfDs) are long-term contracts which provide an investment mechanism that lowers risks and therefore costs. Offshore wind costs have fallen from £140-150/MWh for projects contracted in 2015 to around £40/MWh – below the cost of new gas-fired generation – for projects coming online in the mid-2020s.
- **Carbon pricing.** A price on carbon helps incentivise lower-carbon generation to be dispatched ahead of higher-carbon generation. UK generators currently face a carbon price through the EU Emissions Trading System (EU ETS), and an additional top-up through the UK Carbon Price Support. The Government will introduce a UK ETS or carbon tax after leaving the EU.
- **Coal phase-out.** Use of coal in electricity generation decreased by nearly 95% between 2012 and 2019, driven by a combination of factors, including EU-wide regulations on air quality, carbon pricing, and retirement of old coal power stations (Box 5.1). The UK Government has committed to ending the use of coal for electricity generation by 2024.
- **Energy efficiency.** Energy efficiency policies and standards agreed by EU Member States have helped reduce electricity consumption. For example, the installed share of efficient (A-rated or better) home appliances has increased from 9% in 2012 to 34% in 2019, and the installed share of low-energy lightbulbs from 20% in 2012 to 50% in 2019.
- **Flexibility and security of supply.** The Capacity Market (CM) has ensured security of supply by creating a predictable revenue stream for backup capacity, demand-side response (DSR), and storage. This now includes 15-year CM agreements for DSR, which contribute to securing more flexibility in the electricity system.
- **Networks.** Ofgem has published new guidance that requires network companies to propose and present new evidence on Business Plans that are consistent with the Net Zero target.

This combination of policies has helped emissions fall 72% below 1990 levels.

This set of policies has been effective so far in helping reduce emissions, which have fallen by 64% since 2010 and are now 72% below 1990 levels. This is the fastest rate of any sector of the economy. In doing so, variable renewable capacity has increased from 5.5 GW in 2010 to 37.5 GW in 2019, increasing the share of generation from 3% to 25% over the same period.

The key challenge for the sector is to ensure this progress continues. A number of changes are required:

Reaching Net Zero will need a rapid expansion of low-carbon generation, a move away from unabated gas, and policies to incentivise this.

- **Deploying low-carbon generation,** including variable renewables and dispatchable low-carbon generation.
  - Under our Balanced Net Zero Pathway, demand for electricity increases by 50% by 2035 and 100% by 2050, reflecting increasing electrification of the economy (e.g. use of electric vehicles in transport).
  - With offshore wind as the backbone of the energy system, renewables could contribute up to 90% of generation by 2050.* The aim should be for 75-140 GW of offshore wind capacity by 2050, up from 40 GW in 2030.
  - No single technology can deliver all the generation that is needed to meet new electricity demands, meaning that a portfolio of zero-carbon generation technologies will be needed, also including onshore wind, solar and nuclear. Bioenergy with carbon capture and storage (BECCS) could provide capacity and generation, while also delivering greenhouse gas removals (see section 2a).
  - To manage a system based largely on variable generation, there will need to be greater flexibility. That includes from demand (including demand-side response, and use of surplus generation for hydrogen production), from storage and interconnection, and from use of dispatchable low-carbon generation (e.g. hydrogen, fossil gas with CCS).
- **Moving completely away from unabated fossil fuel generation.** After the end of coal generation by 2024, this will require phasing out the use of unabated gas for electricity generation. The Government should commit to achieving this by 2035, subject to ensuring security of supply.
- **Market design.** A well-functioning market structure will be needed to deliver these changes and provide the right incentives for investors, generators, and consumers. The Government is planning to publish an Energy White Paper in 2020, which is expected to set out their view on the changes needed in the energy system to meet Net Zero.

New policies will be needed to meet the challenge of a Net Zero electricity sector.

Existing policies have helped reduce emissions in the power sector. However, new policies will need to be put in place and others will need to be scaled up to meet the Sixth Carbon Budget and Net Zero, to which we now turn.

* Including generation for hydrogen production.

A strategic approach will be needed to ensure electricity generation decarbonises coherently in a way which minimises costs.

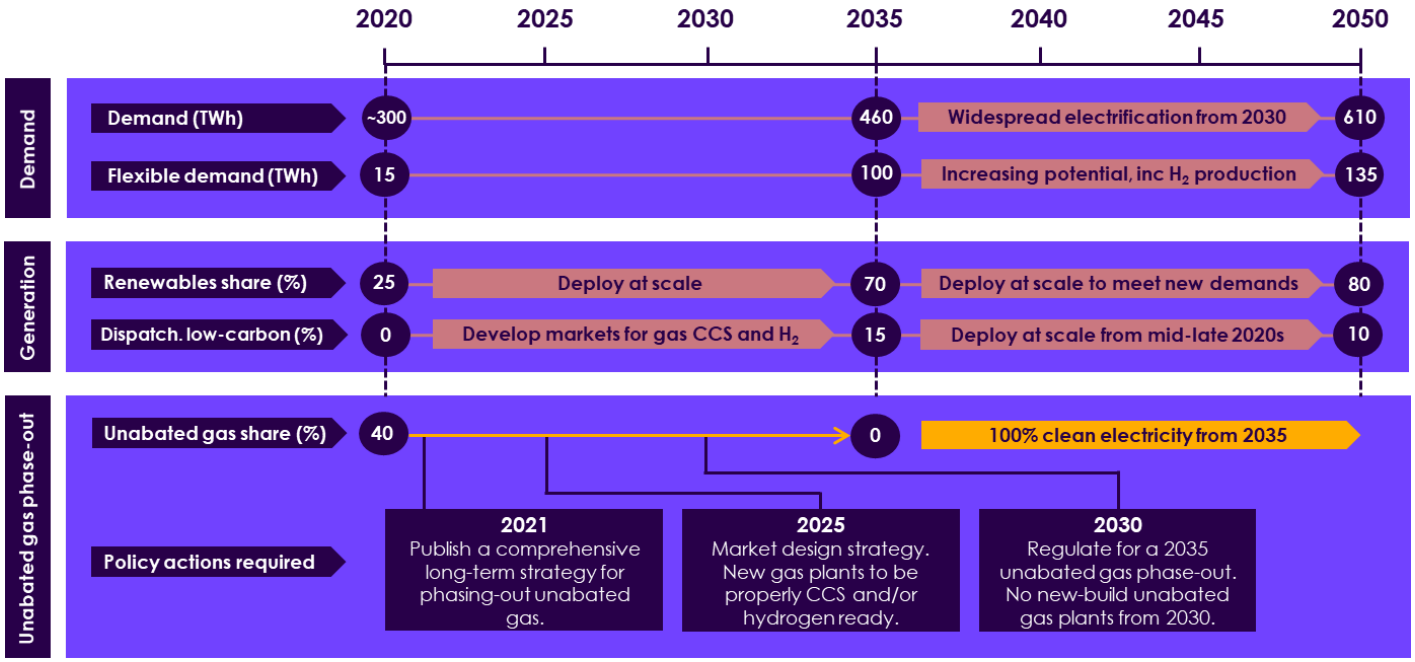
The Sixth Carbon Budget pathways set out the transition to Net Zero, including fully decarbonising electricity generation by 2035. The Government should take a strategic approach to ensure all elements of the transition for electricity generation are developed as a coherent package. In this section we discuss those elements in the following three sections and summarised in Figure 5.1:

a) Deploying low-carbon electricity at scale

b) Phasing-out unabated gas generation

c) Market design to deliver Net Zero

Figure 5.1 Timeline of key outcomes and policy requirements under the Balanced Pathway (2020-50)



Source: CCC analysis.
Notes: Renewables share includes wind and solar. Dispatchable low-carbon generation includes gas CCS, BECCS, and hydrogen plants. Demand is lower than generation, accounting for losses, flexibility services, and interconnection.

Low-carbon generation will need to scale up to meet a 50% increase in electricity demand by 2035.

a) Deploying low-carbon electricity at scale

Our Balanced Pathway involves a reduction in the emissions intensity of electricity generation from around 200 gCO_2/kWh today to 10 gCO_2/kWh in 2035, and 1-2 gCO_2/kWh in 2050.*

Achieving this while meeting a 50% increase in demand by 2035 will require a very significant increase in low-carbon generation.

- Under the Balanced Pathway 485 TWh of generation will be required in 2035, which must all be low-carbon.
  - Currently around half (i.e. 130 TWh) of all generation is low-carbon. However, given expected nuclear plant retirements, that number is likely to fall to around 90 TWh by 2030 without new projects.
  - By 2035 the Balanced Pathway therefore requires around an additional 400 TWh of new low-carbon generation in order to meet demand.
  - Close to 50 TWh of renewables, BECCS, and nuclear have already been committed, meaning around an additional 350 TWh of new low-carbon generation is required beyond that.
- This additional low-carbon generation will need to be met through a scaling up of variable renewables and decarbonised dispatchable generation.
  - Variable renewables (i.e. wind and solar) form the majority - 70% - of electricity generation in 2035.†
  - To balance the system and ensure security of supply there will be a need for dispatchable low-carbon generation. Our scenarios suggest that we would need at least 50 TWh of dispatchable and flexible generation from gas CCS (4-7 GW), BECCS (3-4 GW) and hydrogen (10-20 GW).

There are a range of barriers that will need to be overcome to enable the levels of deployment required under our scenarios:

Potential barriers to offshore wind deployment include supply chains, the consenting regime, and issues of the wider marine environment.

- **Offshore wind.** The pace of offshore wind deployment will need to accelerate in the 2020s in order to meet the 40 GW target and be sustained, if not increased, to meet Net Zero which could require up to 140 GW of capacity by 2050.
  - Supply chains will require long-term signals over capacity needs to provide a predictable environment to investors and developers. This includes certainty on offshore wind consenting and support mechanisms in order to avoid stop/start supply-chain investment.

* Covers direct emissions from electricity generation (i.e. the non-captured CO_2 from gas CCS), but excludes upstream emissions from natural gas used in CCS and/or hydrogen production, and negative emissions from BECCS.

† This includes surplus generation used to produce hydrogen.

  - Crown Estate England and Wales has unlocked a total of 45 GW of offshore wind in the seabed. In addition, the first round of ScotWind leasing could lead to leasing seabed in Scottish waters for an additional 10 GW. This is more than sufficient for the Government's 2030 target. Nonetheless, securing new seabed leases requires several years as projects require pre-development planning, consenting applications, and construction. Accordingly, the UK will need to hold new leasing rounds to provide clarity to developers.
  - There may be constraints to offshore wind deployment from wider factors in the marine environment including wildlife concerns, commercial activities, and radar interference. The Government should develop a deployment strategy and planning and consenting regime that takes these issues into account. Coordination between the Crown Estates, Government, industry, and key stakeholders could ensure wider monitoring of these impacts beyond that of project operators.

Policy will also need to deliver deployment of hydrogen, new nuclear, and CCS.

- **Hydrogen.** Hydrogen plays a key role in our scenarios to ensure security of supply in a low-carbon manner. Policy will need to support the uptake of hydrogen in the 2020s and the accelerated deployment in the 2030s (Chapter 6).
  - In the 2020s, hydrogen blending should be tested with gas before moving on to 100% hydrogen. This will help demonstrate the viability of burning hydrogen in gas turbines in the next decade before accelerating the pace of hydrogen plant deployment in the 2030s.
  - All new-build gas plant should be ready to retrofit hydrogen or CCS from 2025. For hydrogen, this will entail building plants near hydrogen production infrastructure and designing plants that can accommodate the burning and storage of hydrogen.
- **Nuclear.** The Government should consider contracting models which help make new nuclear projects commercially viable for private developers.
- **Carbon capture and storage (CCS).** The development of CCS will be essential across the economy, including for electricity generation where it could help provide dispatchable low-carbon generation (in conjunction with fossil gas) and help remove emissions from the atmosphere (in conjunction with bioenergy, see Chapter 12). The development of this technology could require the support of a long-term contract, which may need to be adjusted for dispatchable generation.

The electricity network will also need to be in a position to manage the expected higher levels of demand and generation out to 2050. That will require additional investment and a more strategic coordination of connections from the offshore to onshore network.

Electricity networks will need to be future-proofed to enable rapid electrification of the economy.

- **Electricity networks.** Many networks will need to be upgraded in a timely manner and future-proofed to limit costs and enable rapid uptake of electric vehicles and heat pumps:
  - The cost of upgrading distribution network capacity is relatively insensitive to the size of the capacity increase, as most of the cost is in the civil works rather than the equipment (e.g. larger cables).
    - It is essential, therefore, that when grid capacity is increased, this is to a sufficient level to avoid having to upgrade the capacity again prior to 2050.

    - A relatively large expansion in capacity is likely to have low regrets, 'future-proofing' the network to enable greater electrification if necessary and/or enabling demand to respond more readily to variations in low-carbon electricity supply.

  - It is important that grid capacity constraints do not impede growth of electric vehicle deployment in the 2020s, given the emissions savings and cost savings they will bring. It will therefore be important either to make anticipatory investments to upgrade electricity networks and/or to re-open the allowed investment partway through the 2023-2028 regulation period (i.e. RIIO-ED2) to ensure timely upgrades.

  - Transmission network capacity will need to keep pace with developments on generation (e.g. large-scale offshore wind) and interconnections, and with the need to ensure that peak demand can be met reliably in all areas on still days as well as on windy days.

Expansion of offshore wind will require a more coordinated approach to offshore networks and their onshore connections.

- **Offshore network connection.** Under current arrangements project developers are responsible for building the networks and connections required to bring offshore energy onshore. While this has helped de-risk project delivery to-date, in future it may be more efficient to coordinate these connections, given the high level of deployment required and the significant local impacts of the onshore infrastructure.

  - The Government has recognised this issue, and in July 2020 announced an *Offshore Transmission Network Review*. This aims to set out an enduring approach in 2021.

  - That approach should include a strategy to coordinate interconnectors and offshore networks for wind farms and their connections to the onshore network and should bring forward any legislation necessary to enable coordination.

b) Phasing-out unabated gas generation

The UK will need to move away from burning unabated gas in order to fully decarbonise electricity generation.

The Government has committed to ending the use of coal for electricity generation by 2024. After this the only significant remaining source of emissions in the power sector will be from unabated gas generation.

It is therefore important to set out a pathway for phasing-out the use of unabated gas generation, after which electricity generation will be entirely low-carbon.

Such a pathway will need to:

Phasing-out unabated gas will require dispatchable low-carbon alternatives, providing the right incentives, and preventing lock-in.

- **Develop markets for dispatchable low-carbon alternatives to unabated gas generation.** These will be needed to complement variable renewable generation, and includes gas with carbon capture and storage (CCS) and hydrogen. These technologies exist but need to be commercialised and deployed at scale.

- **Provide the right incentives for low-carbon generation,** so that these technologies are dispatched ahead of unabated gas in the merit order once they are commercially available.

- **Prevent lock-in of unabated gas technology.** That includes ensuring that any new-build unabated gas plant are properly able to retrofit for CCS or hydrogen and, subsequently, ensuring they are no longer built.

This transition is likely to be more challenging than the move away from coal, given that low-carbon alternatives that could play the same role as gas (e.g. gas CCS, hydrogen) still need to be fully commercialised and deployed at scale. Box 5.1 sets out the key transferable lessons from the coal transition.

Box 5.1
How the UK phased-out coal generation

In 1990, coal provided 80% of UK electricity generation. By 2019 it provided 2%, and the Government has committed to phasing it out completely by 2024.

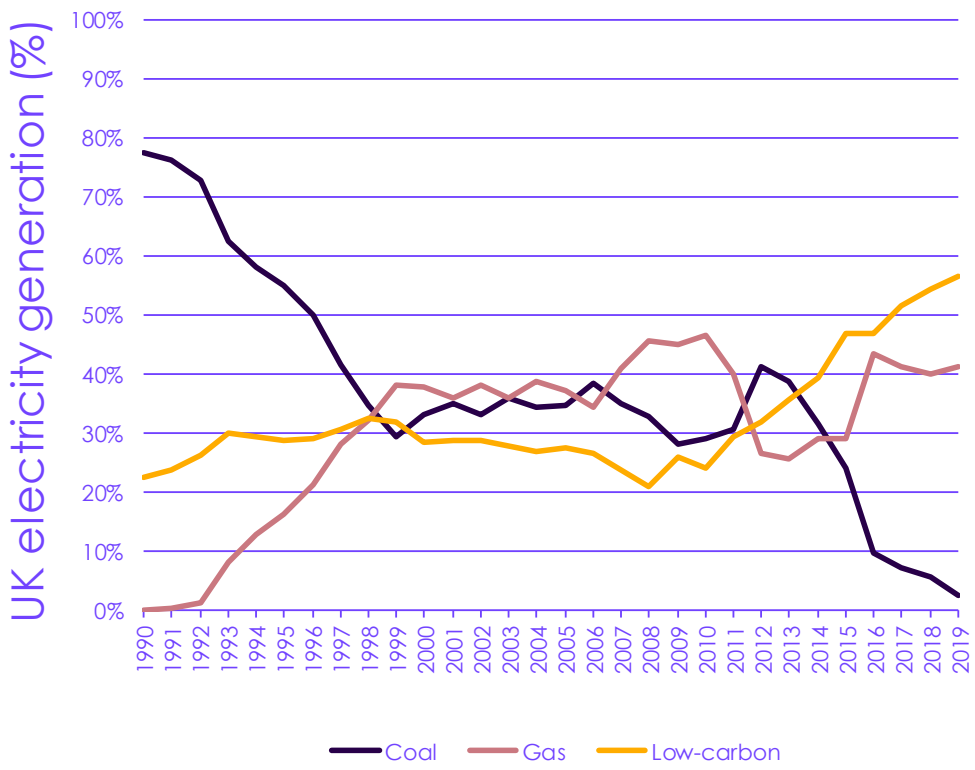
This transition has been the result of a number of factors across three distinct phases, including market forces, air quality legislation, and climate policy:

- **Market forces.** Coal use fell from 80% of generation in 1990 to 30% in 1999 as a result of the 'dash-for-gas' in the 1990s. That was driven by liberalisation of the energy markets and economic forces which favoured gas investment over coal and nuclear.
- **Air quality legislation.** The 2001 Large Combustion Plant Directive (LCPD, superseded by the Industrial Emissions Directive) was a policy agreed by EU Member States to limit air quality emissions. Large plants had a choice to comply with the emissions limits or opt-out. Plants which opted-out were limited to a maximum of 20,000 hours of further operation, and had to close completely by the end of 2015. In the UK nine plants, totalling 12 GW of capacity, decided to opt-out and therefore close.[1] That reflected the age of those plants, meaning retrofit to meet the emissions standards would not be cost-effective.
- **Climate policy.**
  - The introduction of the EU Emissions Trading System (EU ETS) in 2005, and in the UK the Carbon Price Support in 2013, combined to put a price on carbon emissions which has made coal generation less economic compared to unabated gas and low-carbon generation.
  - Support for low-carbon generation (e.g. through long-term contracts) has helped expand supply, creating the potential for alternative sources to substitute for coal while still meeting demand.
  - In addition, the UK Government has committed to ending the use of coal by 2024. While not a legislated target, this has provided a strong signal to investors that new coal is not viable.
  - Combined with LCPD compliance, these policies have helped reduce the share of coal in generation from 40% in 2013 to 2% in 2019.

The lessons from the phase-out of coal are that a range of policy approaches - both regulatory and market-driven - are required in order to influence investment and dispatch decisions. With the right policies in place and sufficient alternative low-carbon generation, the transition away from coal in the UK has ultimately been a smooth one.

Coal fell in the 1990s from 80% to 30% of generation due to the 'dash-for-gas'. In the 2010s it fell to 2%, with a rise in low-carbon and gas generation.

Figure B5.1 Share of electricity generation by source (1990-2019)



Source: CCC analysis based on BEIS (2020) *Energy Trends: Table 5.1* and BEIS (2020) *Energy Trends: Table 6.1*

The Government should commit to phasing-out use of unabated gas in electricity generation by 2035 (subject to ensuring security of supply). Box 5.3 in Chapter 5 of the accompanying Methodology Report sets out why 2035 is an achievable date.

Ensuring unabated gas is phased-out by 2035 will require a range of policy approaches. That includes innovation and market development for gas CCS and hydrogen, and a firmer regulatory approach once these are commercially deployable at scale (Figure 5.1).

By the end of 2021 the Government should:

In 2021 the Government should commit to a 2035 phase-out date, publish a long-term strategy to achieve that, and address new build.

- Commit to phasing-out unabated gas generation by 2035, subject to ensuring security of supply.
- Publish a comprehensive long-term strategy for unabated gas phase-out.
- Ensure new gas plant are properly CCS-ready and/or hydrogen-ready as soon as possible and certainly by 2025.
  - Properly ready means located in areas that will be supported by CO_2 and/or hydrogen infrastructure.
  - The Government should review the current 300 MW threshold for CCS-readiness in light of a 2035 gas phase-out, to avoid risk of new capacity being stranded while ensuring security of supply.

The current 300 MW threshold for CCS-readiness has distorted incentives and should be reviewed.

- Demonstrating that CCS retrofit is technically and economically feasible for new plant has been a requirement of planning consent since 2009.[2]
- A key weakness of those requirements is that they only apply to plant above 300 MW capacity. This has given incentives to developers to build below the threshold (e.g. at 299 MW) in order to avoid those obligations, and has created risk of stranded plant that are not future-proofed.
- Nevertheless, owners of new plants above the 300 MW threshold have known for over a decade that phase-out of unabated operation could be required during their lifetimes.

An effective long-term strategy should set out the actions and timings needed to be in a position to regulate for a phase-out from 2030:

A long-term strategy should develop the markets for gas CCS and hydrogen, and ensure these dispatch ahead of unabated gas.

- In the 2020s the Government should put in place policies to:
  - Deliver decarbonised dispatchable capacity (e.g. gas CCS and hydrogen) and deploy low-carbon generation at scale.
    - That should include developing low-carbon hydrogen supply chains, CCS infrastructure and networks, and identifying the locations where plants can be classed as 'ready'.
  - Ensure operation of low-carbon generation ahead of unabated gas plant, reducing unabated gas solely to a back-up/peaking role.
    - That includes ensuring unabated gas generation faces a carbon price consistent with phasing-out by 2035.

The Government should regulate for a firm pathway to zero unabated gas from 2030.

- From 2030, once further progress has been made and more information is available on the relative economics of different options, the Government should:
  - Regulate for a firm pathway to zero unabated gas by 2035, subject to ensuring security of supply. Policy options include:
    - An emission intensity standard for generation that declines to zero in 2035.
    - An 'hour limit' on generation, which could be spread over several years or decline to zero in 2035.*
  - Not allow new unabated gas capacity to be built, so that all additional capacity built from 2030 onwards is low-carbon.

* This could potentially be a very low but non-zero allowance to allow for some ultra-peaking unabated gas use, depending on security of supply constraints.

c) Market design to deliver Net Zero

Current market arrangements have been successful at delivering low-carbon generation, but Net Zero will bring new challenges.

The current policy framework has succeeded in bringing forward additional low-carbon capacity at low cost. Low-carbon sources are now responsible for over half of electricity generation.

Delivering a fully decarbonised electricity system will bring a range of new challenges which current market arrangements are not fully designed for (Table 5.2).

High uptake of variable renewables is likely to lead to increasing periods of zero or negative prices, which could lead to a hiatus in investment.

- **High proportion of variable renewables.** Our scenarios have variable renewables providing 70% of generation in 2035 and up to 90% in 2050, compared to around 20% in 2019.
  - These technologies have high upfront capital costs, but zero marginal costs of generation.
  - With increasing deployment of zero-marginal-cost renewables, and a market structure designed around marginal cost pricing, there are likely to be an increasing number of periods where the wholesale price is close to zero or negative.
  - This creates a risk that generators may not be able to cover their fixed costs, and hence that investment in low-carbon generation is not delivered at the required levels.

The future electricity system will need to reward flexibility, in order to accommodate high levels of variable renewables.

- **Need for more a more flexible system.** With higher levels of variable renewables comes the need for a more flexible system, including through demand-side response, use of surplus generation to make hydrogen, storage, and interconnection. The market structure will need to provide signals to ensure the system rewards these services and provides the required levels of investment.

Table 5.2
Future structure of the electricity system

	Current system	Net Zero system
Demand	300 TWh	Up to 1,000 TWh
Emissions	~200 gCO_2/kWh	1-2 gCO_2/kWh
Variable renewables	20% of generation	Up to 90% of generation
System structure	Meets demand by flexing supply	Matches supply by flexing demand and/or supply
Role of demand	Passive	Flexible, including for hydrogen production
Cost structure	Mainly marginal	Mainly capital

Source: Adapted from Robinson and Keay (2020) *Glimpses of the future electricity system? Demand flexibility and a proposal for a special auction.*

Current market arrangements have been incrementally developed over several decades.

The current market design has been developed incrementally over the last several decades and includes:[3]

- **Wholesale market.** This provides generators with the price signals to help decide whether they should run their capacity, whether they should invest in new capacity, and whether they should close existing capacity.
- **Capacity market.** This pays generators for the availability of capacity, in order to ensure there is adequate generation at times of high demand.
- **Balancing market.** This is used to reconcile market decisions about plant dispatch with what can actually be delivered through the physical network.
- **Network charges.** These cover the cost of running the electricity transmission and distribution network.
- **Carbon policy.** Various policies are used to reward and incentivise low-carbon generation, including a carbon price (e.g. through the EU ETS, and UK Carbon Price Support), and long-term contracts for generators.

Future market arrangements will need to evolve to meet the Net Zero challenge.

In future the market will need to incentivise:

- Investment in very high levels of variable and low-marginal cost low-carbon capacity.
- Investment in sufficient decarbonised dispatchable low-carbon capacity (including storage) to ensure security of supply.
- Flexible demand, including for hydrogen production.
- Phase-out of unabated gas generation.

Future market arrangements should provide predictable signals across both demand and supply, and should ensure security of supply.

A range of options have been suggested for future market arrangements.[4] Future reform should be guided by three principles:

- **The need for certain and predictable signals.** Clearly signalled in advance, these will reduce costs and give market participants confidence that the regulatory regime will support the levels of investment required. That includes the role for Government in developing new technologies as well as supporting mature ones.
- **The need for a whole-market approach.** This should reflect the importance of both flexible demand and supply of low-carbon electricity, so that both are rewarded in competitive markets to deliver the lowest-cost overall system.
- **The need to ensure security of supply.** Alongside variables renewables, there will be a need for dispatchable low-carbon capacity to ensure security of supply. Business models will be required to support this, even though they may only run at very low load factors.

There are clearly defined phases to the Net Zero transition, which will require different policy approaches.

Figure 5.1 shows that the transition to a near-zero emission electricity system will have several phases, which are likely to require different policy approaches:

- **2020s:** Deploying low-cost renewables at scale and developing the markets for gas CCS and hydrogen.

- **2030s:** Transitioning to a completely low-carbon system by displacing unabated gas with low-carbon alternatives by 2035, alongside ramping up deployment of zero-carbon generation to keep pace with electrification of end-use sectors and increasing potential for demand-side flexibility via electric vehicles, heat pumps, and hydrogen production.
- **2040s:** Running a fully decarbonised electricity system, with variability in renewable generation managed through flexible demand, medium- and long-term storage, and use of dispatchable low-carbon generation.

An evolutionary approach is appropriate in the short-to-medium term.

This suggests an evolutionary approach is likely to be appropriate over the short-to-medium-term, but planning should begin immediately for the more fundamental challenges of running a completely decarbonised system:

- **Long-term contracts remain appropriate.**
  - CfDs have been successful at procuring low-cost, low-carbon capacity.
  - They remain appropriate given the capital-intensive nature of low-carbon technologies, and the need for bankable revenue streams.
- **In the 2020s, Government policy should focus on developing the market for gas CCS and hydrogen.**
  - In order to phase out unabated gas by 2035, the Government will need to put in place policy to develop the markets for dispatchable alternatives.
  - Without further intervention, markets are unlikely to pull through these technologies at the scale and on the timeframes required.

In the 2020s the Government should focus on developing the markets for gas CCS and hydrogen.

- **The Government should develop a clear long-term strategy as soon as possible, and certainly before 2025, on market design for a fully decarbonised electricity system.**
  - Under our scenarios renewables uptake reaches 65-70% of generation by 2030, suggesting the impact of zero marginal cost production on the system will become increasingly apparent during this decade. The system is then entirely low-carbon by 2035.
  - Given lead times for policy development, investment decisions, and construction, and the high and sustained build rates required, it will be important to start planning for a fully decarbonised system soon in order to avoid a hiatus in investment.
  - Government should develop a clear long-term strategy as soon as possible, and certainly before 2025, on the future changes required to deliver a fully decarbonised electricity system.

The Government should develop an approach for market design under a fully decarbonised electricity system as soon as possible.

These recommendations will help ensure the Net Zero transition for electricity generation is delivered smoothly, avoids hiatus in investment, and minimises costs to consumers.

Endnotes

[1] National Grid ESO (2007) *Large Combustion Plant Directive, GCRP 07/32.*

[2] DECC (2009) *Carbon Capture Readiness (CCR). A guidance note for Section 36 Electricity Act 1989 consent applications.*

[3] Cornwall Insight (2020) *The net zero paradox. Challenges of designing markets to bring forward low marginal cost resources.*

[4] Blyth, W, Gross, R, and Rhodes, A (2020) *Electricity markets with a high share of variable renewables. A review of issues and design options.*

Chapter 6

Fuel supply

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2. Low-carbon hydrogen supply and use 137
3. Bioenergy supply and use 143



Table 6.1
Summary of policy recommendations for fuel supply

Decarbonising fossil fuel supply	
Implementation of lower-cost measures	• Set a requirement that from 2021 any new plans for offshore oil and gas platforms and associated installations must use low-carbon energy for their operations. As a result, all new oil and gas platforms should have no direct emissions from operational energy use by 2027, at the latest. • From 2025, flaring and venting should only be permitted when necessary for safety reasons.
Reducing UK and consumption emissions	• Develop a policy to reduce emissions from existing oil and gas platforms in line with our Balanced Pathway. • Develop carbon-intensity (or broader) measurement standards for gas and oil, by working with industry and the international community • Facilitate increased collaboration between the UK's offshore oil and gas and offshore wind sectors, exploring the potential for direct power connections to platforms. • Set ambitious requirements for reductions in leakage of methane from the gas grid.
Hydrogen	
Strategy	• Focus hydrogen demand on areas where that cannot feasibly decarbonise without it. • Pursue proven solutions (e.g. electrification) in the 2020s, in parallel with developing hydrogen. • Set out vision for contributions of hydrogen production from different routes to 2035.
Demonstration / near-term deployment in end-uses	• Power. Establish and grow market for decarbonised dispatchable power solutions (H_2 turbines + gas CCS) to support unabated gas phase-out in power generation by 2035. • Manufacturing. Incentivise hydrogen use, but on level playing field with electrification. • Buildings. Research and pilot projects are needed to provide evidence for strategic decisions. • Surface transport. Build towards decisions on zero-carbon HGVs by undertaking large-scale trials. • Shipping. Incentivise hydrogen/ammonia use and aim to develop a 'clean maritime cluster' by 2030.
Demonstration / near-term deployment in supply	• Get on with low-carbon production to establish low-carbon hydrogen supply chain, and also drive innovation in cost and performance. • Blue hydrogen. It is important to deploy fossil gas CCS early to prove that it can deliver suitable emissions reductions vs. fossil gas (i.e. at least 95% CO_2 capture, 85% lifecycle GHG savings). • Gasification. Support commercialisation of biomass gasification with an aim to establish hydrogen production from bioenergy with CCS. • Electrolysis. An RD&D programme is required to improve the cost and performance of electrolysers.
Regulation	• All new power capacity should be hydrogen- and/or CCS-ready as soon as possible and at the latest by 2025, including being located where hydrogen/CO_2 infrastructure will be available. • Mandate boilers in buildings to be hydrogen-ready from 2025 at the latest, without pre-judging the respective roles of hydrogen and electrification. • Government should consider at what point and what level it would make sense to set a maximum carbon-intensity for hydrogen supply.

Incentives	• Ensure that low-carbon hydrogen capacity is incentivised to contribute emissions reductions (including mixing with fossil gas) at least for power generation, industrial clusters and grid injection. • Ensure that incentives for hydrogen use, together with electricity pricing, don't bias solutions towards hydrogen where electrification is competitive. • Avoid incentivising electrolysis based on (non-curtailed) grid electricity, as likely to push up emissions – focus on curtailed generation and dedicated renewable electrolysis.
Bioenergy and waste	
Align policies with long-term best-uses	• GHG savings from bioenergy and waste to be maximised to achieve Net Zero, via use of CCS and displacement of fossil fuels (in line with our best-use analysis from Chapter 6 of the *Methodology Report*). Scale-up and new applications to be aligned with 2050, or able to transition at low cost. • Develop new support schemes for GHG removals, sustainable aviation fuels, biohydrogen and growing perennial energy crops in the UK.
CCS readiness requirements	• Set new requirements for CCS-readiness at bioenergy & waste conversion facilities (even at small scale), with dates beyond which new facilities should be built with CCS, and dates for when CCS will need to be retrofitted to biomass & waste facilities already in operation.
International leadership on GHG removals	• Follow recommendations on sustainability, governance and monitoring from our 2018 report on *Biomass in a low carbon economy*[1] and 2020 report on *Land Use*.[2]

To meet our Balanced Net Zero Pathway, policies will be required to 1) minimise emissions from fossil fuel supply, even as consumption of fossil fuels falls due to decarbonisation in other sectors 2) enable decarbonisation in other sectors by ensuring that production of hydrogen and bioenergy are low-carbon and sustainable, and that their uses are focused where most valuable to meet Net Zero. Table 6.1 summarises our key recommendations for fuel supply policy.

Policy should also help to ensure a just transition for the fossil fuel supply sectors. The Government's planned North Sea Transition Deal can enable workers in the oil and gas sector to transition to the hydrogen sector. Chapter 6 of our *Advice report* sets out our detailed advice.

We set out the existing policy and policy needs for different parts of the fuel supply sector in three sections:

1. Decarbonising fossil fuel supply
2. Low-carbon hydrogen supply and use
3. Sustainable bioenergy supply

1. Decarbonising fossil fuel supply

Policy will need to enable fuel switching, CCS, and reduced methane venting, flaring and leakage, to decarbonise direct emissions from fossil fuel supply.

Our Balanced Net Zero Pathway requires fossil fuel supply emissions to be reduced by 75% by 2035 from 2018 levels.

- Emissions from offshore oil and gas platforms and from onshore processing terminals, are decarbonised mainly by fuel-switching and measures to reduce unnecessary methane flaring and venting.
- Oil refineries are decarbonised through CCS and energy efficiency improvements.
- Methane leaks from the gas distribution and transmission networks are reduced using a combination of Leakage Detection and Repair (LDAR) technologies and continuous monitoring technologies.

Chapter 3, Section 5 of our *Advice report* and Chapter 6 of our *Methodology report* set out more detail on our Balanced Pathway and exploratory scenarios. To achieve these measures will require a shift in gear in policy to decarbonise fossil fuel supply with policies designed to consider a just transition, carbon leakage and international leadership.

In this section we set out:

a) Existing fossil fuel supply decarbonisation policies;

b) Policies required to deliver our Balanced Pathway.

Our assessment of policy for decarbonising oil refineries and oil and gas processing terminals is mostly captured by Chapter 4, since these emissions sources will mostly be within the scope of the Government's planned Industrial Decarbonisation Strategy. The following subsections focus on policy for decarbonising oil and gas platforms and tackling methane leaks from the gas grid.

a) Existing fossil fuel supply decarbonisation policies

The EU ETS and Oil and Gas Authority's consenting regime can reduce emissions from oil and gas production.

Currently, the key mechanisms to reduce emissions from oil and gas production are through the EU emissions trading system (EU ETS) and the Oil and Gas Authority (OGA) consenting regime for flaring and venting. There is significant scope to strengthen policy in this area.

- The EU ETS covers energy generation and flaring on offshore installations with a rated output of more than 20MW. This has not provided a strong enough incentive for operators of either planned or existing installations to switch to low-carbon energy generation.
- The OGA's current policy on flaring and venting allows for justification of these practices on economic and technical grounds, not solely based on safety considerations.
- Various environmental regulations cover the release of emissions from oil and gas facilities.

There are opportunities for the UK to draw on international experience at reducing emissions in this sector.

While the carbon intensity of UK offshore oil and gas production has been declining in recent years it remains higher than the European average, with Norwegian production having less than half the carbon intensity of UK production.[3]

Norway's ability to connect many of its offshore installations to its onshore electricity grid, which is close to 100% low-carbon, has been a key factor in decarbonising the sector, but it has also adopted strong policies which the UK could draw on, such as:

- requiring developers to consider whether they can provide power to their platforms from onshore sources at the development consent phase.
- applying a carbon tax on top of the EU ETS to further incentivise decarbonisation. The tax is levied on all combustion of gas, oil and diesel in petroleum operations on the continental shelf and on releases of CO_2 and fossil gas.
- permitting flaring of gas only when necessary for safety reasons.

Government and industry have recognised the need for the UK's oil and gas sector to change in order to support the UK's transition to Net Zero. Government is developing a new North Sea Transition Deal in partnership with industry to support the North Sea oil and gas industry in transitioning as part of the UK's move to Net Zero. Government is also reviewing its future licensing arrangements for new oil and gas production, whilst the Oil and Gas Authority (OGA) are reviewing how they can support the industries' transition as part of Net Zero.

On leakage of methane from the gas grid, Ofgem sets out requirements for the network operators through its price control frameworks.

b) Policies needed to decarbonise fossil fuel supply

Government should set a requirement that from 2021 any new plans for offshore oil and gas platforms and associated installations must use low-carbon energy for their operations.

To meet our Balanced Pathway, policy should require lower-cost measures, such as reduce flaring and venting and electrifying new platforms, to be implemented as soon as possible. Higher-cost measures, such as electrifying existing platforms, should also be implemented, taking into consideration how this can be achieved without carbon leakage so that UK consumption emissions do not increase. These should be included in the North Sea Transition Deal.

- Set a requirement that from 2021 any new plans for offshore oil and gas platforms and associated installations must use low-carbon energy for their operations, for example through platform electrification. As a result, all new oil and gas platforms should have no direct emissions from operational energy use by 2027, at the latest.

From 2025, flaring and venting should only be permitted when necessary for safety reasons.

- From 2025, flaring and venting should only be permitted when necessary for safety reasons.
- Develop a policy to reduce emissions from energy generation on existing oil and gas platforms in line with our Balanced Pathway.*

* As outlined in our *Methodology report*, this is aligned with pathway set out on page 10 of: Oil and Gas Authority (2020) *UKCS Energy Integration – Final Report – Annex 1 – Offshore Electrification*.

Government should work with industry and the international community to develop carbon-intensity (or broader) measurement standards for gas and oil.

To ensure the UK has a full set of options for reducing its consumption emissions and for enabling higher-cost measures without causing carbon leakage, the Government should develop the option of applying either border carbon tariffs or minimum standards to imports. Further detail on these policy options is set out in Chapter 6 of the Advice report, which covers their application to a wider set of products.

- Develop carbon-intensity (or broader) measurement standards for gas and oil, by working with industry and the international community.
- Foster international consensus surrounding future carbon border/trade policy for products, using the UK 2021 G7 and COP presidencies. This will likely require engagement with the WTO, to ensure future policy is developed to be WTO compliant.

The Government should also deliver enabling policies to support the UK's upstream oil and gas sector to decarbonise:

- Facilitate increased collaboration between the UK's offshore oil and gas and offshore wind sectors, for example exploring the potential for direct power connections to provide platforms with renewable electricity.
- Take steps to improve the measurement and monitoring of fugitive emissions, venting and flaring.

On leakage of methane from the gas grid, Ofgem should set ambitious requirements for reductions in leakage of methane from the gas grid.

2. Low-carbon hydrogen supply and use

Hydrogen will only make a significant contribution to Net Zero with Government support.

The emergence of hydrogen as a low-carbon energy vector from essentially zero use now to making a crucial contribution to Net Zero will require a concerted, coordinated push from Government.

The Government's Hydrogen Strategy, due to be published in spring 2021, will need to set out a vision for hydrogen's role in meeting Net Zero, together with the actions across end-use applications and supply to develop hydrogen's role over the next decade, and the roles for regulation and incentives in hydrogen deployment.

This section brings together issues across hydrogen supply with our recommendations on hydrogen end-use from other sectors. It is in two parts:

a) Challenges for hydrogen policy and strategy

b) What is needed from the Government's Hydrogen Strategy

a) Challenges for hydrogen policy and strategy

While hydrogen has been discussed for many years as a potential contributor to reducing greenhouse gas emissions, very little progress has been made on its deployment to date. In the UK, although hydrogen is used within some industrial processes currently, this hydrogen production is not low-carbon.

In order for hydrogen to contribute to decarbonisation, it will need to shift from being a theoretical option to a commercial reality, as part of a strategic approach to decarbonising the energy system. Challenges include:

Hydrogen should not be prioritised ahead of proven solutions to reduce emissions.

- **Developing the hydrogen option while deploying established technologies in the 2020s.** Developing the hydrogen option could greatly facilitate the transition to Net Zero. However, even a concerted push to establish hydrogen as a proven decarbonisation option is unlikely to deliver large emissions reductions over the next decade. Rather it would pave the way for reductions in the 2030s and 2040s. Given the need for strong emissions reductions in the next decade and the availability of more established ways to do so, development of the hydrogen option should not be at the expense of pursuing proven decarbonisation options, such as electrification, in the 2020s.

Hydrogen should be targeted in applications where it provides most value.

- **A targeted role.** Focusing hydrogen end-uses in the areas that provide the most value (i.e. where other solutions such as electrification are not feasible or are prohibitively expensive), given challenges with providing sufficient volumes of low-carbon hydrogen.
  - Realistically, extra demand for hydrogen would likely be met at the margin by reforming of fossil gas with carbon capture and storage (CCS). In our Hydrogen Review,[4] we estimated this supply route to reduce emissions by only 60-85% compared to unabated use of fossil gas (e.g. in boilers) – these residual emissions limit its role as we move towards Net Zero. Heavy reliance on this route would also mean increasing reliance on gas imports as well as pushing the amount of CCS required to meet Net Zero to levels that may not turn out to be feasible.

  - A scenario with widespread use of hydrogen across potential applications could have demand of 800 TWh (compared to the demand of 225 TWh in our Balanced Net Zero Pathway), implying 100-150 GW of gas reforming capacity and 175 $MtCO_2$ per year of CCS just for hydrogen supply (or alternatively 300 GW of offshore wind dedicated to electrolysis).
  - Therefore, where options are available to reduce emissions through zero-carbon routes, such as electrification, these are strategically preferable to use of hydrogen. Hydrogen's role should therefore be focused in those areas where it is likely to be infeasible or prohibitively expensive to pursue electrification.

Getting past the 'chicken and egg' barrier will require coordination led by Government.

- **Coordination of supply, demand and infrastructure.** Currently, the UK neither has supplies of low-carbon hydrogen, nor demands for hydrogen from the energy system. A future hydrogen contribution to Net Zero will need both, as well as infrastructure to connect the two and business models that work. Getting from here to there will be challenging, as there is a 'chicken and egg' barrier that means that neither supply or demand can sensibly be developed in the absence of the other – fundamentally this is a coordination challenge, which it falls to the Government to address. There are two key approaches to doing so:
  - **Establish low-carbon hydrogen supplies.** It will be important to get low-carbon hydrogen production facilities in place, so that they are able to meet hydrogen demands as and when they arrive. Putting this capacity in place in anticipation of new demands also provides an opportunity to use hydrogen to reduce emissions from existing uses of fossil gas where this can be done with few barriers (e.g. blending it into the gas grid or mixed with fossil gas in turbines for power generation).
  - **Require new gas appliances to be 'hydrogen ready'.** Requiring new fossil gas boilers and power plants to be 'hydrogen ready' would provide ready-made markets for new low-carbon hydrogen supplies as well as limiting risks of stranding high-carbon assets.
- **Financial support.** It is likely that supplies of low-carbon hydrogen in the UK will remain more expensive than fossil gas without a carbon price, probably all the way to 2050, even with considerable cost reductions to electrolysers and zero-carbon electricity generation.*

* Hydrogen produced from fossil gas with CCS is inherently more expensive than simply burning fossil gas, due to the energy losses and capital costs entailed in producing hydrogen.

b) What is needed from the Government's Hydrogen Strategy

The Government has committed to publishing a Hydrogen Strategy in spring 2021.

Before hydrogen's full role across the economy can be fully established, further work will be required including finalisation of the safety case for hydrogen use in buildings and strategic decisions in the middle of this decade around the balance of hydrogen and electrification in decarbonising buildings in different parts of the country.

Nevertheless, the Hydrogen Strategy is an opportunity to push forward development of the hydrogen option. The following sections set out areas where progress can be made.

i) Developing hydrogen end-uses

Action is required in the 2020s across a range of sectors in order to develop the hydrogen option.

Hydrogen end-use applications will need to be grown steadily over time. It will be essential to make good progress in the 2020s, in order for hydrogen to be able to contribute fully to achieving Net Zero. Within this, it is important to focus on areas where hydrogen can bring greatest value:

- **Power.** Hydrogen turbines are one of the technologies for decarbonised back-up capacity, enabling full decarbonisation of electricity generation. While the Government should aim to phase out unabated fossil generation by 2035, the focus in the near term should be to develop and deploy the options, including hydrogen turbines, to displace unabated gas-fired capacity (see Chapter 5).
- **Manufacturing.** Hydrogen can have an important role in decarbonising industrial clusters, alongside electrification and carbon capture and storage (CCS). Its use should be incentivised on a level playing field with other options, including reforming electricity pricing to be cost-reflective (see Chapter 4).
- **Buildings.** A programme of research will be needed to identify priority candidate areas for hydrogen, along with areas which are unlikely to be suitable, to inform development and network investments. One or more hydrogen trials will be needed at a representative scale in the early 2020s (e.g. 300-3000 homes), to inform decisions on low-carbon zoning from 2025. All new boilers should be hydrogen-ready by 2025 at the latest. Further pilots should follow in the late 2020s, where this is valuable to inform large-scale take-up of hydrogen (see Chapter 3).
- **Surface transport.** Large-scale trials of zero-emission HGVs will be necessary in the early-2020s to demonstrate the commercial feasibility of zero-emission heavy goods vehicle (HGV) technologies, including fuel cell HGVs, and establish the most suitable and cost-effective technology mix ahead of phasing out sale of diesel HGVs by 2040 at the latest (see Chapter 2).
- **Shipping.** Incentives should be put in place for uptake of zero-carbon fuels (i.e. hydrogen and ammonia) in shipping. The UK should aim to have a 'clean maritime cluster' operational and supplying zero-carbon fuels by 2030, as a prelude to potential widespread adoption of these fuels in shipping in the 2030s (see Chapter 8).

ii) Hydrogen production

A strategic priority for the 2020s in developing hydrogen as a decarbonisation route is to develop its low-carbon production. This will help to move past the 'chicken and egg' barrier and enable a range of hydrogen end-uses to develop, while also helping to establish and drive improvements in the costs and performance of low-carbon hydrogen production routes.

Our assessment of path for build rates in the electricity system is that it will be highly challenging to provide very substantial volumes of electrolytic hydrogen over the period to 2040, while also meeting strongly growing demands for electricity during the 2030s. Thereafter, we anticipate that the rate of electricity demand growth will slow, enabling a more rapid scaling-up of electrolytic hydrogen supply with further deployment of zero-carbon generation.

In the interim, there is a choice between:

- **'Green hydrogen only'.** Limiting the role of hydrogen over the next 20 years only to what can be supplied via electrolysis from zero-carbon sources, likely placing substantial limits on hydrogen's potential contribution to getting to Net Zero; or
- **'Blue hydrogen bridge'.** This would entail supplementing electrolysis with scalable production from routes involving carbon capture and storage (CCS) to enable sufficient low-carbon hydrogen production to meet a fuller range of emerging demands.

There is an important transitional role for hydrogen production from fossil gas with CCS in order to enable hydrogen to meet a range of emerging demands.

We recommend the latter approach, as this will both reduce emissions more quickly in the near-term (compared to lesser use of hydrogen to displace unabated fossil fuels) as well as developing the role of hydrogen across a range of sectors, reducing risks around achieving Net Zero.

In its Hydrogen Strategy, the Government should set out its vision for the respective balance between hydrogen produced from electrolysis and from CCS out to 2035. Policy mechanisms will also need to be designed to pull through supply from both routes, rather than just whichever is least-cost.

The role for hydrogen from fossil gas with CCS will depend on it having sufficiently low lifecycle emissions.

However, production of hydrogen from fossil gas with CCS is not zero-carbon. In deploying hydrogen supplies in the 2020s from fossil gas with CCS, it will be important to demonstrate that it can achieve at least the potential 85% lifecycle emissions saving we have estimated it could provide versus unabated use of fossil gas. Doing so will ensure that this form of hydrogen production can have an enduring role as we approach Net Zero. The strategy should also set out how research and development and commercialisation programmes can help to deliver performance/cost improvements for hydrogen production via biomass gasification and electrolysis.

iii) Regulation

In order to ensure that new infrastructure is compatible with Net Zero, we are approaching the point when any new fossil-fuelled appliances risk becoming stranded assets unless they are designed to ensure that they can be converted to being low-carbon later on. Regulation has an important role to ensure that the risk of stranded assets is minimised, through prohibiting investments in high-carbon assets after a certain point in time and/or by mandating that they can be converted for operation in a low-carbon way.

Requiring gas turbines and boilers to be hydrogen ready would reduce risks of them becoming stranded assets and would provide ready-made markets for low-carbon hydrogen.

Requiring hydrogen-readiness for gas appliances such as boilers and turbines would reduce the risk of stranded high-carbon assets and can provide ready-made markets for new low-carbon hydrogen supplies. However, beyond a certain point in time, it will no longer by appropriate to invest in assets designed to operate on fossil fuels:

- **Boilers.** Making new gas boilers hydrogen ready is expected to add a low premium to the upfront cost of a boiler, while reducing the hassle and cost of switching the local gas distribution network over to 100% hydrogen (see Chapter 3).
  - Based on projected additional costs of £100 or less per boiler, and with a view to minimising scrappage, we recommend appliance standards for hydrogen-ready boilers from 2025. Should costs prove higher or safety considerations materialise, this should be reviewed.

    Early commitments and widespread standards would be expected to drive costs down through competition and economies of scale.
  - Outside of zones designated for the gas distribution network to switch to hydrogen, all new heating appliances will need to be low-carbon by 2033.
- **Turbines.** Once dispatchable low-carbon generation solutions have been proven, it is likely that a combination of economic incentives and regulation together will best enable a phase-out of unabated gas-fired electricity generation (see Chapter 5). The role for regulation comes in three phases:
  - Ensure new gas plant are properly CCS-ready and/or hydrogen-ready as soon as possible and certainly by 2025. Properly ready means located in areas that will be supported by CO_2 and/or hydrogen infrastructure.
  - From 2030, once further progress has been made and more information is available on the relative economics of different options, the Government should plan to regulate so that all additional capacity built from 2030 onwards is low-carbon.
  - By 2035, the plan should be that the electricity system can run entirely on low-carbon generation. The precise role for regulation here could take different forms (e.g. a declining emissions intensity standard or an 'hour limit' on unabated gas generation).

It may also make sense to regulate for a limit to the carbon-intensity of hydrogen supplies at some point. The Government's Hydrogen Strategy should consider whether and when it might be sensible to set such a limit. In the meantime, it is important to ensure that all hydrogen supplies are incentivised to be low-carbon.

iv) Incentives

Financial incentives will be important in driving hydrogen uptake.

Costs of hydrogen supply will remain well above that of fossil gas supply before any carbon price, probably all the way to 2050. This means that hydrogen uptake will only occur if a policy framework is put in place to incentivise its use. In doing so, it is important to pull through demand, while attempting to avoid perverse or biased outcomes:

- **Incentives for early use-cases.** In developing the low-carbon hydrogen capacity necessary in the 2020s, it is important use of this hydrogen is incentivised to contribute emissions reductions. This includes blending hydrogen with fossil gas in the gas grid and potentially in gas turbines, as well as 100% hydrogen applications in power generation, industrial clusters and parts of transport.
- **Avoid perverse incentives.** Incentivising electrolysis is sensible where this is based on low-carbon generation that would otherwise be curtailed or from renewable capacity dedicated to hydrogen production. However, it is important to avoid putting in place incentives that lead to a significant increase in fossil-fired electricity generation, as this would increase overall emissions.
- **Level playing field for decarbonisation.** Ensure that incentives for hydrogen use are designed, alongside a shift towards more cost-reflective electricity pricing (see Chapter 6), so that bias is not introduced towards hydrogen solutions where electrification is competitive.

3. Bioenergy supply and use

Bioenergy's role needs to transition to long-term best uses.

Bioenergy is used across many sectors of the UK today, but to contribute fully to Net Zero it will need to grow and transition to uses that maximise available GHG savings. This will require a coordinated approach from multiple Government departments.

The Government's Biomass Strategy, due to be published in 2022, will be critical to setting out this transition, with a clear vision needed for bioenergy's role in meeting Net Zero. This Strategy will need to set out the required actions across end-use applications and support the growth in domestic feedstock supplies over the next decade, as well as ensuring sustainability.

This section brings together issues across bioenergy supply with our recommendations on bioenergy end-use from other sectors. It is in two parts:

a) Challenges for bioenergy policy

b) What is needed from the Government's Biomass Strategy

a) Challenges for bioenergy policy

Our Balanced Net Zero Pathway requires overall primary bioenergy supply (including biomass, biogas, biofuels and the biogenic fraction of waste) available to the UK to grow from 175 TWh/year today to 225 TWh/year by 2050. This includes phasing out of informal and less sustainable feedstock supplies, a significant ramping-up of UK forestry residues and perennial energy crops, large increases in anaerobic digestion as landfill gas declines, and waste prevention, re-use and recycling efforts.

More than 80% of total bioenergy will have to be used with CCS by 2050.

By 2050, CCS will need to be applied to over 80% of the total bioenergy used in the UK. The majority of uses with CCS are likely to be in power, hydrogen and biojet production (and at remaining energy-from-waste facilities), although there are other uses with similar overall GHG savings that may be deployed as well. Chapter 5 of our *Advice report* and Chapter 6 of our *Methodology report* set out more detail on our Balanced Pathway and exploratory scenarios.

A significant investment programme will be required, with construction of new bioenergy facilities with CCS occurring in the late 2020s and early 2030s, across multiple end-use sectors – transport fuels, hydrogen, manufacturing and power.

Key challenges facing bioenergy policy are:

- There are legacy policies across multiple departments, and much of the UK's biomass supply is inherently tied to land use policies (and planting from previous decades). Bioenergy policies can therefore take decades to realise the potential benefits, and there remain 'chicken and egg' issues of feedstock growers not planting before they see local demand. With the transition to new support schemes for land managers (e.g. ELMs), it remains to be seen what the relative economics of biomass production versus other uses of land will be, and the availability of agricultural residues such as straw.

- It is uncertain how bioenergy policies will develop in Europe, North America and other world regions, and long-term what the available potential and costs of any imported supplies will be. Unlike other renewables with high capex and low operating costs, bioenergy feedstock costs are often significant and variable, which can necessitate different policy choices.
- Different power/heat/fuels policies have developed different GHG emission savings thresholds and calculation methods for bioenergy, making it challenging to assess whether certain feedstocks or supply chains will be able to transition to new uses and still meet the required sustainability criteria.
- Successfully achieving emissions reduction and other environment objectives in the waste sector will significantly reduce supplies of landfill gas and residual waste for bioenergy uses. These waste sector objectives need to be prioritised over the utility of the bioenergy resources produced. The biogas resource lost can be compensated for by an increased focus on anaerobic digestion of food wastes, sewage sludge and animal manures.
- Policy gaps remain with limited support for growing perennial energy crops in the UK, no bespoke market-based support for aviation biofuels within wider transport policy, biohydrogen suffering from 'chicken and egg' barriers (section 2 above), and a price signal for GHG removals still lacking.

b) What is needed from the UK's Biomass Strategy

The UK's Biomass Strategy, and subsequent cross-departmental policy realignment, should include:

Best-use of biomass and wastes are those that maximise GHG savings on the path to Net Zero. New applications need to be aligned to 2050 already.

- Examination of the **best-use of biomass and waste** resources on the path to Net Zero that maximises GHG savings, in line with our analysis from Chapter 6 of the *Methodology Report*, and consider how to orientate policy towards these best uses. Scaling up or creating new applications for bioenergy during the 2020s should already be aligned with long-term best-use applications or be able to make sufficient GHG savings before transitioning at low cost to these best-use applications.
- **Develop new support schemes**, including for biogenic CO_2 capture and sequestration, sustainable aviation fuels, biohydrogen and UK production of biomass feedstocks.

CCS should eventually be installed on all applicable bioenergy & waste facilities.

- **Requirements for CCS-readiness** from today, with clear dates beyond which new bioenergy & waste facilities should be built with CCS (not just CCS-ready), and dates for when CCS will need to be retrofitted to UK biomass & waste facilities already in operation, linking to the regional roll-out of CCUS under wider BEIS plans.
- Development of UK and international **governance and sustainability criteria** for bioenergy feedstocks, taking a global lead on their application to GHG removals, in line with our recommendations on sustainability, governance and monitoring from the Committee's 2018 report on *Biomass*[5] and 2020 report on *Land Use*.[6]
- The potential for use of **wood in construction**, existing market barriers and what changes in buildings regulations or support would be required to maximise its use.
- The potential for emerging uses of **biomass in the wider bio-economy** (such as bioplastics and bio-based chemicals), how any new sustainability concerns arisings from these applications should be addressed, and if specific support is recommended, providing a common framework for assessing GHG emissions savings (given the diversity of metrics in use).

Support schemes and CCS measures need to start being developed now, not starting after the Strategy is published in 2022.

However, some of the above work on developing support schemes and CCS requirements needs to progress at pace. Waiting until the Biomass Strategy is published during 2022 before starting to formulate new policies will put at risk the required conversion technology investment programme to 2030, and will delay the ramping-up in biomass supplies.

Endnotes

[1] CCC (2018) *Biomass in a low-carbon economy*.
[2] CCC (2020) *Land use: Policies for a Net Zero UK*.
[3] OGUK (2020) *Production Emissions Targets Report 2020*
[4] CCC (2018) *Hydrogen in a low-carbon economy*.
[5] CCC (2018) *Biomass in a low-carbon economy*.
[6] CCC (2020) *Land use: Policies for a Net Zero UK*.

Chapter 7

Agriculture and land use, land-use change and forestry (LULUCF)

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Table 7.1
Summary of policy recommendations in agriculture and land use

A strong post-CAP regulatory baseline	Regulations are needed to cover low-cost, low-regret options, including standards for emission reduction through the use of existing legislation (e.g. the Nitrates Directive to extend the coverage of Nitrate Vulnerable Zones to all of the UK) and new legislation (e.g. the Clean Air Strategy) to reduce methane emissions. The extraction of peat and rotational burning as well as the sale of peat for use in the horticulture sector should end.
Comprehensive delivery mechanisms for land-scape scale changes and low-carbon farming practices	A comprehensive delivery mechanism to deliver land-scape scale changes is needed. This should include: • An increase in afforestation rates to at least 30,000 hectares per year across the UK by 2025 (in line with the Government's commitment) and an average of 40,000 hectares per year in the 2030s. • Restore 60% upland peat (and where this is not possible, stabilise the peat) by 2035; and restore or stabilise the remaining the area by 2045. • Rewet 20% of lowland cropland area and sustainably manage a further 18% by 2035. • Plant trees on 10% of farmland while maintaining their primary use, extend hedgerows by 20% and better manage hedgerows by 2035. • Plant energy crops on 30,000 hectares per year across the UK by 2035. • High take-up of low-carbon agricultural measures covering livestock (diets, breeding and health), soils (cover crops and grass-legume mix) & waste management (anaerobic digestion and slurry covers). • Government should set out a clear path to incentivise the take-up of zero or near-zero emission options for agricultural machinery and to develop options where these are currently not available. The strategy should cover mechanisms for private and public financing, such as a trading scheme or auctioned contracts. These measures will deliver a range of co-benefits including flood alleviation, improved health, recreation and improved air quality as well as biodiversity gains.
Measures and funding to avoid a hiatus in delivery	Delivery of measures needs to start immediately given time to scale up the sector. It is important that a hiatus in the take-up of measures required for delivering Net Zero is avoided during the transition to a post-CAP framework (e.g. the Environmental Land Management Scheme in 2024): • On-going public funding should continue, and where necessary be increased. • Terms of funding available under existing programmes (e.g. Countryside Stewardship) should be amended to incorporate measures that directly reduce emissions.
Measures to address non-financial barriers to change	Introduce measures to address non-financial barriers including: • Knowledge exchange of low-carbon farming practices, contractual issues for tenant farmers, support upskilling and scale-up of supply chains. • Barriers to invest in R&D to improve productivity and resilience (e.g. crop and tree yields) and develop low-carbon machinery (e.g. tractors).
Policies to encourage a shift in diets and food waste reduction	Implement policies to encourage consumers to shift towards healthier diets and reduce food waste, including: • Low-cost, low-regret actions to encourage a 20% shift away from all meat by 2030 rising to 35% by 2050, and 20% shift from dairy products by 2030. An evidence-based strategy to establish options to successfully change behaviour and demonstrate public sector leadership. • Measures are needed to reduce food waste by 50% by 2030 and 60% by 2050 with the public sector taking a lead through measures such as target setting and effective product labelling.

Reducing emissions and increasing carbon sequestration in agriculture and land-use has been slow, with emissions broadly unchanged over the past decade.

There are some EU regulations and funding that impact Greenhouse Gas (GHG) emissions by incentivising actions on land use and management to deliver environmental benefits. However, there are no national or UK-wide policies that directly target the reduction of GHG emissions beyond voluntary action. Policies are also fully devolved.

Government is currently working on its Environmental Land Management (ELM) scheme, the key policy to pay farmers and land-owners in England for the delivery of environmental benefits, including climate mitigation and adaptation. Similar action is needed in the devolved administrations.

Our recommendations are based on an assessment of existing policies, stakeholder engagement, review of evidence and previously commissioned research which we set out in detail in our '*Land use: Policies for a Net Zero UK*' report earlier this year. We set out a comprehensive new approach which takes account of other strategic priorities for land such as food production and wider environmental objectives, which must be delivered alongside emissions reduction. We also set out new opportunities and revenue streams that reward farmers for measures to reduce emissions and sequester carbon and reflect the benefits this brings to society. Policy should also help deliver a fair transition which recognises the important role farmers play as stewards of the land.

This section covers:

1. Challenges in decarbonising agriculture and land use
2. Current Government policy commitments
3. Key changes needed

Meeting the ambition for emissions reductions set out in our Sixth Carbon Budget advice requires overcoming a range of financial, social and behavioural barriers across key sectors.

a) Low-carbon farming practices and agricultural machinery

Reducing emissions in agriculture to meet our Balanced Net Zero Pathway requires farmers to adopt a range of farming practices and technological options to reduce non-CO_2 emissions, and to switch away from fossil fuel use in agricultural machinery to low-carbon alternatives. The main challenges include:

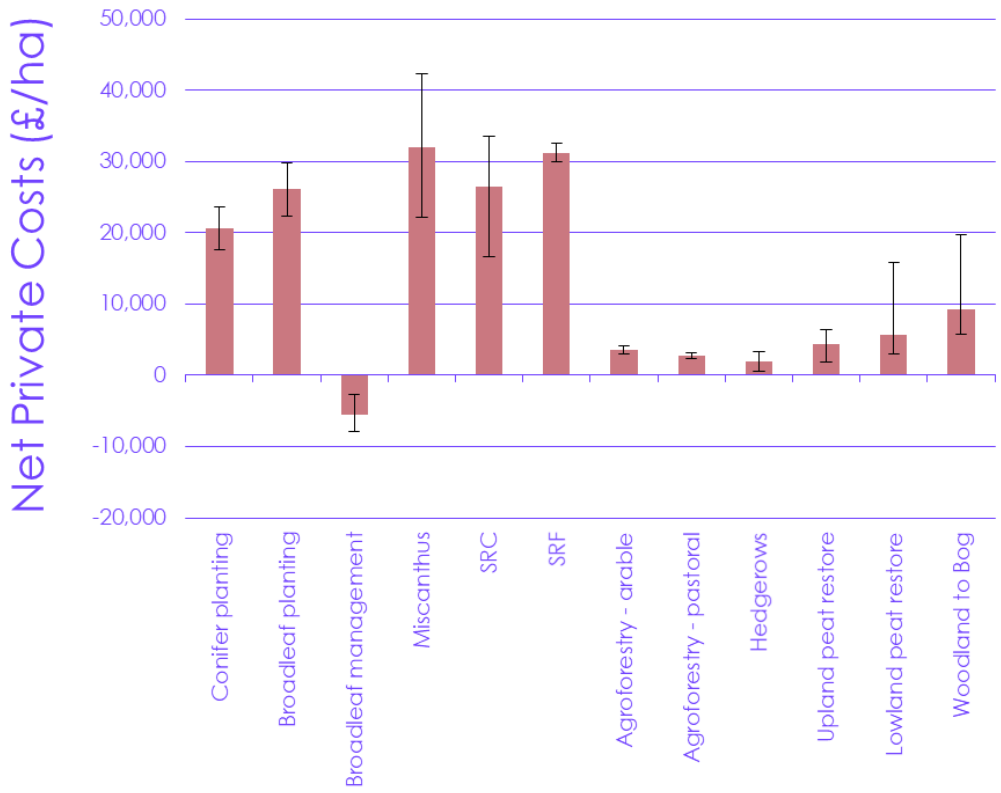
- Some of the measures we identify are cost-saving to farmers (e.g. cover crops and cattle health), while others have high up-front costs (e.g. anaerobic digestion and low-carbon machinery). Lack of financial support to target emissions reduction on-farm has led to limited take-up of these measures. Public subsidy payments under the Common Agricultural Policy (CAP) have been largely based on the area of land farmed rather than the delivery of environmental goods.
- For those options that represent technological solutions (e.g. livestock breeding measures) there is often a disconnect in translating R&D into market commercialisation that would allow for wide-scale adoption. Use of biofuels is the only low-carbon option currently available for agricultural vehicles with electrification of large machinery (e.g. tractors) still at the proto-type stage.
- Action may be constrained by a lack of knowledge, experience and skills in applying farming techniques and practices. The ageing profile of farmers and the lack of new entrants with the rights skills and training may make it more difficult to transition to low-carbon farming.

b) Land-based measures

Measures aimed at increasing sequestration and reducing emissions in land use need to be funded as private costs exceed private revenues.

The measures aimed at reducing land-based emissions in our Balanced Pathway (e.g. afforestation, peatland restoration, bioenergy crops, agroforestry and hedges) are largely not cost-effective from the perspective of farmers or land-managers. Private costs tend to be higher than private benefits and/or have high-up front costs which will need to be funded (Figure 7.1).

Figure. 7.1 Lifetime net private costs of land-based measures



Source: CCC Analysis based on CEH (2020) and Vivid Economics (2020) *Economic Impacts of Net Zero land use scenarios*.
Notes: Error bars show range of upper bound and lower bound costs estimated in the above report.

Non-financial barriers that need to be addressed include:

- **Application process**. Applying for funding from existing schemes can be time-consuming. Despite the availability of grant funding for woodland creation and broadleaf management, take-up has been modest reflecting an overly burdensome application process. The lack of local markets for the sale of the harvested material has also hindered the management of broadleaf woodlands.
- **High up-front costs and price uncertainty.** Measures such as afforestation, peatland restoration and growing bioenergy crops have high upfront costs and long lead in times for revenues, which may need to be bridged through loans or other finance mechanisms. Price uncertainty in existing schemes e.g. the Woodland Carbon Guarantee auctions may be a barrier to widespread adoption.
- **Contractual issues**. Issues around tenancy and common land could be acting as a barrier to action.
  - Around 28% of the land area in England, 22% in Wales, and 24% in Scotland is tenanted. The length (an average of 2.9 years in England and Wales in 2018) and the terms of the tenancy contract may prohibit switching land to alternative uses. Resolving tenancy constraints (e.g. lease renewal arrangements and aligning incentives between landowners and tenants) is important to allow and encourage tenanted farmers to undertake long-term investment decisions.

Awareness raising, information provision and demonstration trials are needed to break down cultural barriers to change.

  - Common land, which is mainly used for grazing, has special status under law. Under this type of tenure, the commoners rather than the landowner control the use and management of land, which could prohibit a willing landowner from making sustainable changes.

- **Lack of awareness**. Lack of information on the range of low-carbon options available to farmers, cultural resistance and risk aversion can act as a barrier to change. Sustainable farming is knowledge-intensive and in order to make the right decision, farmers need trusted advisors and networks (e.g. agricultural colleges and universities) to make informed choices and demonstration projects e.g. for bioenergy and agroforestry to illustrate benefits.

Bringing innovation on-farm is essential to improving productivity and competitiveness of UK farming.

- **Bringing R&D on-farm**. Many low-carbon measures in our scenarios are innovative and will need commercialisation to bring to market (e.g. higher crop yields and breeding of lower-methane emitting livestock). Ensuring widespread deployment of innovative options across a diverse range of farms in the UK will require overcoming existing barriers such as awareness and uncertainty over outcomes.

c) Consumer behaviour change

Meeting emissions reduction in the Balanced Pathway also requires consumers to overcome barriers to shifting towards healthier diets and reduce food waste.

- **Lack of understanding and awareness** on the climate impact of diets may impede change, and where these are known, people may not have the skills to cook plant-based recipes. This extends to both householders and those employed in the catering industry (e.g. kitchen staff in canteens).

- **Common metrics and standards** to measure the carbon footprint of food products are needed to enable consumers to make informed decisions on their purchases. This is crucial if food labelling is to be widely introduced in the retail sector.

- **Date labelling and guidance** on cooking, planning and storing food could help reduce consumer waste. Challenging existing consumer preferences and supermarket standards on the appearance of fruit and vegetables could reduce pre-farm waste.

2. Current Government policy commitments

Land use in the UK has been highly influenced by a complex set of sub-national, national, EU and international policies. These have, to date, rewarded food production over other services that land can provide including climate change mitigation and adaptation and wider environmental benefits.

There are no national or UK-wide policies that directly target the reduction of greenhouse gas (GHG) emissions in the agriculture sector. EU regulations, a voluntary approach to reducing on-farm emissions, and grant funding are key existing mechanisms:

- EU environment legislation to address non-GHG pollutants has indirectly reduced agriculture GHGs through changes in farming practices. For example, the Nitrates Directive restricts fertiliser use in Nitrate Vulnerable Zones (NVZs) and under the Water Framework Directive, farmers are required to meet basic standards to reduce diffuse water pollution.
- Under Pillar II of the CAP, England's £3 billion Rural Development Programme (RDP) was available for environmentally friendly practices, woodland creation and the restoration of priority habitats (e.g. including peatland) for the 2014-2020 period. Similar RDP schemes exist in Scotland, Wales and Northern Ireland. The last round of agreements signed before the end of 2020 will continue as RDP schemes despite the UK exit from the EU.

Provision of information and advice to farmers is the only policy directly targeted at reducing agricultural emissions.

- The provision of information and advice to farmers is the main mechanism to incentivise emissions reductions in agriculture. These voluntary approaches include the industry-led Greenhouse Gas Action Plan in England and the Farming for a Better Climate initiative in Scotland.
- England's Woodland Carbon Fund launched in 2016 is providing £19 million for woodland planting and on-going maintenance. A £10 million Peatland Grant is funding the restoration of around 6,000 hectares of lowland and upland peat in England. The Peatland ACTION project funded by the Scottish Government has awarded £8 million to restoration projects since 2012.

More recent announcements have looked to increase commitments in some areas. However, the planned publications to increase afforestation and peat restoration (the Tree and Peatland Strategies) have both been delayed, while design of the ELM scheme is still on-going:

New post-CAP frameworks for paying farmers are being developed by each devolved administration.

- The passage of the Agriculture Bill into law allows for the replacement of the CAP with a new domestic policy, including subsidy support for farmers. The ELM scheme will be the key mechanism to pay farmers and land-owners for the delivery of environmental benefits in England, including climate mitigation and adaptation. Defra has set out initial proposals on the high-level design of the ELM scheme and a national pilot will be rolled-out in 2021. Action in the devolved administrations includes:
  - Wales are considering responses to its consultation to replace CAP with a similar type of payment scheme for delivering environmental benefits ('Sustainable Farming Payment). A second mechanism is being developed to help farm businesses (Business Support Payment).

  - Scotland has yet to set out the future direction of its rural support policy.
  - Northern Ireland is expected to launch its Future Agricultural Policy Framework in 2021. Increased productivity, environmental sustainability, improved resilience and an integrated effective and efficient supply chain are to be the four main pillars of the framework.

- Some of the £640 million Nature for Climate Fund announced in the 2020 budget will be used to deliver the Government's manifesto commitment to plant 30,000 hectares per year of new woodland by 2025 across the UK and to restore 35,000 hectares of peatland in England over the next five years. This will be delivered in part through the creation of ten Landscape Recovery projects, which aim to establish 30,000 football pitches (~22,000 hectares) of wildlife rich habitat in England over the next four years.

Early auctions for woodland creation were successful but small scale.

- The first and second reverse auction of Defra's Woodland Carbon Guarantee were held earlier this year. Designed to stimulate private sector investment in woodland creation in England, the two auctions generated 108 bids, of which 45 were successful, covering 1,700 hectares. Auctions will be held each year between 2020 and 2025 with £50m committed to the scheme.
- The Scottish Government has committed to funding the restoration of 250,000 hectares of peat by 2030 with funding of £100 million to Scottish Forestry as well as £30 million to Forestry and Land Scotland to expand Scotland's national forests by 18,000 hectares per year until 2024.
- In Northern Ireland, the administration will start a pilot payment for the growing of protein crops (peas, beans and sweet lupins) to demonstrate schemes that can increase farm profitability and sustainability.

The existing policy framework and recent announcement are insufficient to meet the emissions reduction set out in our Sixth Carbon Budget advice. A new set of policies is urgently required to deliver this on the path to Net Zero.

3. Key changes needed

Measures to reduce emissions should also be designed to deliver wider environmental objectives e.g. climate adaptation and biodiversity.

In our report '*Land use: Policies for a Net Zero UK*' earlier this year we set out a comprehensive framework to deliver deep emissions reduction in agriculture and land. These should be designed to deliver other environmental objectives as set out in the Environment Bill, including climate change adaptation and biodiversity, where synergies exist. Key elements of our framework, including paying farmers to store and sequester carbon, information and skills training and low-carbon farming regulations were endorsed by the UK citizens' assembly on climate change.

The recommendations in our report remain valid and cover a mix of regulations and incentives for land managers to overcome financial and non-financial barriers to change and policy levers to shift consumer behaviour:

- **Strengthening the regulatory baseline to ensure low-regret measures are taken up.**
  - Extend existing regulation to reduce on-farm emissions (e.g. Nitrogen Vulnerable Zones) and use new legislation to regulate additional sources of emissions not currently regulated such as enteric fermentation from livestock (e.g. the Clean Air Strategy could require feed additives that reduce methane emissions from livestock).
  - Ban damaging practices such as rotational burning on peatland and peat extraction and end the sale of peat for horticultural use.
  - Set an obligation for water companies to restore peatland on land they own, and on owners of peatland within a site of special scientific interest (SSSI).

Auctioned contracts or a carbon trading scheme are needed for afforestation and could be privately funded.

- **Funding for actions above the baseline to support more costly measures.**
  - The key mechanism for afforestation and some agroforestry schemes should be auctioned contracts (e.g. similar to those offered for renewable electricity) or a carbon trading scheme. These need to be carefully designed to avoid potential negative impacts and ensure carbon credits from land-based solutions are not available to offset emissions reductions that are needed to meet Net Zero in other parts of the economy.
  - Public funding should be used to encourage the non-carbon benefits of afforestation (e.g. alleviating flood risk, recreation); planting trees on farms where it would not occur through the main mechanism above; the take-up of low-carbon farming practices (e.g. robotic milking parlours and cattle breeding) that go beyond the requirements of new regulatory baseline and where they impose costs to farmers.
  - Peatland restoration should also receive public funding, alongside sustainable management practices on lowland peat that remains in agricultural production. In the longer term, this could move to a trading or auctioning system, once emissions reductions can be verified effectively.
  - Bioenergy crops should be supported through existing instruments in the short term.

  - Government should set out a clear path to incentivise the take-up of zero or near-zero emission options for agricultural machinery and to develop options where these are currently not available. We recommend that, failing its inclusion in either the Industrial Decarbonisation Strategy, Heat and Buildings Strategy or Transport Decarbonisation Strategy, it should be covered by the Net Zero Strategy.

- **Enabling measures to address non-financial barriers**
  - Support schemes to strengthen skills, training and market commercialisation of innovative low-carbon farming options (e.g. livestock breeding and diets). Raise awareness and provide training in energy crop and peatland management.
  - Additional measures to support the UK bioenergy market e.g. agreements to source a minimum proportion of biomass feedstock from the UK and concessionary finance for growing energy crops.
  - Address contractual arrangements that may constrain uptake amongst farms that are tenanted or designated as common land.
  - The tax treatment of woodlands should be reviewed and, if necessary, amended to ensure there is no disadvantage to farmers from changing their use of land to forestry.

- **Policies are needed to encourage consumers to shift diets and reduce food waste.**

An ettective strategy to tackle awareness of the climate impacts of what we eat is an essential part of our pathway.

  - **Diets:** Government should implement low-cost, low-regret actions to encourage a shift away from meat and dairy (e.g. the public sector taking a lead in providing plant-based options with all meals). An evidence-based strategy is required to establish which measures will successfully change behaviour, encompassing information provision, skills support, and encouraging greater accountability of business through clear and robust metrics and mandatory reporting. These were also highlighted by the UK citizens' assembly on climate change. If these measures are not enough to change consumption patterns, a second stage will need to look at stronger options, whether regulatory or pricing.
  - **Food waste:** Implement steps to reduce food waste from the farm to the householder. This should include immediate low-cost measures (e.g. target setting in the public and private sectors); measures to 'nudge' consumers towards best practice and mandatory separate food waste collection.

- **A strong monitoring, reporting and verification system (MRV)** is needed to create a robust framework to monitor and pay for actions across the UK.

Interim policies and funding should be implemented to avoid a hiatus in action.

- **Interim policies to avoid a hiatus in action.** Early action is essential to enable the transition to lower carbon uses of land given the time required for some measures to deliver emissions reduction and removals. Interim policies should be implemented to avoid a hiatus in action while awaiting the implementation of the new framework (e.g. the roll-out of the ELM scheme starts in 2024):

- On-going public funding should continue, and where necessary be increased. This includes Treasury matching the level of funding that had been previously been allocated under CAP's Pillar II. As of 2021, all agreements signed for the Countryside Stewardship scheme will be funded by the Treasury under domestic legislation.
- In addition, the terms of funding available under existing programmes (e.g. Countryside Stewardship) should be amended to incorporate measures that directly reduce emissions.

Endnotes

Chapter 8

Aviation and shipping

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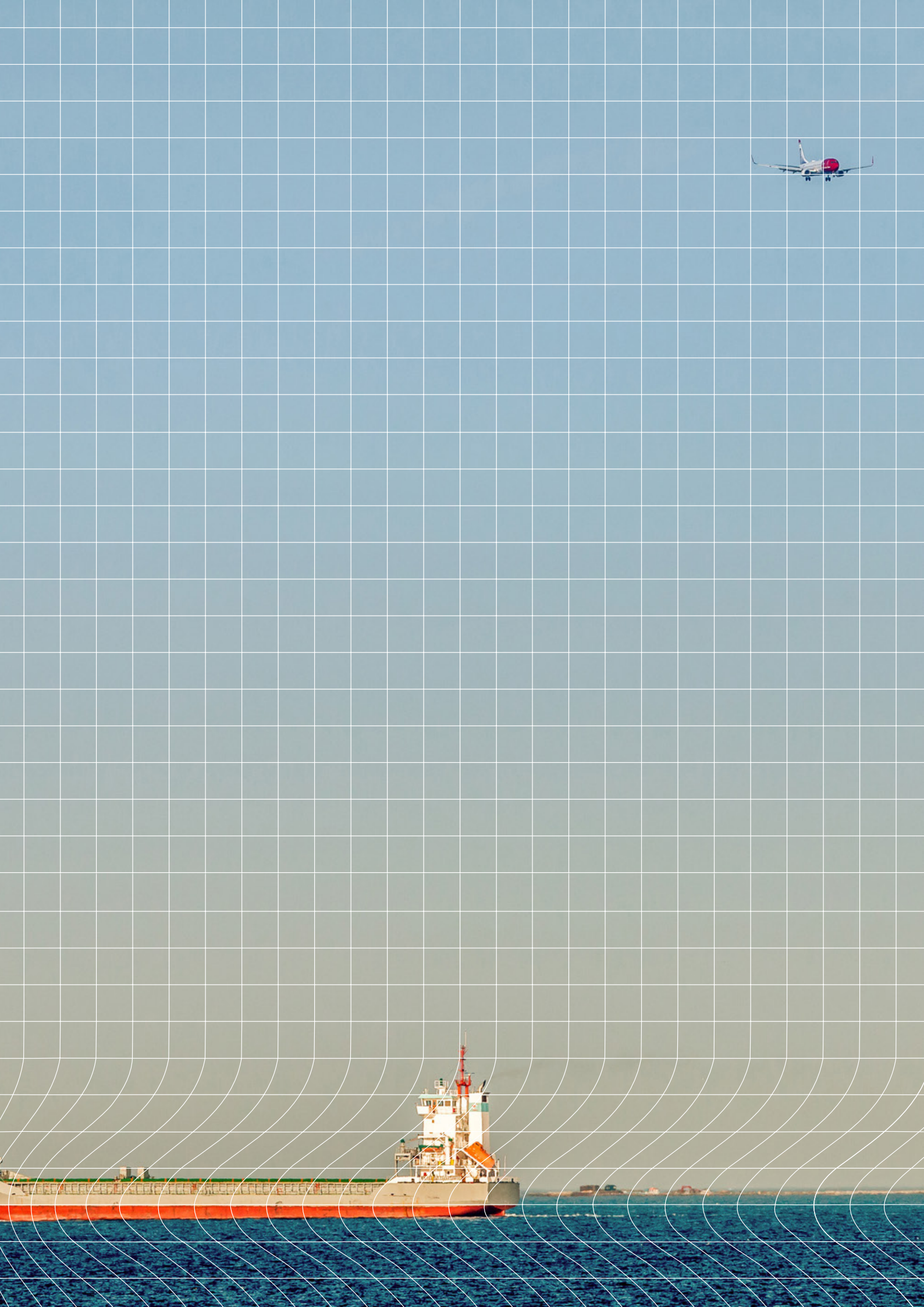


Table 8.1
Summary of policy recommendations in aviation and shipping

Aviation	• Formally include International Aviation emissions within UK climate targets when setting the Sixth Carbon Budget. • Work with ICAO to set a long-term goal for aviation consistent with the Paris Agreement, strengthen the CORSIA scheme and align CORSIA to this long-term goal. • Commit to a Net Zero goal for UK aviation as part of the forthcoming Aviation Decarbonisation Strategy, with UK international aviation reaching Net Zero emissions by 2050 at the latest, and domestic aviation potentially earlier. Plan for residual emissions, after efficiency, low-carbon fuels and demand-side measures, to be offset by verifiable greenhouse gas removals, on a sector net emissions trajectory to Net Zero. • There should be no net expansion of UK airport capacity unless the sector is on track to sufficiently outperform its net emissions trajectory and can accommodate the additional demand. • Monitor non-CO_2 effects of aviation, set a minimum goal of no further warming after 2050, research mitigation options, and consider how best to tackle non-CO_2 effects alongside UK climate targets without increasing CO_2 emissions. • Longer-term, support for sustainable aviation fuel (SAF) should transition to a more bespoke policy, such as a blending mandate. However, near-term construction of commercial SAF facilities in the UK still needs to be supported. • Continue innovation and demonstration support for SAF technologies, aircraft efficiency measures, hybrid, full electric and hydrogen aircraft development and airspace modernisation.
Shipping	• Formally include International Shipping emissions within UK climate targets when setting the Sixth Carbon Budget. • Continue working with the IMO on global shipping policies, research funding, tighter efficiency targets, and strengthening the IMO 2050 global target. • Build on the Clean Maritime Plan to set a Net Zero 2050 goal for UK shipping, and develop incentives for zero-carbon ammonia and hydrogen supply chains. • Commit to the UK's first clean maritime cluster(s) operating at commercial scale (supplying at least 2 TWh/year of zero-carbon fuels) by 2030 at the latest, with zero-carbon fuels expanding to 33% of UK shipping fuel use by 2035. • Provide support for ports' investment in shore power and electric recharging infrastructure. • Continue innovation and demonstration support for zero-carbon fuel technologies and their use in shipping, and ship efficiency measures. • Monitor non-CO_2 effects of shipping and consider how best to tackle them alongside UK climate targets.

Progress in decarbonising aviation and shipping has been slow over the past decade, and changes in emissions have primarily been driven by changes in demands along with some improvements in efficiency. Policy to date has been mainly driven by international fora (negotiations at ICAO and the IMO), although neither organisation has both established ambitious 2050 global goals and a set of policies to meet these goals.

The main policy challenges in aviation and shipping are the international nature of these sectors requiring fuel infrastructure coordination, long asset lifetimes and economic competitiveness concerns.

Aviation policy in the UK has previously focused on aerospace developments, although several announcements have been made in 2020, with an Aviation Decarbonisation Strategy now due in 2021. Funding is still mainly directed at innovation and demonstration activities, rather than long-term market deployment support for sustainable aviation fuels and GHG removals.

Shipping policy in the UK has had much less funding to date, but starting from the Clean Maritime Plan is now progressing to feasibility studies for zero-carbon maritime clusters. Policy incentives still need developed to enable production and use of zero-carbon fuels in shipping.

Our recommendations are based on an assessment of existing policies and announcements, a review of evidence (including the views of the Climate Assembly) and updating our existing findings set out in our 2020 *Progress Report* and 2019 *International aviation & shipping letter*.[1]

This chapter covers:

1. The respective roles for international and domestic policy
2. Existing UK policy, gaps, and planned publications
3. Key policy changes needed

Inclusion of IAS emissions in UK climate targets does not imply taking a unilateral policy approach for them.

Even with their emissions formally included in UK carbon budgets and the Net Zero target, the primary policy approach to reducing emissions from international aviation and shipping (IAS) should be at the international level. These sectors are global in nature and there are some risks that a unilateral UK approach to reducing these emissions could lead to carbon leakage (under certain policy choices) or competitiveness concerns.

The UK has played a key role in progress by both the International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO). In the context of international negotiations at the ICAO and the IMO, inclusion of IAS emissions in the Net Zero target should not be interpreted as a rejection of multi-lateral approaches or as prejudicing discussions on burden sharing.

International approaches are unlikely to overcome all barriers to decarbonising the IAS sectors.

However, international approaches are unlikely to overcome all barriers to decarbonising the IAS sectors. Supplementary domestic policies should also be pursued where these can help overcome UK-specific market barriers, and where these do not lead to adverse impacts on competitiveness and/or carbon leakage.

a) International approaches

At the international level, global policies consistent with the ambition in the Paris Agreement are required to provide a level playing field for airlines and shipping operators, and to guard against the risk of competitive distortions. The international trade bodies for both aviation and shipping have begun to develop their approaches but further progress is required:

- **Aviation.** The ICAO's current carbon policy to 2035, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), aims to ensure that most emissions increases above a baseline year are balanced by offsets.
  - In light of COVID-19, ICAO agreed a baseline year change to 2019 (instead of averaging over 2019-2020). This will reduce offset requirements in the initial years of the scheme as the sector recovers. CORSIA's list of eligible emissions reduction measures has also been finalised.
  - A new long-term goal for global international aviation emissions is now required that is consistent with the Paris Agreement. CORSIA then needs to be extended and aligned with this goal, and rules need to be put in place to ensure that CORSIA offsets deliver genuine emission reductions, transitioning to sustainable, well-governed greenhouse gas removals (see Chapter 11).

ICAO needs to set a long-term goal aligned with the Paris Agreement, and strengthen CORSIA.

IMO needs to strengthen its long-term goals and develop a policy package to meet these.

- **Shipping.** The IMO has agreed to reduce global international shipping emissions by at least 50% by 2050 compared to 2008 levels, and fully decarbonise "as soon as possible" after 2050. It must now put in a place a package of policies to deliver these targets. That should include carbon pricing, measures such as slow steaming and operations optimisation, support for RD&D, and a co-ordinated approach to provision of refuelling infrastructure and engine retrofits for alternative fuels.

- The IMO's 2050 ambition should also be strengthened to align with the more ambitious end of the temperature goal in the Paris Agreement, given the potential for much deeper reductions in global shipping emissions (e.g. to nearly zero by 2050 through use of ammonia or other hydrogen-based fuels).
- In November 2020, IMO formalised some measures towards its 2030 carbon intensity target (a 40% improvement from 2008 levels), agreeing to new energy efficiency requirements from 2023 and mandatory carbon intensity targets from 2026. However, more stretching targets should be introduced for new ship and fleet efficiencies, given that fleet carbon intensities in 2018 had already improved by 30% from 2008 levels.2
- Proposals for an International Maritime Research and Development Board (IMRB), funded by a fuel levy, are still under consideration.

b) Supplementary domestic policies

Domestic policy can focus on supporting low-carbon fuels, managing demand, domestic fleet decarbonisation and developing GHG removals.

Supplementary domestic policies that have limited competitiveness or carbon leakage risks should be pursued in parallel to international approaches to decarbonisation. These include support for developing alternative fuels and associated infrastructure, managing demand, decarbonising domestic fleets, and kick-starting a UK market for greenhouse gas removals (see Chapter 11). These domestic policy recommendations are discussed in section 3 below.

By taking these domestic and international policy approaches in parallel to including IAS formally within carbon budgets and the Net Zero target, the UK will be contributing fully to the global effort to tackle aviation and shipping emissions.

a) Aviation

Aerospace development has been a focus in UK policy, although the RTFO is yet to bring forward renewable jet fuel.

Existing UK policy in Aviation has been focused on match-funding for aircraft technology development (e.g. the £300million Future of Flight Challenge), and traded certificate price support for aviation biofuels and synthetic jet fuels under the Renewable Transport Fuel Obligation (RTFO)'s 'development fuels' sub-mandate. Recent announcements include:

- The Jet Zero Council has also been established as a forum with the ambition for developing zero-emissions commercial flight.
- £15 million has been invested into FlyZero, with the Aerospace Technology Institute looking at design challenges and the market opportunity for zero-emissions aircraft concepts from 2030.
- £15 million will be invested in a new grant-funding competition for SAF production.
- A SAF clearing house will be set up to enable UK to certify new fuels.
- A planned consultation on a SAF blending mandate has been announced, for a potential start in 2025.
- An aviation Net Zero Consultation and following Strategy were planned for 2020. Plans are to now consult on a combined Aviation Decarbonisation Strategy in 2021.

Government announcements and support to date focuses on innovation and demonstration, but long-term deployment policy needs developed.

However, there remain significant gaps within the policy framework for aviation. Government support at present is focused on innovation funding and demonstration activities, but without clear long-term policy mechanisms driving SAF uptake or valuing negative emissions in the UK:

- The RTFO development fuels sub-mandate is unlikely to drive significant development of jet fuels, as it can be met with cheaper fuels.
- There is currently no price signal for GHG removals in the UK.
- There is a lack of larger-scale deployment support and policy frameworks specifically for sustainable aviation fuel and GHG removals.

UK aviation industry has committed to reaching Net Zero by 2050.

Although the UK aviation industry has committed to a Net Zero goal for 2050 (via the Sustainable Aviation coalition),[3] this is not yet a policy goal for Government. Higher-level strategic gaps include the lack of formal inclusion of international emissions in UK carbon budgets and the Net Zero target, and the need for a sector emissions trajectory to inform demand management and airport capacity policies. Further research is also needed on non-CO_2 effects and potential mitigation options.

b) Shipping

UK shipping policy has recently emerged out of the Clean Maritime Plan, and is still ramping up.

Existing UK policy in shipping has been focused on small-scale funding of research projects, establishment of advisory functions and mapping of priority cluster locations, all as outcomes of the 2019 Clean Maritime Plan.[4] Recent developments include:

- £20 million is to be invested into a Clean Maritime Demonstration Programme, to fund several clean maritime cluster feasibility studies at key sites across the UK, including Orkney and Teesside. This activity has a target milestone of 2022 for vessels trials starting in Orkney and work launched on a hydrogen refuelling port in Teesside.
- A consultation on supporting zero-carbon shipping fuels under the Renewable Transport Fuel Obligation (RTFO) has been expected in 2020.
- A Call for Evidence on non-tax incentives in shipping has been delayed. However, Government will be providing a response to HM Treasury's Carbon Emissions Tax consultation that may extend carbon taxation to shipping if a UK ETS is not adopted from 2021.

Shipping innovation and feasibility studies are necessary, but so is a long-term commercial incentive for producing and using zero-carbon fuels in shipping.

The main policy gaps in shipping include the lack of incentives for commercial use of zero-carbon fuels in shipping, plus the lack of deployment support for port infrastructure changes and construction of zero-carbon fuels plants. Higher-level strategic gaps include the lack of formal inclusion of international emissions in UK carbon budgets and the Net Zero target, and the need for a sector trajectory to inform new fuels deployment timings and efficiency expectations.

a) Aviation

International aviation emissions to be included in Carbon Budgets.

The Government should include international aviation emissions within the Sixth Carbon Budget, subsequent carbon budgets and the 2050 Net Zero target.

Government should commit to a 2050 Net Zero goal for UK aviation, with use of verifiable GHG removals.

The forthcoming Aviation Decarbonisation Strategy should commit to a 2050 Net Zero goal for UK aviation, with use of verifiable GHG removals (but with limits), and set out demand management policies to ensure a trajectory to 2050 is achieved and that non-CO_2 effects are addressed.

i) Aviation emissions on the way to Net Zero

The Government should commit to UK international aviation reaching net zero GHG emissions by 2050 at the latest, and UK domestic and military aviation potentially earlier.

An emissions trajectory to 2050 will set expectations for use of GHG removals over time.

This will necessarily entail having a plan for how verifiable greenhouse gas removals will offset residual emissions over time (i.e. after contributions from efficiency improvements, low-carbon fuels and demand-side measures). DfT should set a net emissions trajectory for aviation (net of a constrained level of GHG removals), or as a minimum, interim targets on the way to 2050.

- Following the Balanced Net Zero Pathway, the remaining 23 $MtCO_2e$/year of gross aviation emissions in 2050 would require 40% of total UK engineered greenhouse gas removals to be assigned to the aviation sector to achieve Net Zero within aviation.
- With the ramp-up in GHG removals in the UK over time, Figure 8.1 gives an indicative net aviation emissions trajectory that could be followed if 40% of UK GHG removals were assigned to aviation in all years.
- Interim targets for aviation emissions net of greenhouse gas removals could therefore be 31 $MtCO_2e$/year in 2030, 21 $MtCO_2e$/year in 2035 and 14 $MtCO_2e$/year in 2040.

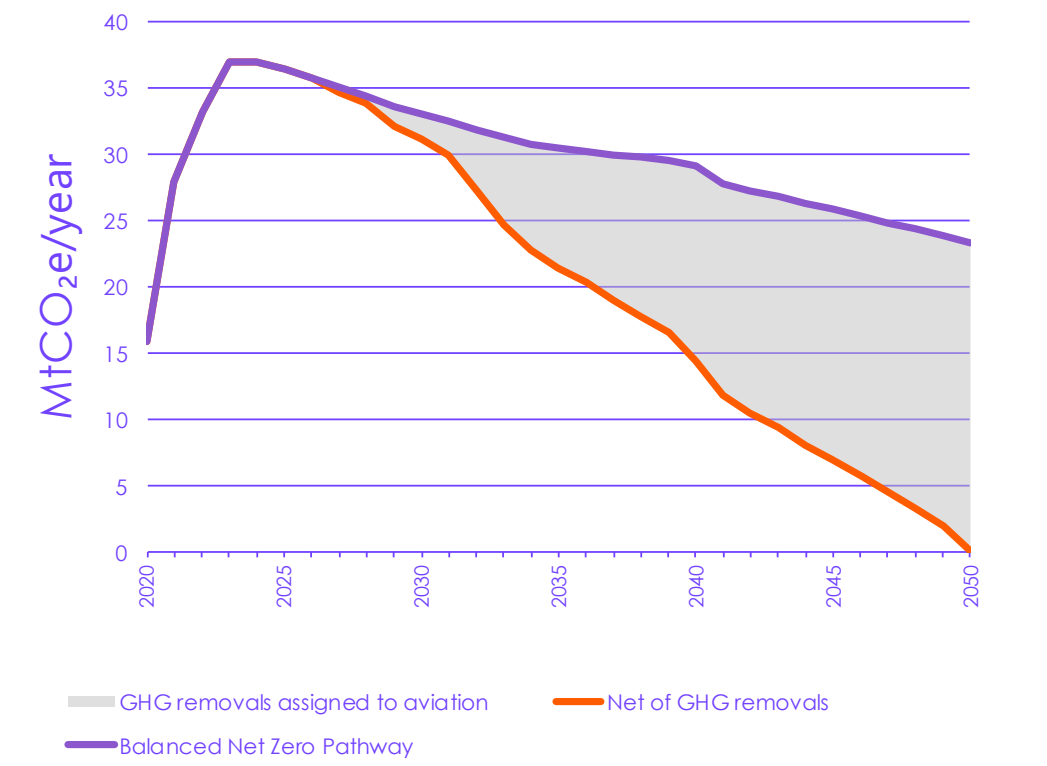
Inclusion of IAS in Carbon Budgets does not diminish the value of a sector target and trajectory.

- Setting an aviation sector net emissions target and trajectory is not obviated by IAS inclusion with carbon budgets. This is more important in aviation than other emitting sectors, given that without policy action aviation emissions could rise significantly (as would non-CO_2 effects) and that, even with appropriate action, residual positive GHG emissions are very likely to remain by 2050 (and need compensating for with greenhouse gas removals). The UK aviation industry has also already committed to a 2050 Net Zero target.

This plan should dovetail with the wider overall strategy for Net Zero, which should set out how this can be achieved with manageable volumes of sustainable greenhouse gas removals.

From the Balanced Net Zero Pathway, aviation emissions net of GHG removals fall relatively smoothly from the mid-2020s to 2050 Net Zero.

Figure 8.1 Indicative UK aviation emissions trajectory to achieve Net Zero with GHG removals



Source: CCC analysis.
Note: Net of GHG removals trajectory assumes that 40% of UK engineered GHG removals are assigned to/bought by the aviation sector. COVID-19 recovery assumed from 2020 to 2024.

ii) Demand management

Demand management policy is required, as demand growth will need significantly constrained from baseline assumptions, and there are non-CO_2 risks.

Demand management policy should be implemented, as given expected developments in efficiency and SAF deployment, demand growth will need to be lower than baseline assumptions, and likely constrained to 25% growth by 2050 from 2018 levels for the sector to contribute to UK Net Zero.

If efficiency or SAF do not develop as expected, further demand management will be required. Conversely, if efficiency and SAF develop quicker, it may be possible for demand growth to rise above 25%, provided that additional non-CO_2 effects are acceptable or can be mitigated.

Demand management needs to act as a back-stop to keep emissions on track to the sector trajectory to Net Zero.

A demand management framework will therefore need to be developed and in place by the mid-2020s to annually assess and, if required, act as a backstop to control sector GHG emissions and non-CO_2 effects.

- There are a number of demand management policies that could be considered, as we outlined in our 2019 *IAS letter*.[1] However, the Climate Assembly has provided valuable evidence that demand management policies will have to be fair and be seen as fair, with a clear preference for any taxes to increase as people fly more and fly further (Box 8.1).

- As part of providing wider information regarding transport choices, Government should also consider the feasibility and benefits of providing flight CO_2 labelling to prospective aviation passengers, building on the work of the Civil Aviation Authority (CAA).

The Government should assess its airport capacity strategy in the context of Net Zero and any lasting impacts on demand from COVID-19. Investments will need to be demonstrated to make economic sense in a Net Zero world and the transition towards it.

- Unless faster than expected progress is made on aircraft technology and SAF deployment, such that the sector is outperforming its trajectory to Net Zero, current planned additional airport capacity would require capacity restrictions placed on other airports.

No net expansion of UK airport capacity unless the sector is on track to sufficiently outperform its trajectory.

- Going forwards, there should be no net expansion of UK airport capacity unless the sector is assessed as being on track to sufficiently outperform a net emissions trajectory that is compatible with achieving Net Zero alongside the rest of the economy, and is able to accommodate the additional demand and still stay on track.

The Climate Assembly stated a clear preference for demand taxes to increase as people fly more and fly further.

Box 8.1
Climate Assembly aviation demand findings

Box 8.1 from the *Methodology Report*, Chapter 8, highlights the Climate Assembly's preferences regarding demand growth. The Assembly recommended 25-50% demand growth by 2050 from 2018, depending on how quickly technology progressed. A weighted average of the scenario votes was a 24% growth.

80% of assembly members 'strongly agreed' or 'agreed' that taxes that increase as people fly more often and as they fly further should be part of how the UK gets to Net Zero. Assembly members saw this as fairer than alternative policy options, such as a carbon tax that would impact all flights.

There were also strong calls for making alternatives to flying cheaper and better, and for the UK to influence the rest of the world in implementing global decarbonisation policies.

Source: Climate Assembly UK (2020).

iii) Wider supporting policies

Alongside the Aviation Decarbonisation Strategy, UK policy should also:

Support is needed for the UK's first commercial SAF plants.

- Set out a policy package for supporting the near-term deployment of commercial sustainable aviation fuel (SAF) facilities in the UK (with carbon capture and storage (CCS) where applicable). This may involve capital or loan guarantee support. In the mid-term, SAF support should transition to a more bespoke policy than the RTFO.
  - The existing RTFO will not be suitable for delivering mass commercial roll-out of SAF, due to decreasing liquid road fuel use. It may also make more sense for long-term SAF deployment to be paid for by the aviation sector rather than road fuel users.

A SAF blending mandate could provide more certainty to SAF plant investors.

  - Government has indicated willingness to consider introducing a SAF blending mandate from 2025,* which could ultimately provide more certainty to SAF plant investors than the RTFO. A SAF mandate is likely to be more effective than Contracts for Difference (as the technology maturity of many routes are not high enough and there are variable feedstock costs), inclusion in an Emissions Trading Scheme (likely insufficient and volatile pricing signal) or carbon taxation (would have to be high to incentivise initial SAF deployment, and not perceived as fair by the Climate Assembly).

Many other European countries already have SAF blending mandates, so carbon leakage risks are decreasing.

  - Whether the mandate's added SAF costs then fall to the aviation sector or general taxation will depend on the policy design and any concerns regarding UK operator competitiveness or carbon leakage. Several other European countries already have SAF blending mandates and are introducing ambitious blending trajectories, which suggests the risk of leakage is decreasing (e.g. France is targeting 5% by 2030 & 50% by 2050; Finland & Sweden 30% by 2030; Germany 2% by 2030; with an EU-wide proposal for 1-2% by 2030).[5]

  - Ongoing uncertainty until 2025 about a new UK SAF mandate, and withdrawal of SAF from the RTFO, may risk delaying first commercial SAF projects in the UK reaching financial close for several years. Consideration could be given to either RTFO grandfathering, starting the SAF mandate earlier or running it in parallel to the RTFO.

- Continue innovation and demonstration support for newer SAF technologies, ensuring fuels can meet international standards. The newly announced £15m competition focused only on SAF is welcome, although is smaller than previous competitions.

- Continue RD&D support for aircraft efficiency measures, hybrid, full electric & hydrogen aircraft development and airspace modernisation. Continue to use existing delivery bodies, such as ATI, the Future of Flight Challenge, NATS, and guided by the Jet Zero Council.

Strict sustainability standards will need to be enforced, any double-counting of removals avoided, and SAF plants should be built with CCS.

- Continue to enforce strict sustainability standards, and work to consistently account for fuels produced with biogenic CO_2 capture without allowing double-counting of any GHG removals.

  - SAF facilities should have to install CCS, or be built CCS ready, in order to maximise GHG savings from any concentrated CO_2 streams or dilute flue gases.* The 2022 Bioenergy Strategy should set a date after which all new build plants must use CCS, and a date after which existing plants should retrofit CCS.

  - An accounting choice needs to be made as to whether the consumer of a fuel made with CCS gets to account for the GHG removals (i.e. fuels can be carbon negative, further reducing end-use sector direct emissions),† or whether the producer of the fuel gets to account for the GHG removals (and the fuel is carbon neutral).

* From our analysis, potential UK SAF blending levels could be 1.5-3.5% by 2030, 4-9% by 2035 and 11-17% by 2040, although the top end of these figures could almost be doubled in a Tailwinds scenario, due to faster technology deployment and higher biofuel imports.

* Some SAF conversion plants do not produce CO_2, and hence these CCS provisions may not apply to them. For example, synthetic jet fuel routes use CO_2 as a feedstock, and waste fats/oils to biojet will produce little CO_2. However, these plants may still have dilute flue gas streams from which CO_2 should still be captured.

† UK biofuels policy currently uses GHG emissions thresholds (gCO2e/MJ of fuel) as one set of eligibility criteria for support. Setting a negative GHG emissions threshold may lead to perverse outcomes, where only less efficient plants meet the threshold. Any negative threshold would have to be accompanied by a minimum efficiency and would preclude carbon-neutral fuels. It is likely more appropriate to maintain low positive GHG emissions thresholds for

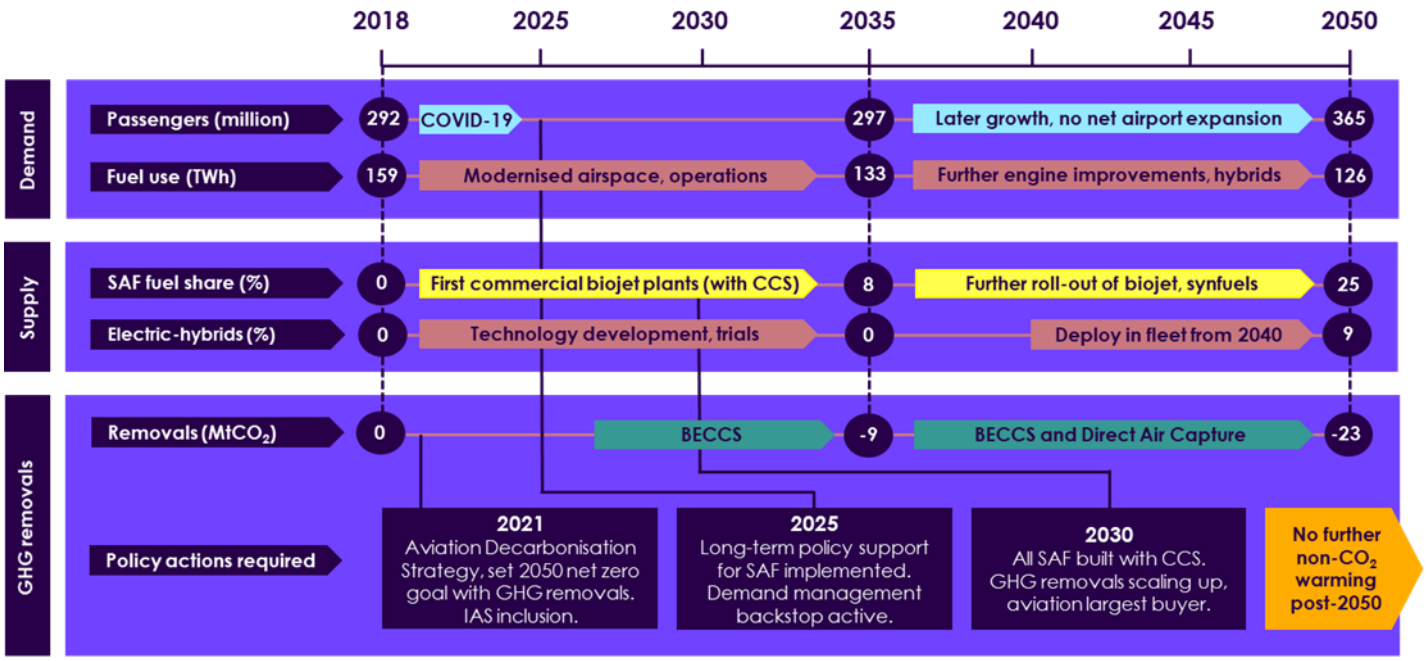
  - Any GHG removals accounted for within a fuel carbon intensity factor or by a producer cannot also be claimed by another actor or sector.
  - A clear GHG savings methodology needs to be established for wastes.

- Monitor non-CO_2 effects of aviation, continue to work to reduce scientific uncertainties, and fund research into mitigation options such as SAF benefits and engine design improvements.
  - Once mitigation options are better characterised, consider policy responses as to how best to tackle them alongside UK climate targets without increasing CO_2 emissions.
  - As a minimum goal, there should be no additional non-CO_2 warming from aviation after 2050. If mitigation options develop quickly, or new risks are identified, DfT could consider an earlier date, or setting a maximum level of allowable non-CO_2 warming from a base year.

There should be no additional non-CO_2 warming after 2050.

Alongside efforts at ICAO, the Aviation Decarbonisation Strategy and the package of domestic policies, plus parallel progress on a mechanism for deploying GHG removals in the UK (see Chapter 11), should put UK aviation emissions on track to contribute fully to meeting the Sixth Carbon Budget and the Net Zero target. A summary of the required steps in aviation is given in Figure 8.2.

Figure 8.2 Timeline of key outcomes and policy requirements under the Balanced Pathway (2020-50)



Source: CCC analysis.
Note: SAF = Sustainable Aviation Fuel. BECCS = Bioenergy with carbon capture and storage

eligibility purposes but allow additional benefits to flow to conversion plants capturing biogenic CO_2 (this may be achieved already by the design of wider GHG removals policies).

b) Shipping

Government should commit to a 2050 Net Zero goal for UK shipping.

The Government should include international shipping emissions within the Sixth Carbon Budget, subsequent carbon budgets and the 2050 Net Zero target.

The Clean Maritime Plan set out many of the initial decarbonisation steps needed and commits the UK to 'moving faster than other countries and faster than international standards', although does not yet commit to a firm sector 2050 target. It should now be strengthened to commit to a 2050 Net Zero goal for UK shipping. Government should also support supply chains and the roll-out of clean maritime clusters by 2030:

Incentives need developed for low-carbon hydrogen and ammonia, and a range of policy options exist.

- Develop incentives for zero-carbon ammonia and hydrogen supply chains for UK shipping.
  - To support the deployment of zero-carbon fuels in shipping at low volumes during the 2020s, one option could be inclusion within the Renewable Transport Fuel Obligation (RTFO). If this option is pursued, given the potential for ammonia to become the lowest-cost transport option for hydrogen globally, and the ability to retrofit existing engines for ammonia, both fuels should be set on an equal basis for development fuel support under the RTFO.

Carbon pricing options will still likely need supplementary policies for zero-carbon fuel infrastructure.

  - However, in the longer term, for commercial roll-out from 2030, more bespoke zero-carbon shipping fuel policy will likely be required than the RTFO, given declining road fuel use. It may also make more sense for deployment to be paid for by the shipping sector rather than road fuel users.
  - Given these longer-term considerations, alternative policy options to RTFO inclusion could be considered. These could be including shipping within a UK emissions trading scheme or carbon taxation. However, there are risks that either of these options do not provide a high enough effective carbon price to incentivise the required zero-carbon fuel infrastructure and any ship retrofits (e.g. we estimate that an effective carbon price well above £200/tCO_2e is likely to be needed in the 2020s). Supplementary support for construction of new zero-carbon fuel infrastructure and ship retrofits may therefore be required alongside these carbon pricing options.
  - Any GHG emissions thresholds should incentivise the use of zero carbon renewable fuels in shipping, with minimal upstream emissions.

A clear timeline and roll-out plan needs to be published to achieve zero-carbon shipping clusters by 2030.

- Commit to delivery of a phased roll-out of clean maritime clusters:
  - Feasibility studies for the UK's first zero-carbon shipping clusters launched in early 2020s.
  - Initial smaller-scale port demonstrations in the early to mid-2020s, and learnings shared.
  - A full roll-out plan for zero-carbon shipping fuels, and accompanying fleet retrofits or modifications, to be in place by the mid-2020s, to allow time for investment and construction.
  - The UK's first clean maritime cluster at commercial scale (e.g. supplying more than 2 TWh/year of zero-carbon fuels) to be operating by 2030 at the latest – and ideally more than one cluster operational by 2030.

  - Roll-out during the early 2030s to achieve a 33% share of zero-carbon fuels being used in UK shipping by 2035 (this is a ten times scale-up from 2030, following the Balanced Pathway deployment profile). The UK's domestic fleet is likely to take a leading role in initial deployment.

Further research should continue into efficiency, zero-carbon fuels production and air quality aspects.

- Accelerate marine RD&D funding, including for ship efficiency measures, alternative propulsion testing, high efficiency cracking of ammonia to hydrogen, electro-chemical synthesis of ammonia, and mitigating ammonia combustion air quality concerns. Conduct further research on the decarbonisation options available to naval shipping.
- Provide financial support (e.g. capital support or loan guarantees) for ports looking to invest in shore power and electric vessel charging infrastructure.
- Monitor non-CO_2 effects of shipping and consider how best to tackle them alongside UK climate targets without increasing CO_2 emissions.

Endnotes

[1] CCC (2019) *Net-zero and the approach to international aviation and shipping emissions*
[2] IMO (2020) *Fourth IMO GHG Study*
[3] Sustainable Aviation (2020) *UK aviation commits to net zero carbon emissions by 2050*
[4] DfT (2019) *Clean Maritime Plan*
[5] Argus (2020) *Europe makes legislative push for aviation transition*

Chapter 9

Waste

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2. Existing policy and planned publications 181
3. Key policy changes needed 185



Table 9.1
Summary of policy recommendations in waste

Waste reduction and recycling	• **Develop further policies to accelerate the Resources & Waste Strategy for England**, introducing greater ambition for efficiency in manufacturing and construction, material substitution for more sustainable alternatives, and reduction in consumer demand for products. Similar focus to be applied in Wales, Scotland and Northern Ireland with their respective circular economy strategies. • **Mandatory business food waste reporting** to be introduced by 2022, building on WRAP's existing voluntary scheme. • **Accelerate investment plans for local authorities to put in place universal municipal waste recycling collections**, along with downstream recycling, composting and anaerobic digestion (AD) facilities. • **Set a target for a 68% recycling rate by 2030 covering all wastes in England** via the Environment Bill, and announce new policies to meet this target. **Northern Ireland to set a 70% target for 2030**. Scotland and Wales to set new targets for 2030 that go beyond their 70% targets for 2025. • **Composting facilities should be incentivised to install forced aeration** as a method of reducing on-site emissions.
Landfill and exports	• Legislate for (in England via the Environment Bill, and in Wales, Scotland and Northern Ireland via new legislation) and **implement a ban on landfilling of all biodegradable municipal and non-municipal waste from 2025**. There must be sufficient recycling/composting/AD treatment capacity made available before the ban comes into force, so that significant increases in energy-from-waste are avoided. • **Phase out exports of waste by 2030.** • Long-term plans should be announced for **eventual diversion of all wastes from landfill**, but with a date conditional on sufficient action on reduction, re-use and recycling, and installation of CCS at energy-from-waste plants, to avoid a surge in fossil emissions when the ban comes into force. • Announce policies and funding for **increased methane capture and oxidation** at landfill sites, to significantly decrease fugitive landfill methane emissions.
Wastewater	• **Ofwat should include decarbonisation as one of its core principles**, to assist the water industry's goal of decarbonising by 2030, and the need to roll out advanced AD systems. • Innovation funding should be committed to development and **demonstration of novel wastewater treatment process** that achieve a step change improvement in direct process emissions. • Outside of the municipal wastewater sector, **industrial wastewater plants should be incentivised** to reduce their process emissions.
Energy from waste	• Examine the impact of waste reduction & recycling targets on the **utilisation of (and need for further) energy-from-waste plants**. Issue guidance notes to align local authority waste contracts and planning policy to these targets. • New waste conversion plants (including incineration, gasification & pyrolysis facilities) **must be built with carbon capture and storage (CCS) or 'CCS ready'.** • **Existing plants should start retrofitting CCS from late 2020s onwards, with 2050 a backstop date for full CCS coverage.** This will require either use of GHG thresholds for generated power & heat (could be set as part of the UK's new Bioenergy Strategy), access to CCS incentives to lower the costs of capture (particularly for smaller facilities further from CCS clusters), and/or carbon taxation (either taxes or inclusion in a UK ETS). Regional retrofit timings should be aligned with BEIS' CCS infrastructure plans.

The circular economy requires moving away from landfill and energy-from-waste, towards prevention, re-use and recycling.

Good progress has been made in decarbonising waste in the past three decades, mainly through landfill taxes reducing waste sent to landfill. However, recent years have seen sector emissions stalling, with increases in energy-from-waste plant emissions. Achieving significant future emission reductions in the waste sector requires a step-change towards a circular economy, moving away from landfill and energy-from-waste and towards a reduction in waste arisings and collection of separated valuable resources for re-use and recycling. This applies at local, regional and national levels.

Without substantial increases in policy ambition, and new policies in a range of areas, waste will become an increasing share of emissions and could still have substantial emissions by 2050. Given lead-times for changing waste management practices without a risk of unintended consequences, the waste sector requires new policy urgently.

Waste policy is mainly devolved, and there are different starting points and targets across the UK.

In this chapter, we set out the set of policy measures consistent with meeting our Balanced Net Zero Pathway across the UK, while recognising that waste policy is a devolved matter and there are different starting points across the UK. Different targets and regulations have been established in England and each devolved administration.

- **Wales** is setting a leading example with long-term circular economy proposals, plus 70% recycling and significant action on food waste by 2025.
- **Scotland** has a similar set of 2025 goals to Wales, although implementation of some prior measures has been delayed.
- **England** is legislating via the Environment Bill for more consistent recycling collections, and targeting 65% municipal recycling and below 10% municipal waste landfilled by 2035.
- **Northern Ireland** is at an earlier pre-legislative stage but is proposing similar targets to England.

Key policy gaps are banning biodegradable waste from landfill, and addressing growing energy-from-waste emissions.

Existing policy frameworks are therefore mainly focused on consistent collections, reuse and recycling efforts, food waste prevention, and some reductions in landfill. The largest policy gap remains preventing biodegradable municipal and non-municipal waste entering landfill. An early ban date of 2025 needs large-scale recycling infrastructure investment brought forward. Growing energy-from-waste plant emissions also need to be addressed, where possible through accelerating waste prevention and recycling efforts, and where necessary installation of carbon capture and storage (CCS).

Our recommendations are based on an assessment of existing policies and announcements, a review of evidence and updating our existing findings set out in our UK 2020 *Progress Report*, 2020 *Scottish Progress Report*, and 2020 *Welsh Progress Report*.

This Chapter is in three sections:

1. Challenges for waste policy and strategy
2. Existing policy and planned publications
3. Key policy changes needed

1. Challenges for waste policy and strategy

The waste sector faces a number of challenges, including diffuse sources and incomplete data, locational and quality variations, a growing population, time lags, long-term contracts and the current lack of carbon capture and storage (CCS) infrastructure in the UK.

- Waste emissions are generally diffuse, dominated by methane and nitrous oxide, and spread across a large number of actors and diverse supply chains. Data regarding commercial & industrial waste recycling is very poor, and the industrial wastewater sector is not well characterised.
- There can be large differences between local authorities as to what materials can currently be recycled, and variations in the quality of materials collected for recycling. Space for additional bins at properties can be limited. Some wastes also cannot currently be recycled or are hazardous.
- Waste volumes are often tied into long-term waste management contracts, making it difficult or expensive to quickly change course and prioritise other uses.
- The UK has a growing population, and so a growing requirement for wastewater treatment, and without action, potentially greater consumption of goods leading to more waste.

Policy benefits can take decades to be fully realised.

- Biodegradable material sent to landfill today will still be producing methane in several decades – policy benefits can therefore take significant time to be fully realised. This makes near-term action all the more important.
- Many new energy-from-waste (EfW) plants are under construction and have been granted planning permission, which if built without CCS will likely significantly increase sector emissions.

The circular economy cuts across multiple departments.

- Policy on developing a circular economy needs to be developed across multiple Government departments, particularly involving manufacturing and construction sectors, as well as areas such as agriculture and transport.

As waste is largely a devolved matter, we discuss developments at a UK level first, before discussing England and each of the devolved administrations in turn. This section summarises the findings from our 2020 UK *Progress Report*, *Scottish Progress Report*, and our forthcoming *Welsh Progress Report*.

a) UK

The Circular Economy Package sets targets of >65% recycling and <10% landfill into law.

The UK published the Circular Economy Package (CEP) in August 2020,[1] which introduces a revised legislative framework, transposing across EU 2020 CEP measures. This package:

- Identifies steps for waste reduction, to ensure better compliance with the waste hierarchy.
- Establishes a long-term path for waste management and recycling, with 2035 targets across the UK of at least 65% municipal recycling, and below 10% municipal waste sent to landfill.[2]
- Bans separately-collected plastic, metal, glass and paper from being landfilled unless it has gone through treatment and is the best environmental outcome.[3]

Waste reduction policies have been relatively modest to date, focusing mainly on plastics, with a new tax on plastic packaging with less than 30% recycled content from April 2022.[4] Support is also provided to campaigns targeting behavioural change (for example, "Love Food Hate Waste").

In the wastewater sector, UK water utilities have committed to achieving zero net emissions by 2030 (counting the savings from the industry's exported biomethane, and removals measures such as tree planting). A 2030 Routemap has been published as an industry-led initiative.[5] BEIS have consulted on a Green Gas Support Scheme to increase the injection of biomethane into the gas grid, which will improve anaerobic digestion prospects beyond the Renewable Heat Incentive.[6]

b) England

The Environment Bill will improve re-use and recycling over 2023-35.

The Environment Bill currently going through Parliament will establish several new policy levers to tackle waste in England:

- Extended Producer Responsibilities on packaging.
- Deposit Return Schemes for drinks containers.
- Provision of resource efficiency information.
- Mandating consistent collections of separate recyclable/compostable materials from households and businesses (starting in 2023 and fully rolled out by 2035). These streams include food waste, plastics, paper and card, metal packaging and glass, plus garden waste collection from households.
- Establishment of binding long-term targets for England, potentially for resource productivity and residual waste targets (with the latter measuring reductions in per capita tonnages sent to landfill or incineration).[7]

Together these reforms aim to achieve Defra's 2019 *Resources & Waste Strategy* (RWS) target of a 65% recycling rate by 2035 in England, now set in law via the CEP. In August 2020, Defra consulted on an updated Waste Management Plan for England. This did not introduce new policies, but reflects the RWS. In September, England also legislated to ban the supply of plastic straws, stirrers & cotton buds.[8]

Government has also committed to mandatory food waste reporting for businesses, and to update their Waste Prevention Programme.

Following on from the RWS, Government has also committed to:

- Introduce mandatory food waste reporting by food businesses in England. A consultation will be held in late 2020 or early 2021.
- Publish an updated Waste Prevention Programme that will focus on efforts at the top of the Waste Hierarchy.

The RWS also set out the following proposals, but these are yet to be enacted in legislation or translated into policy:

- Ban food waste from landfill by 2030, with an aspiration to ban other biodegradable waste by the same date.
- An intention to work towards zero avoidable waste being landfilled by 2050.

c) Scotland

Scotland's Circular Economy Package is ambitious, with strong measures on waste reduction, but has been delayed.

The Scottish Government proposed several 2025 targets in *'Developing Scotland's circular economy'* but this is not being taken forward in this legislative session due to COVID-19, although may be reintroduced in 2021.[9] These 2025 targets include:

- A 70% recycling rate for all wastes (with households achieving a 60% recycling rate by 2020).
- A 15% reduction in total waste (against 2011 levels).
- A 33% reduction in food waste (per capita against 2013 levels), following the *Food waste reduction: action plan*.
- No more than 5% of all waste being sent to landfill.

In conjunction with the Convention of Scottish Local Authorities, the Scottish Government has also committed to evaluating the Household Recycling Charter and its Code of Practice and to form a steering group to change the way Scotland tackles waste and recycling. Zero Waste Scotland has provided a total of £7.5 million since 2015 to eight Councils in support for transition to Charter-compliant waste and recycling collection services.

A landfilling ban on biodegradable municipal waste is in force, but has delayed.

1.02 million tonnes of biodegradable municipal waste were landfilled in 2018.[10] Scotland's previous commitment to ban the landfill of biodegradable municipal waste by 2021 has been delayed to January 2025, as many local authorities lacked sufficient processing infrastructure and would have been forced to export their waste.[11] Although some local authorities had made significant progress towards the 2021 target, this delay will lead to fewer avoided landfill methane emissions.

The Scottish Government is proposing centrally supported procurement and use of the Scottish Landfill Tax to ensure the transition occurs by 2025. The 2020-21 *Programme for Government* also allocates a £70 million fund to the improvement of local authority refuse collection infrastructure. The introduction of a national Deposit Return Scheme for drinks containers has also been delayed until 2022.

d) Wales

Wales' Beyond Recycling strategy has both long-term goals and ambitious near-term targets.

Wales currently recycles 62.8% of municipal waste today, which is one of the highest recycling rates globally. In December 2019, the Welsh Government consulted on a new circular economy strategy '*Beyond Recycling*'.[12] This contains a number of ambitious near-term and longer-term targets:

- A 'zero waste' goal for 2050, aiming to phase out residual waste to landfill and incineration (an effective 100% recycling rate from all sectors).
- Development of minimum preparation for re-use targets for Local Authorities, and prioritising re-used and remanufactured content in the goods that the public sector procures.
- A 50% reduction in food waste by 2025, against a 2006-07 baseline, and looking to go further after 2025.

Business recycling collections are already being improved, with bans on landfilling or incineration of some collected materials.

- 70% recycling of all waste by 2025, as well as statutory local authority recycling targets at the same level. A £6.5 million fund is available for local authorities and public bodies to increase their recycling rates. Improved waste collections for Welsh businesses are also being implemented,[13] with bans on the landfilling or incineration of specified separately collected recyclable materials.

If all successfully enacted, the above goals would substantially reduce future waste sector emissions. Wales currently has a target of an 80% reduction in waste sector emissions by 2020, and 92% by 2030, compared to 1990 levels. However, the 2020 target looks extremely challenging, given the latest 2018 data of a 62% reduction and little change since 2016.* Wales' Landfill Allowance Scheme, which focused on reducing landfill of biodegradable municipal waste, also ended in March 2020.

Wales' current '*Towards Zero Waste*' strategy from 2010 has similar recycling targets, along with targets for <10% of municipal waste to be landfilled by 2020, and <5% by 2025.[14] These existing targets may be built on or superseded by other metrics when Wales' final circular economy strategy is published.

e) Northern Ireland

The Department of Agriculture, Environment & Rural Affairs (DAERA) consulted on its 2019 Waste Prevention Programme '*Stopping Waste in its Tracks*' in early 2020.[15] However, this was an interim extension of existing actions, rather than proposing new policies or targets. Northern Ireland's Landfill Allowance Scheme, which focused on reducing landfill of biodegradable municipal waste, also ended in March 2020.

Northern Ireland are proposing new targets that match the ambition of the Circular Economy Package to 2035.

A discussion document on the '*Future of recycling and the separate collection of waste of a household nature in Northern Ireland*' was published in June 2020.[16] The proposed targets match the CEP, with a municipal recycling rate of 65% by 2035 (with interim targets of 55% by 2025, 60% by 2030) and less than 10% of municipal waste going to landfill by 2035. A consultation response is now pending. Northern Ireland's 2013 waste management strategy '*Delivering Resource Efficiency*' is due to be revised as a result.[2]

* Data given based on the UK's current National Inventory methodology (IPCC AR4 GWPs, and a waste sector classification that does not include energy-from-waste plant emissions).

Other recent announcements and plans include:

- £23 million provided to local government to improve recycling services and facilities. To date, seven projects have been supported totalling £3.5 million.[17]
- DAERA consulted on the reform of the producer responsibility system for packaging and the introduction of a deposit and return scheme for drinks containers in 2019. Further consultation is planned in 2021.
- DAERA is also currently developing an '*Environment Strategy for Northern Ireland*', due to be published for consultation in March 2021.

3. Key policy changes needed

Waste sector emissions will become increasingly important to UK Net Zero by 2050. Policy needs developed in multiple areas.

Without substantial increases in policy ambition, and new policies in a range of areas, waste will become an increasing share of emissions and could still have substantial emissions by 2050. Given lead-times for changing waste management practices without a risk of unintended consequences, the waste sector requires new policy urgently.

In this section, we set out the set of policy measures consistent with meeting our Balanced Net Zero Pathway across the UK, while recognising that waste policy is a devolved matter and there are different starting points across the UK.

Develop further policies to accelerate the transition to a circular economy.

- Following on from the Resources and Waste Strategy for England, introduce greater ambition for efficiency in manufacturing and construction, material substitution for more sustainable alternatives, and reduction in consumer demand for products.
- Similar policies to be followed in Wales, Scotland and Northern Ireland with their respective waste strategies. For example, Scotland should reintroduce their Circular Economy Bill in the next Parliament, setting out specific plans for material efficiency, including material substitution, to reduce emissions through reduced demand.

Food waste policy needs to align with agricultural policy.

Food waste remains one of the biggest source of emissions in the sector. Action is needed in businesses and households.

- Policy should include immediate low-cost measures to reduce food waste (e.g. target setting in the public and private sectors, redistribution of surplus food), measures to 'nudge' consumers towards best practice and mandating of separate food waste collection. Changes in dietary preferences and behaviour change to lower meat and dairy consumption will also impact the composition of food waste collections.
- Mandatory business food waste reporting will help achieve reductions in food waste, alongside reductions in household food waste.

Biodegradable waste should be banned from landfill by 2025.

Banning biodegradable waste from landfill from 2025 is a priority, and should be achieved via prevention, re-use and recycling, not via more energy-from-waste.

- A ban on key biodegradable wastes, across municipal and non-municipal sectors, to include at least paper and cardboard, food, textiles, wood and garden wastes. Achieving this ban would decrease the tonnage of biogenic material entering landfill by at least 85% by 2025 from 2018 levels.[*] Where Local Authorities are able to move faster than 2025, they should be incentivised to do so.
- This ban will require waste prevention, re-use and recycling efforts (including AD and composting) to be significantly ramped-up, and should not be met by increased waste exports or a significant (more than 20%) increase in EfW emissions.[†]

[*] This is not 100%, due to the presence of biogenic material in other less well categorised waste streams that would continue to enter landfill after 2025.

[†] Although biodegradable waste streams are being banned from landfill, there is some fossil carbon in these streams, and so increases in EfW emissions should be limited to a maximum of 20% above 2018 levels.

The Environment Bill is an important step, but timelines need to be more ambitious, particularly on business recycling.

An expansion in Scottish EfW capacity occurred ahead of their original 2021 biodegradable municipal waste ban date, and a repeat of this should be avoided (across the UK), due to the risk of locking-in increased EfW fossil emissions.

- While the Environment Bill will assist in removing several important biodegradable wastes from English residual waste streams, reducing the amount of biodegradable waste that is landfilled, this will only happen in stages over 2023-35. This timeline, and the RWS proposed landfill ban on food waste and potentially other biodegradable wastes from 2030 (which are yet to legislated for), will lead to significantly higher landfill methane emissions over the period to 2050 than in our Balanced Pathway.

Exporting of waste from the UK should stop by 2030, but full landfill waste bans should not be rushed.

Waste exports should be phased out by 2030.

- Governments should work towards banning the export of waste from the UK by 2030. Current UK export volumes are falling mainly due to the increase in UK energy-from-waste plants, but this goal should be achieved via prevention and recycling.
- Banning all landfill will lead to further modest reductions in landfill methane emissions. However, achieving the RWS aspiration of zero avoidable waste being landfilled by 2050 in England needs careful planning. Similar caution will be required in the DAs if implementing full landfill bans.
  - If full landfill bans are imposed without accompanying improvements in prevention or recycling, and before CCS is widely available, this could substantially increase waste volumes going to EfW and increase sector emissions by several $MtCO_2e$/year.
  - A full ban should only be enacted once residual volumes have been significantly lowered and CCS installed on remaining EfW plants.*

Recycling rate ambitions need to be raised.

England should target 68% recycling by 2030 – household, commercial and industrial shares of this are achievable.

- England should target 68% recycling across all wastes by 2030.
  - Experience from Wales and Northern Ireland indicates that it is feasible for England to achieve a 56% household recycling rate by 2030 (similar to Wales today), from its current 45% position.†
  - The non-household municipal waste sector has significant potential for improvement.[18] RWS/CEP targets in England require 74% non-household municipal recycling by 2035 (up from 30-40% today). Defra have proposed costs be spread over 12 years, focusing on cheaper action at larger businesses first before later more expensive action for smaller businesses. Achieving 74%, or close to this level, by 2030 could be feasible with more support for smaller businesses during the mid/late-2020s, instead of during the 2030s.

* Our Tailwinds and Headwinds scenarios both achieve full landfill bans (in 2050 and 2035 respectively) without emissions increases, due to sufficient CCS being in place and sufficient prior action on prevention and recycling.

† Wales and Northern Ireland have been able to achieve high household recycling rates of 54% and 48% in 2018, having both started at only 5% twenty years ago.

  - With other commercial & industrial waste* outside of the municipal sector also achieving 74% by 2030, this would lead to a combined English recycling rate of 68% by 2030. There may be potential to go further in the long-term as well, and we understand work is ongoing with WRAP to assess the options and costs. Ambitious new goals should be consulted on.

Northern Ireland should target 70% recycling by 2030, driven by business recycling improvements.

- Northern Ireland should target 70% recycling across all wastes by 2030.
  - Evidence from WRAP shows 'it is possible to achieve and surpass a municipal recycling rate of 65% in Northern Ireland well before the target date of 2035', with non-household municipal sectors potentially achieving over 80%.[19]
- Wales and Scotland should ensure compliance with their 2025 targets, and set new 2030 targets.
  - By targeting 2025 for 70% recycling of all wastes, Wales and Scotland are already well ahead of the rest of the UK. Both countries need to formalise their 2025 targets in legislation, with funding committed for the required infrastructure. Scotland is also starting from a lower recycling rate, and progress will need to be carefully monitored.
  - Both countries should set out proposed recycling rate targets for 2030 that go beyond 70%.

Statutory targets for Welsh local authorities, and available central funding, were key to driving progress in Wales.

- Best practice and successful implementation lessons should be shared. An important reason for Welsh recycling success has been the setting of statutory recycling targets for local authorities. Welsh Government support has also been made available for increasing recycling rates (e.g. Circular Economy Funding). Scotland, England and Northern Ireland should assess the potential benefits of following a similar statutory approach.
- Waste recycling policy over time should evolve away from just weight-based measures, and focus more on carbon and resource supply chains. While weight-based targets still have an important role given the large improvements needing to be made, there should be increasing focus on recycling of wastes that reduce national carbon footprints and improve resource security. For example, food, textile, metal and plastic wastes only made up 9% of Scotland's waste by weight in 2016, but accounted for 49% of waste carbon impacts (and food waste is particularly important).[20]

Energy-from-waste emissions continue to grow, but need to be constrained by waste prevention, re-use and recycling, and over time further mitigated via carbon capture and storage.

- EfW fossil GHG emissions in 2018 were 5.3 $MtCO_2e$/year. Achieving the Balanced Pathway will require waste prevention, re-use and recycling efforts to keep EfW emissions approximately flat over time (between 5-6 $MtCO_2e$/year) before CCS starts being retrofitted to plants.†
- New circular economy measures, prevention and recycling targets need to be translated into their impact on regional residual waste arisings, and these findings communicated to Local Authorities.

* Industrial wastes have a comparable composition to non-household municipal waste (since commercial waste makes up two thirds of C&I waste), although industrial waste tends to be purer, so industrial recycling rates are currently estimated to above those for non-household municipal waste.

† Our other exploratory scenarios stay within 4.5-6.5 $MtCO_2e$/year of EfW emissions before CCS is applied.

- Guidance should be issued to help align Local Authority waste contracts and planning policy to the expected improved residual arisings trajectories. For example, in Wales, energy-from-waste plants will have to be phased out by 2050 to achieve Welsh Zero Waste targets (no waste sent to landfill or incineration).

EfW emissions could rise significantly over the coming years if all approved plants built.

- If EfW plants under construction and granted planning approval in the UK were all built, and plant utilisation rates remain unchanged, this would add 3-10 $MtCO_2e$/year to UK emissions. To prevent this major increase, either a substantial fraction – potentially a majority – of the EfW plant pipeline will have to remain unbuilt, EfW fleet utilisation rates will have to fall, or else carbon capture and storage (CCS) will need to be installed on plants from the mid/late-2020s onwards to mitigate the additional emissions.
  - Falling EfW utilisation rates may only be possible in some cases via renegotiation of waste management contracts, in order to prioritise prevention and recycling efforts instead. Government support to assist Local Authorities will likely be required.
  - Government policy could also focus on EfW emissions, either through carbon taxation or inclusion in a UK ETS, and/or providing incentives for CCUS to be installed.

New EfW plants should be built with CCS, or CCS-ready in areas soon to have CO_2 infrastructure.

  - For those plants not yet under construction, new energy-from-waste plants (and plant expansions) should only be constructed in areas confirmed to soon have CO_2 infrastructure available, and should be built 'CCS ready' or with CCS.
- EfW policy should cover all waste facilities generating energy, whether by combustion, gasification, pyrolysis or similar methods. Any plants that produce jet fuel from residual waste should also install CCS.

Incentives for landfill operators to reduce methane emissions are required.

There is now no incentive for landfill operators to install methane capture equipment (beyond wholesale power prices).

- With the closure of the Renewables Obligation in 2017 to new entrants, one of the primary incentives for landfill methane capture in the UK was removed. The latest evidence from the NAEI shows that methane capture rates have recently been falling. If this trend continues, this will significantly increase fugitive landfill methane emissions.
- Policy is needed to fill this gap, to provide incentives for landfill operators to invest in increasing methane capture rates over time, even when sites are shut to new waste and gas volumes are decreasing. This could be emissions-based policy via Defra rather than energy policy via BEIS.
- Funding is also required for demonstrating the methane oxidation potential and applicability of biocovers and biowindows at a range of different UK landfill types, and assessing how these technologies might interact with tree planting on older landfill sites.

Wastewater decarbonisation needs to be embedded into the sector's investment framework.

Ofwat should have decarbonisation of the wastewater sector as a core principle.

- Ofwat should include sector decarbonisation as one of its core principles, as the capital costs of continuing to roll out advanced Anaerobic Digestion systems (and more expensive novel technology after 2030) need to be met.
- Research, development and deployment funding should be committed by the mid-2020s to develop and demonstrate novel treatment processes that achieve a step change improvement in direct process emissions.

- Outside of the municipal wastewater sector, industrial wastewater process emissions are large and need tackled, whether via carbon pricing, regulation or manufacturing policy levers.

Composting facilities should be incentivised to install forced aeration.

- This method of reducing on-site emissions will also have benefits of improving product quality and consistency. Although aeration is a low-cost solution, the composting sector faces competition from peat, and any additional costs on the sector should only be imposed after peat has been banned for horticultural use in the UK (as recommended in Chapter 7).

Waste data need improvement.

Waste sector data is in places poor, and requires improvement.

- Energy-from-waste data are only available in the National Atmospheric Emissions Inventory at a UK level. Collection of devolved administration data should occur to allow reporting of DA-level estimates, given their increasing importance.
- Commercial & Industry waste data are currently uncertain, particularly for recycling rates. Efforts via the Waste Tracking programme should be built on, so as to be able to annually report C&I waste arising tonnages in England and each DA, and more accurate estimate recycling rates.

Endnotes

[1] *The Waste (Circular Economy) (Amendment) Regulations 2020*

[2] Defra, DAERA, Scottish Government, Welsh Government (2020) *Circular Economy Package policy statement*

[3] Environment Agency (2020) *Separate collection of waste paper, plastic, metal or glass*

[4] HMRC (2020) *Introduction of a new plastic packaging tax*

[5] Water UK (2020) *Net Zero 2030 Routemap*

[6] BEIS (2020) *Future support for low carbon heat*

[7] Defra (2020) *Environment Bill - environmental targets*

[8] *The Environmental Protection (Plastic Straws, Cotton Buds and Stirrers) (England) Regulations 2020*

[9] Scottish Government (2019) *Circular economy: Proposals for legislation*

[10] SEPA (2020) *Waste from all sources: summary document and commentary text*

[11] Scottish Government (2019) *Climate Change Plan: monitoring report 2019*

[12] Welsh Government (2019) *Beyond Recycling*

[13] Welsh Government (2019) *Increasing Business Recycling in Wales: Consultation Document*

[14] Welsh Government (2010) *Towards Zero Waste, One Wales: One Planet*

[15] DAERA (2020) *Waste Prevention Programme for Northern Ireland 2019*

[16] DAERA (2020) *Discussion on the "Future Recycling and Separate Collection of Waste of a Household Nature in Northern Ireland"*

[17] DAERA (2020) *DAERA pumps £23 million into making recycling easier*

[18] Defra (2019) *Consistent municipal recycling collections in England: Impact Assessment*

[19] WRAP (2020) *Municipal Recycling Potential in Northern Ireland*

[20] Zero Waste Scotland (2016) *The Carbon Footprint of Scotland's Waste 2016: Carbon Metric Summary Report*

Chapter 10

F-gases

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The UK has signed up to a strong international legal framework for reducing F-gas emissions the Kigali Amendment to the UN Montreal Protocol, and was previously subject to the F-Gas Regulation (EU) 517/2014 and the Mobile Air Conditioning (MAC) Directive. This existing regulatory framework is expected to drive the significant majority of reduction of F-gases required for Net Zero.

Legislation has been the key driver of a transition to lower-GWP alternatives in recent years:

- The Kigali Amendment to the UN Montreal Protocol sets out pathways for developed and developing countries for controlling the production and consumption of HFCs. Under the amendment HFCs in developed countries will be reduced through incremental targets up to a cut of 86% by 2036. These plans are less stringent than the EU F-Gas Regulation up to 2034, after which the Kigali Amendment targets are currently more ambitious. This may not remain the case as the EU plans to consider an extension of the ambition of the F-Gas Regulation beyond 2030 in 2022. The UK ratified the Kigali Amendment in November 2017 and the amendment took effect in January 2019.
- The 2014 EU F-Gas Regulation came into force in the UK in January 2015, and equivalent measures will be enforced into UK law in at the end of the transition period of leaving the EU. It introduced a number of new measures and strengthened the 2006 EU F-Gas Regulation:
  - The regulation sets a cap on the amount of HFCs that producers and importers are allowed to place on the market. The cap will be cut every three years until reaching a 79% cut by 2030 from 2015 levels.
  - Some uses of HFCs are exempt from the regulation, including medical use, military equipment and manufacturing of semiconductors. Emissions from SF_6 and PFCs are not included in the cap.
  - The regulation bans the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air-conditioning and foams and aerosols.
  - The regulation strengthens existing obligations in terms of mandatory 'management measures' including regular leak checks and repair, gas recovery at end-of-life, record keeping, training and certification of technicians and product labelling.
- The 2006 MAC Directive focuses on emissions from air-conditioning in new cars and vans. From 2017, all new cars and vans are required to use substances with a GWP less than 150.
- Emissions of PFCs from aluminium production are priced under the EU Emissions Trading System.

2. Policy recommendations

In our 2020 Progress Report to Parliament, we reported that the Government was yet to publish a plan to restrict the use of F-gases to the very limited uses where there is no viable alternative – going beyond the requirements of the Kigali Amendment and existing F-gas regulations. The Government should bring forward such a plan as part of its Net Zero strategy. Priority areas for policy development are to:

- **Ensure that any increase in ambition in EU F-gases regulation is matched or exceed by the UK.** Legislation has been passed that enables the UK to set a quota system that is independent from – but equivalent to – the EU quota. The EU is currently looking into strengthening its F-gas regulation and should this occur, the UK should ensure that equivalent or more rigorous standards are maintained.
- **Minimise non-compliance, especially in the RACHP sector.** The Environment Audit Committee has reported evidence of suspected non-compliance, especially as EU F-Gas Regulation increase demand for lower-GWP refrigerants, and a lack of resources for the Environment Agency to carry out adequate inspections. The Government should ensure that the Environment Agency is sufficiently resourced to allow it to ensure compliance.
- **Increase training and certification for F-gas users.** The current regulatory framework does not require retrospective training for workers trained under previous regulations and allows untrained members of the public to top-up their own car air-conditioning units with high-GWP refrigerants. The Government should consult with industry and bring forward proposals to ensure that all those who handle refrigerants have up-to-date training.
- **Encourage the use of more sustainable inhalers in the NHS.** Practitioners and patients must be educated about the global warming effects of medical inhalers and the importance of proper disposal. Dry powdered inhalers (DPIs) – used commonly in other countries – can be more clinically effective and have zero greenhouse gas emissions. Lower-GWP alternatives to existing metered dose inhalers are currently being developed, and should be adopted from the mid-2020s in cases where DPIs are not suitable.

Table 10.1
Summary of policy recommendations for F-gases sector

	Recommendation	Department	Date
F-gases	Publish a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives beyond the limits of the Kigali amendment.	DEFRA and devolved agencies	Overdue
	Ensure that any increase in ambition in EU F-gases regulation is matched or exceeded by the UK.	DEFRA and devolved agencies	Ongoing
	Minimise non-compliance, especially in the RACHP sector by ensuring that the Environment Agency and equivalent devolved bodies are sufficiently funded.	DEFRA and devolved agencies	2021
	Increase training and certification for F-gas users.	DEFRA and devolved agencies	2021
	Encourage the use of more sustainable inhalers in the NHS.	DHSC, NHS England, NHS Scotland, NHS Wales, HSCNI	Before mid-2020s
	Support research into lower-GWP refrigerants for heat pumps	UKRI	2020s

Chapter 11

Greenhouse gas removals

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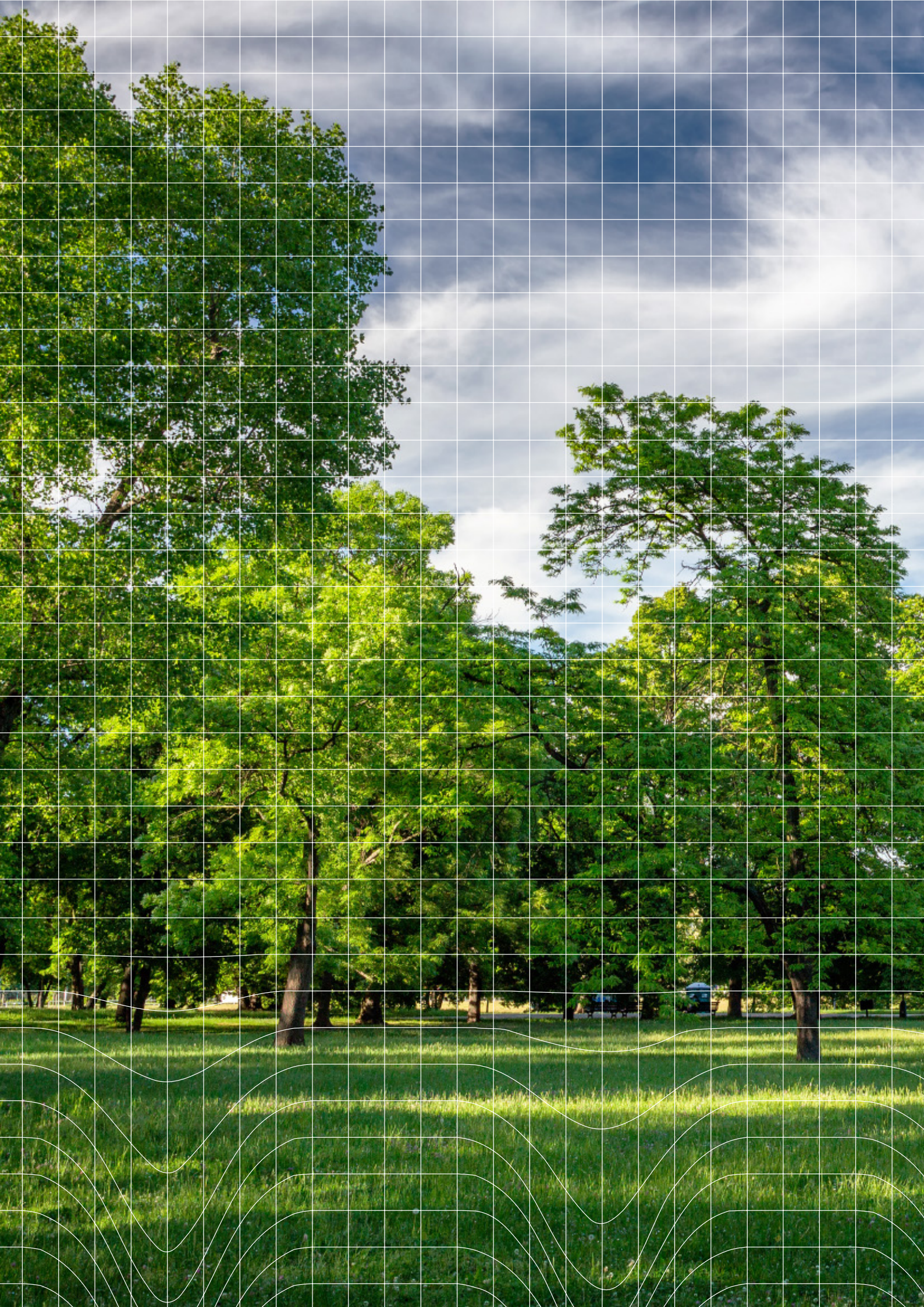


Table 11.1
Summary of policy recommendations for GGRs

Policy to commercialise GGRs	• After the forthcoming GGR Call for Evidence is concluded, launch a consultation on the Government's preferred strategy and long-term expected requirement for GHG removals, including a proposed market design, a set of governance principles and proposals that recognise the need for a long-term price signal. • Deliver on existing and proposed land-based policies that remove carbon from the atmosphere (e.g. tree planting, ELMs, peatland restoration). • Given long lead-times and the need to demonstrate engineered GGRs at scale in the 2020s, either amend existing policies to support early projects with a clear policy transition plan for later projects, or else introduce a new support mechanism by 2022 to cover all GGR projects. • Research and demonstration (R&D) support should focus on newer removals routes involving biomass gasification and Direct Air Capture, as well as other removals, such as biochar and enhanced weathering. These should include field experiments and pilots, through an expanded UK Greenhouse Gas Removal Demonstrators programme (building on the £30 million to take newer technologies from TRL 4 to TRL 6). • Commit to further support the demonstration and commercialisation of GHG removal technologies and approaches, from TRL 5 to TRL 8, building on the now launched £70 million 'Direct Air Capture and other Greenhouse Gas Removals Competition'.
Wider policy actions	• Establish GGR Monitoring, Verification and Reporting (MRV) structures in the UK, recognising that different frameworks may be required for different types of GGRs. This will include developing and publishing criteria for sustainable, verifiable GHG removals within the UK that can be used by UK sectors to offset their gross emissions, and ensuring no double-counting between different schemes, sectors, nations or accounting systems. • Ensure that a public engagement strategy for Net Zero includes national, regional and local communities to improve the public's understanding and acceptance of GGR approaches and their implications – awareness is currently very low, and support is mixed or uncertain. • The overall Net Zero Strategy should place GGRs in the context of a wider strategic approach to reaching Net Zero, setting out a plan for development and deployment of removals, but also for actions elsewhere to limit the need for them. • The UK's forthcoming Biomass Strategy should ensure bioenergy use in the UK transitions to achieving maximal GHG savings (with CCS and/or in applications that still displace fossil fuels in the long-term). The UK should also continue to take a global lead on further developing and improving UK and international biomass governance and sustainability criteria. • Allow engineered removals (BECCS, DACCS and others) that occur within the UK to be included within Climate Change Act's definition of removals (either via amending Section 29 or defining a new UK 'removals credit'). • Align with adaptation policies to ensure long-term resilience and effectiveness of GGRs in the face of climate impacts and exploit potential for co-benefits (e.g. choice of tree species, protecting new infrastructure from flood risks).

This chapter sets out the policy implications of the Committee's scenarios for Greenhouse Gas Removals (GGRs) that underpin the Sixth Carbon Budget.

GGRs encompass a broad range of technologies including nature-based removals such as tree-planting and peatland restoration, and engineered removals such as wood in construction, Bioenergy with carbon capture and storage (BECCS) and Direct Air Capture of CO_2 and storage (DACCS). Though other forms of GGRs exist, they are not included in our scenarios.

Chapter 7 contains recommendations on how nature-based removals can be scaled up over time. This chapter focuses on engineered removals, but also considers how overarching policy can incentivise the scale up of GGRs in the UK.

The scenario results of our costed pathways are set out in the accompanying Advice and Methodology Reports. For ease, sections covering pathways, method and policy advice for GGRs are collated in one document: *The Sixth Carbon Budget – Greenhouse Gas Removals*. A full dataset including key charts is also available alongside this document.

The key messages for GGRs are:

Removals are essential to meeting Net Zero in the UK.

- **Removals are essential for meeting Net Zero in the UK**, but are currently not available at scale in the UK, outside of the land sector.
- **The annual costs of removing emissions from the atmosphere are potentially large in our scenarios** (e.g. of the order of £6 billion/year by 2050, from an initial scale of around £1 billion/year in 2030). Initial development of these technologies is likely to require some Exchequer funding, although in the longer term, costs should be paid for by polluting industries (e.g. aviation).
- **Initial pilot and demonstration support are now available** under the UK *Greenhouse Gas Removal Demonstrators Programme*, and the *Direct Air Capture and other Greenhouse Gas Removals Competition*. These programmes should aim to cover a broad range of removals, and early lessons learnt should be shared to inform commercialisation policy development.
- **The Government's consultation on carbon taxation and Call for Evidence on GGRs will need to develop swiftly** into policy proposals during the early 2020s for the long-term market design, with a set of governance principles. A long-term price signal needs to be established in the UK.

We set out our assessment in two sections:

1. Current policy and gaps to be addressed
2. Key policy actions required

1. Current policy and gaps to be addressed

Greenhouse Gas Removals (GGRs) are essential to meeting the UK's 2050 Net Zero target, but support for them is currently limited.

Greenhouse Gas Removals (GGRs) are essential to meeting the UK's 2050 Net Zero target, offsetting residual emissions in our scenarios.

As large-scale GGRs outside of the land use sector have not been deployed to date, current policy in this area is limited. However, innovation support for GGRs has recently been made available, and the Government is consulting on how a scale up of GGRs can be supported:

- Currently, funding for nature-based actions that have environmental benefits (e.g. tree-planting) is available through the EU's Common Agricultural Policy (under Pillar II) payments. The UK's departure from the EU provides an opportunity to focus more of this funding towards actions that provide environmental benefits, including decarbonisation, via the UK's Environmental Land Management (ELM) scheme (see Chapter 7).
- Innovation and development funding for GGRs is now available through the £31.5 million *Greenhouse Gas Removal Demonstrators Programme* (with up to five pilots and a directorate hub),[1] as well as up to £70 million in BEIS competition funding for '*Direct Air Capture and other Greenhouse Gas Removals*'[2] which aims to commercialise these technologies in the UK. These activities have built on the 2017-21 *Greenhouse Gas Removal Research Programme*.[3]
- Emissions removals are not currently included in carbon pricing mechanisms. However, a recent Government consultation on carbon taxation sought views on using tax incentives to support the scale up of negative emissions technologies in the UK. Separately, a call for evidence on GGRs is due to be launched in late 2020.
- A new cross-government Biomass Strategy in 2022 will look at how biomass should be sourced and used across the economy to best contribute to Net Zero. More details will be in the forthcoming Energy White Paper.

The key policy gap to address is the lack of a long-term price signal in the UK for emissions removals.

A key policy gap to address remains the lack of a long-term price signal. The Government will need to identify where technology-specific support will be required and at what level, or where there is scope for competitive mechanisms to support multiple approaches.

New policies will need to be put in place, and others will need to be scaled up, to meet the Sixth Carbon Budget and Net Zero, to which we now turn.

Policy will need to be developed in the first half of the 2020s, to ensure removals are available at scale by 2030.

The Sixth Carbon Budget pathway requires that both land-based and engineered greenhouse gas removals (GGRs) are available at scale by 2030. Policy will need to be developed in the first half of the 2020s in order to achieve this. Although this may require initial support from the Exchequer, a longer-term vision for the sector could see emissions removals paid for by higher emitting sectors, such as aviation.

This section is set out in three parts:

a) Innovation support and enabling actions

b) Scaling up GGRs in the UK

c) The UK's role in developing GGRs globally

a) Innovation support and enabling actions

As large-scale GGR outside of the land use sector has not been deployed to date, near-term actions and innovation support will be important in a number of different areas for removals to be a plausible contributor at scale to a UK Net Zero target and reduce the substantial uncertainties that remain over UK removal potential:

- **Carbon capture and storage (CCS).** For engineered removals to play a role in offsetting residual emissions, CCS will be required to provide long-term secure geological storage for both BECCS and DACCS. CO_2 infrastructure deployment should start as soon as possible, through a regional cluster-based approach. A stable long-term policy environment is required to support this deployment pathway.

If the UK wants to have sufficient biomass available to meet expected removals requirements by 2050, scale-up of domestic resources have to start now.

- **Biomass supply.** Near-term actions are required to ensure that the supply of sustainable low-carbon biomass can be scaled up to provide the necessary resource by 2050.
  - **Increasing UK supply.** In our 2018 report on *Biomass in a low-carbon economy* we recommended that the Government undertake efforts to increase the supply of sustainable harvested biomass from UK sources. This involves meeting and exceeding current tree-planting targets and overcoming the incentive barriers to the planting of sustainable perennial bioenergy crops on lower-grade agricultural land.
  - **Governance.** Similarly, we recommend that the UK take an active role in further developing and improving UK and international biomass governance and sustainability criteria. This will be vital for ensuring imported biomass can play a role in reaching Net Zero. The Government's forthcoming Bioenergy Strategy should address this.
- **Innovation support.**
  - **Bioenergy with CCS (BECCS).** For BECCS applications outside the power sector, gasification (or similar) technologies are required to turn biomass into energy carriers such as hydrogen or biojet (e.g. via Fischer-Tropsch catalysis). Current UK market support schemes have failed to bring forward gasification plants at scale capable of producing genuinely ultra-clean syngas that would be suitable for catalysis routes to fuels.

- In our 2018 Biomass report, we recommended that the Government re-examine its gasification incentive scheme (for 'Advanced Conversion Technologies') and shift away from a focus on the power sector to other more valuable sectors, such as transport.*
- The newly announced DfT innovation competition focused on Sustainable Aviation Fuels should assist in developing gasification routes to jet fuel, although £15 million may only be enough funding to support one or two medium-scale demonstration plants.

Direct Air Capture technologies remain at an early stage, requiring innovation support.

– **Direct air carbon capture with storage (DACCS).** As direct air capture (DAC) technologies are at an early stage, further research and development support is important. To date, DAC development has had only very limited public investment. Given the potentially large but uncertain future contribution from DACCS, we recommend Government consider further strategic investment to support its development towards large-scale demonstration in the UK, enabling cost discovery.

– **Other removals.** Innovation support will also be required for other removals, such as biochar and enhanced weathering, including field experiments and trialling. In the near-term, this can initially be delivered through the UK *Greenhouse Gas Removal Demonstrators Programme*.† Subject to the results of this research, further support is suggested to develop up-scaling potential and assess corresponding environmental impacts and risk.

* In our 2020 *Progress Report to Parliament* we recommended that these technologies be moved from 'Pot 2' to 'Pot 1' of the Contract-for-Difference allocation rounds for renewable electricity.

† This is a new 4.5-year, £31.5 million UK programme to support up to five individual GGR pilot plants (exploring the effectiveness, cost and limitations of large-scale GGR methods) commissioned by BBSRC, as well as a central coordinating Directorate Hub commissioned by NERC.

Only nature-based removals are currently deployed in the UK. Policy will need to incentivise both nature-based and engineered removals.

b) Scaling up Greenhouse gas removals in the UK

Although GGRs will be required at scale by 2050, deployment today is only from nature-based land sinks and at limited scale (Table 11.1).

Table 11.1
Scale of greenhouse gas removals that may be required to achieve Net Zero

		Scale today	Scale required by 2050
Nature-based removals	Tree-planting (kha/year)	13	35-70
	Peatland area restored (%)	25%	77-79%*
	Energy crop area (kha)	10	230 – 1,400
	Total land sinks ($MtCO_2e$/year)	**18**	**28-35**
Engineered removals	BECCS ($MtCO_2$/year)	0	44-97
	DACCS ($MtCO_2$/year)	0	0-15
	Wood in construction ($MtCO_2$/year)	<1	0.4 (excl. 1.0 already in Land Use sector)
	Total engineered removals ($MtCO_2e$/year)	**<1**	**44-112**

Action on land-related removals needs to start now, as it cannot be accelerated later if delays occur now.

Policy mechanisms will need to be developed in the early 2020s in order for sufficient planting to take place, and for engineered GGRs to be commercialised in the late 2020s or 2030s, so that both can ramp up to achieve the necessary scales by 2050. In particular, for land-related measures, such as afforestation and peatland restoration, there are physical limits that mean that natural rates of growth and carbon sequestration cannot simply be accelerated, and so delays in policy implementation will lead to reduced sequestration in 2050.

The scale-up of greenhouse gas removals to the level necessary to achieve Net Zero will require funding, public support, rules and governance to ensure sustainability, placement within a wider Net Zero strategy, a transition of biomass uses towards BECCS and a stable policy framework:

Positive public attitudes will be important for developing and deploying engineered removals.

- **Public acceptance.** Consideration of public attitudes will be an important part of a strategy to scale up emissions removals in the UK, including attitudes on the types of removals that should be included in a UK GGR strategy.
  - The Climate Assembly were generally very supportive of nature-based emissions removals but expressed more concern and uncertainty about engineered emissions removals that relied on CCS. Their overall conclusion was that emissions reductions should be prioritised over emissions removals. This is in line with our Sixth Carbon Budget advice.
  - Positive public attitudes will be important for developing and deploying engineered removals, particularly regarding perceptions of the safety of CO_2 transport and storage infrastructure and the extent to which removals are viewed as a way of avoiding emissions reductions instead of a necessary complement to it. Early and sequential small-scale deployment can help build a social license for GGR technologies and test their longer-term sustainability, building public acceptance for large-scale deployment of GGR.

The need for removals should be limited based on sufficient action across the rest of the economy.

- **Placing removals within a wider vision for Net Zero.** It will also be necessary for the Government's overall Net Zero Strategy to place GGRs in the context of a wider strategic approach to reducing emissions. This should set out a plan for development and deployment of removals, but also for actions elsewhere to limit the need for them.

- **Governance and sustainability.** Ensuring that removals are sustainable will require rules and policies based on the best current evidence and that can evolve and be revised as more information is gained (e.g. by introducing or tightening sustainability thresholds). As with CCS infrastructure development more widely, a clear liability structure needs to be established for CO_2 storage, along with requirements for permanence and remediation in case of loss.

Without financial rewards for greenhouse gas removal, BECCS and DACCS will not be deployed.

- **Funding.** Without financial rewards for greenhouse gas removal, BECCS and DACCS will not be deployed. The annual costs of removing emissions from the atmosphere are potentially large in our scenarios (e.g. of the order of £6 billion/year by 2050, from an initial scale of around £1 billion/year in 2030). Initial development of these technologies is likely to require some Exchequer funding. However, in Chapter 10 of the *Advice Report* we highlight the potential for sectors with significant residual emissions (e.g. aviation) to fund GGR solutions.

Existing uses of bioenergy should transition towards removals.

- **Transition bioenergy towards removals.** Over the coming decades, it will necessary for uses of biomass to transition to those consistent with Net Zero. This means moving towards those applications that maximise emissions saving per tonne of biomass, generally by using CCS (i.e. BECCS) and displacing fossil fuels – we set out these best uses in Chapter 6 of the accompanying Methodology Report. This transition will need to be a core part of the Government's forthcoming Biomass Strategy.

- **A stable long-term policy framework** for developing and deploying removals, alongside appropriate governance arrangements to ensure sustainability, will be crucial to ensure that a net-zero emissions target can be achieved in the UK.

  – As part of our advice on the Sixth Carbon Budget, we convened an expert roundtable discussion on GGR policy. A summary of the discussion, published alongside our Sixth Carbon Budget advice and summarised in Box 11.1, suggests key principles that should be considered in developing policies to support GGRs.

  – A Government Call for Evidence on GGRs is planned for late 2020, and should take these principles into account. After this is concluded, the Government should launch a consultation on the preferred strategy and long-term expected requirement for GHG removals, including a proposed market design & set of governance principles.

Box 11.1
Summary of roundtable discussion on policy options for Greenhouse Gas Removals

To further understand the policy requirements for GGRs, Dr. Clair Gough from the University of Manchester and Dr. Naomi Vaughan from the University of East Anglia hosted a roundtable discussion for the CCC in September 2020, with participants from academia, CCS industry, BEIS, the National Farmers Union and the Forestry Commission. This considered policy options for both nature-based and engineered removals, including the potential for bringing forward both general and differentiated approaches to scale up GGRs. The discussion resulted in six principles to inform UK GGR policy development:

- **Timescales - account for different timescales of carbon removal.** Different GGR approaches remove carbon across different timeframes and policies must balance immediate and longer-term benefits.
- **Permanence - account for risks to carbon storage.** Different carbon storage mechanisms are exposed to different risks to storage security and opportunities for remediation in the event of carbon losses. Policies must support removals which are permanent or secure over the long-term.
- **Transparency - be open and responsive to societal concerns.** Engaging with national and local communities alongside policy development will improve the prospects for successful and resilient policies and support procedural justice. Public engagement processes on GGR will be well-placed to take advantage of on-going support for Net Zero and can build on the success of Climate Assembly UK.
- **Fairness - support fair and just transitions.** Establishing GGR policies that deliver incentives and obligations that are fair and contribute to a just transition will garner wider support for both policies and the approaches they underpin. This may entail principles such as the 'polluter pays', recognising that costs ultimately fall to consumers rather than taxpayers.
- **Clarity - provide clear and strong policy signals.** Commercial organisations need market certainty, and this is historically low at the moment. Establishing confidence is crucial to secure investment and establish changes in practices (e.g. perennial energy crops to power, use of timber in construction).
- **Flexibility - be able to respond to innovation and learning.** Policies must be robust to the uncertainty and diversity which characterises GGRs. Given the variety of approaches at different stages of readiness and which interact with multiple actors, industries, sectors and existing policies, resilient policies will balance long-term predictability with adaptability as new GGR approaches become ready.

Additionally, the group noted the need to deliver on existing policy frameworks that remove carbon (such as ELMs, woodland creation schemes), the potential to incorporate GGRs into existing/forthcoming policies, and the opportunity to implement low-regret, well-evidenced measures that can be delivered quickly (e.g. peat extraction bans, building regulations, approving CO_2 transport by pipeline). Also important are defining robust Monitoring, Reporting and Verification (MRV) frameworks to ensure genuine climate benefits, continued support for technology innovation to avoid lock-in, and ensuring that plans for GGRs are aligned to the UK's climate adaptation needs.

A summary of the discussion is published on the CCC's website. Defra and BEIS should consider these findings their development of ELMs, CCUS business models and the GGR Call for Evidence.

Source: Gough and Vaughan (2020) Summary note of GGR policy options roundtable for the CCC.
Notes: *Despite extensive restoration, the UK's peatlands are still expected to be a source of emissions by 2050, rather than a sink.

c) The UK's role in developing greenhouse gas removals globally

The UK can lead the development of international frameworks for GGRs.

At a global level, removals of CO_2 from the atmosphere will be a critical strand of the global effort to achieve the long-term temperature goal of the Paris Agreement. The UK's GGR strategy can play a leading role in global policy development for greenhouse gas removals:

- **Governance.**
  - Without effective safeguards, the large-scale harvesting of biomass can both be high-carbon and have substantial impacts on the provision of food, biodiversity and other sustainability concerns. Strengthened governance is needed to manage these risks as the global biomass market scales up, and for any new public subsidies.
  - The long-term role of imported biomass feedstock into the UK should depend on these efforts. This requires a broader approach than existing focuses on sustainability standards to fully consider the impact of biomass production on land-carbon stocks and to drive up standards globally. Biomass sourced from high-carbon content land or with detrimental impacts on other aspects of sustainability should be ruled out by sustainability criteria, with a ratchetting-up of standards over time to incentivise best practice.

BECCS removals are likely to be accounted for in the country of CO_2 capture.

- **International accounting of biomass-based removals.** Many world regions will have either large potential biomass supplies or large CCS capacities, but not many countries will have both.
  - Application of the IPCC Guidelines for National Greenhouse Gas Inventories suggests that BECCS removals from imported biomass are reported by the jurisdiction where the capture of CO_2 occurs, with no removals reported in the jurisdictions producing the biomass or storing the CO_2.
  - However, Article 6 of the Paris Agreement supports collaboration between countries to support higher mitigation ambition around the world. The UK can lead the development of international effort sharing frameworks for biomass-based GGRs, to help provide incentives to ensure that the world's sustainable low-carbon biomass resource is used as efficiently as possible.
- **National and international removals markets.** Market-based mechanisms will be important in providing at-scale GGR in the UK and abroad. The UK can support the creation of removals markets by developing rules that would enable removals to be integrated into carbon markets such as a UK ETS. The UK should also work through international forums to ensure that sustainable, verifiable GHG removals can be included within the Paris Agreement's successor to the Kyoto Protocol's Clean Development Mechanism and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) with strong environmental safeguards (see Chapter 10 of the *Advice Report*).

Endnotes

[1] Engineering and Physical Sciences Research Council (2019) *Greenhouse Gas Removal Demonstrators Programme calls and workshop*

[2] BEIS (2020) *Direct Air Capture and other Greenhouse Gas Removal technologies competition*

[3] The Greenhouse Gas Removal Programme (2020)

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Policies for the Sixth Carbon Budget and Net Zero

Climate Change Committee
151 Buckingham Palace Road London
SW1W 9SW

Climate Change Committee

www.theccc.org.uk
@theCCCuk