



An independent assessment of the UK's Clean Growth Strategy

From ambition to action

Committee on Climate Change
January 2018



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All enquiries related to this publication should be sent to: communications@theccc.gsi.gov.uk

Acknowledgements

The Committee would like to thank:

The team that prepared the analysis for this report. This was led by Adrian Gault, David Joffe and Mike Thompson, and included Sasha Abraham, Owen Bellamy, Ellie Davies, Aaron Goater, Rachel Hay, Mike Hemsley, Jenny Hill, Ewa Kmietowicz, Sarah Livermore, Alexandra Scudo, Indra Thillainathan, and Nathan Wyatt.

Other members of the Secretariat who contributed to this report, including Jo Barrett and Steve Westlake.

A number of organisations and stakeholders for their support, including the Department for Business, Energy and Industrial Strategy, the Department for Environment, Food and Rural Affairs, and the Department for Transport.

A wide range of stakeholders who engaged with us or met with the Committee bilaterally.

Contents

Foreword	5
The Committee	6
Executive Summary	9
Chapter 1: Carbon budgets and the Clean Growth Strategy	26
Chapter 2: Overall assessment of the Clean Growth Strategy	36
Chapter 3: Policies and proposals in the Clean Growth Strategy	48
Chapter 4: Closing the policy gap and priorities for monitoring	70

Foreword

Seven months ago, in the foreword that Baroness Brown and I wrote to the Committee's joint adaptation and mitigation Progress Report to Parliament, we stressed the urgent need for action. We said that strong steps and clear signposts are needed now to keep the UK on track to its climate change targets and to support international action.

In its Clean Growth Strategy, published in October 2017, the Government sets out plans to meet the legislated fourth and fifth carbon budgets, covering UK emissions in the periods 2023-2027 and 2028-2032. The report you are now reading assesses how the Strategy stacks up against the challenge, and provides advice on what further needs to be done.

The first thing to say is that the Clean Growth Strategy, whilst much delayed, has changed the tone surrounding consideration of emissions reduction in the UK. Alongside the Industrial Strategy, it has recognised the essential contribution of the low-carbon transition to the economy as a whole. The Strategy, and related announcements, has set out strong ambitions – including to improve the energy efficiency of our homes; to phase out the sale of new conventional petrol and diesel cars and vans by 2040; and to reach 85% of UK electricity generation from low-carbon sources in 2032.

These are very positive signals. However, whilst some new policies are announced in the Strategy, the detailed policies and measures to meet the targets are not, in general, set out. Furthermore, even taking account of the Strategy's aspirations, a gap in meeting the fourth and fifth carbon budgets remains.

Urgent policy development is therefore required.

We set out in this report our assessment of what is needed from the Government by way of next steps – to firm up the current set of policies, proposals and intentions and to develop further ways of closing the gap. This builds on, but goes further than, what the Government has itself announced. We will monitor developments closely in our annual Progress Report to Parliament and look to advise the Government as best we are able as it develops its plans.

As ever, I am particularly grateful for the dedication and commitment of the Committee and Secretariat for producing this report in the short period of time since the publication of the Government's Strategy.



Lord Deben

Chairman, Committee on Climate Change

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). He has consistently championed the strong links between environmental concerns and business interests. Lord Deben also runs Sancroft, a corporate responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues. He is Chairman of Valpak Limited and the Personal Investment Management and Financial Advice Association.



Baroness Brown of Cambridge FRS

Baroness Brown of Cambridge DBE FREng FRS (Julia King) is an engineer, a crossbench member of the House of Lords, a Fellow of the Royal Society, Chair of the Adaptation Sub-Committee of the Committee on Climate Change, and Deputy Chair of the Committee on Climate Change. She is also Chair of the Henry Royce Institute for Advanced Materials, Non-Executive Director of the Offshore Renewable Energy Catapult and Chair of STEM Learning Ltd. She was previously Non-Executive Director of the Green Investment Bank, held senior engineering and manufacturing positions at Rolls-Royce plc, and academic positions at Cambridge University and Imperial College. She is a former Vice Chancellor of Aston University.



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. He has previously held the posts of Professor of Psychology at both Warwick University and University College London (UCL), and Associate Editor for the journals Cognitive Science, Psychological Review, Psychological Science and Management Science.

**Dr Rebecca Heaton FICFor**

Rebecca Heaton is Head of Sustainability and Policy at Drax Group. She is responsible for the sustainability of the global forest supply chains used to produce biomass for its power station, and for research and policy work. She has extensive experience working for a number of energy businesses on a range of topics, including biofuels, land-use and forestry, and climate change adaptation. She previously led the work of the Energy Research Partnership (ERP) Bioenergy Review 2011 and was a member of the Editorial Board of Global Change Biology – Bioenergy.

**Professor Sir Brian Hoskins**

Sir Brian Hoskins is Professor of Meteorology at the University of Reading, specialising in weather and climate processes. He is also Chair of the Grantham Institute for Climate Change and the Environment at Imperial College London and a member of the national scientific academies of the UK, USA, and China.

**Paul Johnson**

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) and Head of Economics of Financial Regulation at the Financial Services Authority (1999 to 2000).



Professor Corinne Le Quéré FRS

Corinne Le Quéré is Professor of Climate Change Science and Policy at the University of East Anglia (UEA), specialising in the interactions between climate change and the carbon cycle. She is also Director of the Tyndall Centre for Climate Change Research, a lead author of several assessment reports for the UN's Intergovernmental Panel on Climate Change (IPCC), and Director of the annual update of the global carbon budget by the Global Carbon Project (GCP).



Professor Jim Skea

Jim Skea is Professor of Sustainable Energy at Imperial College, with research interests in energy, climate change and technological innovation. He is also Research Councils UK Energy Strategy Fellow and President of the Energy Institute. Jim was Research Director of the UK Energy Research Centre (2004 to 2012) and Director of the Policy Studies Institute (1998 to 2004). He was awarded a CBE for services to sustainable energy in 2013 and an OBE for services to sustainable transport in 2004.

Executive Summary

Under the Climate Change Act, the Government is required to publish a set of policies and proposals that will enable the legally-binding carbon budgets, on track to the 2050 target, to be met. The Clean Growth Strategy, published in October 2017, presents the Government's plans.

In this report we set out our assessment of that Strategy. Our key conclusions are:

- **The Government has made a strong commitment to achieving the UK's climate targets.** It has placed the low-carbon economy at the heart of the UK's industrial strategy, framing the Clean Growth Strategy as a positive contribution to the economy (rather than a burden to be minimised). It has committed to a position of international leadership. There is great interest internationally in the model provided by the UK Climate Change Act. This makes it all the more important to have plans in place to meet the targets through domestic actions – this is the basis on which the carbon budgets were set.
- **Policies and proposals need to be firmed up.** The Strategy includes some new policies to reduce emissions. In other areas – covering the majority of the emissions reductions in the Strategy – it sets out some ambitious new proposals, but policy to deliver those aspirations has not yet been worked up. Development of policy in these areas (e.g. upgrading as many homes as possible to Energy Performance Certificate Band C by 2035, improved standards of new buildings, phasing out the sale of new conventional petrol and diesel cars and vans by 2040) will need to progress urgently.
- **Gaps to meeting the fourth and fifth carbon budgets remain. These must be closed.** Whilst the Strategy sets out a '2032 Pathway' for sectoral emissions that would just meet the fifth carbon budget, there is no clear link to the policies, proposals and intentions that the Strategy presents. Our assessment of the policies and proposals set out in the Strategy indicates that, even if these deliver in full, there remain gaps of around 10-65 MtCO₂e to meeting both the fourth and fifth carbon budgets on the basis of central projections.
 - **Fourth carbon budget (2023 to 2027).** There is a particular risk around meeting the fourth carbon budget, given that it begins in only five years' time and that plans set out so far are insufficient. The Government should set out in 2018 the additional policies that will close the remaining gap to meeting the budget (e.g. on energy efficiency, low-carbon heating, afforestation, waste). By 2020 there should be a plan that provides confidence that the fourth carbon budget will be met through UK domestic action.
 - **Fifth carbon budget (2028 to 2032).** There are only 10 years until the start of the fifth carbon budget. Lead-times, particularly for UK supply chains, mean that clarity is required soon in order to drive the necessary investments. It is urgent that the Government sets out how the Strategy's ambitions and intentions will be delivered in full, and develops new policies to close the remaining gap.
- **Risks of under-delivery must be addressed and carbon budgets met on time.**
 - **Managing risks.** For both new and existing policies significant risks of under-delivery remain. There is also uncertainty in emissions projections (Box 1). Risks that cannot be removed now must be actively managed. The Government should aim to outperform the carbon budgets, in-line with our cost-effective path. This would provide contingency and is important in the context of the Paris Agreement, under which the UK – along with almost every other country in the world – has signed up to a deal that will require increasing efforts in future.

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- **Ensuring timely delivery.** The Government recognises that publication of the Strategy is not the end of the process. It has proposed a set of milestones for policy development. The Committee has identified further key milestones that need to be achieved to close the gaps to meeting the carbon budgets and provide greater confidence that the policies, proposals and intentions announced to date will be delivered in full. We will monitor policy development, and implications for meeting the fourth and fifth carbon budgets, against both these sets of milestones.

The Government has also announced an ambitious programme of innovation spending, in many cases with clear goals to support the low-carbon transition. This spending could have a positive impact in reducing the costs and increasing the attractiveness of low-carbon options, as well as helping the UK to gain industrial advantage in low-carbon goods and services. It will not be enough by itself to meet the UK's carbon targets:

- The programme is generally focused at early-stage innovation: research, development and some demonstration. To drive commercialisation and cost reduction successfully, it must be supported by funding and policies to drive deployment and learning-by-doing. Recent innovation successes, such as in offshore wind, have benefited from effective policies throughout the innovation chain, including a sustained period of deployment support before costs have fallen rapidly.
- Given innovation lead-times, the announced programme will contribute little to existing legislated carbon budgets, particularly the fourth (2023-27). The Government will need to be prepared to act to reduce UK domestic emissions with existing technologies, and should not rely on its success in promoting innovation.

The Clean Growth Strategy sets out three illustrative pathways to 2050, one of which excludes carbon capture and storage (CCS). The Government should not plan to meet the 2050 target without CCS. A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve. Furthermore, deeper reductions requiring the deployment of CCS will be needed to meet the aims of the Paris Agreement, whether by 2050 or subsequently. Although the Strategy states an ambition to deploy carbon capture use and storage (CCUS) in the 2030s, the level of detail and funding (which is directed at innovation only) are not commensurate with its importance. The Government should set out plans in 2018 that kick-start a UK CCS industry in the 2020s.

In providing the assessment in this report our focus is on what is needed now to make a success of the Clean Growth Strategy. Next steps for the Government are, as a matter of urgency, to firm up the current set of policies, proposals and intentions and develop further ways of closing the gap in ambition in order to be on track to meet the fourth and fifth carbon budgets.

As part of the regular monitoring and updating of the Strategy and through the Clean Growth Inter-Ministerial Group, the Government will also need to ensure that milestones are being achieved, identify any areas of underperformance and agree corrective actions to ensure progress remains on track. We will support this work with our annual Progress Reports to Parliament every June.

We set out further detail underpinning our key messages in the following four sections of this summary: ambition in the Clean Growth Strategy; the need for policy development; preparing for 2050; and monitoring progress and updating the plan.

Box 1. Government emission projections and the Clean Growth Strategy

The Government's Clean Growth Strategy presents analysis using their 2016 Energy and Emission Projections.¹ Our assessment for this report is consistent with the Clean Growth Strategy, and is therefore also based around these same emission projections.

Emission projections are of course uncertain and subject to change (e.g. new projections are published annually). New government energy and emission projections were published in January 2018,² and these imply a smaller policy gap than previously projected:

- The new projections reduce 'business-as-usual' baseline emissions by around 3% in 2025 and 2030, compared to the previous projections used in the Clean Growth Strategy. This reflects a range of factors unrelated to Government policies. These include changes in projected fossil fuel prices, and inclusion of outturn data for the previous year on energy demand and temperatures.
- The implication of this change is that future emissions are now projected to be lower than they were previously, and the gap to meeting the carbon budgets is smaller than previously projected.
- The total change is a lowering of emissions by around 50 MtCO₂e over both the fourth and fifth carbon budgets. This implies that the policy gaps may have reduced to around 10 MtCO₂e, rather than 65 MtCO₂e under the previous projections, although it may also be appropriate to revise down estimates of emissions savings.

Policy and ambition should be consistent in the face of these changes, whilst evolving over time in response to sustained changes. In particular, we would not expect a reduction in policy ambition in response to a downward adjustment to the projections given the risk that this is reversed in later years and given the commitment in the Paris Agreement to increase effort and deliver beyond existing targets.

Overall, these new projections do not change our key conclusion: there remains a gap to meeting the fourth and fifth carbon budgets, and new policies beyond those in the Clean Growth Strategy are required to close this gap.

Ambition in the Clean Growth Strategy

Overall ambition and use of 'flexibility mechanisms'

The Climate Change Act includes mechanisms to provide flexibility in meeting carbon budgets (e.g. carrying forward outperformance of one carbon budget to help meet the subsequent one). These should only be employed in the case of unexpected conditions that, despite strong policy action, would otherwise cause the carbon budgets to be missed. They should not be used to enable ambition to be weakened:

- The fourth and fifth carbon budgets were set on the basis of the cost-effective path for action in the UK on the way to achieving an emissions reduction of at least 80% below 1990 levels by 2050.
- To ensure the best value for UK taxpayers, businesses and consumers the plan must continue to be to meet the budgets in full, without reliance on accounting 'flexibilities' in the Climate Change Act.

¹ BEIS (2017) *Updated Energy and Emissions Projections 2016*.

² BEIS (2018) *Updated Energy and Emissions Projections 2017*.

- Use of these mechanisms would risk failing to develop leading low-carbon industries in the UK and storing up larger costs for future generations. Their use would also undermine the UK's position of leadership and be counter to the commitments made under the Paris Agreement (Box 2).

The Government has been clear in its statements to Parliament³ that it intends to deliver the carbon budgets through domestic action. This includes actions to cut emissions from electricity generation and heavy industry in the UK, which are currently covered by the EU Emissions Trading System (EU ETS).

We welcome the Government's stated intention to meet all of the legislated carbon budgets without use of credits or carrying forward of outperformance of earlier budgets. It is imperative that the Government continues to plan on the basis that it will not rely on these mechanisms and that the budgets will be met in full through UK action. We will provide advice at specific points in time, as required under the Climate Change Act, on the use of these mechanisms.

Box 2. The Committee's advice on use of 'flexibility mechanisms' in the Climate Change Act

The Committee has, since 2009, consistently taken the position that outperformance of the first three carbon budgets should not be carried over to help meet later budgets. The levels of the fourth and fifth carbon budgets were both set on this basis, while the ambition in the Paris Agreement provides a further reason not to use these mechanisms to weaken action to meet later carbon budgets:

- The first three carbon budgets were set at 'Interim' levels recommended by the Committee, with the intention that the third budget should be moved to a more ambitious 'Intended' budget level in the event of a global deal on climate change. The budgets remain at the levels originally legislated.
- These three carbon budgets have turned out to be easier to meet than expected for a range of reasons. This includes economic weakness during and following the financial crisis, and the UK having a different share of allowances in the EU Emissions Trading System (EU ETS) than anticipated when the budgets were legislated. The Committee stated in 2009 that the first three carbon budgets were likely to be outperformed for reasons other than effective policy, and that outperformance should therefore not be carried over.
- The levels of the fourth and fifth carbon budgets, recommended in 2010 and 2015 respectively, were based on the Committee's assessment of cost-effective UK action on the path to meeting the 2050 target, assuming that outperformance of earlier budgets would not be carried forward.
- In 2014, as required under the Climate Change Act, the Committee provided advice on whether the 36 MtCO₂e outperformance of the first carbon budget should be carried over. Our advice was that it should not be carried over, as doing so 'would increase costs and risks associated with meeting longer-term emissions targets'.⁴ The Government followed the Committee's advice not to carry forward this outperformance for use in the second carbon budget.⁵
- In our October 2016 report on *UK Climate Action Following the Paris Agreement*, the Committee was clear that the Paris Agreement is likely to require more ambitious long-term emissions targets than

³ <https://hansard.parliament.uk/Commons/2017-10-12/debates/E9354BA9-5321-4630-9F93-1342E5246996/CleanGrowthStrategy>

⁴ Letter to Gregory Barker MP (2014) *Decision on whether to carry forward emissions from first to second carbon budget*, available at: <https://www.theccc.org.uk/wp-content/uploads/2014/04/20140414-CCC-advice.pdf>

⁵ Letter from Edward Davey (2015) *Preserving the integrity of the UK's climate change regime*, available at: <https://www.theccc.org.uk/wp-content/uploads/2015/03/150310-SoS-to-Deben-re-carbon-budgets.pdf>

Box 2. The Committee's advice on use of 'flexibility mechanisms' in the Climate Change Act

currently legislated. Should any carbon budget be outperformed, these lower emissions should provide the basis to prepare for tighter targets to be met in future; outperformance of carbon budgets should not be used to reduce ambition under existing targets.

The Committee will continue to assess progress towards meeting the fourth and fifth carbon budgets on the basis that they must be met in full through UK action to reduce emissions.

Policies and proposals compared to the requirements of the carbon budgets

The Clean Growth Strategy contains a '2032 Pathway' for levels of emissions in the fifth carbon budget period that would result in actual UK emissions in 2030 that are 62% below 1990 levels. This is in-line with the Committee's scenarios and would meet the fifth carbon budget after allowing for trading of emissions allowances within the EU ETS.

However, as acknowledged by the Government, the current set of policies that can be considered as firm – including new policies announced in the Clean Growth Strategy (Box 3) – fall well short of achieving this pathway and meeting the fourth and fifth carbon budgets. Many of these have risks associated with delivery.

Box 3. Firm new policies in the Clean Growth Strategy or announced separately

Five firm new policies are set out in the Clean Growth Strategy and separate recent announcements:

- **Power auctions.** £557 million of the £730 million budget for low-carbon electricity generation was unspent in 2017's auctions. The Government has committed this remainder to further auctions for low-carbon generation. Given the success of the most recent auction in procuring offshore wind well below target prices, this budget is likely to deliver substantially more low-carbon generation than previously anticipated.
- **Energy Company Obligation (ECO)** funding has been extended out to 2028, with funding levels at least at today's levels. Delivery of energy efficiency improvements under the obligation have now been focused on fuel-poor homes.
- **Industrial heat recovery programme.** An £18m fund has been announced to encourage investment by manufacturers to recover and reuse heat from industrial processes that would otherwise be wasted.
- **Streamlined business energy and carbon reporting framework.** The Government will replace the business reporting element of the discontinued CRC Energy Efficiency Scheme, to align with mandatory annual greenhouse gas reporting for UK quoted companies.
- **Renewable Transport Fuels Obligation (RTFO).** The level of the obligation for renewable transport fuels has been increased from the current level of 4.75% to 9.75% for 2020, rising to 12.4% in 2032.

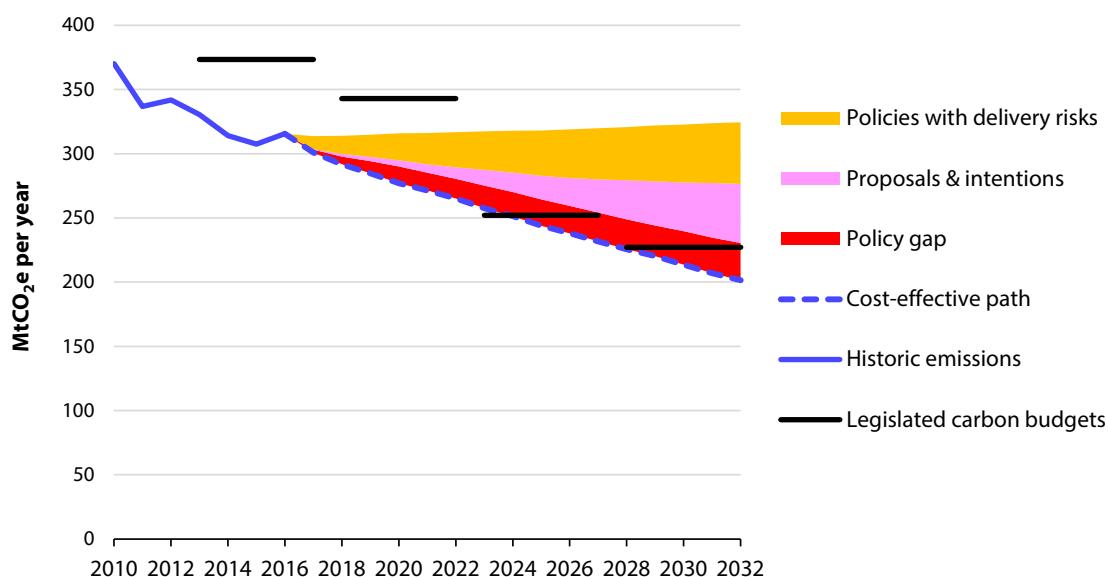
The Clean Growth Strategy makes a number of new high-level commitments to go further and reduce this gap. These are a welcome recognition of the challenge that the Government intends to meet. However, none of the proposals are as yet firm enough. The proposals and intentions include:

- Phasing out the sale of new conventional petrol and diesel cars and vans by 2040.

- Upgrading as many homes as possible to Energy Performance Certificate (EPC) Band C by 2035, including all rented and fuel-poor homes by 2030.
- Phasing out installation of high-carbon fossil fuel heating in homes and businesses off the gas grid during the 2020s.
- Improving the route to market for renewable technologies and progressing discussions with developers of new nuclear power, with a view to reaching 85% of UK generation from low-carbon sources in 2032.
- Improving business energy efficiency by at least 20% by 2030, including through an Industrial Energy Efficiency Scheme and changes to building regulations and standards.
- Deploying carbon capture use and storage (CCUS) at scale in the UK in the 2030s.

Whilst they are welcome statements of ambition, many of the proposals and intentions in the Clean Growth Strategy lack detail. This has required us to make assumptions and judgments on what they could deliver (more details of which are set out in Chapter 3). Overall, our assessment is that even with the proposals and intentions added to the current set of policies – and even if interpreted generously and if all delivered in full – the gaps would not be closed to the fourth or fifth carbon budgets. On central projections we estimate that there remains a gap of up to 65 MtCO₂e to meeting each of the fourth and fifth carbon budgets (Figure 1).

Figure 1. Remaining gaps to the fourth and fifth carbon budgets (non-traded sector)



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, BEIS (2017) *2016 UK Greenhouse Gas Emissions, provisional figures*, HMG & HMT (2009) *Building a low-carbon economy: implementing the Climate Change Act 2008*, CCC analysis.

Notes: The chart presents emissions in the 'non-traded' sector only (i.e. sources of emissions not covered by the EU Emissions Trading System – EU ETS), as it is these emissions that determine whether or not a carbon budget is met. Chart is on the basis of Government emission projections used in the Clean Growth Strategy, for which our assessment of the gap is around 65 MtCO₂e. The Government's latest projections suggest the gap could be lower, at around 10 MtCO₂e. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding, see Box 1.2) are coloured amber. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy. These are coloured pink. The remaining gap to the cost-effective path is coloured red. The cost-effective path outperforms carbon budgets, so not all this gap would need to be filled to meet the legislated budgets.

The Government must firm up the set of proposals and intentions, and deliver them on time and in full. But since these appear insufficient, it must also develop further ways to close the remaining gap. Updated plans should also provide contingency, in case of under-delivery in some areas and/or if emissions projections prove too optimistic. We identify opportunities for further action in the following section.

The need for policy development

Areas for action identified in the Clean Growth Strategy are broad-based and cover most sectors. However, gaps remain to meeting the carbon budgets and there are risks relating to existing policies and to the new proposals and intentions (Box 4).

The Government has set out key actions and milestones for developing the proposals in the Clean Growth Strategy. These will need to be delivered, and supplemented by further ambition. Actions taken in the near future should:

- Remove delivery risks around existing and new policies
- Provide greater detail and clarity on how the Clean Growth Strategy proposals and intentions are to be delivered at a high level of ambition
- Set out further policy ambition, to close the remaining gaps to the fourth and fifth carbon budgets.

Taking actions in these areas (e.g. as set out below) should lead to the gap to the fourth carbon budget being essentially eliminated by the end of 2018 and the delivery risks being very largely removed by the end of 2020 – two years before the budget period starts – so that there can be confidence that this budget will be met (Figure 2).

It will be necessary to reach the same, or greater, level of confidence regarding the fifth carbon budget by the end of 2025. Policies to fill the gap to the fifth carbon budget should be identified by 2020 and contingency options developed in case of under-delivery in some areas and/or the emissions projections proving too optimistic. Greater detail must also be provided on how the Clean Growth Strategy proposals are to be delivered. Further firming up of policies is then likely to be needed over the first half of the 2020s (Figure 3).

If policies are not in place on this timeline, the carbon budgets are liable to be missed given the lead-times from policy implementation to investment and then to their impact on reducing emissions. Any reductions in ambition or delays in implementation of policies aiming to reduce greenhouse gas emissions must be made up by increased effort in other areas.

Box 4. Gaps in the policies and proposals included in the Clean Growth Strategy

Gaps in the policies and proposals announced in the Clean Growth Strategy include:

- **Buildings energy efficiency.** The overarching trajectory set out for improving the efficiency of the existing building stock is promising. Details need to be set out on how this will be delivered, particularly for 'able-to-pay' homeowners for whom there are still no firm policies to drive the necessary actions.
- **Low-carbon heat in homes, businesses and industry.** The commitment to phase out the installation of high carbon fossil fuel heating in buildings off the gas grid is welcome. This should include heat pump deployment, which, together with installation in new-build properties, would develop heat pump markets and supply chains in order to prepare, if necessary, for potential

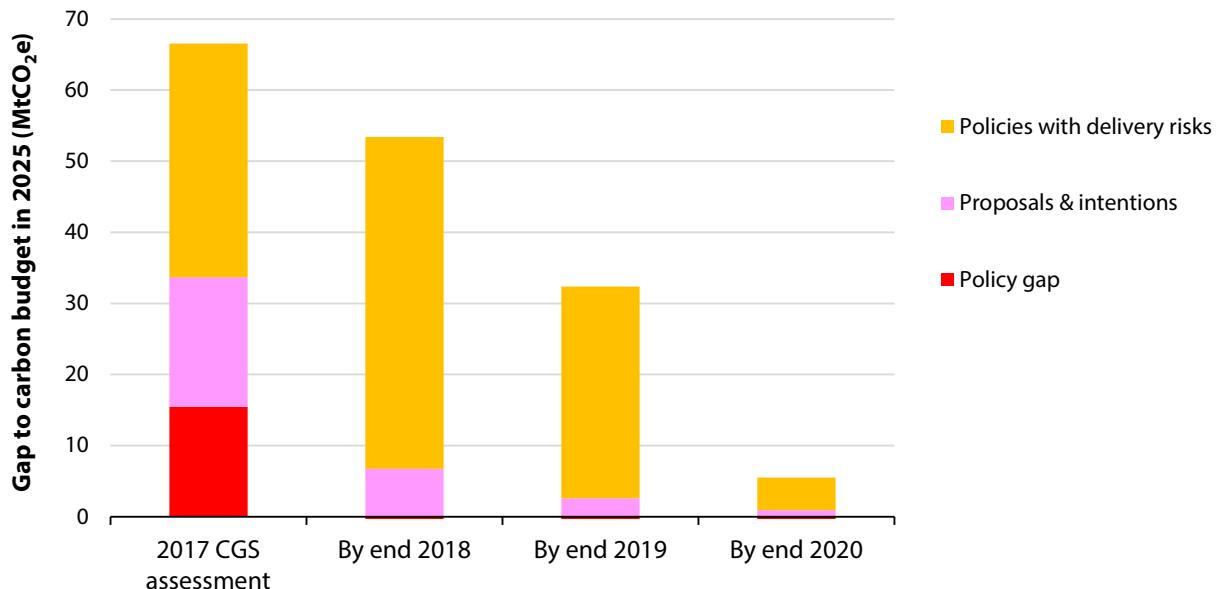
Box 4. Gaps in the policies and proposals included in the Clean Growth Strategy

widespread deployment in buildings connected to the gas grid from the 2030s. However, the Strategy provides little commitment to a low-carbon supply mix in heat networks and no commitment to biomethane post-2021, both of which the Committee has identified as 'low-regrets' options at this stage. There is also little commitment to support an increase in the use of bioenergy for industrial process heat.

- **Surface transport.** The Government has set out an ambition for 30-70% of car sales and up to 40% of van sales in 2030 to be ultra-low emission vehicles (ULEVs). It will be necessary to deliver towards the upper end of the range for cars, and greater ambition will be needed for vans. There is little concrete action on emissions from HGVs. More is also needed on shifting travel demand from passenger cars to lower-emission modes.
- **Power generation.** The Government has set out plans for the decarbonisation of UK power generation to below 100 gCO₂ per kWh by 2030. However, this places a high reliance on new nuclear build and net imports across interconnectors, both of which have associated risks. More is needed to provide a route to market for low-carbon electricity generation, especially lower-cost options such as onshore wind and solar, and to contract for additional low-carbon generation should the Government's expected contributions from new nuclear plants and overseas generators under-deliver.
- **Agriculture and land use.** A commitment to include climate change mitigation as part of a new system of future agricultural support is welcome. However, strong policies to deliver emissions reductions in agriculture need to be developed soon. The acceleration of tree-planting rates should occur earlier than the Strategy's proposed timeline of the 2020s, to ensure that around 70,000 hectares of afforestation is delivered in England by 2025.
- **Aviation.** The Government have committed to publish a new Aviation Strategy by the end of 2018. This will need to include a plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set (i.e. around 2005 levels by 2050, likely to imply around a 60% potential increase in demand), supported by strong international policies.

We will continue to monitor progress reducing the policy and delivery risks in these areas as part of our annual reports to Parliament on meeting carbon budgets.

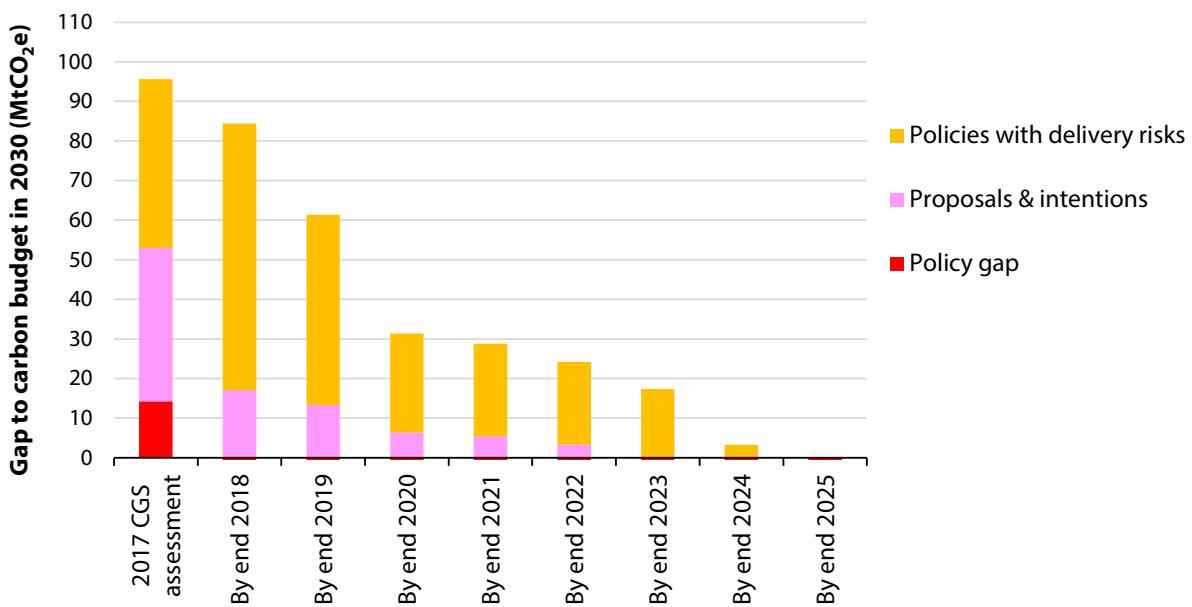
Figure 2. Fourth carbon budget: The policy gap in 2025 and how Government policies should develop over time to close this gap (non-traded sector)



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, CCC analysis.

Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the fourth carbon budget can be closed and how current policies, proposals and intentions firmed up so that delivery risks are largely eliminated. This is based on sectoral assessments of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2020. These sectoral assessments are set out in more detail in the supporting technical annex. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period, and the gap to meeting the average annual level of the carbon budget. It reflects actions to close the gap for the non-traded sectors, as it is these emissions that determine whether or not a carbon budget is met. This assessment is based on the government emission projections used in the Clean Growth Strategy. New projections were published in January 2018 (Box 1). These reduced the level of projected future emissions by 3% in 2025, and therefore imply a smaller policy gap to be closed.

Figure 3. Fifth carbon budget: The policy gap in 2030 and how Government policies should develop over time to close this gap (non-traded sector)



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, CCC analysis.

Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the fourth carbon budget can be closed and how current policies, proposals and intentions firmed up so that delivery risks are largely eliminated. This is based on sectoral assessments of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2025. These sectoral assessments are set out in more detail in the supporting technical annex. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period, and the gap to meeting the average annual level of the carbon budget. It reflects actions to close the gap for the non-traded sectors, as it is these emissions that determine whether or not a carbon budget is met. This assessment is based on the government emission projections used in the Clean Growth Strategy. New projections were published in January 2018 (Box 1). These reduced the level of projected future emissions by 3% in 2030, and therefore imply a smaller policy gap to be closed.

Time has already been lost in the delayed publication of the Clean Growth Strategy. The window for development of new policies to reduce emissions by the mid-2020s, in order to meet the fourth carbon budget, is small. To be confident that the fourth carbon budget will be met, it is urgent that the Government brings forward firm policies that go beyond those already set out.

Particular areas where the Committee identify a need for urgency in progressing to firm policies and delivery of abatement actions include:

- **Energy efficiency in existing buildings.**

- An ambitious action plan for able-to-pay homeowners must be published swiftly, as this segment is large and current policies are not driving significant improvements. It should set out a robust policy framework including efficiency incentives, with firm commitments on the level of ambition and funding. If insufficient take-up is achieved, options that are initially incentivised may later need to be mandated. Policies should be in force by the end of 2019 at the latest (earlier action would reduce the policy gap, provided this is not at the expense of quality or ambition).

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- Action is also needed now to make the private-rented sector regulations fully effective (in the absence of the Green Deal financing mechanism),⁶ to develop proposals for a trajectory for standards to 2030 across all rented properties, to put in place a performance-based labelling scheme for commercial properties, and to take forward actions to improve compliance, including the effective use of data on actual performance.
 - **Low-carbon heat.** Immediate priorities include retargeting the Renewable Heat Incentive (RHI) towards heat pumps and biomethane, developing and setting out proposals for the fossil fuel phase-out for buildings off the gas grid, and further work to secure low-carbon supply mixes for new and existing heat networks (including waste heat from industry and large water- and sewage-source heat pumps).
 - **New buildings.** Standards need to be developed that deliver high levels of fabric efficiency and future-proof properties for low-carbon heat. Existing commitments under EU law will need to remain in place or be replaced with equivalent standards following the UK's exit from the EU. It is also vital that the performance gap between design and actual performance is addressed in order to realise energy savings and deliver high-quality homes.
 - **Public sector.** Plans for a voluntary target across the public sector to 2020/21 need to be developed alongside the monitoring and reporting framework. This should be combined with further work on how public procurement can be harnessed to drive higher standards in commercial buildings and new homes, and to support low-carbon heat supply chains.
 - **Surface Transport.** The Government's 'Road to Zero' strategy, due in 2018, should set out:
 - Proposals for incentives for the uptake of ULEVs (e.g. extension of the grants for plug-in vehicles, until the private costs of ownership reach parity with conventional vehicles), and lay out a clear plan for public charging infrastructure.
 - Future requirements for conventional vehicle efficiency, to go beyond recently announced EU proposals for emissions standards for 2025 and 2030, which are not ambitious enough.
 - Measures to incentivise freight operators to improve logistics efficiency and shift to less carbon-intensive modes, and to increase uptake of eco-driving training and fuel-saving technologies for HGVs where cost-effective.
 - Additional measures to incentivise a shift of travel demand to lower-emission modes including walking, cycling and public transport.
 - **Carbon capture and storage (CCS).** The Development Pathway due to be published in 2018 must set out the Government's proposals for: the delivery model for CO₂ transport and storage infrastructure, the funding mechanism for industrial CCS, and the allocation of risks between Government and developers, especially relating to long-term storage liabilities. Several promising projects exist in strategic cluster locations that could be in operation by 2025. If a decision on the future of the gas grid by 2025 is to be credible, then progress on demonstrating the business model for CCS will be needed before then.
 - **Agriculture and land use.** There has been no progress in reducing agricultural emissions over the past six years. The publication of a new Strategy for Agriculture and Land Use must

⁶ The Government set out a proposed cap of £2,500 per home in a consultation in December 2017. Under these proposals, Government estimates put the percentage of F and G rated private-rented homes reaching band E by 2020 at 30%. More will be needed to deliver on the EPC band C by 2030 ambition and fuel-poverty targets.

set out policy proposals, to take effect by 2022, for the delivery of emissions reduction and increased carbon sequestration. Informed by improved information from the forthcoming Smart Inventory, this Strategy should set out measures to implement a range of cost-effective emissions reduction from soils, crops, and livestock. In forestry, appropriate incentives and measures to address non-financial barriers should be put in place to accelerate the rate of tree planting beyond current low levels.

- **Waste.** The Government's new Resources and Waste Strategy, due in 2018, should set out firm policies to end food waste going to landfill and this should be implemented by 2025, five years earlier than currently planned. The Strategy should also require landfilling is ended for other waste streams including paper and card, wood, textiles and garden waste on the same timescale.

Other areas should progress according to the timelines that the Government has laid out:

- **Power generation.** The Government has committed to spending £557m of funding for Contracts for Difference, with the next auction taking place in Spring 2019. The Government should announce the funding that will be allocated to this auction, and continue to run subsequent auctions in order to procure the low-carbon generation required to reduce carbon intensity of generation to below 100 gCO₂/kWh by 2030. The Government's approach to procuring low-carbon generation should include cost-competitive technologies, such as onshore wind and solar PV. Latest estimates from BEIS⁷ and others suggest onshore wind is the cheapest form of new-build generation in the UK.
- **Replacement of EU standards.** Whatever happens in terms of leaving the EU, it is essential to maintain continuity and comparability in standards with those across the European Union. The Government needs to ensure that the Clean Growth Strategy commitments to maintain and, where necessary, go beyond EU ambition are delivered.

As well as developing effective new policies, success will require that existing policies are monitored, and adjusted as required to ensure delivery remains on track at lowest cost. We identify a number of specific risks (Box 5) along with options for policy strengthening.

Box 5. Key risks requiring management and options for policy strengthening

Our assessment of Government policies to reduce emissions highlights a number of existing policies that have risks around delivery:

- **Power generation.** The Government's Energy and Emissions Projections envisage an ambitious programme of new nuclear build. For this to be achieved we would expect contracts to be signed over the coming years. The Government also envisages electricity imports from European countries providing 15-20% of the UK's generation in 2030. To the extent that imports are used it is important that these reflect additional low-carbon generation. There is also a risk, if imports were lower, that generation from UK gas plants may increase leading to increased emissions. The Government will need to put in place a progress monitoring and contingency scheme to identify risks relating to delivery and, in the event that new nuclear plants are delayed or electricity imports lower, allow for additional low-carbon generation to be contracted.
- **Other policy development that is impacted by exiting the EU.** As we prepare to leave the EU, it is essential to deal with economic uncertainty and to maintain ambition in the areas in which EU policies are important in reducing UK greenhouse gas emissions. Some of these policies already

⁷ BEIS (2016) Electricity Generation Costs

Box 5. Key risks requiring management and options for policy strengthening

had existing delivery risks. There is also an opportunity to develop a UK policy framework that links support to actions that reduce emissions (e.g. for farming after the Common Agricultural Policy).

- **Product standards.** EU product standards have led to substantial improvements in the efficiency of appliances used in the UK, saving money and cutting carbon emissions. It is essential that the Strategy's commitment to match or exceed EU standards is delivered.
- **New vehicle regulations.** Efficiency standards for new cars and vans have operated at EU level, setting average levels of grams of CO₂ per kilometre that decline over time. The Strategy states the Government will "seek to ensure our future approach is at least as ambitious as the current arrangements", but offers no further details. Current EU proposed targets for 2025 and 2030 are not ambitious enough – the UK should adopt more stretching standards.
- **F-gases.** The EU F-Gas Regulation sets quotas for use of F-gases that fall over time, such that UK F-gas emissions are expected to fall by 68% between 2015 and 2030. Again, the Strategy states that the Government will "seek to ensure our future approach is at least as ambitious as the current arrangements". The Committee believes there are cost-effective opportunities to go further, and is commissioning new work to better understand the potential.
- **EU Emissions Trading System (EU ETS).** The Government has committed to a total carbon price at around today's level of £24/tCO₂ for the UK power sector regardless of whether the UK continues to participate in the EU ETS. However, it is not clear what the framework will be to drive necessary emissions reductions in industry (e.g. through improvements in energy efficiency). The Strategy states that the Government will "seek to ensure that our future approach is at least as ambitious as the existing scheme and provide a smooth transition for the relevant sectors", but more detail will be needed once the question over future UK participation in the EU ETS is settled.

It is essential that alongside developing further options to close the gap to meeting carbon budgets and firming up the new ambitions and intentions, these risks are addressed and the associated emissions reductions are delivered in full.

Preparing for 2050

As well as setting out how carbon budgets to 2032 will be met, the Climate Change Act also requires that the Government's plans should make preparations for meeting the 2050 target. This is currently set in legislation as a reduction of at least 80% on 1990 emissions. However, the Paris Agreement is likely to require greater ambition by 2050 and for emissions to reach net-zero at some point in the second half of the century. It is therefore essential that actions are taken now to enable these deeper reductions to be achieved.

The Clean Growth Strategy identifies further priorities to prepare for the 2050 target. These align to priorities previously identified by the Committee:

- **Decisions on the future of the gas grid.** The Strategy acknowledges the need to make decisions in the first half of the next decade about the long-term question of how we heat our homes. This includes the future of the gas grid and the respective roles for heat pumps and hydrogen. The Government is beginning active preparations, including innovation support to test and bring down the cost of low-carbon heating technologies. Use of hydrogen would require deployment of CCS at scale.

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- **Greenhouse gas removal (GGR).** GGR is likely to be required to some extent globally to achieve the ambitions of the Paris Agreement. However, it is not a substitute for action to reduce emissions. GGR can be undertaken using proven options such as afforestation; relatively well understood ones such as bioenergy with carbon capture and storage (BECCS); and others that are less well understood. The Strategy commits to the development of a strategic approach to GGR technologies, building on the Government's programme of research and development and addressing the barriers to their long-term deployment.

These areas must progress alongside emissions reductions from nearer-term options (i.e. energy efficiency, low-carbon power generation, ultra-low emission vehicles, heat networks, low-carbon heating for buildings off the gas grid) to ensure that the UK prepares effectively for meeting the 2050 target.

The Strategy sets out three illustrative pathways to 2050, one of which excludes carbon capture and storage (CCS). The Government should not plan to meet the 2050 target without CCS. A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve. It would also rule out the use of hydrogen to decarbonise areas such as heating, given that CCS is likely to be required in order to produce low-carbon hydrogen.

Although the Strategy states an ambition to deploy carbon capture use and storage (CCUS) in the 2030s, the scale of financial support is far lower than previously committed: the Strategy commits £100m for innovation spending, focusing on early stage R&D support for carbon capture and use (CCU), far lower than the previous commitment of £1bn capital spending for CCS. Given the importance of CCS for reaching the necessary levels of emissions in the longer-term – decarbonisation of heavy industry relies heavily on CCS, as do both the GGR and hydrogen options – this commitment is not yet strong enough. The Government should set out plans in 2018 that kick-start a UK CCS industry in the 2020s.

Furthermore, deeper reductions will be required to meet the aims of the Paris Agreement, whether by 2050 or subsequently. Development of CCS, combined with very low emissions from transport, buildings and power generation by 2050 (i.e. emissions reductions across those sectors of at least 90%), progress in 'difficult to reduce' sectors (e.g. agriculture and aviation) and, if feasible, deployment of GGR technologies, would retain the potential for reductions of more than 80% to be achieved.

In our advice on *UK Climate Action Following the Paris Agreement*, the Committee recommended that the Government wait to set more ambitious long-term targets until it had strong policies in place for meeting existing budgets and the evidence base is firmer on the appropriate level of such targets. The Government has now published its strategy to meet the legislated carbon budgets. The Intergovernmental Panel on Climate Change (IPCC) will produce a Special Report on the implications of the Paris Agreement's 1.5°C ambition in 2018. At that point, the Government should request further advice from the Committee on the implications of the Paris Agreement for the UK's long-term emissions targets.

Monitoring progress and updating the plan

The Government has clearly identified that publication of the Strategy is not the end of the process. The approach will have to develop and adapt to changing circumstances over time. To facilitate that, the Government has reinstated a cross-government ministerial group (the Clean Growth Inter-Ministerial Group) to drive implementation of the Clean Growth Strategy and has committed to annual monitoring and updating of the Strategy.

Effective monitoring will require a detailed understanding of progress across all sectors and whether corrective action or greater ambition is needed to be on track to meeting the budgets. Next steps for the Government are, as a matter of urgency, to firm up the current set of policies, proposals, and intentions, and develop further ways of closing the gap in ambition. We would expect priorities for the Clean Growth Inter-Ministerial Group to include:

- Progress against both the milestones set out in the Clean Growth Strategy and identified in this report (Chapter 4) and our annual reports to Parliament.
- Latest expectations for emissions reduction from policy areas that are not currently quantified, and expectations for emissions overall.
- Monitoring of delivery risks against existing policy expectations (e.g. Box 5).
- Identification of areas where further progress and emissions reduction is possible, should expected progress not be delivered elsewhere.
- Agreement of actions for specific Departments to continue progress or to get back on track.

To help focus the Clean Growth Inter-Ministerial Group on areas where progress is currently off-track or could be in future we have created a simplified summary of our monitoring indicators to keep on track to 2030 (Table 1). Some of the actions are required urgently.

The Committee welcomes the milestones set out in the Clean Growth Strategy and has added further milestones aimed at ensuring the necessary steps are taken to meet the carbon budgets. We will use this fuller set of milestones, together with our quantified assessment of how the gap should be closed and the expected impact of policies increased, to monitor Government progress in our annual Progress Reports to Parliament every June.

It is important that the UK Government works with the devolved administrations to ensure delivery against the carbon budgets. This should be both in areas that are devolved (e.g. waste, forestry), and in those that are reserved to UK Government but have important roles for local action (e.g. home energy efficiency, Contracts for Difference for low-carbon electricity generation). The Government should ensure that full account is taken of areas where ambition in the devolved administrations is greater.

Due to the large gap that already existed to meet the fourth carbon budget and the delay between setting the fifth budget and publication of the Clean Growth Strategy, the next steps of this process – closing the remaining policy gaps, removing delivery risks and providing detail on new proposals – now need to happen urgently. They must be pursued with vigour, urgency, and sustained commitment to ensure further delays do not make the carbon budgets unattainable.

The rest of this report is set out in four chapters:

- 1. Carbon budgets and the Clean Growth Strategy**
- 2. Overall assessment of the Clean Growth Strategy**
- 3. Policies and proposals in the Clean Growth Strategy**
- 4. Closing the policy gap and priorities for monitoring**

Further detail on the sectoral analysis underpinning this report is set out in separate technical annexes, available at www.theccc.org.uk

Table 1. Progress required in key areas to be on track to 2030

Sector	Lead dept	Key outcome required in 2030	Recent progress	Further actions required to keep on track for 2030
Power	BEIS	Emissions intensity of electricity system <100 gCO ₂ /kWh	<ul style="list-style-type: none"> 25 TWh renewables added 2014-2016 70 TWh low-carbon generation contracted for 2017-2025 	<ul style="list-style-type: none"> £557m Contract for Difference funding could support over 45 TWh of generation Further 50-70 TWh required to be contracted
Buildings	CLG / BEIS	Around a 20% reduction in emissions below 2016 & develop options for near-zero emissions in 2050: 14% reduction in energy demand for heat A quarter of heat from low-carbon sources by 2030	<p>Progress has stalled:</p> <ul style="list-style-type: none"> Insulation rates have fallen by 90% since 2012 Continued low uptake of low-carbon heat 	<ul style="list-style-type: none"> Policy to incentivise able-to-pay energy efficiency improvements Support for uptake of low-carbon heat in the 2020s Tighter low-carbon standards for new build & rented properties
Industry	BEIS	Around a 20% reduction in emissions below 2016 levels through industrial CCS, low-carbon heat, energy efficiency	<ul style="list-style-type: none"> Emissions fell about 1%/yr between 2009-14 Up to half of this due to energy efficiency or fuel switching 	<ul style="list-style-type: none"> Urgently set out an approach to deploy industrial CCS Set out further policies on low-carbon heat in industry & energy efficiency
Transport	DfT	Around a 44% reduction in emissions below 2016 levels, through stretching standards for new car, van & HGV CO ₂ , modal shift, & improved freight operations	Transport emissions have increased over the past 3 years	Implement more stretching targets than the EU 2030 proposal that deliver high levels of ULEV uptake (e.g. 60% of new sales). Set out policies to encourage modal shift to public transport & improve freight operations
Agriculture	Defra	Reduce emissions from crops, soils and livestock by around 19% below 2015 levels	No progress reducing agriculture emissions over the past 6 years	Publish a new strategy for agriculture & land-use, setting out policies to reduce emissions & sequester carbon
Land use and forestry	Defra	Tree-planting rates to reach 15,000 hectares/yr	Tree-planting rates currently around 6,000 hectares/yr	Develop policies to accelerate the rate of tree planting
Waste	Defra	Stop biodegradable waste to landfill by 2025	Between 2005-15 biodegradable waste sent to landfill fell from 31 million to 9 million tonnes	Go beyond plans set out in the Clean Growth Strategy & phase out all biodegradable waste streams to landfill by 2025
F-gases	Defra	Reduce emissions by at least 68% below 2016 levels	No progress – emissions have been flat since 2010	<ul style="list-style-type: none"> Implement policy at least in line with EU approach to phase out HFCs Look for cost-effective opportunities to go further
Cross-cutting	BEIS	Deployment of 1-2 strategic carbon capture and storage (CCS) clusters, to allow deployment at scale in the 2030s	No progress deploying CCS in the UK and backward steps in funding available	Establish plans for separate support mechanisms for CO ₂ capture, and for CO ₂ transport and storage infrastructure

Chapter 1: Carbon budgets and the Clean Growth Strategy



The UK's approach to tackling climate change is framed by the Climate Change Act (2008). In 2015 countries around the world agreed the Paris Agreement, which frames a global effort to reduce emissions. In this chapter we set out the requirements the Climate Change Act places on the government to bring forward policies and proposals to meet carbon budgets, the implications of the Paris Agreement for UK action, and our approach to assessing the Clean Growth Strategy.

a) The UK's approach to tackling climate change

The Climate Change Act sets the UK's long-term target to reduce emissions of greenhouse gases by at least 80% from 1990 to 2050. The carbon budgets provide the trajectory to get there. The fourth carbon budget requires a reduction of 51% from 1990 to 2025 and the fifth carbon budget a 57% reduction from 1990 to 2030. This compares to the 42% reduction achieved by 2016 (Figure 1.1). The first carbon budget was met, the second will be met, and emissions are on track to meet the third.

The Act also requires that the Government put forward 'proposals and policies' that will enable the budgets to be met and stay on track to the 2050 target. The Clean Growth Strategy, published in October 2017, aims to fulfil this requirement. It recognises the need to cut emissions – and the benefit to the UK economy of doing so in a predictable, steady and stable way. It recognises that current policies do not go far enough. It identifies areas where policies remain to be worked up, but where the Government has set ambitious goals that together could help to meet the budgets.

This is broadly how the policy development process is intended to work under the Climate Change Act (Figure 1.2):

- The Committee advises on a carbon budget that best balances the criteria in the Act to keep the UK on the lowest cost path to the long-term 2050 target.
- Parliament sets the budget, taking account of that advice.
- The Government and the Committee identify areas where policies would need to be strengthened to meet the budget.
- The Government implements policies and proposes areas for further development consistent with that strengthening.
- The Committee monitors implementation on an annual basis, and the Government update their plans on a similar cycle.

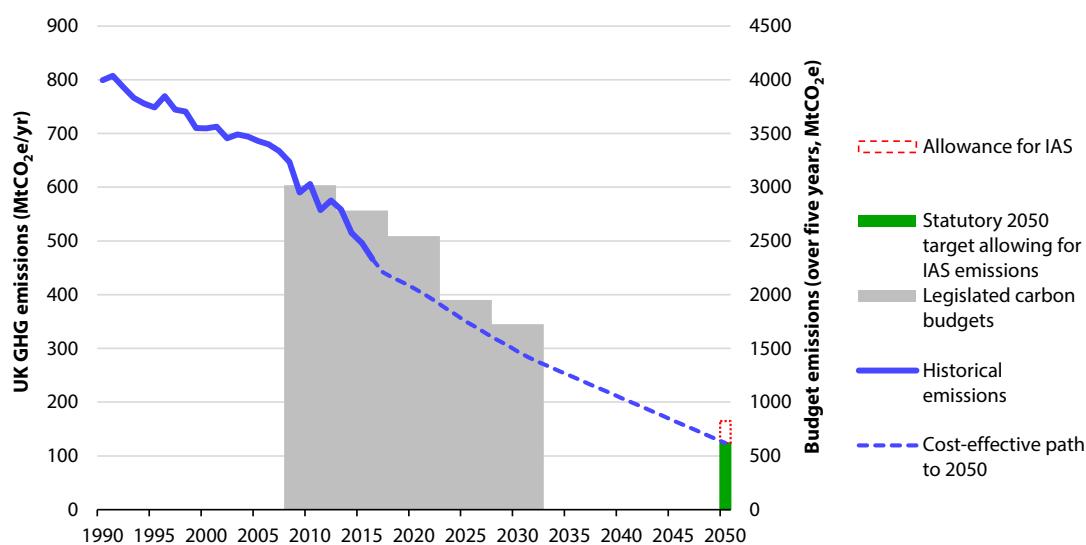
Prior to setting the fifth carbon budget, existing plans left a gap to meeting the fourth carbon budget. This has been highlighted by the Committee in successive Progress Reports to Parliament. As well as setting out how the fifth carbon budget would be met, it was therefore also incumbent on the Clean Growth Strategy to close the gap to the fourth budget.

Government projections in 2017⁹ indicated that existing policies could achieve a reduction of up to 48% by 2025 (compared to a required 51% reduction) and 51% by 2030 (compared to a required 57% reduction), against 1990 levels. This means that prior to publication of the Clean Growth Strategy the UK had in place policies that could, if delivered in full, achieve 93% of the emissions reductions from 1990 required to meet the fourth budget and 89% of those for the fifth budget. These were the gaps that needed to be closed.

⁹ BEIS (2017) *Updated Energy and Emission Projections 2016*.

Ideally the Strategy would have been published earlier. It is now a year and a half since the fifth carbon budget was set, and two years since the Committee first advised on its level and how it could be met. It is over six years since the fourth carbon budget was set. Given these delays, it is even more important that policy development now proceeds with the greatest urgency.

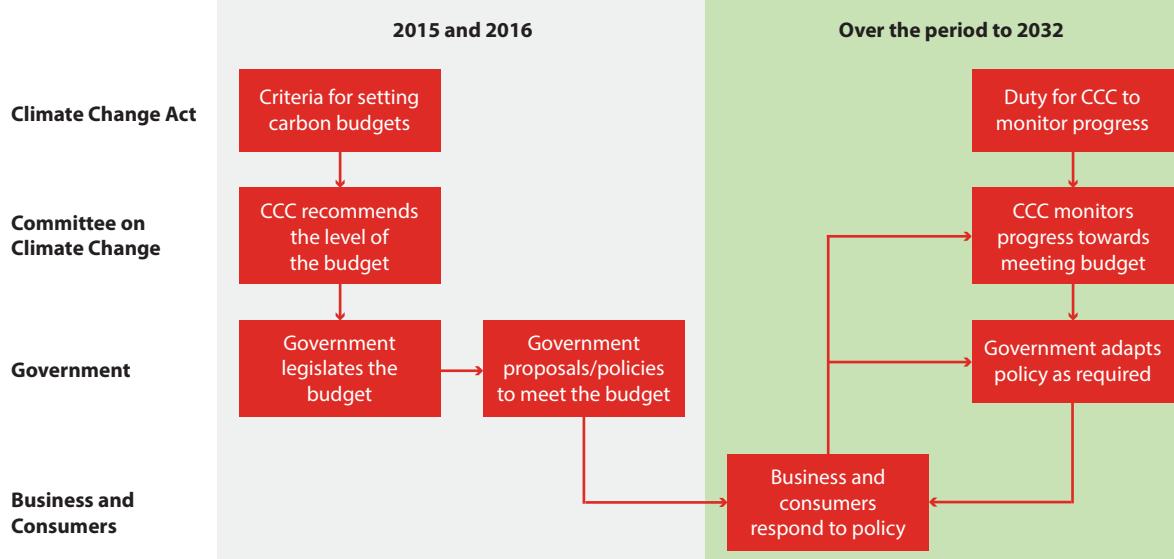
Figure 1.1. The carbon budgets continue emissions reductions on the path to the 2050 target



Source: BEIS (2017) 2016 UK Greenhouse Gas Emissions, provisional figures, CCC analysis.

Notes: Historical emissions are on a 'gross' basis (i.e. actual emissions). Carbon budgets are on the current budget accounting basis, excluding international aviation and shipping (IAS), but allowing for IAS in the 2050 target.

Figure 1.2. How the Climate Change Act process works



Source: CCC (2015) *The Fifth Carbon Budget – The next step towards a low-carbon economy*.

b) Taking into account the Paris Agreement

International negotiations on climate change are governed through the United Nations Framework Convention on Climate Change (UNFCCC). In 2008, when the Climate Change Act was legislated, there was neither a UNFCCC-agreed global quantitative goal for limiting climate change, nor a universal effort to reduce emissions.

The Paris Agreement was reached at the UNFCCC negotiations in 2015. It marked a number of new developments in international climate policy. These include commitments to reduce emissions across both developed and developing countries, a more ambitious aim for limiting global temperature rise, and an aim to reach net-zero global emissions this century:

- The overarching aim of the Paris Agreement is to hold the increase in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C. Previous UNFCCC texts have referred to the aim of limiting to below 2°C.
- To achieve this, it sets a new aim of balancing 'anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century' (i.e. net-zero global emissions by sometime between 2050 and 2100).
- Each party to the Agreement is required to make a national pledge of action, either to 2025 or 2030, to contribute to emissions reduction. Nearly all parties have now made pledges.¹⁰ EU Member States have collectively pledged to reduce their emissions by at least 40% below 1990 levels by 2030.

Despite the now-global effort to reduce emissions, current pledges of action to 2030 do not add up to a credible pathway to achieve either 2°C or more ambitious temperature aims.

Recognising this, the Paris Agreement created a 'ratchet' mechanism designed to encourage greater action over time:

- The pledges indicate a wide range of ambition from different nations. In aggregate, achievement of the pledges would lower emissions compared to previous expectations, but they would still grow from current levels of around 50 billion tonnes of CO₂-equivalent (50 GtCO₂e) to around 56 GtCO₂e in 2030.¹¹
- Parties to the Paris Agreement recognised 40 GtCO₂e as the 2030 level consistent with a path below 2°C.
- The Agreement sets a five-yearly 'ratchet' system to review pledges, starting in 2023, with the intention that their ambition will rise over time in a nationally-determined manner. Ahead of this, nations agreed to a "facilitative dialogue" in 2018 to take stock of the current pledges.

We concluded in our October 2016 report on *UK Climate Action Following the Paris Agreement* that aligning to the aims of the Paris Agreement would entail a steeper downward path for global emissions than implied by the UK 2050 target, on the assumption that countries have approximately equal per-capita emissions in 2050 (Table 1.1):¹²

¹⁰ <http://www4.unfccc.int/Submissions/INDC/>

¹¹ UNFCCC (2016) Updated synthesis report on the aggregate effect of INDCs:
http://unfccc.int/focus/indc_portal/items/9240.php

¹² An assumption of equal per-capita 2050 emissions is the basis of the Committee's 2008 recommendation for the 2050 target, enacted within the Climate Change Act, for an emissions reduction of at least 80% on 1990. See Letter to Ed Miliband (2008) *Interim advice by the Committee on Climate Change*, available at:
<https://www.theccc.org.uk/wp-content/uploads/2013/03/Interim-report-letter-to-DECC-SofS-071008.pdf>

- The UK's current targets are already at the more ambitious end of the range of international pledges to 2030 (in terms of percentage reduction below 1990 levels), and are broadly aligned to limiting temperature rise to 2°C.
- Keeping global temperature rise below 2°C with a 66% likelihood requires a reduction in global emissions to 17-29 GtCO₂e, equivalent to 1.8-3.0 tCO₂e per-capita. A reduction to this level of per-capita emissions in the UK implies a reduction of 71-83% on 1990 levels.
- Aligning more closely to 1.5°C ambition would imply global emissions reducing to 4-14 Gt in 2050 (0.4-1.4 tonnes per-capita). Reaching this level of per-capita emissions would imply UK emissions of greenhouse gases in 2050 at least 86-96% below 1990 levels.
- Aligning to the 1.5°C ambition is also likely to imply reaching net-zero CO₂ emissions globally by 2050, whereas to keeping temperature rise below 2°C implies that this would need to occur sometime between 2055 and 2075.

These emissions paths assume significant net CO₂ removals (i.e. net negative emissions) after reaching net-zero (through afforestation, bioenergy with carbon capture and storage, direct air capture or other methods). To the extent that significant net removals cannot be achieved, emissions would have to reach net-zero even sooner to stay within a global CO₂ budget.

Table 1.1. UK emissions in 2050 and time to reach net-zero emissions for paths consistent with the range of ambition implied by the Paris Agreement, assuming emissions per-capita equal to the global average

	Below 2°C	Return to 1.5°C
UK 2050 GHG emissions (reduction on 1990 levels)	71-83%	86-96%
Year to reach zero UK CO ₂ emissions	2055-75	2045-50

Source: CCC (2016) *UK Climate Action Following the Paris Agreement*, based on UNEP (2015) *The emissions gap report 2015*.

The Government has signalled an intention to set a new target in the future that reflects the global need to reach net-zero emissions. In our report on *UK Climate Action Following the Paris Agreement*, we agreed with this intention but said that a new long-term target should not be set yet:

- To be credible, a new long-term target needs to be evidence-based, accompanied by strong policies to deliver existing targets and a strategy to develop technology that is likely to be important to meeting any such target (notably greenhouse gas removals).
- Only by delivering on existing carbon budgets can higher ambition be delivered in future, as is likely to be required to meet the aims of the Paris Agreement.
- As part of good budget management the Government should aim to deliver ambitious emissions reductions in all areas of the economy. That would provide some contingency should any one area under-deliver. If all areas deliver fully, emissions would be reduced below the level of the existing targets (e.g. our most ambitious scenarios imply actual UK emissions 66% below 1990 levels in 2030 and around 90% below by 2050).

- If UK emissions do fall further than required by carbon budgets, this would help support the aim in the Paris Agreement of pursuing efforts to limit global temperature rise to 1.5°C. The presumption in this case should be that effort is not reduced and that any excess emissions reductions are not carried forward to reduce effort and ambition in future budgets (see Box 2.2).

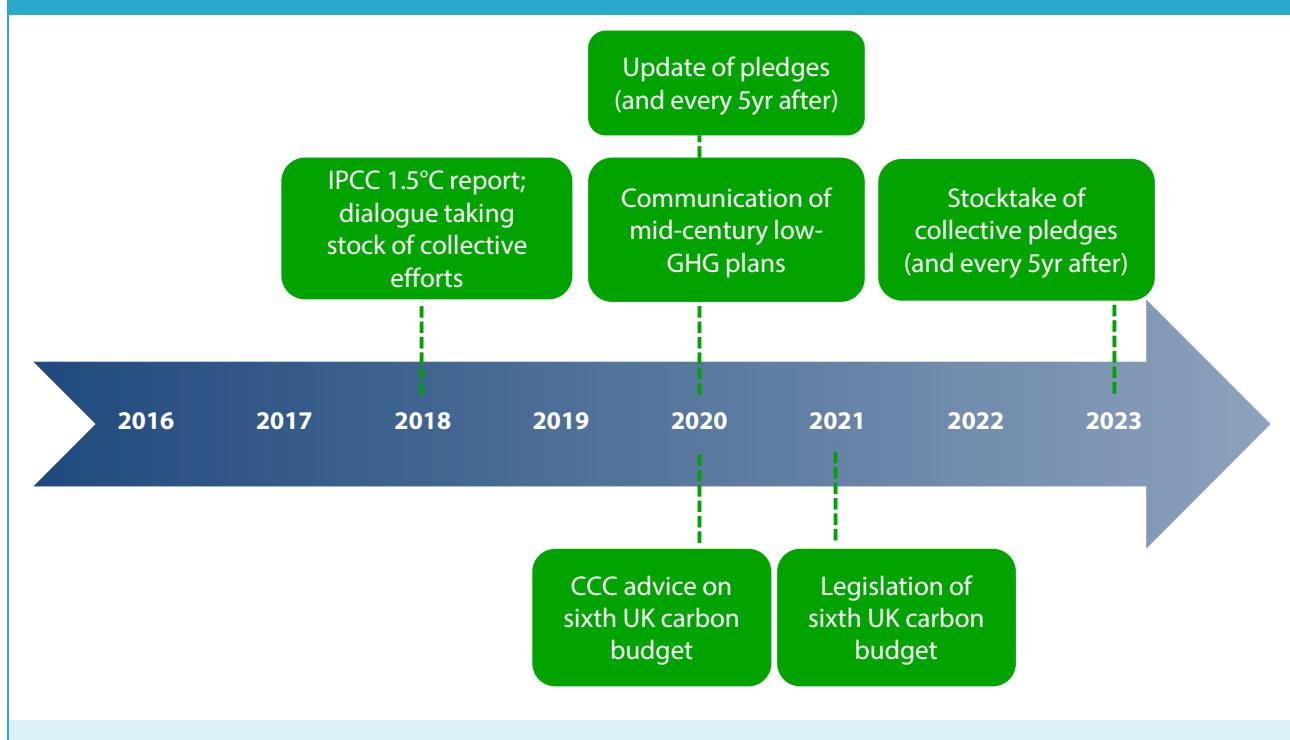
The expectation should be that the UK will set a new long-term target to reflect the need to reach net-zero emissions globally. There will be several opportunities to revisit the UK's long-term targets in future as low-carbon technologies and options for greenhouse gas removals are developed, and as more is learnt about ambition in other countries and potential global paths to well below 2°C and to 1.5°C (Figure 1.3):

- Later in 2018:** the Intergovernmental Panel on Climate Change (IPCC) will publish a Special Report on 1.5°C, and there will be an international dialogue to take stock of national actions.
- 2020:** the Committee will provide its advice on the UK's sixth carbon budget, including our view of progress to date, and nations will publish mid-century greenhouse gas development plans.
- 2023:** the first formal global stocktake of submitted pledges will take place.

Our previous advice was that the Government should wait to set more ambitious long-term targets until it had strong policies in place for meeting existing budgets, and until the evidence base is firmer on the appropriate level of such targets. The Government has now published its strategy to meet the legislated carbon budgets.

Once the IPCC has published its Special Report on the implications of the Paris Agreement's 1.5°C ambition in 2018, the Government should request further advice from the Committee on the implications of the Paris Agreement for the UK's long-term emissions targets.

Figure 1.3. Timeline of decision points for reassessing UK emissions targets



Source: CCC (2016) *UK Climate Action Following the Paris Agreement*.

c) Our approach to assessing the Clean Growth Strategy

In our June 2017 Progress Report to Parliament the Committee set out the three principles against which we would judge the Government's plans (Box 1.1):

- **Emissions.** The plans must enable the carbon budgets to be met and prepare for the 2050 target.
- **Policy.** Policy proposals must be flexible, robust and joined-up with other priorities.
- **Timetable.** There should be a clear process to turn proposals into action.

We also set out a possible package of measures to deliver the changes required (Table 1.2).

Box 1.1. Principles for the Government's plans for meeting the carbon budgets

In our June 2017 Progress Report to Parliament, we set out the principles the Clean Growth Strategy should follow for meeting carbon budgets. Proposals should be flexible and credible, integrated with other policy priorities, and should include clear timelines to move from proposals to actions:

- **The plans must enable the carbon budgets to be met and prepare for the 2050 target.**
 - The numbers must add up – taken together the Government's policies and proposals must be expected to deliver the emissions reductions required by the carbon budgets. The aim should be to meet the budgets without the use of international carbon units (i.e. credits) outside the EU Emissions Trading System.
 - The Climate Change Act also specifies that plans must prepare for meeting the 2050 target to cut emissions by at least 80% relative to 1990. As well as reducing emissions to 2032, proposals should lay the ground for further reductions in the 2030s and 2040s. That implies, for example, that it will be important to develop carbon capture and storage and to prepare for a widespread shift away from natural gas for heating.
- **Policy proposals should be flexible, robust, and joined-up with other priorities.**
 - Proposals should be flexible with respect to various uncertainties.
 - That includes uncertainties over how policies currently applied at the EU level will operate after the UK leaves the EU. The Committee's previous analysis suggests that EU-level policies currently cover around half of the UK's potential emissions reductions to 2030. New UK policies will be needed to reduce emissions where policies previously agreed through the EU no longer apply or are weakened.
 - Proposals should also leave open the possibility of reducing emissions more quickly than required by the budgets, given that the Paris Agreement has more ambitious aims to limit global temperature increase than the aims on which the UK's carbon budgets are based.
 - Policy should be flexible to uncertainties relating to changing technology and behaviour, including potential changes to travel behaviour and energy use as autonomous vehicles and smart technologies become more widespread.
 - Proposals should address areas with no current policy and where there are risks that existing policy will under-deliver. For example, efficiency standards for new vehicles must be extended beyond 2020 and to HGVs, but should also be strengthened to reflect real-world driving performance more closely.
 - Proposals should be joined-up with other policy priorities, including the Industrial Strategy, the review of energy costs, efforts to improve air quality and actions to prepare for the impacts of a changing climate.

Box 1.1. Principles for the Government's plans for meeting the carbon budgets

- **There should be a clear process to turn proposals into action.**
 - Where plans are only presented at the proposal stage there should be clear timelines for translating these into firm and funded policy and actions. For example, for residential heating an overhaul of the current policy approach is needed, and some aspects will require initial consultation, followed by implementation before current policies expire around 2020.
 - The Government should set out how it intends to monitor progress and adjust plans to remain on track. For example, the Government could link reviews to the annual Progress Reports provided by the Committee and/or to the annual emissions projections that BEIS already produces.

Source: CCC (2017) *Meeting Carbon Budgets: Closing the policy gap – 2017 Report to Parliament*.

Table 1.2. Possible package of measures to deliver the changes required

36% reduction in UK emissions required from 2016 to 2030				
Power (79 MtCO ₂ e in 2016) 62% reduction 2016-2030	Buildings (89 MtCO ₂ e) -20%	Industry (100 MtCO ₂ e) -20%	Transport (121 MtCO ₂ e) -44%	Agriculture, LULUCF, Waste, F-gases (77 MtCO ₂ e) -38%
<ul style="list-style-type: none"> • CfD contracts for further 80-100 TWh low-carbon generation (beyond delivery of Hinkley and planned auctions) • CCS strategy to allow deployment at scale by the 2030s • Additional storage, interconnection, flexible generation, and demand-side response to deliver smart flexible power 	<ul style="list-style-type: none"> • Insulation of all practicable lofts by 2022 and cavity walls by 2030, and 2 million solid walls by 2030 • Stronger new build standards for energy efficiency and low-carbon heat • 2.5 million heat pumps in homes by 2030 • Around 40 TWh of low-carbon heat networks by 2030 • Around 20 TWh of biomethane to the gas grid by 2030 	<ul style="list-style-type: none"> • CCS strategy to allow deployment at scale by the 2030s • Effective approach to drive uptake of low-carbon heat • Stronger framework for industrial energy efficiency 	<ul style="list-style-type: none"> • 60% of new car and van sales ultra-low emission (e.g. electric) by 2030 • 32% improvement in efficiency of conventional cars by 2030 • Sustainable biofuels to supply 11% of road fuel by energy in 2030 • 5% reduction in travel demand below baseline levels by 2030 	<ul style="list-style-type: none"> • Moving beyond a voluntary approach for on-farm emissions reductions • Afforestation rate to deliver 15,000 hectares per year • Near-zero biodegradable waste sent to landfill by 2025 • F-gases cut by at least 68%

Source: CCC (2017) *Meeting Carbon Budgets: Closing the policy gap – 2017 Report to Parliament*.

Notes: The fifth carbon budget requires a 26% reduction in the UK's net carbon account from 2016 to 2030. However, this allows for trading in the EU ETS, where the UK is expected to be a net seller of allowances. On the basis of actual emissions and the latest projections the Committee scenarios involve a 36% reduction (equivalent to a 63% reduction from 1990 to 2030). This would keep the UK on the lowest-cost path to the 2050 target and to meet the fifth carbon budget taking account of possible trading of allowances within the EU ETS.

In this report we assess the Clean Growth Strategy against the three principles we laid out in our Progress Report in June 2017:

- **Emissions.** The Government have not fully quantified the potential impact on emissions of the specific policies and proposals included in the Strategy. Where they have not quantified impacts, we have identified how the Government's proposals relate to the possible package of measures we set out in June 2017 and estimated the potential impact on emissions on that basis.
- **Policy.** Where firm new policies have been identified since our June 2017 report we assess whether they are effectively designed, have strong enough incentives and are adequately funded (Box 1.2). In many cases policy details have not yet been set. Where that is the case we consider the options for effective policy development and whether these can be implemented on the timetable required.
- **Timetable.** The Government has published a set of milestones and timetables for policy development. We assess whether these are quick enough to deliver on the necessary emissions reductions, whether they are realistically achievable and whether there are additional milestones that should be included. The Government has also set out a new approach to monitoring progress and updating the Clean Growth Strategy.

It is clear from this assessment that there is a lot of work still to be done to translate the Government's high-level proposals into more specific goals and effective policies to deliver them. There also remains a gap that will need to be filled. The Government has recognised there are such requirements in setting out its own approach. In this report where possible we therefore identify what is now required and make recommendations for the Government to consider in taking the next steps.

Box 1.2. Criteria to evaluate the likely effectiveness of Government proposals

The criteria that we use to assess policies are:

- **Design and implementation.** We assess whether the design and implementation of the policy tackles the right barriers; whether the policy has established a track record or there is evidence of similar policies working before; and whether there are risks to the policy due to various factors such as lack of coherence or lack of political support. We also assess whether the government's original Impact Assessment makes a prudent assessment of the level of abatement delivered by the policy.
- **Incentives.** We assess whether the right incentives – monetary or regulatory – are in place for the policy to deliver the necessary abatement.
- **Funding.** We assess whether, if required, there is adequate funding in place for the policy, both now and in the future.

If policies meet all three criteria we would expect them to deliver and classify them as 'lower risk', whereas if they fail any one of the criteria we classify them as having 'delivery risks'. Proposals which are not specified in sufficient detail to be classified as policies are labelled separately as 'proposals and intentions'.

Chapter 2: Overall assessment of the Clean Growth Strategy



The Clean Growth Strategy sets out a range of policies and proposals (including on innovation), as well as possible long-term pathways for UK emissions. In this chapter we set out our high-level overall assessment of the Strategy, including whether it is sufficient to meet the fourth and fifth carbon budgets and prepare for the 2050 80% target.

a) Enabling measures on green finance and innovation

In the Clean Growth Strategy, the Government announced measures to improve access to green finance, together with additional funding for innovation. These will help to deliver emissions reduction at reduced costs and help position the UK to take advantage of new market and employment opportunities. This supports wider plans in the Industrial Strategy which recognises that the UK is not investing enough in research and development (R&D). That strategy committed to increasing UK R&D spend (both public and private) from 1.7% of GDP in 2015 (less than most of our competitors) to 2.4% by 2027.

In relation to low-carbon innovation, the Clean Growth Strategy includes £2.6 billion Government spend on clean technology innovation from 2015 to 2021. A substantial proportion is devoted to basic and applied research (44%), with lesser amounts for technology development (35%) and demonstration (21%) (Table 2.1).

Innovation spending, together with announced measures on green finance, will tend to make low-carbon options more attractive and reduce their costs. But they are unlikely to deliver significant emissions reductions unless they are backed by policies that more explicitly target deployment and investment.

The Government says that it 'cannot predict the exact technological changes that will help us deliver on the fourth and fifth carbon budgets (and beyond)'. It does not include specific estimates for emissions reduction resulting from this investment in innovation. We agree that specific estimates for emissions reduction should not be attributed directly to innovation spending.

Whilst the commitment to increased support to innovation is welcome, there are – as the Government recognises – many uncertainties about what this spend will deliver. It cannot be assumed that R&D spend, by itself, will close any emissions gap to future targets given that:

- **The process of innovation is not linear.** There are feedbacks between the different stages. The innovation system as a whole may have under-delivered in the UK. An internationally leading research base has not necessarily delivered new products and services at the commercial level.
- **The development of new technologies, and their deployment at scale, takes time.** It can take several decades for new technological innovations to reach commercial maturity. We covered this in detail in our advice for the fifth carbon budget (Box 2.1).
- **R&D efforts need to be complemented by targeted deployment support.** Deployment also drives innovation and learning. This has been an important driver of recent reductions in cost of some energy technologies. The success of offshore wind, for which costs have fallen by half in the last two years, reflects a sustained period of deployment support as well as effective innovation policy.

Overall, therefore, it is sensible to plan to meet the fourth and fifth carbon budgets, and the 2050 target, through currently-known technologies. Flexibility should also be retained to adapt the strategy as new evidence emerges on the lowest-cost and most-effective ways of cutting emissions. Support for innovation can help to manage risks around meeting longer-term emissions targets by creating a wider range of ways to reduce emissions at reasonable cost.

Table 2.1. Government investments in clean growth technology (2015-2021)

	Basic & Applied Research	Technology Development	Technology Demonstration	Total
Innovation in Smart Systems (including energy storage)	175	43	47	265
Innovation in the Power Sector (including renewables)	209	276	154	638
Innovation in Homes (including heat and energy efficiency)	100	31	53	184
Innovation in the Transport Sector (including electric vehicles and batteries)	296	413	132	841
Innovation for Business and Industry, including carbon capture, use & storage (CCUS)	57	47	58	162
Innovation in Natural Resources	69	30	0	99
Cross-sector Clean Tech Innovation (including for entrepreneurs)	234	62	91	387
Total (£ million)	1,140	902	534	2,576

Source: UK Government (2017) *Clean Growth Strategy*.

Box 2.1. Timescales for innovation

Deployment of currently known technologies through the 2020s will be of critical importance to meeting legislated carbon budgets and the 2050 target, given factors including time frames for innovation and time remaining to those targets:

- As a contribution to our fifth carbon budget advice, the UK Energy Research Centre (UKERC) reviewed evidence on the time new technological innovations take to reach commercial maturity.
- Across the 14 innovations considered, the average time from invention to commercialisation was 39 years. For energy generation technologies the average time was significantly longer, at 48 years, due to a longer market deployment and commercialisation phase.

There are only 5 years left to the start of the fourth carbon budget period; 10 years to the fifth carbon budget and 32 years until 2050. These are short periods in the context of assets which may have lives of up to 30 years or more.

Source: UKERC (2015) *Innovation timelines from invention to maturity*.

b) Policies and proposals in the Clean Growth Strategy are not sufficient to meet the fourth and fifth carbon budgets

The Clean Growth Strategy represents the Government's package of policies and proposals to meet future carbon budgets and stay on track to the 2050 target. It contains a set of policies and proposals that, if delivered in full, would go some way towards closing the gaps to the fourth and fifth carbon budgets (see Chapter 3).

The Strategy also presents a '2032 Pathway', which provides a high-level scenario for reducing emissions across sectors. Timelines for sectoral emissions by year are included in graphical form, consistent with the 2032 Pathway but not based on an assessment of the required policies and proposals. We have not focused on the 2032 Pathway in our analysis. Instead we concentrate on the policies and proposals which have been set out and how they can close the gaps to the fourth and fifth carbon budgets:

- Even if the emissions levels within the 2032 Pathway were to be achieved, this would be insufficient to meet the fourth budget (legislated at 1,950 MtCO₂e) by around 50 Mt (Figure 2.1) on the basis of the projections used for the Strategy.
- There is no clear link in the Strategy between the 2032 Pathway and the policies and proposals that it sets out. It does not attempt to specify the emissions saving from each of these, and how together they can close the gaps to the fourth and fifth carbon budgets.

In assessing the Strategy, we therefore concentrate on the policies and proposals set out and make an assessment of the emissions reduction these might deliver. Our assessment in Chapter 3 is that the set of policies and proposals contained in the Clean Growth Strategy do not fully close the gap to either the fourth or the fifth carbon budget.

The Climate Change Act includes mechanisms to provide flexibility in meeting carbon budgets (e.g. carrying forward outperformance of one carbon budget to help meet the subsequent one). These should only be employed in the case of unexpected conditions that, despite strong policy action, would otherwise cause the carbon budgets to be missed. They should not be used to enable ambition to be weakened.

The Strategy indicates that the Government is prepared to use these 'flexibility' mechanisms to bank outperformance of the second and third carbon budgets to meet the fourth and/or fifth budgets. The use of these mechanisms is subject to the advice of the Committee. We have been very clear in the past that outperformance of the first three carbon budgets should not be carried over to meet the fourth and subsequent budgets (Box 2.2), as this does not result from Government policies. In 2014 the Government followed our advice that the 36 Mt outperformance of the first carbon budget should not be carried over.¹³

The fourth and fifth carbon budgets were set on the basis of the cost-effective path for action in the UK on the way to achieving an emissions reduction of at least 80% below 1990 levels by 2050. To ensure the best value for UK taxpayers, businesses and consumers the plan must continue to be to meet the budgets in full, without reliance on accounting 'flexibilities' in the Climate Change Act. Use of these mechanisms would risk failing to develop leading low-carbon industries in the UK and storing up larger costs for future generations. Their use would also

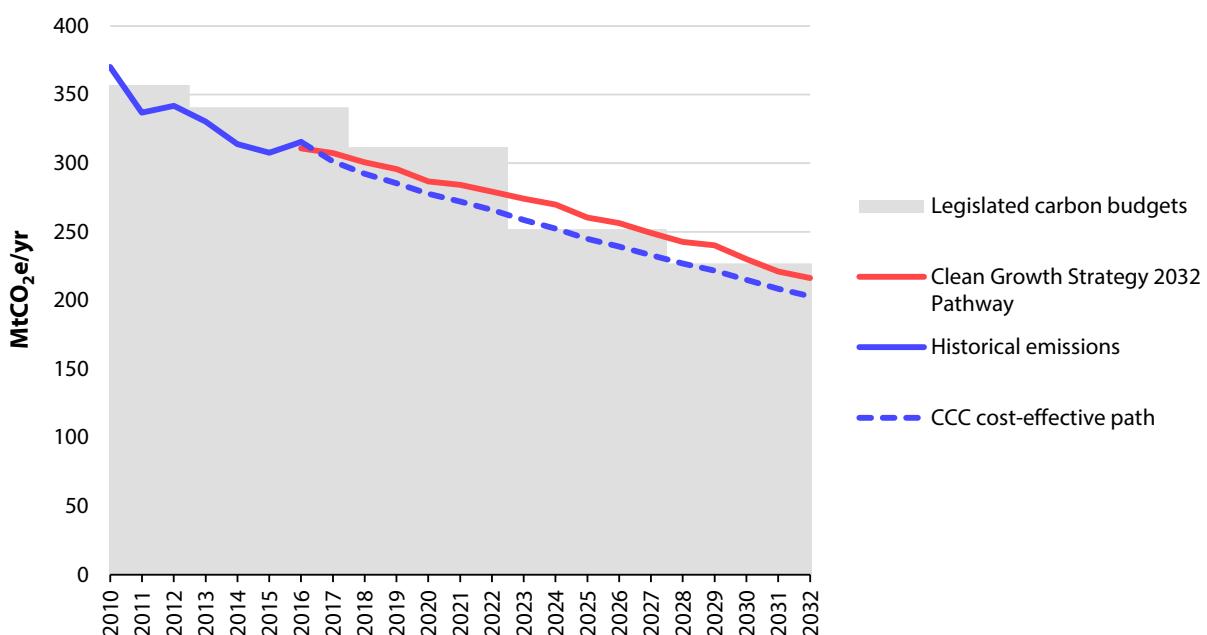
¹³ Letter from Edward Davey (2015) *Preserving the integrity of the UK's climate change regime*, available at: <https://www.theccc.org.uk/wp-content/uploads/2015/03/150310-SoS-to-Deben-re-carbon-budgets.pdf>

undermine the UK's position of leadership and be counter to the commitments made under the Paris Agreement.

We welcome the intention of the Government, clarified in Parliament,¹⁴ to meet all of the legislated carbon budgets without use of credits or carrying forward of outperformance of earlier budgets. It is imperative that the Government continues on the basis that it will not rely on these 'flexibility' mechanisms and that the budgets will be met through UK action, which was the basis on which they were set. Any use of these mechanisms to reduce UK ambition would be inconsistent with the Paris Agreement.

It is therefore urgent that the Government puts in place policies to close the gap to the fourth carbon budget, which has been in legislation since 2011, and the fifth carbon budget. We set out in Chapter 4 how this can be done.

Figure 2.1. Emissions pathways for the non-traded sector (2010-2032)



Source: BEIS (2017) 2016 UK Greenhouse Gas Emissions, provisional figures, HMG & HMT (2009) *Building a low-carbon economy: implementing the Climate Change Act 2008*, CCC analysis; HM Government (2017) *The Clean Growth Strategy*.

Notes: The chart presents emissions in the 'non-traded' sector only (i.e. sources of emissions not covered by the EU Emissions Trading System – EU ETS), as it is these emissions that determine whether or not a carbon budget is met. The Clean Growth Strategy's 2032 Pathway was only published for total emissions. To estimate the non-traded share of this we assume power generation is 100% in the traded sector, and 60% of Business & Industry is traded.

¹⁴ <http://hansard.parliament.uk/Commons/2017-10-12/debates/E9354BA9-5321-4630-9F93-1342E5246996/CleanGrowthStrategy>

Box 2.2. Outperformance of the first three carbon budgets should not be carried over to meet the fourth and subsequent budgets

The Committee has, since 2009, consistently taken the position that outperformance of the first three carbon budgets should not be carried over to help meet later budgets. The levels of the fourth and fifth carbon budgets were both set on this basis, while the ambition in the Paris Agreement provides a further reason not to use these mechanisms to weaken action to meet later carbon budgets:

- The first three carbon budgets were set at 'Interim' levels recommended by the Committee, with the intention that the third budget should be moved to a more ambitious 'Intended' budget level in the event of a global deal on climate change. The budgets remain at the levels originally legislated.
- These three carbon budgets have turned out to be easier to meet than expected for a range of reasons. This includes economic weakness during and following the financial crisis, and the UK having a different share of allowances in the EU Emissions Trading System (EU ETS) than anticipated when the budgets were legislated. The Committee stated in 2009 that the first three carbon budgets were likely to be outperformed for reasons other than effective policy, and that outperformance should therefore not be carried over.
- The levels of the fourth and fifth carbon budgets, recommended in 2010 and 2015 respectively, were based on the Committee's assessment of cost-effective UK action on the path to meeting the 2050 target, assuming that outperformance of earlier budgets would not be carried forward.
- In 2014, as required under the Climate Change Act, the Committee provided advice on whether the 36 MtCO₂e outperformance of the first carbon budget should be carried over. Our advice was that it should not be carried over, as doing so 'would increase costs and risks associated with meeting longer-term emissions targets'.¹⁵ The Government followed the Committee's advice not to carry forward this outperformance for use in the second carbon budget.¹⁶
- In our October 2016 report on *UK Climate Action Following the Paris Agreement*,¹⁷ the Committee was clear that the Paris Agreement is likely to require more ambitious long-term emissions targets than currently legislated. Should any carbon budget be outperformed, these lower emissions should provide the basis to prepare for tighter targets to be met in future; outperformance of carbon budgets should not be used to reduce ambition under existing targets.

The Committee will continue to assess progress towards meeting the fourth and fifth carbon budgets on the basis that they must be met in full through UK action to reduce emissions.

c) The remaining policy gap to carbon budgets must be closed, contingency identified and policy development proceed so that all proposals deliver in full

The Clean Growth Strategy states clearly that the publication of the document is not the end of the process. The approach will have to develop and adapt to changing circumstances over time.

To ensure that the carbon budgets are met the government will need to:

¹⁵ Letter to Gregory Barker MP (2014) *Decision on whether to carry forward emissions from first to second carbon budget*, available at: <https://www.theccc.org.uk/wp-content/uploads/2014/04/20140414-CCC-advice.pdf>

¹⁶ Letter from Edward Davey (2015) *Preserving the integrity of the UK's climate change regime*, available at: <https://www.theccc.org.uk/wp-content/uploads/2015/03/150310-SoS-to-Deben-re-carbon-budgets.pdf>

¹⁷ CCC (2016) *UK Climate Action Following the Paris Agreement*.

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- Continue to deliver existing low-risk policies
 - Ensure policies with delivery risks are managed and strengthened so that the intended emission savings occur
 - Convert policy proposals from the Clean Growth Strategy into firm and funded policies
 - Put in place new policies to address the remaining policy gap.

To facilitate this process, the Government has reinstated a cross-government Inter-Ministerial group to drive implementation of the Clean Growth Strategy and has committed to annual monitoring and updating of the Strategy.

The Government has set out key actions and milestones for developing the proposals in the Clean Growth Strategy. These must be followed effectively, and delivery risks for existing and new policies addressed, so that by 2020 there is a plan that provides confidence that the fourth carbon budget will be met through UK domestic action, and that by 2025 the same or greater level of confidence is achieved regarding the fifth carbon budget.

The end of the fifth carbon budget period is 15 years away. Key uncertainties over this timeframe which could affect how the carbon budgets are met include:

- The level of economic activity, which in many sectors remains a strong driver of emissions.
- Developments in technology performance, cost and consumer acceptance, including but not limited to that driven by spending on innovation by UK government.
- The success or otherwise of government policies, both pre-existing and those set out in the Clean Growth Strategy.
- Changes in the required UK contribution to reducing greenhouse gas emissions as a result of developments in the scientific evidence and/or international circumstances.

In terms of potential impact on emissions, these uncertainties point in both directions. However, the latter two are more likely to point towards extra policy effort to reduce emissions being required rather than less.

The Strategy highlights some of these uncertainties, particularly those related to technologies and potential future cost reductions, which it uses to justify a lack of detail over how the fifth carbon budget will be met.

It is important that the Government's strategy develops into one in which there is a full plan to meet the budgets, but which can be adapted as new evidence emerges on the lowest-cost and most-effective ways of cutting emissions:

- Over time, the policies and proposals set out in the Strategy must be firmed up and the gap closed (see Chapter 4).
- As part of good budget management and in response to what is likely to be required under the Paris Agreement, the Government will also need to identify specific areas for further action.
- The plan should be ambitious enough to cope if progress proves more challenging than anticipated and/or the scientific evidence and international circumstances require it. It should provide contingency options to go further in some areas if progress turns out to be limited in others.

We consider how the Government can close the remaining gap and put in place further ambition that can provide a contingency in Chapter 4. It is also important that actions are taken to keep open the possibility to go beyond an 80% reduction by 2050.

d) Preparing for the 2050 target

Under the Climate Change Act, the Government's policies and proposals must be prepared to enable the 2050 target to be met. The legislated level of the 2050 target is for a reduction of at least 80% below 1990 levels. However, in our October 2016 report on *UK Climate Action Following the Paris Agreement*, we stated that ambition under the Paris Agreement means that it is likely that a greater reduction will be necessary by 2050, although the precise level is not yet clear. A full and successful deployment of all measures from our published 2050 scenarios would reduce emissions by around 90% in 2050 compared to 1990 levels.

The Clean Growth Strategy presents three scenarios to achieve an 80% reduction in emissions by 2050 on 1990 levels. It also commits to the development of a strategic approach for greenhouse gas removal (GGR) technologies and to decisions on the future of the gas grid (i.e. the respective roles of hydrogen and heat pumps in decarbonising heat for buildings).

The Strategy states that there are a number of ways an 80% reduction by 2050 could be achieved, but that it is too early to say which technologies will make a major contribution. It explores three pathways. Each pathway has, by design, a heavy reliance on a particular set of technologies, although there is also a set of 'low-regrets' actions which emerge as being common to all three:

- **Electrification, without carbon capture and storage (CCS).** In this scenario there is extensive electrification by 2050: all cars and vans are fully electrified and 80% of space heating. In order to meet the extra demand, UK electricity generation would need to be double that of today's total supply by 2050 combined with a very low carbon-intensity.
- **Hydrogen, with repurposing of the gas grid.** In this scenario, low-carbon hydrogen is the dominant energy carrier across the economy by 2050. It powers all cars and vans and meets over half of all heating needs and a third of industrial energy demand. To be fully operational, this scenario would require extensive development of infrastructure, both in repurposing the UK gas grid to accept hydrogen and for transportation and storage of CO₂ captured in hydrogen production from fossil fuels.
- **Emissions removals.** In this scenario, removal of CO₂ from the atmosphere is achieved by using bioenergy together with CCS, resulting in overall negative emissions from electricity generation, of around 20 MtCO₂e per year by 2050. Due to the 'headroom' created by the removal of emissions, transport and home heating continue to use a substantial amount of high-carbon fuels.
- **Low-regrets actions common to all three scenarios.** These include improving the energy efficiency of buildings and industry; increasing the uptake of ultra-low emission vehicles (ULEVs) and low-carbon heating, especially district heating; continuing the decarbonisation of the electricity system, whilst ensuring it remains responsive to future demand patterns; working with industry on a switch to low-carbon fuels.

In practice, each of the pathways is likely to be highly challenging to achieve due to the strong reliance on a particular set of technologies rather than a more balanced approach. It would be sensible to keep open a range of options in order to provide contingencies in case some parts of the pathway fall short. Moreover, the likely need to go beyond a reduction of 80% by 2050, as

well as to reach net-zero emissions at some point, means that a combination of actions from all three pathways will most likely be needed.

The plan now should be to reach very low emissions from transport, buildings and power generation by 2050 (e.g. as in the Strategy's no CCS scenario), combined with industrial CCS and, if feasible, greenhouse gas removal (including BECCS) so that a reduction of significantly more than 80% can be achieved (Box 2.3).

The Government should not plan to meet the 2050 target without CCS. A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve. Furthermore, deeper reductions will be required to meet the aims of the Paris Agreement, whether by 2050 or subsequently.

The Government should actively work to keep all three of the identified sets of solutions open for potential large-scale deployment by 2050 until the appropriate pathway for decarbonisation is clearer. The pathways in the Strategy are focused on an 80% reduction by 2050. The Government should assess what would be required under pathways to deeper emissions reductions by 2050 (e.g. 85% and 90% reductions), as well as those for 80% reductions where there are greater limits on decarbonisation of particular sectors that require additional effort elsewhere to compensate.

The Strategy states that the 2032 Pathway it presents is consistent with achieving any of the three 2050 scenarios. It is not clear that this is the case, given that the 2032 Pathway lacks technological detail while the 2050 scenarios rely on specific technological solutions supported by the appropriate infrastructure (i.e. for hydrogen, CO₂ transportation and storage and/or high levels of electricity). Keeping open these scenarios means creating options at the level of technologies and infrastructures. There are specific actions needed now to keep open the possibility of large-scale deployment of key technologies (Box 2.4).

The key actions that the Government will need to take in the medium-term are:

- **Market development for ULEVs to keep open 2035 as a phase-out date for conventional cars and vans.** Given that it takes around 15 years for the stock of cars and vans to turn over, it may be necessary for the sales of petrol and diesel vehicles to end by 2035. A high uptake of ultra-low emission (i.e. plug-in and hydrogen) vehicles by 2030 (i.e. at least 60% of new sales) is required in order to keep open the possibility of 100% of new sales by 2035 and be on track to achieve this by 2040, as the Government has currently committed.
- **Heat pumps.** In order to keep open a high electrification scenario for buildings, action is required now to prepare for the high rates of heat pump deployment this would entail in the 2030s and 2040s. Deployment of 2.5m heat pumps is likely to be the minimum necessary by 2030 (Box 2.4). There is a lack of detail in the Strategy over the role of heat pumps in the period to 2032, which risks closing off the option for them to play a large role by 2050.
- **Decisions on the future of the gas grid.** The Government recognises the need to make strategic decisions in the early 2020s on the balance between repurposing gas distribution networks to carry substantial volumes of hydrogen as against high rates of electrification. The active work that the Government is undertaking to improve the evidence base is important and welcome. Current estimates for the costs of low-carbon hydrogen production indicate that production from fossil fuels with CCS is likely to be the lowest-cost route, although this will need to be supplemented by sources of hydrogen with even lower emissions footprints over time. In order for a decision to pursue hydrogen for heating to be

credible, especially given the UK's lack of progress on CCS to date, progress on demonstrating the business model for CCS will also be needed by 2025.

- **Industrial CCS at scale from 2030.** Industry is one area in which it is very likely that extensive deployment of CCS will be required by 2050. Indeed, the Clean Growth Strategy identifies that around half of the current emission reduction opportunities in industry are from CCS. In order to gain full benefit from industrial CCS, the plan should be to deploy it at scale in clusters from 2030, with initial smaller projects and infrastructure development occurring before this.

Progress also needs to continue on the low-regrets options set out in the Strategy. This should help to ensure that targets are met in the most cost-effective way, alongside creating a sufficient set of options to keep open different ways of achieving an 80% reduction by 2050 and the possibility to go further. In addition to those highlighted in the Strategy, the Committee's assessment is that low-regrets actions in the medium term should include pursuing industrial CCS, and that the plan should be that greenhouse gas removals including BECCS will follow from the 2030s, if feasible.

Box 2.3. A strategy for greenhouse gas removals

Even with full deployment of known low-carbon measures some UK emissions will remain, especially from aviation, agriculture and parts of industry. Greenhouse gas removal options (e.g. afforestation, carbon-storing materials, bioenergy with carbon capture and storage, and direct air capture and storage) will be required alongside widespread decarbonisation in order to reach net-zero emissions. Success requires a globally co-ordinated effort across the full innovation chain from basic research to market readiness, reflecting the differing levels of development of removal options.

In the Clean Growth Strategy the Government committed to developing a strategic approach to greenhouse gas removals technologies. Such a strategy should include:

- **Support for research, development and demonstration** to help clarify whether options deliver genuine long-term greenhouse gas removal and to address technical, environmental and social challenges. Examples include improving measurement of land carbon, assessing impacts over the lifecycle of bioenergy crops and biochar, and testing of direct air capture processes.
- **Support for deployment** by removing barriers and providing incentives for options that are technically more mature. Targeted deployment can help in bringing down costs and understanding more about impacts. Examples for deployment include carbon capture and storage infrastructure, sustainable bioenergy crops, afforestation and wood in construction.
- **Integration into policy and accounting frameworks** so that removals count equally with reduction of emissions. The lack of long-term policy commitment is a key barrier to development. Schemes such as the EU Emissions Trading System (ETS) and the Common Agricultural Policy (CAP) could be structured to reward removals but currently are not.

We will continue to monitor development of a greenhouse gas removal strategy as part of our annual Progress Reports to Parliament.

Box 2.4. Key technologies and infrastructures for long-term emissions reduction

There are several options which could play a major role in achieving long-term emissions targets. However, the size of their contribution is currently uncertain. The Government should continue to ensure that deployment at the scales outlined below remains feasible for all options, until such a time that a clearer picture emerges.

- **Deployment of low-carbon heating.** The Government should take action to keep open the possibility to reach very low emissions from heating of buildings. In our 2016 report on *Next Steps for UK Heat Policy*, we identified a set of low-regrets actions that should be pursued now: strong standards for new-build properties, substantial improvements to the efficiency of existing buildings, as well as deployment of low-carbon heat networks, heat pumps in properties off the gas grid and biomethane injection into the gas grid. This set of low-regrets actions is more wide-ranging than those identified in the Clean Growth Strategy. These actions should be complemented by strategic decisions on the roles of electrification and hydrogen in the first half of the 2020s.
 - **Heat pumps.** The Strategy's high electrification scenario highlights the possibility that a large proportion of heat demand for buildings could be met through low-carbon electricity, predominantly via heat pumps. In order to keep this option open, action is required now to prepare for the high rates of deployment this would entail in the 2030s and 2040s. Deployment of 2.5 million heat pumps by 2030 is likely to be the minimum necessary to develop markets and supply chains sufficiently for accelerated roll-out after this point.¹⁸ In our scenarios, these 2.5 million are split evenly between properties off the gas grid and new-build properties.
 - **Hydrogen.** There could be an important role for repurposing gas distribution networks to supply hydrogen, although the evidence base to support this is still in development. Conversion of the network must start by 2030 if it is to be substantially completed by 2050. This would require the Government to make strategic decisions in the early 2020s on whether the network could be repurposed to carry substantial volumes of hydrogen.
- **Decarbonisation of surface transport.** By 2050, a near-total decarbonisation of surface transport may be necessary. The trajectory of uptake of ultra-low emission vehicles (ULEVs) throughout the next three decades must be such that a total switch of light vehicles to either battery electric or hydrogen fuel cell power could be achieved. Credible options must also be developed for the decarbonisation of heavy goods vehicles.
 - **Market development of ultra-low emission cars and vans.** Given that it takes around 15 years to turn over the stock of cars and vans, the Government should keep open the possibility that all car and van sales are battery electric or hydrogen by 2035. This is five years earlier than the 2040 date to which the Government has so far committed. To keep open a date of 2035 would require that by 2030 the share of car and van sales that are ULEVs is towards the upper end of the range of 30-70% in the Clean Growth Strategy (e.g. the 60% of sales in the Committee's scenario).
 - **Heavy goods vehicles.** With current battery technology, options for electrification of long-distance HGVs are limited. Further research and development is needed on options, such as hydrogen fuel cell HGVs or electrification of roads. The entire HGV fleet may need to switch away from fossil fuels if emissions reductions beyond 80% are required. We welcome the announcement in the Strategy that the Government will set out further measures, by March 2018, to support the decarbonisation of freight.

¹⁸ See CCC (2015) *Sectoral scenarios for the fifth carbon budget*; Frontier Economics and Element Energy (2013) *Pathways to high penetration of heat pumps*.

Box 2.4. Key technologies and infrastructures for long-term emissions reduction

- **Aviation.** The government should plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set (i.e. around 2005 levels by 2050), supported by strong international policies. Emissions at this level could be achieved through a combination of fuel and operational efficiency improvement, use of sustainable biofuels, and by limiting demand growth to around 60% above 2005 levels by 2050.
- **Carbon capture and storage (CCS)** is part of the cost-effective pathway for an emissions reduction of 80% by 2050, and its absence could double the cost of achieving that reduction.¹⁹ CCS becomes even more important for deeper reductions by 2050 and is essential to reach net-zero emissions, committed to under the Paris Agreement. It is positive that the Strategy reaffirmed Government commitment in this area. The Strategy reframes it as carbon capture use and storage (CCUS). Whilst CCU could help to facilitate progress in the 2020s, the volumes of CO₂ that can be utilised as a feedstock rather than permanently sequestered appear likely to be small relative to the necessary role for CCS in the long-term. However, CCU could be of benefit in particular niche areas (e.g. where CO₂ capture costs are relatively low but geological sequestration of the CO₂ is impractical). Application of CCS to industry and bioenergy provides additional emissions reduction potential that cannot be substituted through other measures, while application of CCS to fossil power generation and hydrogen production are important options for developing low-carbon energy carriers that can be used throughout the economy:
 - **Industrial CCS** can be done cost-effectively in areas in which there are sufficient volumes of CO₂, enabling development of CCS clusters that exploit economies of scale in infrastructure. This could be 'end-of-pipe' CCS, capturing CO₂ from the flues of industrial sites, but there could also be an important role for low-carbon hydrogen in achieving some of these reductions – low-carbon hydrogen production is also likely to require CCS.
 - **Bioenergy with CCS (and other greenhouse gas removal (GGR) options).** In our 2016 report *UK Climate Action Following the Paris Agreement* we identified three sets of technologies that are at a sufficient level of technical readiness to include in our scenarios. These are the planting of trees and wood crops; the use of wood in place of other construction materials; and the use of bioenergy for the generation of power or heat, with CCS to capture the resulting emissions (BECCS). Our analysis suggested that BECCS could remove up to 47 MtCO₂ annually by 2050. However, this requires action on CCS as laid out above, together with development of sustainable bioenergy supplies. A range of other GGR options exist although their effectiveness, cost and wider impacts are as yet unclear. We welcome the Government's plans for a programme of research and development in this area, including options for removing barriers and incentivising use. However, development of GGR options is not a substitute for action to reduce emissions.
- **Low-carbon electricity generation.** The scenario based on high electrification without CCS would require low-carbon generation to be more than quadrupled between now and 2050. To ensure this remains feasible, there must be sustained growth in the installation of low-carbon generation capacity and a sufficiently flexible electricity system such that it could manage a high level of generation from intermittent renewables.
- **The wider role of low-carbon hydrogen.** Progress should be broadened beyond provision of heating for buildings to cover areas such as industrial processes and heavy-duty transport, where the use of hydrogen may be particularly important due to a lack of other options currently. The Government should also consider whether the methods of hydrogen production under consideration would still be feasible if more ambitious long-term emissions targets were to come into force.

¹⁹ CCC (2012) *The 2050 target – achieving an 80% reduction including emissions from international aviation and shipping*; ETI (2015) *Building the UK carbon capture and storage sector by 2030 – Scenarios and actions*.

Chapter 3: Policies and proposals in the Clean Growth Strategy



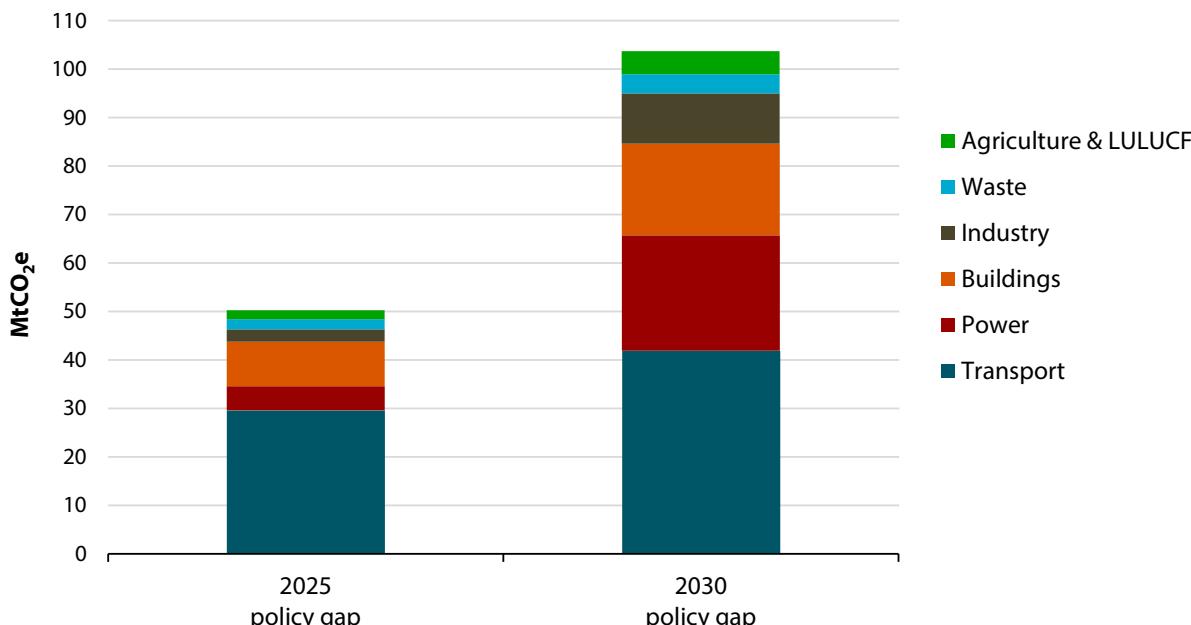
The Clean Growth Strategy sets out around 100 policies, proposals and intentions to reduce emissions. Around 20 of these are related directly to actions to reduce emissions. In this chapter we assess whether the policies and proposals in the Clean Growth Strategy are sufficient to close these gaps and, if not, what further actions need to be taken.

While the legal requirement under the Climate Change Act is to meet the legislated carbon budgets, our assessment of the Clean Growth Strategy policies and proposals is made against the Committee's cost-effective path, which would outperform the legislated budgets. Planning to outperform the budgets would provide contingency options in case of policies falling short in some areas and is consistent with the ambitions of the Paris Agreement.

Across the economy, the gap to the cost-effective path that we estimated in our June 2017 Progress Report was around 50 MtCO₂e per annum in 2025 (the middle of the fourth carbon budget period) and 100 Mt per annum in 2030 (middle of the fifth carbon budget) (Figure 3.1).

In our Progress Report to Parliament in June 2017, we made a set of recommendations for the Clean Growth Strategy. The Strategy makes some progress in most of these areas, but generally fails to meet them fully (Table 3.1).

Figure 3.1. The size of the policy gap by sector in 2025 and 2030, prior to the Clean Growth Strategy



Source: CCC analysis.

Notes: Represents the gap to the cost-effective path, rather than to carbon budgets.

Table 3.1. Progress against the Committee's recommendations in the 2017 Progress Report

Recommendation	Assessment
Power (17% of 2016 emissions): Emissions intensity to fall by around 65% (to below 100 gCO₂/kWh) between 2016 and 2030, with options developed to allow near-zero emissions by 2050.	
Extension of existing approaches to contract an additional 80-100 TWh low-carbon generation in the 2020s	Partially met
A new strategic approach to carbon capture and storage deployment in the UK should include power plants as anchor loads for strategic clusters	Not met
Implementation of plans for increasing flexibility (e.g. storage, interconnection, demand response, flexible generation)	Partially met
Continued application of a carbon price after leaving the EU	Met
Contingency plans for delay or cancellation of planned projects, for example of new nuclear power plants	No progress
Buildings (19% of 2016 emissions): Emissions to fall by around 20% between 2016 and 2030, with options developed to allow near-zero emissions by 2050	
New-build: Standards to ensure new-build properties are highly energy efficient and can use low-carbon heating systems from the start	Partially met
Existing buildings: A stable framework and direction of travel for improving the energy and carbon efficiency of existing buildings joining up energy efficiency and low-carbon heat, with: an attractive, well-timed offer to households and SMEs; simple, highly visible information and certification, including enhanced business reporting, alongside installer training; backed by standards for emissions performance of buildings that tighten over time	Partially met
Reformed support for low-carbon heat through the 2020s, that deals with current barriers, provides a process for decisions on heat infrastructure, and is attractive enough to drive deployment of heat pumps, heat networks and biomethane in line with CCC scenarios	Partially met
Active preparations for strategic decisions in the early 2020s on the role for hydrogen for heat and the future of the gas grid, including pilots, demonstrations, and research on the challenges of a wider-scale hydrogen switchover	Partially met
Industry (22% of 2016 emissions): Emissions to fall by around 20% between 2016 and 2030	
An overall approach to long-term industrial decarbonisation, developing existing 'Roadmaps' into specific actions and milestones and extending coverage to other industries	Partially met
A strategic, funded approach to industrial carbon capture and storage, based around clusters alongside power installations and shared infrastructure, with a new funding mechanism for industry	Partially met
An effective approach to drive sustained uptake of low-carbon heat in industrial processes and buildings	Partially met
The EU ETS and EU efficiency standards and policy to be preserved or replicated and strengthened in future	Partially met
A stronger policy framework for industrial energy efficiency, including an effective reporting mechanism	Partially met

Table 3.1. Progress against the Committee's recommendations in the 2017 Progress Report

Recommendation	Assessment
<u>Transport</u> (26% of 2016 emissions): Emissions to fall by around 44% between 2015 and 2030 with options developed to allow near-zero emissions by 2050	
Stretching standards for new car and van CO₂ beyond 2020 , that require increased electric vehicle sales, are independently enforced and use real-world testing procedures	Partially met
Policies to deliver a high uptake of electric vehicles, of around 60% of new car and van sales by 2030 , including: time-limited financial support, preferential tax rates and effective roll-out of charging infrastructure	Partially met
Implementation of policy to deliver 8% of sustainable biofuels by energy by 2020 and maintain the biofuels volume after 2020	Met
Policies to support emissions reduction from HGVs , including new vehicle efficiency standards requiring electric options for smaller trucks, more efficient logistics, increased uptake of eco-driving measures, and a shift to lower-carbon modes (e.g. rail)	No progress
National and local policies to reduce demand , to deliver car-km reductions of at least 5% below the baseline trajectory	No progress
A plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set : around 2005 levels by 2050, implying around a 60% potential increase in demand, supported by strong international policies	No progress
<u>Agriculture, land-use and forestry</u> (8% of 2015 emissions): Emissions to fall by around 19% between 2015 and 2030, and afforestation rates to deliver 15,000 hectares per year	
The new 'Smart' inventory for agriculture emissions to be introduced in 2018 , to enable better monitoring and tracking of progress	Partially met
A stronger policy framework for reducing emissions from agriculture and land use in all UK nations to 2022	Not met
New farming policies to 2030 that move beyond the current voluntary approach and replace CAP with a framework that links support to emissions reduction and removals	Partially met
Addressing financial and non-financial barriers to increase afforestation and on-farm tree planting	Partially met
<u>Waste</u> (4% of 2015 emissions): Emissions to fall by around 53% between 2015 and 2030	
Strengthened approaches through the waste chain, from creation to disposal , including reducing waste arising, separate collections (e.g. of food waste), stopping biodegradable waste going to landfill, and maintaining or increasing methane capture at landfill sites	Partially met
<u>F-gases</u> (3% of 2015 emissions): Emissions to fall by at least 68% between 2015 and 2030	
A UK approach to reduce F-gas emissions by at least 68% , in line with the EU regulatory minimum; Government to investigate and pursue any further cost-effective opportunities	Partially met
<u>Cross-cutting priorities</u>	
A new strategic approach to carbon capture and storage deployment in the UK , including preparations for possible use in the production of low-carbon hydrogen	Partially met
An updated strategy for increasing the supply of sustainable bioenergy feedstock and using it effectively	No progress
A strategy for developing options for removing greenhouse gases from the air	Partially met

a) Firm new policies and expectations for emissions reductions

The Committee last set out our expectations for emissions reductions resulting from current policy in June 2017, in our annual Progress Report to Parliament. The Government has since introduced or announced a number of firm new policies in the build-up to, and as part of, the Clean Growth Strategy. These include the commitment to hold further auctions for low-carbon electricity generation, extension of the Energy Company Obligation to 2028 with funding at least at current levels, and to increase the level of biofuels supported under the Renewable Transport Fuel Obligation.

Some of these policies carry risks, while others are likely to deliver as planned (Table 3.2). Further policy development is required in order for all of them to be considered low-risk. For example, Contracts for Difference (CfDs) for low-carbon electricity generation must be held as planned, and contracts signed.

There have also been developments affecting our expectations for existing commitments that were reaffirmed in the Clean Growth Strategy. The most important of these was the very low cost of offshore wind power revealed by the latest competitive auction for low-carbon CfDs. Given those low costs, we now expect the funding that the Government has committed for future auctions to support significantly more low-carbon electricity (Box 3.1).

Taken together, our assessment is that the firm new policies in the Clean Growth Strategy could save around an additional 4 MtCO₂e in 2025 and 17 MtCO₂e in 2030. This is not sufficient to close the gap to meeting the carbon budgets. The Government has also been clear about that. Even if all existing and new policies deliver as planned, there would still be a policy gap of 45 MtCO₂e in 2025 and 85 Mt in 2030 (Figures 3.2 and 3.3).

Table 3.2. New policies in the Clean Growth Strategy or separate announcements

Policy	Ambition	Emission savings in 2030	Assessment
Power auctions	£557m funding, which could support over 45 TWh low-carbon generation	15 MtCO ₂ e	 Amber
Energy Company Obligation (ECO) extension	Funding extended to 2028 with a focus on fuel-poor homes	<1 MtCO ₂ e	 Amber
Industrial heat recovery programme	£18m to encourage recovery and re-use of heat from industrial processes	<1 MtCO ₂ e	 Amber
New business reporting framework	To align with mandatory reporting under the Energy Savings Opportunity Scheme	<1 MtCO ₂ e	 Amber
Renewable Transport Fuels Obligation	Renewable transport fuel levels increased to 9.75% for 2020 and 12.4% in 2032	<1 MtCO ₂ e	 Green

Source: CCC analysis.

Box 3.1. Funding for future low-carbon electricity auctions

In the 2016 Budget the Government announced funding of up to £730m per year for further auctions for low-carbon electricity generation. Funding for these 'Contracts for Difference' (CfDs) is available for less established ('Pot 2') technologies including offshore wind.²⁰

In September 2017 the results of the first round of auctions funded from this money were announced. Three offshore wind projects won contracts at an average strike price of £62/MWh (one project at £74.75/MWh, two projects at £57.50/MWh):

- This is significantly lower than previous prices for offshore wind and is lower than projected costs for gas-fired power plant in 2020 on the basis of the BEIS central gas price scenario.
- This secured 3.2 GW of wind capacity and 0.2 GW of other technologies (approximately 14 TWh of generation) and accounts for £173m of the originally allocated funding.

In the Clean Growth Strategy the Government has committed to spending the remaining £557m of allocated funding on further CfDs. The next auction is planned for Spring 2019.

In our 2017 Progress Report we estimated that the £730m funding would secure around 25 TWh of low-carbon generation. However, as the strike prices in the latest auction were much lower than expected, we now estimate that the £730 million will be able to contract for around 55 TWh of low-carbon generation, if these prices are sustained (Figure B3.1). There is potential for the contracted generation to be higher if even lower strike prices are achieved.

²⁰ Pot 2 auctions are for less-established technologies and include: offshore wind, tidal stream, wave, 'Advanced Conversion Technologies', and Biomass Combined Heat and Power (CHP).

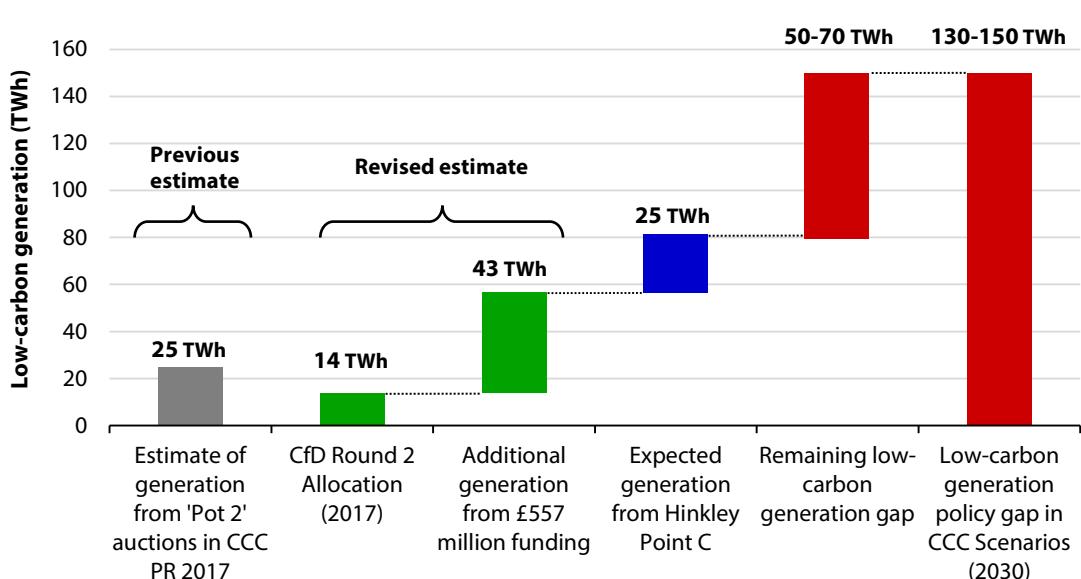
Box 3.1. Funding for future low-carbon electricity auctions

The number and the capacity of offshore wind projects in the pipeline are both important factors for a robust supply chain:

- Generally, more projects provide opportunities for more supply chain companies.
- Between 2010 and 2020 there is expected to be around 9 GW of offshore wind capacity built in the UK, spread across 27 projects.
- The September 2017 CfD auction will sustain the same GW per annum build rate into the early 2020s, though the number of projects being built will drop to three (albeit across only a four year period).

Continued CfD auctions, supporting multiple offshore wind projects, should maintain a healthy and competitive offshore wind supply chain through a consistent and diverse project pipeline provided market players can be confident in the regularity and volume of future auctions.

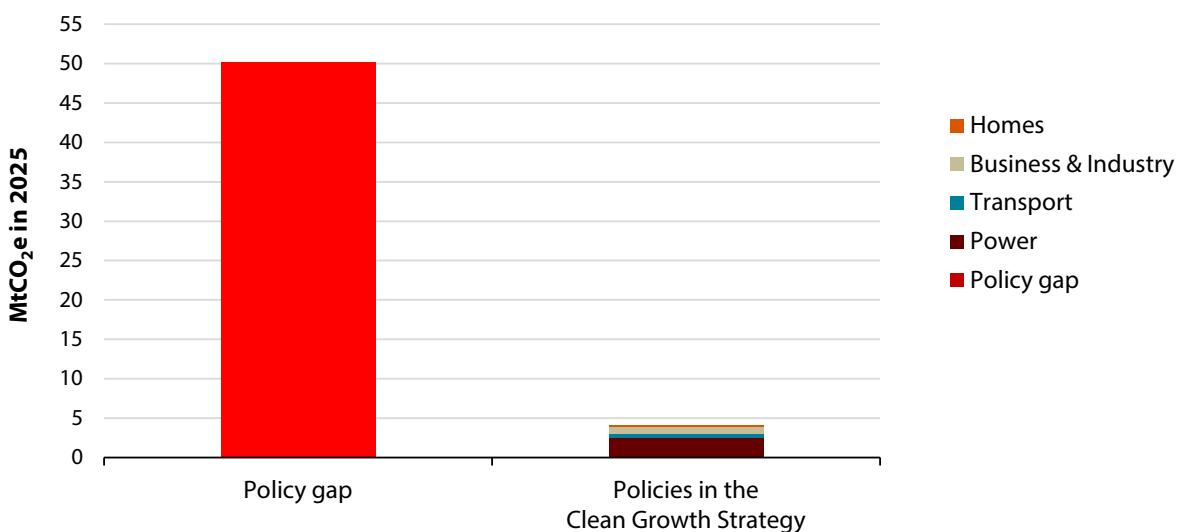
Figure B3.1. The power sector policy gap



Source: CCC analysis.

Notes: Pot 2 auctions are for less-established technologies and include: offshore wind, tidal stream, wave, 'Advanced Conversion Technologies', and Biomass Combined Heat and Power (CHP).

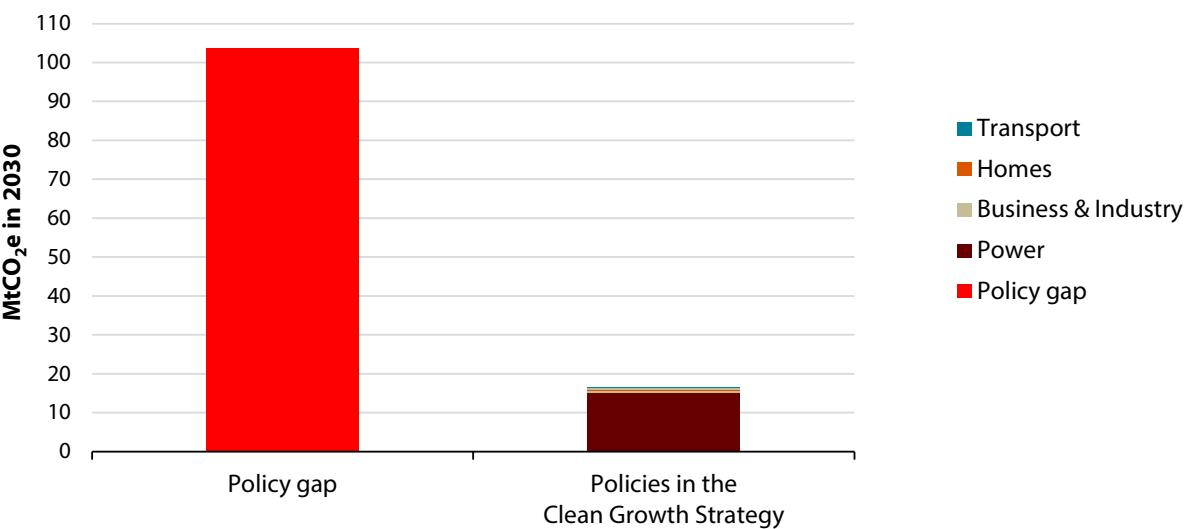
Figure 3.2. Emission savings from new policies, compared to the policy gap (2025)



Source: CCC analysis.

Notes: Policy gap assessment in our 2017 Progress Report to Parliament; represents the gap to the cost-effective path, rather than to carbon budgets. The Business sector corresponds to non-residential buildings; Homes corresponds to residential buildings. The chart includes the following new policies: offshore wind funding for the 2020s (Power); extension of ECO funding to 2028 (Homes); funding for industrial heat recovery programme (Business & Industry); new energy and carbon reporting framework (Business & Industry); revised RTFO (Transport).

Figure 3.3. Emission savings from new policies, compared to the policy gap (2030)



Source: CCC analysis.

Notes: Policy gap assessment in our 2017 Progress Report to Parliament; represents the gap to the cost-effective path, rather than to carbon budgets. The Business sector corresponds to non-residential buildings; Homes corresponds to residential buildings. The chart includes the following new policies: offshore wind funding for the 2020s (Power); extension of ECO funding to 2028 (Homes); funding for industrial heat recovery programme (Business & Industry); new energy and carbon reporting framework (Business & Industry); revised RTFO (Transport).

b) High-level proposals in the Clean Growth Strategy in need of further development

The Government has made a number of ambitious new commitments through the Clean Growth Strategy. These address some of the Committee's recommendations. Specific policies have not yet been developed in these areas, but will need to be effective in all cases in order to meet the carbon budgets. This section considers the main areas of new commitments in turn:

- i) Phasing out all sales of conventional petrol and diesel cars and vans by 2040
- ii) Upgrading the UK's building stock to Energy Performance Certificate Band C by 2035
- iii) Phasing out installation of fossil fuel heating off the gas grid by 2030
- iv) New low-carbon electricity generation
- v) Improving business energy efficiency by at least 20% by 2030
- vi) Deploying carbon capture and storage (CCS) at scale in the UK

i) Phasing out all sales of conventional petrol and diesel cars and vans by 2040

The Government has committed to end the sale of new conventional petrol and diesel cars and vans by 2040. However, they have not announced a specific policy mechanism to deliver this and it has not been set in legislation. The Government has also committed to a £400 million charging infrastructure fund in Autumn Budget 2017.²¹

Our analysis of these commitments is based on our scenarios for the uptake of ultra-low emission cars and vans (i.e. rising to 60% of new sales by 2030). It takes into account the EU's recently announced proposed CO₂ emissions targets for new cars and vans in 2025 and 2030.²² This scenario is in-line with the upper end of the Government's range for electric cars of 30-70% of new sales in 2030. However, the Government proposal for up to 40% of electric vans by 2030 is lower than our scenario of a 60% share.

Given that it takes around 15 years for the stock of cars and vans to turn over, it may be necessary for the sales of petrol and diesel vehicles to end by 2035. A high uptake of ultra-low emission vehicles (ULEVs) by 2030 (i.e. at least 60% of new sales) is therefore required in order to keep open the possibility of 100% of new sales by 2035 and be on track to achieve this by 2040, as the Government has committed. Delaying ambition (e.g. at the lower end of the Government's range) may not be consistent with meeting the Government's proposal for 2040 and is likely to make longer-term targets more expensive and significantly more difficult to achieve.

Sales of electric vehicles are likely to be cost-effective by the early 2020s, but new commitments will be required to give confidence this can be delivered:

- **Sales of electric vehicles consistent with the Government's proposal are likely to become cost-effective from a social perspective in the first half of the 2020s**, given the continued rapid development of battery technology and the projected reduction in costs

²¹ The £400 million charging infrastructure fund consists of £200 million from government and matched private investment to support the wider roll-out of electric vehicle charging infrastructure, as well as additional funding for rapid charging points from Highways England.

²² European Commission (2017) *Proposal for a regulation of the European Parliament and of the Council setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO₂ emissions from light-duty vehicles and amending Regulation (EC) No 715/2007*.

-
- over the next few years. As such, achieving a high rate of sales by 2030 will not necessarily have higher costs than a lower ambition.
- **New commitments will be required to give confidence that this proposal can be delivered.** In particular, this will require time-limited extension to the plug-in car and van grants (i.e. until cost-parity is achieved with conventional vehicles on a private cost basis over the lifetime of the vehicles; expected to be in the early 2020s) and/or further incentives provided to ULEVs in Vehicle Excise Duty (e.g. by increasing the differential with higher-emitting vehicles).
 - **Charging infrastructure must be installed to address issues of range and charging anxiety** and underpin market confidence to deliver these rapid uptake trajectories. Charging infrastructure investments should cover both rapid charging provision for long-distance journeys on motorways and major roads (where at least an additional 700 chargers are required by 2030), as well as local charging for topping up vehicles on streets, at retail locations and in car parks (which will require an additional 25,000 chargers).²³

Manufacturers should be incentivised to continue to develop ULEV models by a combination of ambitious targets for new car and van efficiency in 2025 and 2030, as well as legislation to end the sale of new conventional cars and vans by 2040.

Overall, we estimate that this proposal could save around 5 MtCO₂e in 2025 and 15 MtCO₂e in 2030, assuming 60% of car and 40% of van sales are ULEVs by 2030.

ii) Upgrading the UK's building stock to Energy Performance Certificate (EPC) Band C by 2035

The Government have set out an aspiration for as many homes as possible across the UK to be EPC band C by 2035 (where 'practical, cost-effective and affordable'). They also want all fuel-poor homes, as many privately rented homes, and as much social housing as possible to reach EPC band C by 2030.

EPC energy efficiency ratings grade properties by their energy costs for a given size of property, on a scale from A (best) to G (worst). Analysis on fuel poverty undertaken for our fifth carbon budget advice suggested that common measures necessary to help bring a fuel-poor home up to EPC band C include draught proofing, low-energy lighting, solar PV, loft top-up insulation, solar PV and gas boiler replacement.²⁴ Other important measures include wall insulation and double glazing.

Since they are more energy efficient, homes in band C or above are cheaper to run, but most homes are rated below band C:

- BEIS analysis puts the average annual energy bill for a band C home at around £1,000, compared to over £1,500 for a band E home and over £2,000 for a band F home.²⁵
- Currently, of all Energy Performance Certificates registered in England and Wales, 64% are rated below EPC band C. Whilst most registered for new build properties are rated above EPC

²³ Systra, Cenex & Next Green Car (2018) *Plugging the gap: An assessment of future demand for Britain's electric vehicle public charging network*.

²⁴ Centre for Sustainable Energy (2014) *Meeting the proposed fuel poverty targets*.

²⁵ BEIS analysis, based on English Housing Survey data.

band C, only a small proportion of all certificates (10%) have these ratings. This indicates that only a limited number of homes benefit from these high levels of energy efficiency.²⁶

The Government's commitments on energy efficiency have the potential to deliver the ambition in our central scenario for meeting the fifth carbon budget, provided that the limitations of 'practical' and 'affordable' do not significantly limit cost-effective uptake:²⁷

- The Government states that a possible pathway to 2032 could see a further 6-9 million properties insulated, with further able-to-pay owner-occupied homes insulated to 2035.
- Our Central Scenario includes the insulation of a further 1.5 million solid walls, 2.5 million cavity walls, and 3 million loft top-ups to 2030, with a further 2 million solid walls insulated to 2050.²⁸

There are currently 19 million homes in the UK with an EPC rating below C, out of a total of 27 million.²⁹ By focusing on cost-effective uptake within these homes, the Government's ambition should realise the cost-effective potential included in our scenario.

Whilst some UK Government policies (such as the Energy Company Obligation) extend to Scotland and Wales, the devolved administrations have separate fuel poverty targets alongside a range of separate policies. For example, Scotland recently consulted on bringing energy efficiency standards for private-rented housing up to band D by 2025.³⁰ The UK Government and devolved administrations must work together to deliver the necessary energy efficiency improvements on a UK-wide basis.

The Clean Growth Strategy proposals do not provide sufficient detail to estimate the implementation costs and associated benefits. However, our analysis for the fifth carbon budget found that for the domestic energy efficiency measures included in our Central Scenario, emissions savings of 15.5 MtCO₂ would deliver overall cost savings of £0.6 billion in 2030. There would also be wider advantages of improving homes to band C, such as reductions in fuel poverty and health benefits from reduced damp and improved warmth.³¹

Whilst a number of intended or potential policy mechanisms are mentioned, the Clean Growth Strategy does not confirm the full suite of policy mechanisms necessary to deliver on the 2030 and 2035 ambitions. Further detail is needed on the scale of ambition, the policy package to support able-to-pay owner occupiers, and the trajectories for 2030 and 2035:

²⁶ Department for Communities and Local Government, *Live Tables of Energy Performance of Buildings Certificates*, <https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates>

²⁷ Our analysis assumes the remaining cost-effective potential in our central scenario is achieved by 2032, along with 1 million solid walls which we include due to their wider benefits in reducing fuel poverty and improving comfort.

²⁸ Other insulation measures include floor insulation and draught-proofing. See CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget*.

²⁹ Frontier Economics (2017) *Affordable Warmth, Clean Growth: Action Plan for a comprehensive Buildings Energy Infrastructure Programme*.

³⁰ Scottish Government (2017) *Energy efficiency and condition standards in private rented housing*.

³¹ In relation to fuel poverty specifically, the Centre for Sustainable Energy undertook analysis in 2014 on the costs of bringing fuel-poor homes in England up to band C by 2030, via the interim targets of band E by 2020 and band D by 2025. This analysis identified the need for 10.4 million measures to meet these targets. The measures were selected through a least net present cost approach, and included insulating around 640,000 cavity walls, 460,000 solid walls and 850,000 loft insulation top-ups to 2030. The analysis put the cumulative investment costs at around £18 billion to 2030, largely offset by subsequent bill savings. For further detail see Centre for Sustainable Energy (2014) *Meeting the proposed fuel poverty targets*.

- There is a need for Government to clarify the scale of its ambition across the housing stock, for example by setting out the number of homes or measures it considers practical, cost-effective and affordable, and the associated costs and benefits.
- There is a significant question remaining over how energy efficiency improvements can be delivered in the able-to-pay owner occupier segment of the housing stock. The 2018 Action Plan announced in the Strategy will need to develop a robust policy framework to maximise both bill and carbon savings for these householders (see Chapter 4).
- Decisions are needed on the framework for delivering the 2030 ambitions for the private rented sector, social housing and the fuel poor. Further consideration should be given to the trade-offs between a trajectory which seeks to upgrade homes to a C in one step, as against a tiered approach. Evidence suggests that a tiered approach risks multiple interventions for over 1 million dwellings (incurring additional costs in the process).³²

There is evidence of a performance gap between required standards and real world installations. Effective compliance and monitoring procedures will therefore need to sit alongside the policy framework, in order to ensure quality and confidence around installation.

Overall, we estimate that the proposal for as many homes as possible to be EPC band C by 2035 would save around 1.5 MtCO₂e in 2025 and 3 MtCO₂e in 2030, over and above the existing policy savings included in the Government's Reference scenario.³³

iii) Phasing out installation of fossil fuel heating off the gas grid by 2030

The Government has committed to phase out the installation of high carbon fossil fuel heating in new and existing homes and in non-residential buildings during the 2020s. This is comparable to our central scenario for meeting the fifth carbon budget:

- In homes, we assume a mix of heat pumps and biomass boilers are installed where cost-effective in 1.5 million homes currently using heating oil, LPG and coal (out of a total of four million homes off the gas grid). This is broadly equivalent to around 60% of installations in oil-heated homes in 2024, reaching 100% of suitable oil-heated homes by 2028. In assessing potential savings from the Government's new commitments, we do not include the additional uptake in our scenario where displacing resistive electric heating.
- This would require new homes to be built with heat pumps or alternative low-carbon heating for the limited number of new properties not connected to the gas grid.
- In non-residential buildings, heat pumps and biomass boilers are cost-effective relative to fossil fuel and conventional electric heating through the 2020s. Our scenarios assume 100% phase out from 2022, with an increase to this point from 2018.

Starting to phase out the installation of fossil fuel heating in homes off the gas grid is a sensible low-regrets strategy, given the higher heating costs and the need to develop supply chains and the heat pump market in order to keep open the option of high electrification of heat to 2050. In practice, this means installing low-carbon heating alongside insulation upgrades, and therefore requires a planned intervention rather than a typical 'distressed purchase'.

³² Centre for Sustainable Energy (2014) *Meeting the proposed fuel poverty targets*.

³³ These estimates exclude the savings delivered through the proposed extensions to ECO.

New commitments will be required to give confidence that this proposal can be delivered. In particular, this will require a firming up of proposals by 2020 along with any incentives and regulatory proposals.

Overall, we estimate that this proposal – phasing out installation of fossil fuel heating for buildings off the gas grid from 2022 – would save around 1 MtCO₂e in 2025 and 2.5 MtCO₂e in 2030.

iv) New low-carbon electricity generation

The Government has an ambition to ensure that 85% of the UK's electricity is generated from low-carbon sources by 2032. Within that they have committed to deliver new nuclear power by progressing discussions with developers to secure a competitive price for future projects in the pipeline, alongside an additional £557m for low-carbon generation, via Contracts for Difference (CfDs).

The Government's ambition is consistent with our range of scenarios, but is reliant on securing a large amount of imported electricity:

- The CCC scenarios for the fifth carbon budget were based on a portfolio of deployment of cost-effective low-carbon generation options (e.g. onshore wind, solar PV, nuclear power, offshore wind in the 2020s) and UK deployment where this has a role in reducing costs (e.g. offshore wind in early years and carbon capture and storage).³⁴ They have a similar level of low-carbon generation to the Government's pathway (based on an assessment of the Energy and Emissions Projections used for the Clean Growth Strategy), meeting a slightly higher share of UK demand.
- However, the Government scenario also assumes a large amount of imported electricity (meeting 15% of demand in 2032). Since this implies less UK generation for a given demand, this pushes up the share of low-carbon sources in UK generation (to a level similar to that in the CCC's scenarios).
- Both our scenario and the Government's pathway would be consistent with reaching an emissions intensity of less than 100 gCO₂/kWh in 2030. However, relying on importing electricity to meet carbon budgets is likely to lead to higher emissions elsewhere in Europe (Box 3.2), particularly if fuel and carbon prices change in favour of coal. It could also increase costs and miss out on economic benefits for the UK given the potential for UK based low-carbon generation to be procured at, or below, the cost of imported generation.

We also note that the Government appears to assume an electricity mix that is highly reliant on successful delivery of new nuclear power. BEIS's Energy and Emissions Projections³⁵ assume two to three new nuclear reactors commissioned between 2028 and 2032, in addition to the Hinkley Point C plant (which is currently expected to commence operation in 2025). The last nuclear reactor to be commissioned in the UK was Sizewell B (1.2 GW) in 1995. This is an ambitious programme of new nuclear build, particularly in light of the lower costs recently awarded to wind generators compared to Hinkley Point C. For this programme to be achieved contracts must be signed over the coming years. A progress monitoring and reporting scheme should be put in place by the Government to allow for additional low-carbon generation to be contracted if new nuclear plants are delayed.

³⁴ See CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.

³⁵ BEIS (2017) *Updated Energy and Emissions Projections 2016*.

The Government's spending commitments for renewables imply an expansion of renewable generation to meet 50% of UK demand by 2032. This could be increased at no cost to billpayers by also offering contracts to onshore wind and solar developers:

- The Government has recommitted to spending the remaining £557m of the £730m of funding allocated for CfDs in the 2020s (£173m of funding was awarded in the September 2017 CfD allocation round). We now estimate this funding could procure around 55 TWh of low-carbon generation, following the low prices for offshore wind projects contracted in the latest auction (see Box 3.1).
- Estimates from both Government and industry suggest onshore wind is the cheapest form of new build generation in the UK.³⁶ The Government's approach to procuring low-carbon generation should not exclude cost-competitive renewable technologies, such as onshore wind and solar PV. Where they are cost-competitive and meet local planning criteria, these technologies should be allowed to compete for contracts against other low-carbon options.
- The recent coal phase-out announcement, and the November 2017 Budget announcements on the future of carbon pricing and levy controls provide a level of investment certainty into the mid-2020s. Further low-carbon generation will need to be contracted over this period for projects commencing operation in the late 2020s. The new control will only allow for new levies to be added to bills if they come at no additional cost or if a sustained decrease in the overall cost of levies is projected. The Government estimates this date to be 2025, though the bulk of levies will start to fall when Renewables Obligation projects come offline, from 2027.

Delivering the low-carbon investment required by the Government's and the CCC's scenarios will require efficient and effective UK electricity markets, and – where appropriate – interventions by Government in order to address market failures. The recent Cost of Energy Review³⁷ proposes wide-ranging reforms to contracting for capacity and generation in UK markets. It recognises that these are issues for the longer term. Whilst in the long-run there is a case for reviewing market arrangements, the CfD and capacity market instruments developed under Electricity Market Reform provide competitive means of securing energy policy goals, and are broadly working effectively. Upheaval of the existing market arrangements could deter investment (Box 3.3).

Overall, we estimate that the power sector proposals in the Clean Growth Strategy could save around 17 MtCO₂e in 2030.

³⁶ BEIS (2016) *Electricity Generation Costs*; Arup (2017) *Market Stabilisation Analysis*; Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*.

³⁷ Helm (2017) *Cost of Energy Review*.

Box 3.2. The role of imported electricity in UK power sector decarbonisation

Emissions from imported electricity occur outside the UK and therefore do not count towards UK emissions on a production basis, although they are covered in the exporting countries by the EU ETS.

The Committee's scenarios for the development of the UK power sector assume that by 2030 UK generation matches UK consumption on annual basis (i.e. inflows balance outflows over the year). Interconnection plays an important role, but as a provider of flexibility and cost reduction rather than as a net source of power. The Government envisages an increase in interconnection and in imports from connected markets, resulting in lower UK emissions than if this generation was provided by UK gas plant.

- The Committee's scenarios for carbon budgets consider interconnectors to provide no net imports across the year. This is due, in part, to our assumption that long-term UK carbon targets cannot rely on being met through large-scale imports. It also reflects the difficulty in predicting relative costs in different markets decades into the future. Our scenarios therefore require a consistent build out of low-carbon generation to 2050. However, even without net imports, interconnection can be valuable in increasing system security and flexibility.
- The UK currently has 4 GW capacity of interconnectors and 4.4 GW capacity under construction. Ofgem has either approved – or is considering – agreements with a further 8 GW of interconnection capacity.
- Imports of electricity to the UK have increased in recent years, largely due to the UK's carbon price floor (currently £18/tCO₂) having increased wholesale electricity prices in the UK, relative to other European countries. EU fossil-fired plants do not face this extra carbon price, and are not charged certain network costs that UK generators face, though they do incur charges for using interconnectors. BEIS projections forecast this reliance on imports will grow, estimating the UK to be a net importer of over 50 TWh of generation in 2030, based on 18 GW of interconnection capacity.
- Expected flows of electricity to the UK over the fifth carbon budget period would likely be from European coal, gas or hydro plants. There are multiple risks to relying on importing energy over this period, and UK generation may be cheaper than imported generation in any case:
 - UK imports are largely driven by the difference in the cost of generating electricity faced by European and UK generators. We estimate marginal costs for European coal and gas plant in 2030 to be £40-60/MWh and £30-50/MWh³⁸ respectively (before accounting for interconnector tariffs). UK generation could be purchased at a similar cost: we estimate costs around £50/MWh or less for UK based low-carbon or gas generation.
 - Additionally, structural changes to neighbouring electricity systems, changes to coal or carbon prices in Europe or potential consequences from the UK leaving the European Union could impact the amount of electricity the UK is able to import at acceptable prices.
- Imports from other countries can increase emissions in the rest of Europe. The European grid is highly interconnected. Given a limited amount of available low-carbon generation, an increase in exports from that grid will likely result in increased fossil-fired generation. Given the current EU ETS market arrangements and the surplus of emission allowances, this would result in an increase in emissions.³⁹ For imports to be genuinely low-carbon they would need to come from surplus low-carbon generation.

Notes: Estimates for 2030 based on BEIS's fuel price assumptions: £47-93/tonne of coal, 38-72p/therm of gas; Aurora's EU ETS price forecasts of £17-27/tCO₂; and a total UK carbon price of around £24/tCO₂.

³⁸ BEIS (2017) *Energy and Emissions Projections: Annex M*; Aurora Energy Research (Q3 2017) *UK Power Market Forecast*.

³⁹ Sandbag (2016) *Puncturing the waterbed myth*.

Box 3.3. Cost of Energy Review and longer-term options for market design

Professor Dieter Helm's independent Cost of Energy Review was recently published by the Government.⁴⁰ While it does cover some other sectors, including the imposition of an economy-wide carbon price – which the Committee has previously endorsed in principle⁴¹ – it focuses primarily on the power sector. Within this, it focuses primarily on electricity prices, rather than bills.

The Review proposes significant reforms to UK electricity markets with the intention of reducing complexity and transitioning away from the Contracts for Difference (CfD) support mechanism for low-carbon generators. UK electricity markets and associated policy instruments are both numerous and complex, and could benefit from simplification. However, the Capacity Mechanism and CfDs are proving successful in contracting for cost-competitive capacity and low-carbon generation respectively, and reducing the cost of capital. Longer-term proposals for the redesign of these markets should therefore be considered in this context.

- Multiple market interventions have made investing in the UK energy system complex, though both the Capacity Market and CfD schemes are now well known to developers and are proving effective in contracting for cost-competitive capacity and low-carbon generation respectively, whilst reducing investment risk and the cost of capital.
- Long-term contracts (i.e. CfDs) offer low-carbon generators fixed price contracts which provide predictable returns in the face of wholesale market price fluctuations. These are valuable in securing a lower cost of capital for developers and therefore lower costs for consumers.
 - Fossil-fired generators that are able to set the price in UK electricity markets can pass through fluctuations in fuel prices, hedging their risks.
 - Conversely, low-carbon generators have low marginal costs and are price-takers – their revenues from the wholesale market are dictated by fluctuating fossil fuel prices.
 - Work in support of the UK's recent Electricity Market Reform suggested that moving wholesale power price risk away from low-carbon generators could decrease costs by around £5/MWh through reducing the cost of capital by 0.75-1.5%.⁴² Recent analysis of the CfD auctions that have taken place supports this.⁴³
 - A move away from long-term contracts, and a reintroduction of wholesale price risk could increase the costs of securing low-carbon generation.
- Replacing long-term contracts with an increased carbon price, as proposed, is unlikely to provide a bankable revenue stream for low-carbon investors (the 'Carbon Price Floor', for example, was frozen one year after it was introduced). This would risk increasing the cost of capital to investors, raising the overall cost of procuring low-carbon generation.
- In the longer term (i.e. post-2030), and as low-carbon generation continues to decrease in cost, a more mature market for long-term contracts may materialise (e.g. via energy supplier or corporate Power Purchase Agreements), reducing the need for Government intervention. Government may also be able to support this development through simple regulations, such as an Emissions Performance Standard. Currently, genuine markets for long-term contracts for low-carbon generation are insufficient to support the scale of decarbonisation required by the UK's carbon targets.
- In principle, all technologies that contribute to security of supply should be rewarded for their capacity. However, the increased complexity and the risk of not winning a capacity contract could

⁴⁰ Helm (2017) *Cost of Energy Review*.

⁴¹ See CCC (2016) *Next Steps for UK Heat Policy*.

⁴² DECC (2013) *Electricity Market Reform Delivery Plan, Annex H: Modelling*.

⁴³ NERA (2017) *Offshore revolution?*

Box 3.3. Cost of Energy Review and longer-term options for market design

also raise the cost of capital for project developers. Furthermore, as capacity payments for renewable generators would make up a small proportion of overall revenue and may be hard to predict, bidders may discount this revenue stream when bidding for CfDs, leading to potential 'double payments' to low-carbon generators.

- The Committee supports a move towards technology neutrality, supplemented by innovation spending for less-mature technologies. Some of the lowest-cost generating options (e.g. onshore wind and solar) are currently excluded from contract auctions. The Government should consult on how and when a move towards technology neutrality would be possible.
- Other proposals within the Review – such as staggered contracts and legacy cost proposals – are beyond the scope of the Committee's advice.

The Government has launched a Call for Evidence in response to the Cost of Energy Review, although there is concern that the lack of specificity in the questions under consideration may not allow sufficient detail to come forward to inform future market arrangements. These could benefit from a further consultation in 2018, to gauge industry's views on efficient future market designs, technology neutrality, opportunities for 'subsidy-free' CfDs and instruments for securing generation from projects reaching the end of their lifetimes (known as 'repowering').

v) Improving business energy efficiency by at least 20% by 2030

The Government has committed to developing a package of measures to support businesses to improve their energy efficiency by at least 20% by 2030. This package of measures includes:

- Improving the energy efficiency of new and existing commercial buildings.
- Raising minimum standards of energy efficiency for rented commercial buildings.
- Simplifying requirements for businesses to measure and report their energy use.
- Establishing an Industrial Energy Efficiency scheme.

Collectively, the 20% target and package of measures potentially provides a greater improvement in energy efficiency than our scenarios for meeting carbon budgets. Our scenarios include improving energy management and process control in the more carbon-intensive manufacturing and refining sectors, insulating buildings, retrofitting a steel plant, upgrading machinery, and further waste heat recovery.

However, the magnitude of the improvement in energy efficiency that the target and measures will encourage is not clear because the baseline and metric against which the 20% improvement will be measured is not defined. In particular, it is not clear what the relative ambition is in industrial process efficiency compared to buildings efficiency, and whether or not the target is calculated on an energy intensity or an absolute basis.

Further details on this proposal are required in order to give confidence that an improvement in energy efficiency of at least 20% can be delivered. This should include details on the proposed industrial energy efficiency scheme and improvements to buildings regulations, as well as details of further initiatives. The baseline and intended metric should also be set out.

For this assessment, we estimate that the proposal to deliver a 20% improvement in energy efficiency by 2030 would save around 3 MtCO₂e in 2025 and 5 MtCO₂e in 2030 compared with

the policies that existed before the Clean Growth Strategy was published. This assessment assumes a 20% reduction in energy use per unit of GVA in industry and a 20% reduction in energy use in the commercial sector, both from 2016 levels, and excludes savings from the Industrial heat recovery programme and the New business reporting framework (see new policies in Table 3.2).

vi) Deploying carbon capture and storage (CCS) at scale in the UK

Deployment of CCS is crucial to meeting the UK's long-term climate targets at least cost (see Chapter 2). The Government has set out its ambition of deploying carbon capture and use (CCUS) at scale in the 2030s, subject to cost reductions. In support of this, it has committed to:

- Set out a deployment pathway in 2018.
- Establish a Cost Challenge Taskforce and CCUS Council.
- Identify the most appropriate way to test the potential for development of CCUS industrial decarbonisation clusters.
- Spend £100m to support industry and CCUS innovation and deployment.

Existing work has already shown how CCS costs can be reduced via sharing of infrastructure. Work by the Teesside Collective shows how industrial CCS can reduce emissions at an estimated cost of £58 per tonne,⁴⁴ a similar cost to other measures in the cost-effective path by 2030.

The Strategy groups CCS and CO₂ use together as carbon capture use and storage (CCUS). However, estimates suggest that the volume of CO₂ that would need to be stored in scenarios to meet the UK's 80% 2050 target would far exceed the potential market for CCU, meaning that CCS will be of much greater importance in the long-term.⁴⁵ However, CCU could be of benefit in particular niche areas (e.g. where CO₂ capture costs are relatively low but geological sequestration of the CO₂ is impractical). Long-term deployment of CCS in the UK requires the development of transport and storage infrastructure beyond what would be required for CCU alone.

The CCUS deployment pathway published in 2018 should provide a clear path for CCS deployment, taking into account existing and new evidence on cost reduction. It should:

- Be prepared on the basis that deployment of CCS at scale should start by 2030. Smaller-scale projects and infrastructure development should occur prior to this, in order to prove business models and prepare for deployment at scale.
- Establish plans for separate support mechanisms for CO₂ capture and for infrastructure for CO₂ transport and storage. These plans should limit risks that cannot be borne by the private sector (e.g. with these risks being managed by a CCS Delivery Company).
- Set out to finalise support in the early 2020s for capture projects to come online in the second half of the 2020s, alongside infrastructure roll-out.
- Focus initially on one or two strategic clusters.
- Keep open the option of projects for power generation or hydrogen production in order to maintain the optionality of the Clean Growth Strategy's long-term decarbonisation pathways.

⁴⁴ Pöyry on behalf of Teesside Collective (2017) *A Business Case For a UK Industrial CCS Support Mechanism*.

⁴⁵ See CCSA (2016) *Lowest Cost Decarbonisation for the UK: The Critical Role of CCS*.

Should the decisions that need to be taken by 2025 on the future of heating in the UK (see Chapter 2) set out an important role for repurposing gas distribution networks to hydrogen, these will only be credible if active progress has been made on CCS.

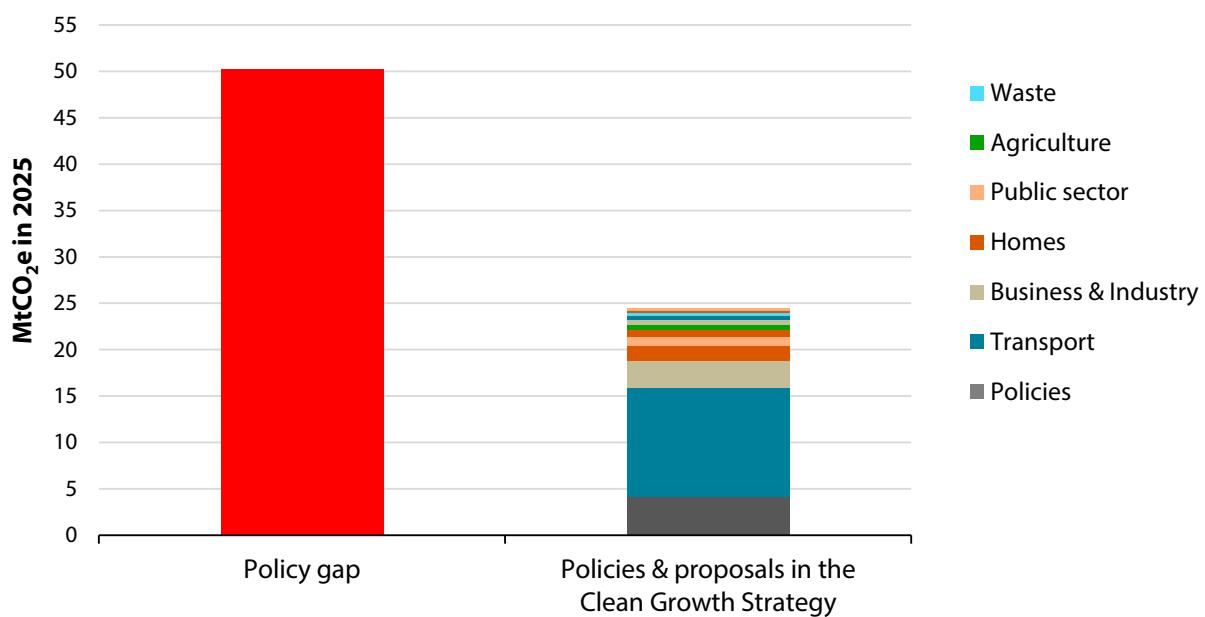
We estimate that the CCUS proposals in the Clean Growth Strategy would save around 2.5 MtCO₂e in 2030, based on one or two small, but scalable, industrial CCS clusters coming online from 2026 and increasing their capacity in 2030. This is less abatement than set out in our scenarios for meeting carbon budgets.

Whilst the emissions savings to 2030 are relatively modest, they would pave the way for the larger emissions reductions that will be required in the 2030s and 2040s.

c) The remaining gap to meeting the fourth and fifth carbon budgets

We have quantified the emission reductions attached to the policy proposals outlined in the Clean Growth Strategy. Our assessment is that the proposals announced in the Clean Growth Strategy (set out in section b) above could save around 20 MtCO₂e in 2025 and around 60 MtCO₂e in 2030 if fully delivered. These proposals, together with the firm new policies committed to, would not be sufficient to close the policy gap even if delivered in full (Figures 3.4 and 3.5). Overall, even if all policies and proposals that we have been able to quantify are fully delivered, there would still be a gap of 65 MtCO₂e to each of the fourth and fifth carbon budgets on central projections (Figure 3.6).

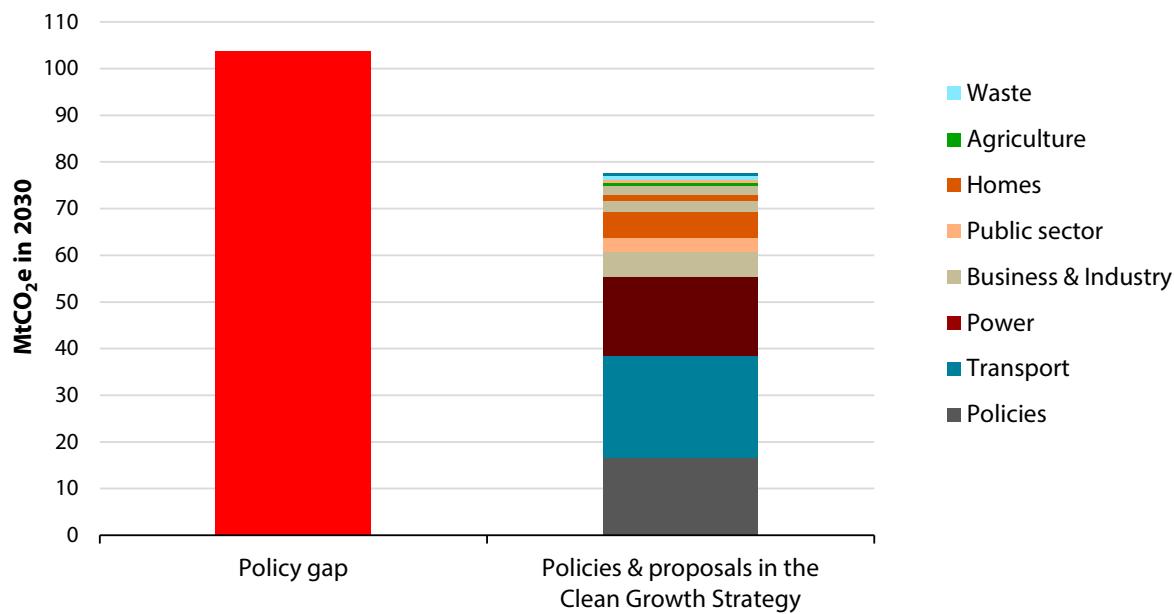
Figure 3.4. Policies and proposals in the Clean Growth Strategy do not fully close the policy gap (2025)



Source: CCC analysis.

Note: Breakdown of firm policies shown in Figure 3.2. Policy gap assessment in our 2017 Progress Report to Parliament; represents the gap to the cost-effective path, rather than to carbon budgets. The Business sector corresponds to non-residential buildings; Homes corresponds to residential buildings. The chart includes the following proposals or intentions: phase-out of conventional petrol and diesel car and vans by 2040 (Transport); general car and van efficiency measures (Transport); cycling & walking strategy, shift of freight to rail, and improved bus efficiency (Transport); an improvement in energy efficiency of at least 20% by 2030 (Business & Industry); phase-out of installation of high-carbon fossil fuel heating during the 2020s (Business & Industry, Homes); growing the heat networks market so it is self-sustaining in the longer-term (Business & Industry, Public sector, Homes); an emissions reduction target (Public sector); as many homes as possible to be EPC Band C by 2035 (Homes); no food waste to landfill by 2030 (Waste); improved livestock health (Agriculture); use of low-carbon fertiliser (Agriculture).

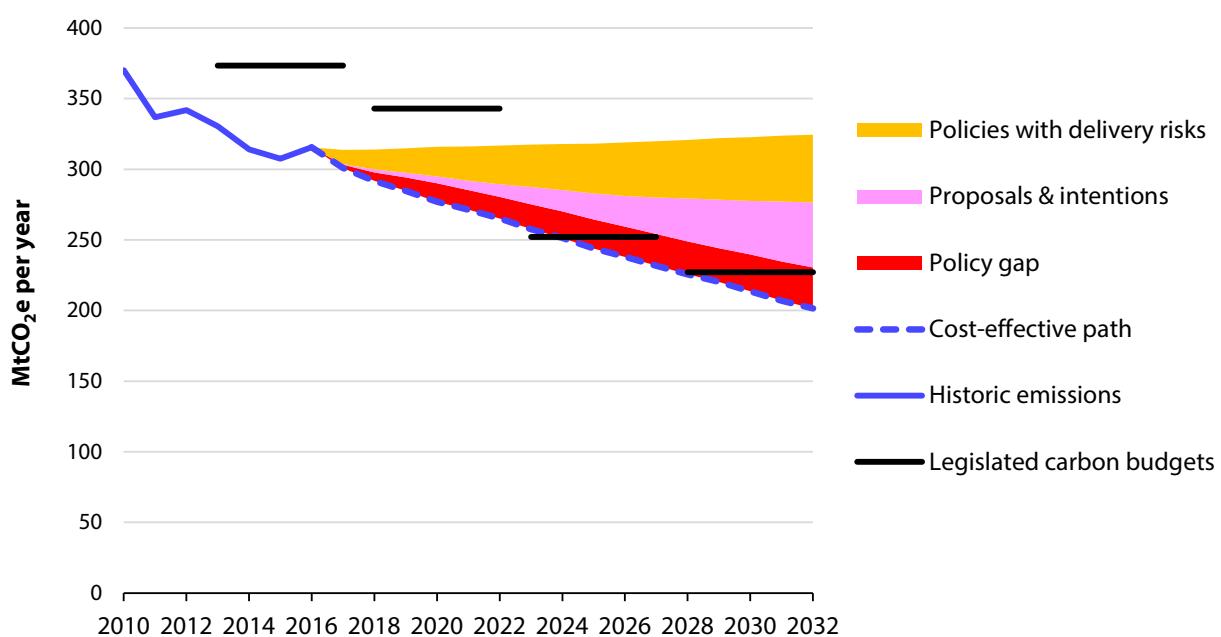
Figure 3.5. Policies and proposals in the Clean Growth Strategy do not fully close the policy gap (2030)



Source: CCC analysis.

Note: Breakdown of firm policies shown in Figure 3.3. Policy gap assessment in our 2017 Progress Report to Parliament; represents the gap to the cost-effective path, rather than to carbon budgets. The Business sector corresponds to non-residential buildings; Homes corresponds to residential buildings. The chart includes the following proposals or intentions: phase-out of conventional petrol and diesel car and vans by 2040 (Transport); general car and van efficiency measures (Transport); cycling & walking strategy, shift of freight to rail, and improved bus efficiency (Transport); nuclear new-build beyond Hinkley Point C (Power); an improvement in energy efficiency of at least 20% by 2030 (Business & Industry); phase-out of installation of high-carbon fossil fuel heating during the 2020s (Business & Industry, Homes); deployment of CCS at scale by 2030 (Business & Industry); growing the heat networks market so it is self-sustaining in the longer-term (Business & Industry, Public sector, Homes); an emissions reduction target (Public sector); as many homes as possible to be EPC Band C by 2035 (Homes); no food waste to landfill by 2030 (Waste); improved livestock health (Agriculture); use of low-carbon fertiliser (Agriculture).

Figure 3.6. There remains a gap to the fourth and fifth carbon budgets even with full delivery of policies and proposals



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, BEIS (2017) *2016 UK Greenhouse Gas Emissions, provisional figures*, HMG & HMT (2009) *Building a low-carbon economy: implementing the Climate Change Act 2008*, CCC analysis.

Notes: The chart presents emissions in the 'non-traded' sector only (i.e. sources of emissions not covered by the EU Emissions Trading System – EU ETS), as it is these emissions that determine whether or not a carbon budget is met. Chart is on the basis of Government emission projections used in the Clean Growth Strategy, for which our assessment of the gap is around 65 MtCO₂e. The Government's latest projections suggest the gap could be lower, at around 10 MtCO₂e. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding, see Box 1.2) are coloured amber. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy. These are coloured pink. The remaining gap to the cost-effective path is coloured red. The cost-effective path outperforms carbon budgets, so not all this gap would need to be filled to meet the legislated budgets.

Chapter 4: Closing the policy gap and priorities for monitoring



The Government has clearly stated that the Clean Growth Strategy should not be seen as the end of the process. The approach will have to develop and adapt to changing circumstances over time. In this chapter we set out what will need to happen, and by when, to ensure that the legally binding carbon budgets are met, how we will monitor progress and how the Government will need to drive the process to strengthen low-carbon policies.

a) What needs to happen to ensure carbon budgets are met

Areas for action identified in the Clean Growth Strategy are broad-based and cover most sectors. However, gaps remain to meeting the carbon budgets and there are risks relating to existing policies and to the new proposals and intentions (Box 4.1).

Box 4.1. Gaps in the policies and proposals included in the Clean Growth Strategy

Gaps in the policies and proposals announced in the Clean Growth Strategy include:

- **Buildings energy efficiency.** The overarching trajectory set out for improving the efficiency of the existing building stock is promising. Details need to be set out on how this will be delivered, particularly for 'able-to-pay' homeowners for whom there are still no firm policies to drive the necessary actions.
- **Low-carbon heat in homes, businesses and industry.** The commitment to phase out the installation of high carbon fossil fuel heating in buildings off the gas grid is welcome. This should include heat pump deployment, which, together with installation in new-build properties, would develop heat pump markets and supply chains in order to prepare, if necessary, for potential widespread deployment in buildings connected to the gas grid from the 2030s. However, the Strategy provides little commitment to a low-carbon supply mix in heat networks and no commitment to biomethane post-2021, both of which the Committee has identified as 'low-regrets' options at this stage. There is also little commitment to support an increase in the use of bioenergy for industrial process heat.
- **Surface transport.** The Government has set out an ambition for 30-70% of car sales and up to 40% of van sales in 2030 to be ultra-low emission vehicles (ULEVs). It is will be necessary to deliver towards the upper end of the range for cars, and greater ambition will be needed for vans. There is little concrete action on emissions from HGVs. More is also needed on shifting travel demand from passenger cars to lower-emission modes.
- **Power generation.** The Government has set out plans for the decarbonisation of UK power generation to below 100 gCO₂ per kWh by 2030. However, this places a high reliance on new nuclear build and net imports across interconnectors, both of which have associated risks. More is needed to provide a route to market for low-carbon electricity generation, especially lower-cost options such as onshore wind and solar, and to contract for additional low-carbon generation should the Government's expected contributions from new nuclear plants and overseas generators under-deliver.
- **Agriculture and land use.** A commitment to include climate change mitigation as part of a new system of future agricultural support is welcome. However, strong policies to deliver emissions reductions in agriculture need to be developed soon. The acceleration of tree-planting rates should occur earlier than the Strategy's proposed timeline of the 2020s, to ensure that around 70,000 hectares of afforestation is delivered in England by 2025.

Box 4.1. Gaps in the policies and proposals included in the Clean Growth Strategy

- **Aviation.** The Government have committed to publish a new Aviation Strategy by the end of 2018. This will need to include a plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set (i.e. around 2005 levels by 2050, likely to imply around a 60% potential increase in demand), supported by strong international policies.

We will continue to monitor progress reducing the policy and delivery risks in these areas as part of our annual reports to Parliament on meeting carbon budgets.

The set of policies and proposals set out in the Clean Growth Strategy are insufficient to meet the fourth and fifth carbon budgets, even if delivered in full. There are a number of areas identified in the cost-effective path we set out in our advice on the fifth carbon budget that would enable this gap to be closed.

Our latest assessment is that the set of actions contained in our cost-effective path would lead to both the fourth and fifth carbon budgets being outperformed by around 35 MtCO₂e for the fourth carbon budget and around 65 Mt for the fifth carbon budget. In principle, therefore, of the identified measures to contribute to meeting the budgets that are not covered by the Strategy, only a subset of these (i.e. up to two-thirds for the fourth budget, and up to half for the fifth budget) would be needed to close the gaps to the budgets.

In practice, given the risk of under-delivery, it would be prudent to aim to deliver across a wider range of these areas in order to provide contingency for meeting the budgets. Outperforming the budgets would also prepare better to achieve the 2050 target and potentially deeper reductions committed to under the Paris Agreement.

Particular areas where the Committee identify a need for urgency in progressing to firm policies and delivery of abatement actions include:

- **Energy efficiency in existing buildings.**
 - An ambitious action plan for able-to-pay homeowners must be published swiftly, as this segment is large and current policies are not driving significant improvements. It should set out a robust policy framework including efficiency incentives, with firm commitments on the level of ambition and funding. If insufficient take-up is achieved, options that are initially incentivised may later need to be mandated. Policies should be in force by the end of 2019 at the latest (earlier action would reduce the policy gap, provided this is not at the expense of quality or ambition).
 - Action is also needed now to make the private-rented sector regulations fully effective (in the absence of the Green Deal financing mechanism),⁴⁶ to develop proposals for a trajectory for standards to 2030 across all rented properties, to put in place a performance-based labelling scheme for commercial properties, and to take forward actions to improve compliance, including the effective use of data on actual performance.
- **Low-carbon heat.** Immediate priorities include retargeting the Renewable Heat Incentive (RHI) towards heat pumps and biomethane, developing and setting out proposals for the

⁴⁶ The Government set out a proposed cap of £2,500 per home in a consultation in December 2017. Under these proposals, Government estimates put the percentage of F and G rated private-rented homes reaching band E by 2020 at 30%. More will be needed to deliver on the EPC band C by 2030 ambition and fuel-poverty targets.

fossil fuel phase-out for buildings off the gas grid, and further work to secure low-carbon supply mixes for new and existing heat networks (including waste heat from industry and large water- and sewage-source heat pumps).

- **New buildings.** Standards need to be developed that deliver high levels of fabric efficiency and future-proof properties for low-carbon heat. Existing commitments under EU law will need to remain in place or be replaced with equivalent standards following the UK's exit from the EU. It is also vital that the performance gap between design and actual performance is addressed in order to realise energy savings and deliver high-quality homes.
- **Public sector.** Plans for a voluntary target across the public sector to 2020/21 need to be developed alongside the monitoring and reporting framework. This should be combined with further work on how public procurement can be harnessed to drive higher standards in commercial buildings and new homes, and to support low-carbon heat supply chains.
- **Surface Transport.** The Government's 'Road to Zero' strategy, due in 2018, should set out:
 - Proposals for incentives for the uptake of ULEVs (e.g. extension of the grants for plug-in vehicles, until the private costs of ownership reach parity with conventional vehicles), and lay out a clear plan for public charging infrastructure.
 - Future requirements for conventional vehicle efficiency, to go beyond recently announced EU proposals for emissions standards for 2025 and 2030, which are not ambitious enough.
 - Measures to incentivise freight operators to improve logistics efficiency and shift to less carbon-intensive modes, and to increase uptake of eco-driving training and fuel-saving technologies for HGVs where cost-effective.
 - Additional measures to incentivise a shift of travel demand to lower-emission modes including walking, cycling and public transport.
- **Carbon capture and storage (CCS).** The Development Pathway due to be published in 2018 must set out the Government's proposals for: the delivery model for CO₂ transport and storage infrastructure, the funding mechanism for industrial CCS, and the allocation of risks between Government and developers, especially relating to long-term storage liabilities. Several promising projects exist in strategic cluster locations that could be in operation by 2025. If a decision on the future of the gas grid by 2025 is to be credible, then progress on demonstrating the business model for CCS will be needed before then.
- **Agriculture and land use.** There has been no progress in reducing agricultural emissions over the past six years. The publication of a new Strategy for Agriculture and Land Use must set out policy proposals, to take effect by 2022, for the delivery of emissions reduction and increased carbon sequestration. Informed by improved information from the forthcoming Smart Inventory, this Strategy should set out measures to implement a range of cost-effective emissions reductions from soils, crops, and livestock. In forestry, appropriate incentives and measures to address non-financial barriers should be put in place to accelerate the rate of tree planting beyond current low levels.
- **Waste.** The Government's new Resources and Waste Strategy, due in 2018, should set out firm policies to end food waste going to landfill and this should be implemented by 2025, five years earlier than currently planned. The Strategy should also require landfilling is ended for other waste streams including paper and card, wood, textiles and garden waste on the same timescale.

Other areas should progress according to the timelines that the Government has laid out:

- **Power generation.** The Government has committed to spending £557m of funding for Contracts for Difference, with the next auction taking place in Spring 2019. The Government should announce the funding that will be allocated to this auction, and continue to run subsequent auctions in order to procure the low-carbon generation required to reduce carbon intensity of generation to below 100 gCO₂/kWh by 2030. The Government's approach to procuring low-carbon generation should include cost-competitive technologies, such as onshore wind and solar PV. Latest estimates from BEIS⁴⁷ and others suggest onshore wind is the cheapest form of new-build generation in the UK.
- **Replacement of EU standards.** Whatever happens in terms of leaving the EU, it is essential to maintain continuity and comparability in standards with those across the European Union. The Government needs to ensure that the Clean Growth Strategy commitments to maintain and, where necessary, go beyond EU ambition are delivered.

As well as developing effective new policies, success will require that existing policies are monitored, and adjusted as required to ensure delivery remains on track at lowest cost. We identify a number of specific risks (Box 4.2) along with options for policy strengthening.

Box 4.2. Key risks requiring management and options for policy strengthening

Our assessment of Government policies to reduce emissions highlights a number of existing policies that have risks around delivery:

- **Power generation.** The Government's Energy and Emissions Projections envisage an ambitious programme of new nuclear build. For this to be achieved we would expect contracts to be signed over the coming years. The Government also envisages electricity imports from European countries providing 15-20% of the UK's generation in 2030. To the extent that imports are used it is important that these reflect additional low-carbon generation. There is also a risk, if imports were lower, that generation from UK gas plants may increase leading to increased emissions. The Government will need to put in place a progress monitoring and contingency scheme to identify risks relating to delivery and, in the event that new nuclear plants are delayed or electricity imports lower, allow for additional low-carbon generation to be contracted.
- **Other policy development that is impacted by exiting the EU.** As we prepare to leave the EU, it is essential to deal with economic uncertainty and to maintain ambition in the areas in which EU policies are important in reducing UK greenhouse gas emissions. Some of these policies already had existing delivery risks. There is also an opportunity to develop a UK policy framework that links support to actions that reduce emissions (e.g. for farming after the Common Agricultural Policy).
 - **Product standards.** EU product standards have led to substantial improvements in the efficiency of appliances used in the UK, saving money and cutting carbon emissions. It is essential that the Strategy's commitment to match or exceed EU standards is delivered.
 - **New vehicle regulations.** Efficiency standards for new cars and vans have operated at EU level, setting average levels of grams of CO₂ per kilometre that decline over time. The Strategy states the Government will "seek to ensure our future approach is at least as ambitious as the current arrangements", but offers no further details. Current EU proposed targets for 2025 and 2030 are not ambitious enough – the UK should adopt more stretching standards.

⁴⁷ BEIS (2016) *Electricity Generation Costs*.

Box 4.2. Key risks requiring management and options for policy strengthening

- **F-gases.** The EU F-Gas Regulation sets quotas for use of F-gases that fall over time, such that UK F-gas emissions are expected to fall by 68% between 2015 and 2030. Again, the Strategy states that the Government will "seek to ensure our future approach is at least as ambitious as the current arrangements". The Committee believes there are cost-effective opportunities to go further, and is commissioning new work to better understand the potential.
- **EU Emissions Trading System (EU ETS).** The Government has committed to a total carbon price at around today's level of £24/tCO₂ for the UK power sector regardless of whether the UK continues to participate in the EU ETS. However, it is not clear what the framework will be to drive necessary emissions reductions in industry (e.g. through improvements in energy efficiency). The Strategy states that the Government will "seek to ensure that our future approach is at least as ambitious as the existing scheme and provide a smooth transition for the relevant sectors", but more detail will be needed once the question over future UK participation in the EU ETS is settled.

It is essential that alongside developing further options to close the gap to meeting carbon budgets and firming up the new ambitions and intentions, these risks are addressed and the associated emissions reductions are delivered in full.

b) How we will monitor progress

To ensure that the carbon budgets are met the government will need to put in place policies to close the policy gap and make sure these deliver the required emission savings:

- Continue to deliver existing low-risk policies.
- Ensure policies with delivery risks are managed and strengthened so that the intended emission savings occur.
- Convert policy proposals from the Clean Growth Strategy into firm and funded policies.
- Put in place new policies to address the remaining policy gap (65 MtCO₂e to both the fourth and fifth carbon budgets) and to provide contingency in case policies fall short.

In order to have confidence that the carbon budgets will be met, it will be necessary to close the policy gap in advance of the start of the budget periods. This will be necessary given policy lead-times and the need for other companies, consumers and organisations to respond (e.g. the need to develop markets and supply chains).

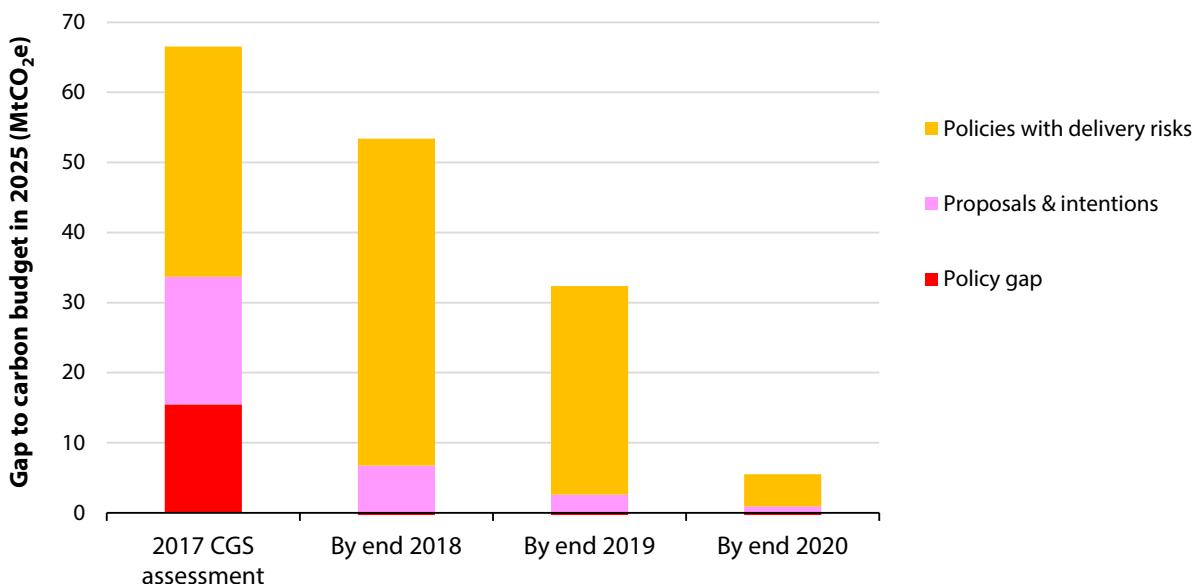
We will monitor on the basis that there should be a full set of firm policies with minimal delivery risks at least two years before the start of the relevant carbon budget period (i.e. by the end of 2020 for the fourth carbon budget and by the end of 2025 for the fifth carbon budget). Delays or under-delivery will require further effort elsewhere. Any new gap resulting from wider economic or other changes would also need to be closed.

The Government has rightly stated that it is not possible to predict the exact technology mix that will deliver the carbon budgets (and later targets). However, in monitoring progress it is important to have a set of specific indicators to monitor against. We will therefore track monitoring indicators and policy milestones:

- **Monitoring indicators.** To support the Government's annual updating of the Clean Growth Strategy the Committee will continue to report progress against defined trajectories for roll-out of low-carbon technologies and behaviours that would meet the carbon budgets on current expectations. We will publish a full set of monitoring indicators in our June 2018 Progress Report to Parliament. This will include the Government's 'Emission Intensity Ratio'.
- **Policy milestones.** The Clean Growth Strategy presents a set of policy milestones, which should lead to a clearer, more defined set of firm policies over time. We have supplemented these with further milestones that are needed:
 - Figures 4.1 and 4.2 show how our assessment of the policy gaps for 2025 and 2030 should evolve over time. Existing policies with delivery risks, policy proposals from the Clean Growth Strategy, and further new policies all need to become low-risk policies.
 - Taking these actions should lead to the gap to the fourth carbon budget being essentially eliminated by the end of 2018 and the delivery risks being very largely removed by the end of 2020 – two years before the budget period starts – so that there can be confidence that this budget will be met (Figure 4.1).
 - It will be necessary to reach the same, or greater, level of confidence regarding the fifth carbon budget by the end of 2025. Policies to fill the gap to the fifth carbon budget should be identified by 2020 and contingency options developed in case of under-delivery in some areas and/or emission projections proving too optimistic.
 - Table 4.1 sets out the main deliverables and their timings. Further details are set out in the sector annexes to this report.

In our annual reports to Parliament we will monitor against the specific milestones for actions to have occurred and also our quantitative assessment of policies, proposals and any remaining policy gap.

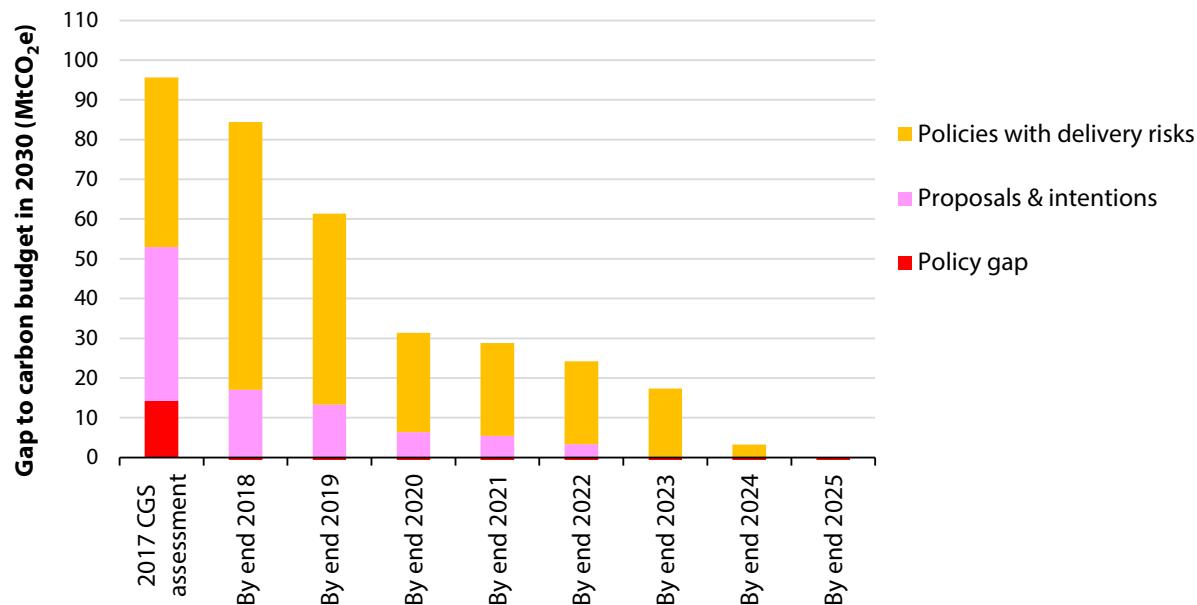
Figure 4.1. Fourth carbon budget: The policy gap in 2025 and how Government policies should develop over time to close this gap (non-traded sector)



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, CCC analysis.

Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the fourth carbon budget can be closed and how current policies, proposals and intentions firmed up so that delivery risks are largely eliminated. This is based on sectoral assessments of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2020. These sectoral assessments are set out in more detail in the supporting technical annex. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period, and the gap to meeting the average annual level of the carbon budget. It reflects actions to close the gap for the non-traded sectors, as it is these emissions that determine whether or not a carbon budget is met. This assessment is based on the government emission projections used in the Clean Growth Strategy. New projections were published in January 2018 (Box 1). These reduced the level of projected future emissions by 3% in 2025, and therefore imply a smaller policy gap to be closed.

Figure 4.2. Fifth carbon budget: The policy gap in 2030 and how Government policies should develop over time to close this gap (non-traded sector)



Source: BEIS (2017) *Updated Energy and Emission Projections 2016*, CCC analysis.

Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the fourth carbon budget can be closed and how current policies, proposals and intentions firmed up so that delivery risks are largely eliminated. This is based on sectoral assessments of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2025. These sectoral assessments are set out in more detail in the supporting technical annex. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period, and the gap to meeting the average annual level of the carbon budget. It reflects actions to close the gap for the non-traded sectors, as it is these emissions that determine whether or not a carbon budget is met. This assessment is based on the government emission projections used in the Clean Growth Strategy. New projections were published in January 2018 (Box 1). These reduced the level of projected future emissions by 3% in 2030, and therefore imply a smaller policy gap to be closed.

Table 4.1. Key milestones and timings

Sector	Key action required	Timing
Power	Continue to contract for low-carbon electricity generation sufficient to meet the fifth carbon budget, beyond the Spring 2019 Contracts for Difference auctions already announced.	2019 onwards
Buildings	Targeted support for lower-carbon heat networks	By 2021
	Extend support for biomethane through the 2020s	By 2021
	Tighten new-build standards including futureproofing for low-carbon heat	By 2020
	Tighten standards for all new-build properties to drive uptake of low-carbon heating in the 2020s	By 2023
Industry	Put in place mechanism to support industrial carbon capture and storage, including storage and transport infrastructure	By 2021
Transport	Set out measures for HGVs to improve logistics, increase eco-driving and fuel saving technologies	2018
Agriculture	Set out policies to deliver emissions reductions through a range of measures including: crop & soil management; livestock diet, health & breeding; waste & manure management; energy efficiency	By 2020
Land-use & forestry	Ensure rate of tree planting is accelerated in a timely manner in order to deliver around 70,000 hectares afforestation in England by 2025	By 2020
Waste	Commitment to ban by 2025 all biodegradable waste streams – including food waste – from entering landfill	By 2020
F-gases	Investigate cost-effective opportunities to reduce emissions beyond the EU F-gas Regulation	By 2019

c) Role for government in driving progress

To facilitate the process for meeting carbon budgets, the Government has reinstated a cross-government Inter-Ministerial group to drive implementation of the Clean Growth Strategy. It has also committed to annual monitoring and updating of the Strategy.

In monitoring progress, we would expect priorities of the Clean Growth Inter-Ministerial Group to include:

- Progress against both the milestones set out in the Clean Growth Strategy and identified in this report (Tables 4.1 and 4.2) and our annual reports to Parliament.
- Latest expectations for emissions reduction from policy areas that are not currently quantified, and expectations for emissions overall.
- Monitoring of delivery risks against existing policy expectations (e.g. see Box 4.2).
- Identification of areas where further progress and emissions reductions are possible should expected progress not be delivered elsewhere.
- Agreement of actions for specific Departments to continue progress or to get back on track.

* * *

The Clean Growth Strategy continues the policy development process broadly as it is intended to work under the Climate Change Act: carbon budgets are proposed, then set, proposals are made as to how they can be met, policies are developed, progress is monitored and government takes corrective action to stay on track as required.

Due to the large gap that already existed to meet the fourth carbon budget and the delays between setting the fifth budget and the publication of the Clean Growth Strategy, the later parts of this process are now heavily condensed, particularly for the fourth carbon budget. The next steps – closing the remaining policy gaps, removing delivery risks and providing detail on new proposals – must be pursued with vigour, urgency and sustained commitment to ensure that further delays do not make the carbon budgets unattainable.

Further detail on the sectoral analysis underpinning this report is set out in separate technical annexes, available at www.theccc.org.uk

Table 4.2. Progress required in key areas to be on track to 2030

Sector	Lead dept	Key outcome required in 2030	Recent progress	Further actions required to keep on track for 2030
Power	BEIS	Emissions intensity of electricity system <100 gCO ₂ /kWh	<ul style="list-style-type: none"> • 25 TWh renewables added 2014-2016 • 70 TWh low-carbon generation contracted for 2017-2025 	<ul style="list-style-type: none"> • £557m Contract for Difference funding could support over 45 TWh of generation • Further 50-70 TWh required to be contracted
Buildings	CLG / BEIS	Around a 20% reduction in emissions below 2016 & develop options for near-zero emissions in 2050: 14% reduction in energy demand for heat A quarter of heat from low-carbon sources by 2030	<p>Progress has stalled:</p> <ul style="list-style-type: none"> • Insulation rates have fallen by 90% since 2012 • Continued low uptake of low-carbon heat 	<ul style="list-style-type: none"> • Policy to incentivise able-to-pay energy efficiency improvements • Support for uptake of low-carbon heat in the 2020s • Tighter low-carbon standards for new build & rented properties
Industry	BEIS	Around a 20% reduction in emissions below 2016 levels through industrial CCS, low-carbon heat, energy efficiency	<ul style="list-style-type: none"> • Emissions fell about 1%/yr between 2009-14 • Up to half of this due to energy efficiency or fuel switching 	<ul style="list-style-type: none"> • Urgently set out an approach to deploy industrial CCS • Set out further policies on low-carbon heat in industry & energy efficiency
Transport	DfT	Around a 44% reduction in emissions below 2016 levels, through stretching standards for new car, van & HGV CO ₂ , modal shift, & improved freight operations	Transport emissions have increased over the past 3 years	Implement more stretching targets than the EU 2030 proposal that deliver high levels of ULEV uptake (e.g. 60% of new sales). Set out policies to encourage modal shift to public transport & improve freight operations
Agriculture	Defra	Reduce emissions from crops, soils and livestock by around 19% below 2015 levels	No progress reducing agriculture emissions over the past 6 years	Publish a new strategy for agriculture & land-use, setting out policies to reduce emissions & sequester carbon
Land use and forestry	Defra	Tree-planting rates to reach 15,000 hectares/yr	Tree-planting rates currently around 6,000 hectares/yr	Develop policies to accelerate the rate of tree planting
Waste	Defra	Stop biodegradable waste to landfill by 2025	Between 2005-15 biodegradable waste sent to landfill fell from 31 million to 9 million tonnes	Go beyond plans set out in the Clean Growth Strategy & phase out all biodegradable waste streams to landfill by 2025
F-gases	Defra	Reduce emissions by at least 68% below 2016 levels	No progress – emissions have been flat since 2010	<ul style="list-style-type: none"> • Implement policy at least in line with EU approach to phase out HFCs • Look for cost-effective opportunities to go further
Cross-cutting	BEIS	Deployment of 1-2 strategic carbon capture and storage (CCS) clusters, to allow deployment at scale in the 2030s	No progress deploying CCS in the UK and backward steps in funding available	Establish plans for separate support mechanisms for CO ₂ capture, and for CO ₂ transport and storage infrastructure



Committee on
Climate Change

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7 Holbein Place
London
SW1W 8NR

www.theccc.org.uk

 @theCCCuk