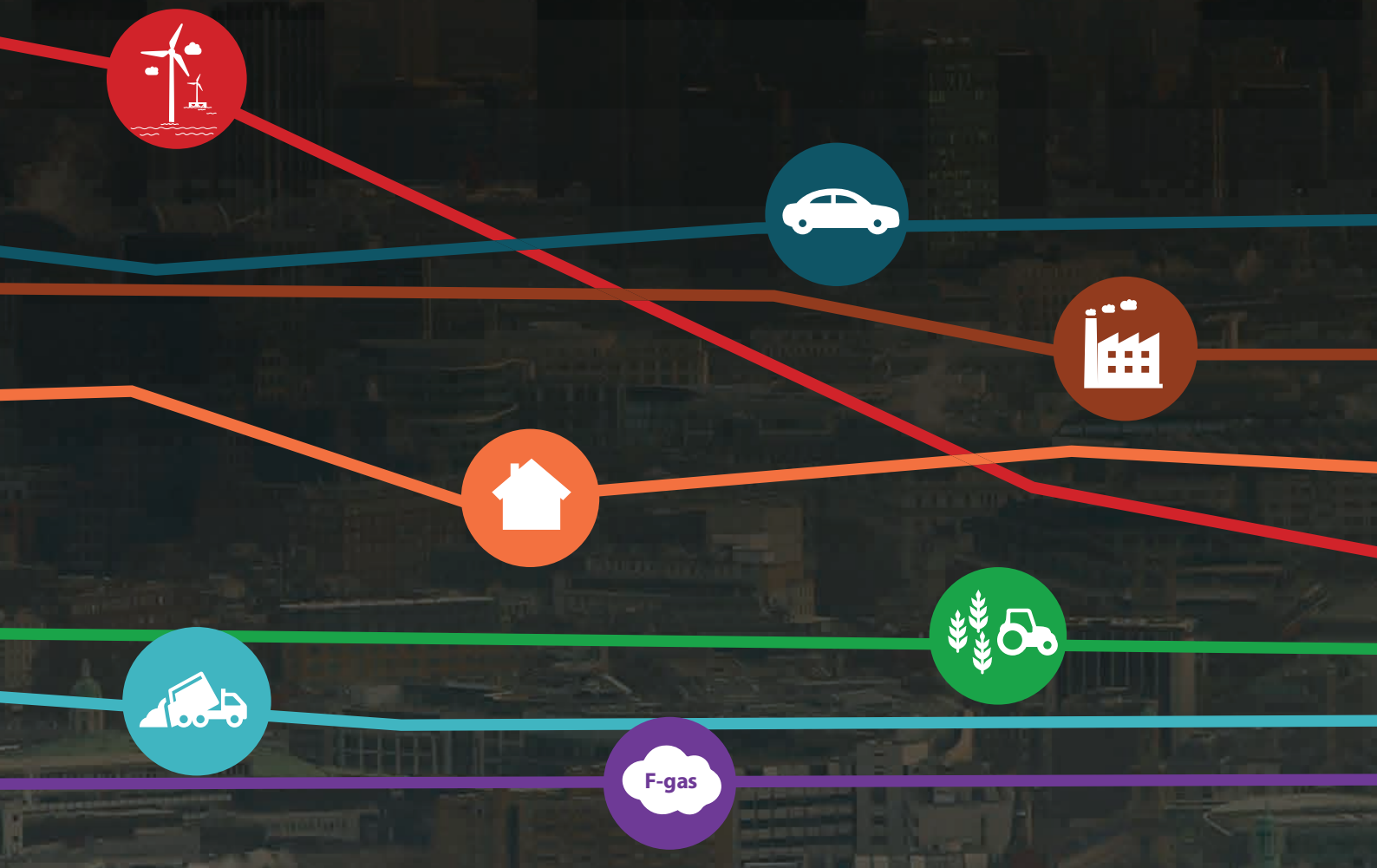
Reducing UK emissions

2018 Progress Report to Parliament

Committee on Climate Change
June 2018



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Foreword

Since 2008, the Committee has become accustomed to an annual cycle of inquiry. Each May and June, we draw together the work of the previous 12 months, assemble the latest evidence, refine our methodology, and produce our best assessment of the recent past and prospects for the future. This discipline has served us well. This annual assessment is our tenth, marking an important milestone in the UK's efforts to reduce emissions under the framework provided by the Climate Change Act.

In this report, the Committee has inevitably looked beyond the previous 12 months to reflect on the achievements of the last ten years. Our annual cycle was also interrupted by the welcome publication of the Government's Clean Growth Strategy, which we considered in January.

Stepping out of the yearly ritual has been revealing. We have reviewed the progress of the last decade and reframed the challenges of the next. It's clear how far we've come.

UK emissions continue to fall and we've seen progress wherever policymakers have been bold enough to make strategic commitments. Since 2008, successive Governments have focused on reducing emissions from electricity generation, just as this Committee recommended they should. Strong UK policies have closed coal plants and supported remarkable increases in renewable generation, accompanied by dramatic reductions in costs, far beyond the level the naysayers said was possible. Emissions from waste are also down 48% since 2008 – an unsung story, the outcome of EU regulation and the UK landfill tax.

We should celebrate this progress, but it masks a worrying trend in other sectors. In this report, we refer to the 'uneven' balance of emissions reduction, a polite way of drawing attention to Government inaction in a host of areas. Our stalwarts, the power sector, have again propped up the 3% fall in overall emissions this year.

This can't go on. In the last five years, emissions outside of power and waste have plateaued. My Committee has chosen this moment to give a strong message to Government: Act now, climate change will not pause while we consider our options. And act in the consumer interest: pursue the low-cost, low-risk options, like onshore wind, and enforce the standards that will reduce emissions from vehicles and buildings, where consumers have been cheated by misleading industry claims.

It is my hope that this report will give ammunition to those battling to give climate change the priority it deserves within government. Cutting emissions from industry, transport and housing requires integrated policy development across Whitehall and throughout the UK. The new prominence given to environmental protection by Defra is heartening, but we need this enthusiasm to stretch into reducing carbon from agriculture and land use, where voluntary measures have failed. It is particularly disappointing that we could not consider the new strategy for road transport, delayed from its planned publication in March. With each delay, we stray further from the cost-effective path to the 2050 target.

At the ten year anniversary of the Climate Change Act, we have reached a critical moment. We must now step beyond the well-trodden path into every sector of the economy. Indecision risks undermining the remarkable successes of the last decade. In 2008, there was a moment of consensus and enthusiasm for bold action on the climate. I now look forward to recapturing that enthusiasm, as we plan the next decade of action.

Lord Deben

Chairman, Committee on Climate Change

Contents

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.

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Baroness Brown of Cambridge DBE FREng FRS (Julia King) is an engineer, with a career spanning senior engineering and leadership roles in industry and academia. She currently serves as Chair of the CCC's Adaptation Sub-Committee; non-executive director of the Offshore Renewable Energy Catapult; member of the WEF Global Agenda Council on Decarbonising Energy and Chair of the Carbon Trust. She was non-executive director of the Green Investment Bank, she led the King Review on decarbonising transport (2008), and she is the UK's Low Carbon Business Ambassador. She is currently supporting the UK offshore wind sector as Sector Champion for the development of the Sector Deal as part of the Government's Industrial Strategy. She is a Fellow of the Royal Academy of Engineering and of the Royal Society, and was awarded DBE for services to higher education and technology. She is a crossbench Peer and a member of the House of Lords European Union Select Committee.

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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).

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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

A decade of progress

This is the Committee on Climate Change's (CCC) tenth statutory Progress Report to Parliament – an important moment to reflect on the UK's achievements in tackling climate change to date. 2018 also marks the tenth year since the Climate Change Act came into force and, with it, the creation of the CCC as an independent statutory adviser.

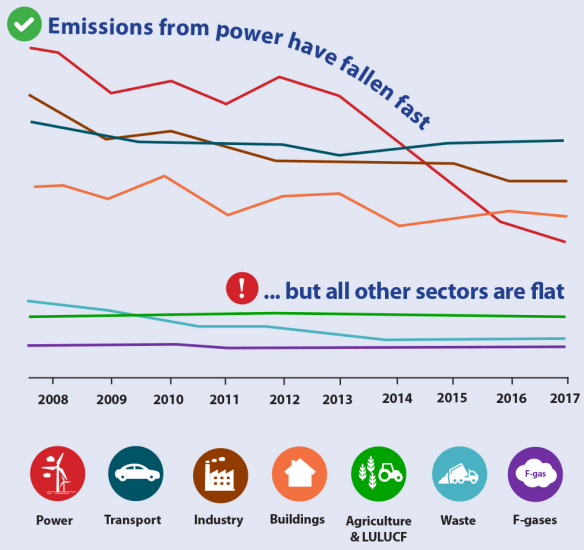
Decarbonising electricity generation is the clear achievement of the last decade – a notable success, in line with the Committee's early recommendations, which will underpin a strategy of shifting progressively from fossil fuels to low-carbon electricity. But progress in the power sector masks a marked failure to decarbonise other sectors. In the last five years, this failure has become more acute, as emissions reductions in these sectors have stalled.

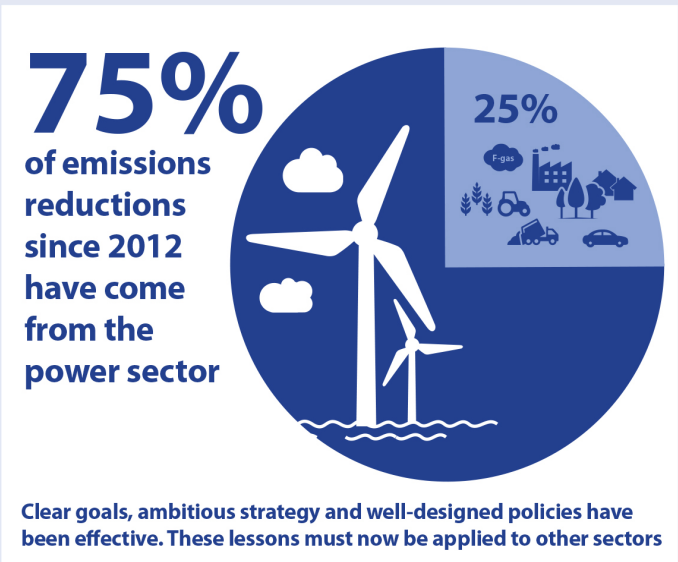
Offshore wind deployment exemplifies how clear goals, an ambitious strategy and well-designed mechanisms, can encourage and enable the market to reduce cost and help to build wider economic co-benefits. These lessons should be applied more broadly – to meet the challenges we highlight in this report in transport, industry, buildings and agriculture. It is in the consumer interest to act early and avoid the need for more costly interventions later. There is also potential for economic advantage, in line with the Government's aim to develop industrial and commercial advantage from emissions reduction.

We now enter a new decade of action to address climate change. So far, the governance framework under the Climate Change Act has worked to deliver overall UK emissions reduction, but a much tougher challenge is presented by the fourth and fifth carbon budgets. The formal request from the UK Government to provide advice on the implications of the Paris Agreement on the UK's long-term emissions targets, announced for later this year, will mark the next phase of the UK's climate leadership.

Excellent progress in reducing emissions from electricity generation masks failure in other sectors

The UK's greenhouse gas emissions have reduced by 43% compared to 1990 levels, on the way to a target of at least an 80% reduction by 2050.





Clear goals, ambitious strategy and well-designed policies have been effective. These lessons must now be applied to other sectors

Messages to Government

The UK is not on course to meet the legally binding fourth and fifth carbon budgets. It will not be on course unless risks to the delivery of existing policies are reduced significantly and until Government brings forward new fully funded policies, beyond the achievements to date on electricity generation and waste.

It is five months since our assessment of the UK Government's Clean Growth Strategy. Over this period, a number of worthwhile commitments have been made, including the recent 'mission' to at least halve the energy use of new buildings in the UK by 2030. But these new announcements do not alter substantively our assessment of the UK's long-term emissions trajectory. The coming period is critical, therefore, in demonstrating that the UK Government's strategy has moved decisively to a new set of priorities.

In this report, we highlight four messages to Government to put emissions reduction on track:

- **Support the simple, low-cost options**

  Low-cost, low-risk options to reduce emissions are not being supported by Government. This penalises the consumer. There is no route to market for cheap onshore wind; withdrawal of incentives has cut home insulation installations to 5% of their 2012 level; woodland creation falls short of stated Government ambition in every part of the UK. Worries over the short-term cost of these options are misguided. The whole-economy cost of meeting the legally binding targets will be higher without cost-effective measures in every sector.

- **Commit to effective regulation and strict enforcement**

  Tougher long-term standards, for construction and vehicle emissions for example, can cut emissions, while driving consumer demand, innovation, and cost reduction. Providing long line of sight to new regulation also reduces the overall economic costs of compliance. Regulations must also be enforced to be effective: the consumer is cheated when their car's fuel consumption and real emissions exceed the quoted test-cycle numbers; or when higher energy bills are locked-in for generations when stated building standards are not enforced.

- **End the chopping and changing of policy**

  A number of important programmes have been cancelled in recent years at short notice, including Zero Carbon Homes and the CCS Commercialisation Programme. This has led to uncertainty, which carries a real cost. A consistent policy environment keeps investor risk low, reduces the cost of capital, provides clear signals to the consumer and gives businesses the confidence to build UK-based supply chains.

- **Act now to keep long-term options open**

  An 80% reduction in emissions has always implied the need for new national infrastructure - to transport and store CO_2 for example, or to provide decarbonised heat. The deeper emissions reductions implied by the Paris Agreement make these developments even more important. We cannot yet define the 2050 systems for carbon capture, zero-carbon transport, hydrogen or electrification of heat, but the Government must now demonstrate it is serious about their future deployment. Key technologies should be pulled through to bring down costs and support the growth of the low-carbon goods and services sector.

We present at the end of this Summary the Committee's expectations of the policy actions and commitments required by the time of our next statutory progress report, in 2019.

Four messages to Government to put emissions reduction on track

Support the simple, low-cost options

Onshore wind and Solar are likely to be **25% cheaper** than new gas plants by the 2020s

see p68

Efficiency in buildings is an obvious practical step. But insulation rates in homes are **95% lower** than they were in 2012

see p85

Tree planting rates are **two-thirds lower** than they need to be

see p202

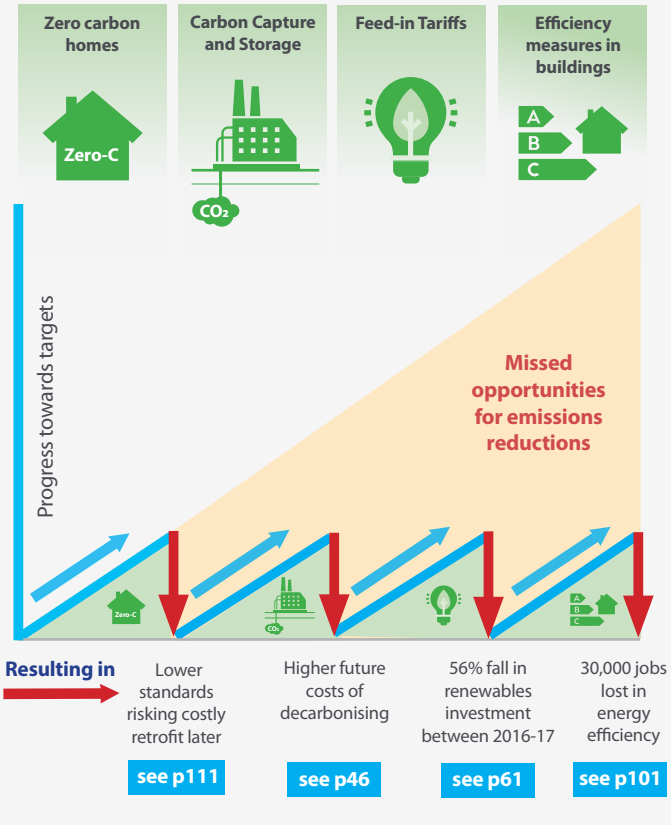
Recycling food waste reduces emissions. By 2025 all **food waste** should be **recycled**

see p211

Failure to pursue these options increases energy bills and adds to the cost of decarbonisation

End the chopping and changing of policy

Recent policies to reduce emissions have been cancelled...



Consistent policies drive investment, cut bills and help to build UK business

Commit to effective regulation and strict enforcement

Poor enforcement and low standards result in…

- Wasted energy !
- Higher bills !
- Higher emissions !

see p105

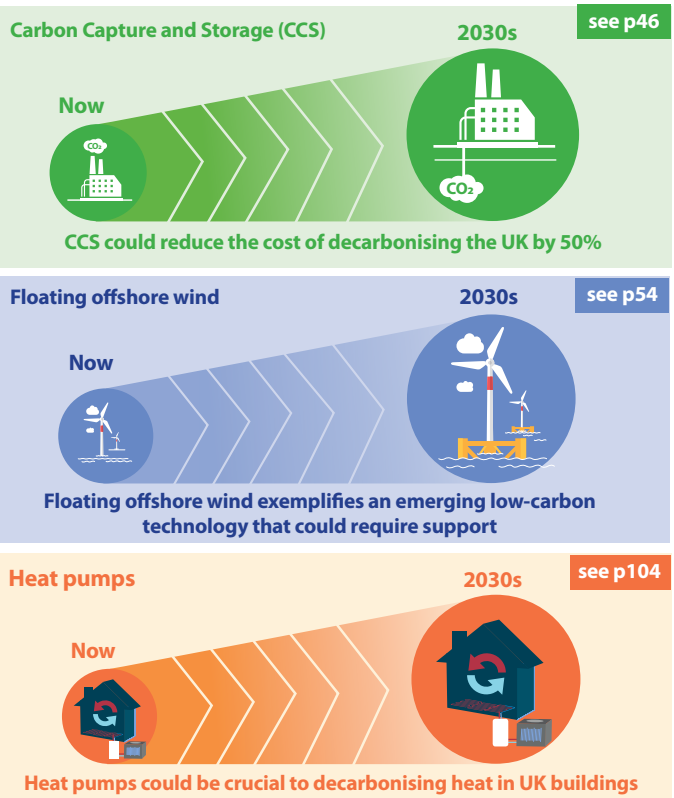
- ! Long EV waiting lists
- ! Higher fuel bills
- ! Worse air quality
- ! Higher emissions

see p164

Ambitious, strictly enforced standards drive innovation and protect consumers from being cheated

Act now to keep long-term options open

Infrastructure requires long-term investment



Further delays will increase costs and reduce options

Continuing evidence of a changing climate

Compelling evidence of a changing climate and the economic cost of inaction led to the broad consensus for the Climate Change Act in 2008. In the decade since, evidence of climate change has continued to accumulate, reinforcing the need for action. In Chapter 1 we summarise the most recent observations.

Evidence of a changing climate is clearer than ever, including in the UK.

Box 1. A changing climate

Evidence of a changing climate is growing across a number of key indicators:

- **Atmospheric CO_2 concentrations.** In recent years, atmospheric CO_2 concentrations have continued to rise and now exceed 400 parts per million.
- **Global average surface temperature.** Human-induced warming, combined with a small and temporary warming contribution from a natural El Niño event, contributed to record-breaking global average surface temperatures in 2015 and 2016. Despite no substantial contributions from natural climate variability, 2017 was in the top three warmest years on record. Global average surface temperatures have consistently exceeded 1°C above pre-industrial levels over the last few years.
- **Arctic sea ice decline.** A substantial and pronounced decline in the extent of Arctic sea ice has been observed over the last decade. Since 1979, September sea-ice extent has declined by on average 13% per decade.
- **Global sea-level rise.** Recent satellite data indicate an increase in the observed rate of global sea-level rise since the 1990s.
- **Climate change in the UK.** Of the top ten warmest years recorded for UK average surface temperature, eight have occurred since 2002. Sea levels around the UK have risen at a rate of around 1.4 mm per year based on the long-term trends in the observational dataset.

UK emissions

UK emissions fell by 3% in 2017. Measured from 1990, emissions have now fallen by 43%, over a period when the economy grew by over 70%. This is the most substantial emissions reduction in the G7, over a period when economic growth was above the G7 average.

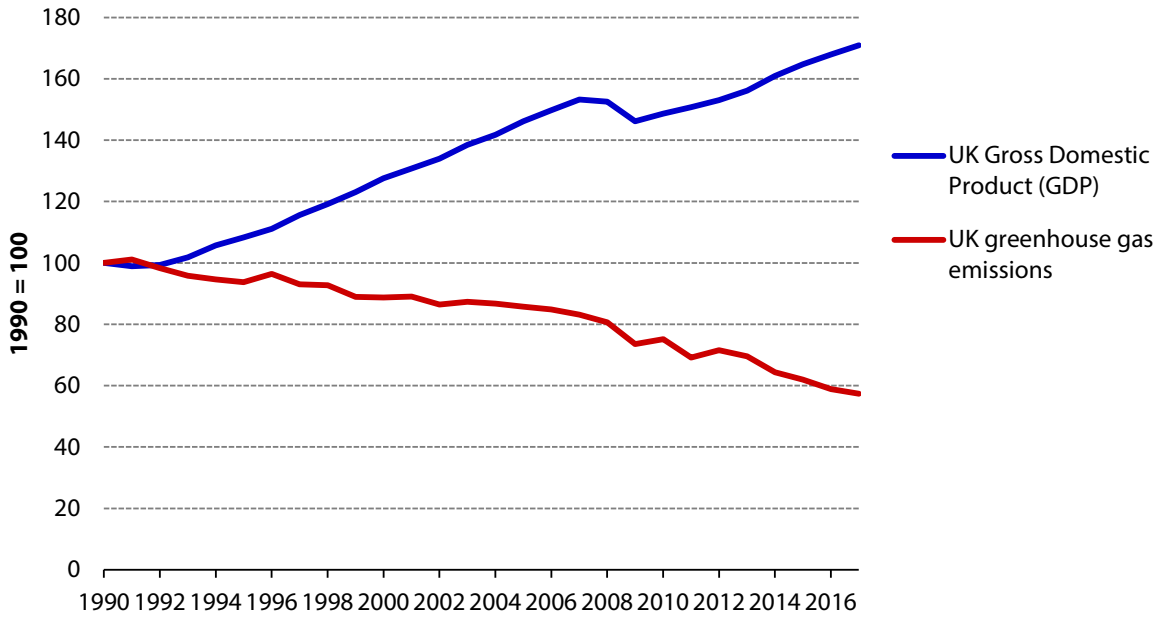
The UK can rightly claim early leadership on decarbonisation and the governance framework to deliver it, but the Government must not be complacent. Market-led developments explain much of the fall since 1990: energy efficiency improvements, a shift from coal to gas in the power sector and a broader shift to less energy-intensive UK industry.

The concerted effort this decade to decarbonise the power sector is the best demonstration of strong UK policies prompting a clear market and technological response. Emissions from electricity generation fell by 59% between 2008 and 2017, while security of supply was maintained and average energy bills fell. In 2017, as in each of the preceding four years, power sector emission reductions were largely responsible for the fall in economy-wide emissions.

As impressive as the achievements in the power sector have been, reducing emissions from electricity generation is one of the simpler challenges for policy. Power is an aggregated sector, involving relatively few commercial players, with centralised UK regulatory policy tools and only a limited requirement for consumers to change their behaviour so far. The UK's continued claim for climate change leadership now rests on continuing the reduction in power sector emissions, while making new commitments at a similar scale in other sectors. These must include laying the foundations for the long-term solutions, such as carbon capture and storage, which are needed to meet the long-term goals of the Climate Change Act and the Paris Agreement.

Other sectors present harder challenges for emissions reduction, with fewer aggregated sectors to aim at and the requirement for policy to drive real changes in consumer behaviour. These issues are not an excuse for inaction. Sufficient evidence of effective policy interventions now exists to support major new commitments to reduce emissions in every sector. We highlight these in each chapter.

Figure 1. Since 1990 UK emissions have fallen 43% while the economy has grown over 70%



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; ONS; CCC calculations.
Notes: Series indexed to start at 100. In 2017 UK GDP was £1.9 trillion and GHG emissions were 456 $MtCO_2e$.

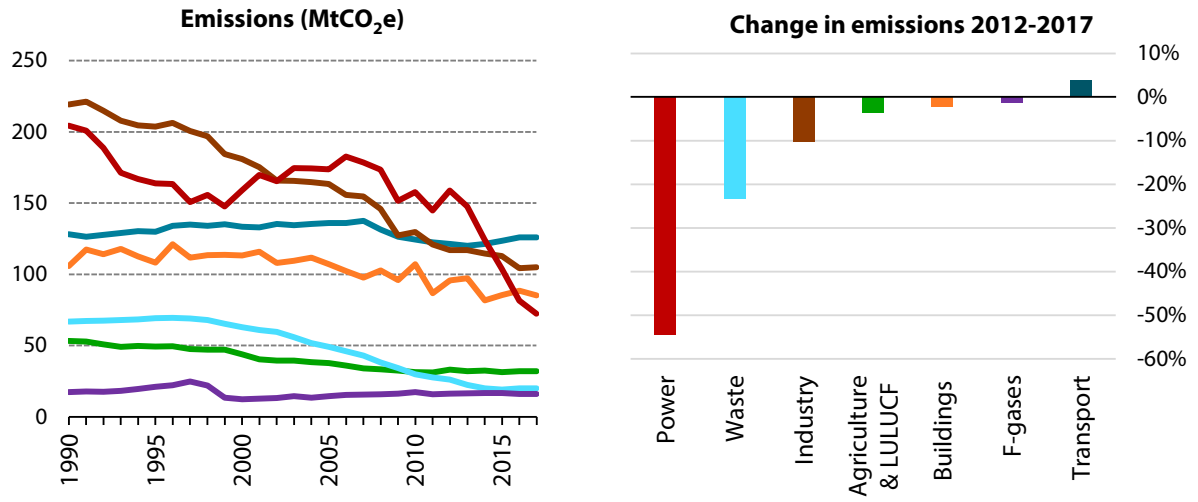
Performance across sectors

Sectoral progress to reduce emissions since 2008 has been uneven. There is a danger that progress in decarbonising electricity is masking a lack of progress elsewhere. The legally binding carbon budgets will only be achieved if effective policy extends beyond waste and power, into sectors that have not so far achieved significant reductions.

The market alone is unlikely to deliver a solution. This year,[1] emissions in the industry, buildings[2] and waste sectors have increased; and emissions in transport and agriculture are flat. Only power and F-gas emissions have fallen. This is now an acute concern - progress in the last five years has effectively stalled.

Over the past ten years, as emissions in power and industry have reduced, transport has become the largest emitting sector of the UK economy, accounting for 28% of UK greenhouse gas (GHG) emissions in 2017.

Figure 2. Emissions reductions have been focused in the power and waste sectors



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*.
Notes: The chart on the right-hand side shows changes in sectoral emissions between 2012 and 2017; buildings emissions in this chart are temperature-adjusted. 2017 emissions are provisional estimates and assume no change in non-CO_2 emissions from 2016.

Policy implementation

The Committee has made an independent assessment of the cost-effective path to long-term emissions reduction. We have also considered the extent to which policy will deliver reduced emissions.

In October 2017, the UK Government launched the Clean Growth Strategy (CGS), fulfilling its legal obligation to set out policies and proposals to enable the carbon budgets set by Parliament to be met. In our January assessment of the CGS, we commended its ambition, but found few new specific policies to deliver real emissions reduction. We emphasised the need to progress urgently with policies to deliver on the ambition of the Strategy.

There is still little detail on the policies that will deliver the ambitions of the CGS. The Committee has not, therefore, changed its summary assessment of the impact of the Strategy. We are particularly disappointed that the key road transport strategy from the Department for Transport, 'Road to Zero', has been delayed from its planned March publication. We will comment separately on this strategy when we have seen the detail of the Government's plans.

[1] 2017 for power, buildings, industry and transport; 2016 for agriculture, waste and F-gases.
[2] On a temperature-adjusted basis.

Box 2. The CGS and recent policy announcements

With the Clean Growth Strategy, the Government set out its intention to meet the fifth carbon budget through domestic efforts, and introduced new ambitions in several areas. The Strategy's higher-level proposals and intentions have the potential to provide reductions in emissions that could contribute strongly to meeting the fourth and fifth carbon budgets, if delivered in full:

- 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.

Detailed new policies were few, however, and will lead to only modest emissions savings.

As we emphasised in our assessment of the Strategy in January this year, it is a matter of urgency to follow up the high-level statements of intent with more detailed policies, to provide confidence that they deliver the Government's ambitions and provide the necessary reductions in emissions.

Since January, there have been some developments such as publication of the main features of the Heat Networks Investment Project scheme and the refocusing of the Renewable Heat Incentive. In the Committee's view, their scope does not move the policy framework substantially from where it stood at the beginning of the year.

The Department for Transport's road transport strategy 'Road to Zero' was a key milestone expected by March 2018. The strategy was not published in time for it to be reflected in this report to Parliament.

The fourth carbon budget will provide a much tougher test of the UK's commitment than the first three carbon budgets. Robust, fully funded, low-risk policies are required with sufficient lead-in time for the market to respond. On this basis, the UK is not on course to meet the legally binding fourth (2023-2027) and fifth (2028-2032) carbon budgets.

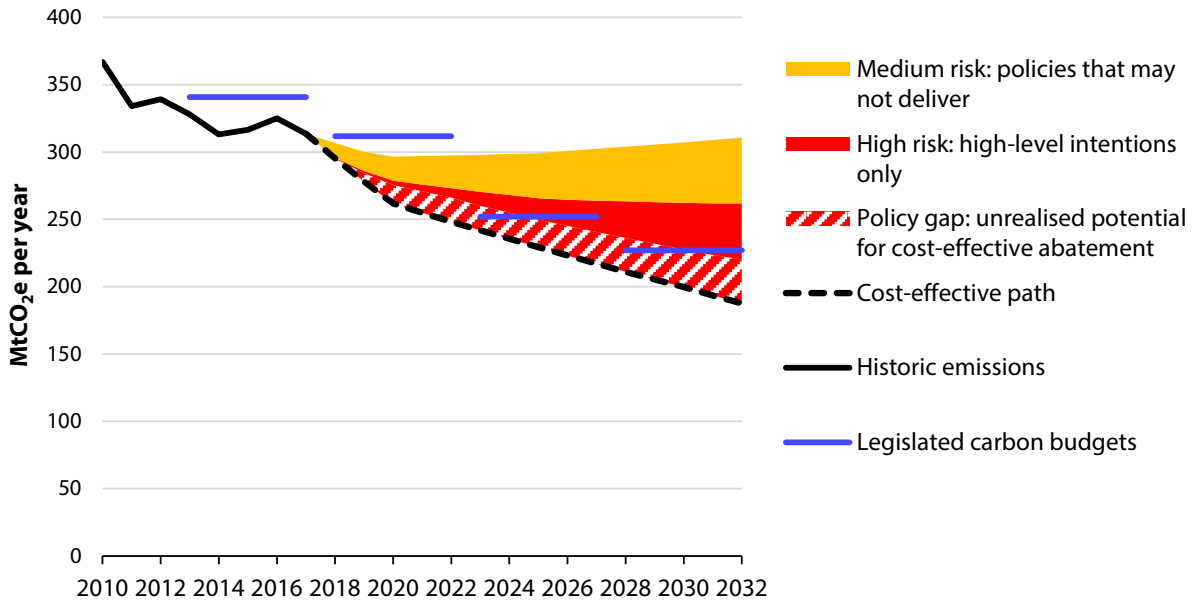
Risks to existing policy commitments continue to be too high - on car fuel efficiency, for example, or on reducing emissions from agriculture and F-gases. Government should act to reduce these risks and put in place contingency plans in case major infrastructure projects, like new nuclear plants, are delayed or cancelled. New policies to flesh out the ambitions presented in the Clean Growth Strategy are also required to address the sectoral imbalance in emissions reduction.

Low-cost opportunities to reduce emissions are also being missed - often in areas of proven technology and established markets. These include the continued failure to provide a route to market for onshore wind, effective incentives for home insulation to improve the energy efficiency of buildings, abatement measures in agriculture (which the voluntary approach is failing to realise), and more tree planting.

Taking actions in all of these areas could enable the cost-effective path to 2050 to be met. Revisions to our analysis and changes in the baseline mean that the best estimate of the cost-effective path has now dropped beneath the level of emissions required to meet the fourth and fifth carbon budgets. Aiming for this lower path still makes sense.

The cost-effective path reflects the adoption of low-cost measures and those required to deliver the deep reductions in the longer-term. Overshooting the carbon budgets would also provide a measure of contingency for failure of policy to deliver fully in some areas, or for future revisions in projected baseline emissions. It would also support the aims of the Paris Agreement, to which the Government is committed, to pursue efforts to limit global temperature rise to 1.5°C.

Figure 3. Risks remain around delivery of policies to meet the fourth and fifth carbon budgets



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final 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 the latest Government emissions projections published in January 2018. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path - this path outperforms carbon budgets, so not all this gap would need to be filled to meet the legislated budgets, but would provide a contingency and/or contribute to meeting longer-term targets.

The coming year

This Progress Report is a necessary staging post between the setting of a new UK-wide strategy, the Clean Growth Strategy, and the delivery of real commitments under that new framework. By the time of our next statutory Progress Report in July 2019, the Committee's expectation is that the Government will have begun introducing credible new policies in the areas set out in Table 1 – helping to close the policy gaps and reduce the policy risks that we identify in each of the sectors in the following chapters.

A fully fleshed-out programme of policy from Government is now required, one that takes the UK decisively into committed emissions reduction programmes in the key sectoral priority areas for the next decade: road transport; land use and agriculture; carbon capture and storage; and improved energy efficiency and low-carbon heat in buildings. Failing to do so will set the UK on a path to miss its legally binding carbon budgets and store up unnecessary costs for the future.

Box 3. Sharing best practice from around the UK

Chapter 9 provides a progress update on emissions reduction in Wales, Scotland and Northern Ireland. There are notable commitments by the devolved administrations and city regions in a number of important areas. These include the new 'Energy Efficient Scotland: Route Map'; London's Ultra Low Emission Zone and Zero Carbon Homes commitments; and Wales's targets to halve food waste by 2025 and generate 70% of its electricity from renewable sources by 2030.

The Scottish Government has also laid a new, more ambitious, Climate Change Bill in Parliament. The Welsh Government will set statutory targets for emissions reduction this year.

These developments demonstrate the benefits of a shared focus on climate change at every level of government in the UK. We highlight these developments throughout this report. They should act as an example and an additional incentive to UK-wide policymakers to deliver on, and in some cases raise, their ambition. They also illustrate the growing complexity of creating an integrated UK-wide position in some sectors, requiring a mix of national, devolved and local policies. This is an area in which the Committee also hopes to strengthen in its programme of work over the coming years.

This year the impact of EU Exit is expected to become clearer. This is an important moment to ensure that the UK legal framework over climate change is at least as strong as that provided under EU membership. Priorities for the Committee's consideration are the future of carbon trading, currently under the EU ETS, maintaining and improving product standards to drive energy efficiency, and measures to improve agriculture's climate contribution after the Common Agricultural Policy.

This year will also be a critical demonstration of the Government's willingness to translate the Paris Agreement into domestic action. Claire Perry, Minister of State for Energy and Clean Growth, has announced that she will ask the Committee to provide new advice on the implications of the 2015 Paris Agreement for the UK's long-term targets to reduce greenhouse gas emissions. We will welcome this request, delivering one of our recommendations from our recent assessment of the Clean Growth Strategy. We also look forward to the publication of the Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change in the autumn.

Already, a central theme of our advice on the Paris Agreement is clear, however. Acting with greater urgency now will reduce long-term costs and keep options open for the future. As

testament to this, our latest analysis demonstrates that lower carbon intensity in generation of electricity, to below 100 gCO_2 per kWh, is now possible at a similar cost to the consumer as alternative, higher carbon intensity pathways. This has been achieved by supporting deployment at scale, with well-designed policy to reduce cost. We can expect similar progress in other sectors where there is the same willingness to act with urgency and ambition.

Government must not wait, therefore, for new long-term targets to prompt more ambitious short-term action. The lesson of the successful power sector strategy of the last ten years is that acting early and decisively opens new pathways to even cheaper decarbonisation overall. A decade on since the Climate Change Act, the UK is much admired globally for its climate governance and progress to date. To retain global leadership in the next decade, we now need new action at home.

Table 1. Milestones for the coming year		
Sector	**Action**	**Timing**
Power	Provide a long-term view of future low-carbon power auctions and continue to run auctions beyond the Spring 2019 Contract-for-Difference auction. These should be sufficient to reach an emissions intensity below 100 gCO_2/kWh by 2030, including a route to market for the cheapest forms of low-carbon generation (i.e. onshore wind and solar).	Spring 2019 onwards
Buildings	Publish concrete policies to deliver the Government's ambition on retrofit (EPC band C by 2035) - including firm policies for able-to-pay (ATP) homeowners and a delivery mechanism for the social housing minimum standards.	2018
	Address major delivery risks around the Private Rented Sector (PRS) regulations - in particular, the exemptions capping landlord contributions which severely limit the scope and impact - and set out a trajectory for tightening to EPC band C by 2030.	Risks to be addressed in 2018; longer-term framework in 2019
	Strengthen new-build standards to ensure they are designed for a changing climate, are future-proofed for low-carbon heating and deliver high levels of energy efficiency.	Consultation in 2018 and standard announced in 2019
	Strengthen compliance and enforcement framework so that it is outcomes-based, places risk with those able to control it, provides transparent information and a clear audit trail, with effective oversight and sanctions.	First half of 2019
	Set out concrete policies to deliver the ambition on non-residential buildings, and address existing policy risks including tightening non-domestic PRS regulations.	2018
	Establish support framework for heat pumps and biomethane post-2021, as well as support for low-carbon technologies in heat networks. Re-balance subsidies for heat pumps and other capital-intensive technologies towards a capital grant, in line with international best practice.	Decision on RHI successor in 2018
Industry	Make the ambition to improve business energy efficiency by 20% into specific, concrete and measurable policies with clear timings and outcomes, showing how the projected savings add up to 20% and any assumptions on fuel shares.	Summer 2018
	Confirm funding and start implementation of the Industrial Energy Efficiency Scheme.	2018
	Publish (a) additional milestones on the timeline for the 'framework to support industrial decarbonisation', including for consulting on the framework (b) a call for evidence on the potential options for a mechanism to support investment in industrial decarbonisation.	2018

Table 1. Milestones for the coming year		
Sector	**Action**	**Timing**
	Set out plans for ensuring a continued carbon price in the UK, in the case that the UK leaves the EU ETS.	Spring 2019
Carbon Capture and Storage (CCS)	Publish the CCS Deployment Pathway, and the review of CCS delivery and investment models, consistent with having the first CCS cluster operational by 2026.	Deployment Pathway by end of 2018
Transport	Clarify the UK regulatory approach to the EU 2020/21 new car and van CO_2 targets.	First half of 2019
	Set stretching CO_2 targets for new cars and vans beyond 2020, requiring a high electric vehicle market share. A real-world testing regime must be used alongside standardised tests.	First half of 2019
	Implement policies, including fiscal instruments, to strengthen incentives to purchase cleaner vehicles. Current purchasing trends are undermining new car and van emissions targets and must be reversed.	2018
	Set stretching targets for CO_2 emissions reductions from new HGVs to address the rise in emissions and exploit opportunities to improve logistics and increase uptake of eco-driving.	First half of 2019
	Publish a plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set (i.e. around 2005 levels in 2050, implying around a 60% potential increase in demand), supported by strong international policies.	First half of 2019
Agriculture	Replace voluntary industry-led framework, which has so far failed to meet emissions targets in England, Wales or Scotland, with a stronger framework to deliver GHG abatement to take effect from 2019.	Early 2019
	Allocate the £90m Industrial Strategy Challenge Fund to projects that deliver GHG emissions reduction in addition to Government's other stated objectives, demonstrating action prior to the introduction of a post-CAP framework.	2018
	Set out in the 2018 Agriculture Bill a post-CAP framework that links financial support to agricultural emissions reduction and increased carbon sequestration, to take effect from 2022.	2018
Land use, land-use change and forestry	Act on the commitment to plant 11 million trees in England between 2017 and 2022 (equivalent to over 2,000 hectares per annum). Remove non-financial barriers to rapid afforestation.	2018
Waste	Set out in the new Waste and Resource Strategy a commitment to ban the landfilling of most bio-degradable waste streams including food by 2025 at the very latest.	2018
F-gases	Publish a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives.	Spring 2019

Chapter 1: Economy-wide progress

Key messages and recommendations

This Progress Report sets out our view, as required under the Climate Change Act, on progress towards meeting the statutory carbon budgets and the 2050 target to reduce emissions by at least 80% compared to 1990 levels. It assesses the policy risks around delivering these targets and identifies key priorities for the Government to address to ensure progress is on track to meet the fourth and fifth carbon budgets.

Our key messages for the economy as a whole are:

- **UK greenhouse gas emissions fell 3% in 2017 but progress was very unbalanced.** As in the preceding four years, most of the reduction in emissions came from electricity generation, but this masks a marked failure to decarbonise other sectors. In the last five years, this failure has become more acute, as emissions reductions in these sectors have stalled.
- **The UK is not on course to meet the legally binding fourth and fifth carbon budgets.** It will not be on course unless risks to the delivery of existing policies are reduced significantly and until Government brings forward new fully funded policies, beyond the achievements to date in electricity generation and waste.
  - **Policies with delivery risks.** At the economy-wide level, two-thirds (75 $MtCO_2e$) of potential emissions reductions from existing policies are at risk of under-delivery in 2030. These include savings from the delivery of low-carbon electricity generation and a wide range of policies potentially impacted by exiting the EU (e.g. energy efficiency standards for products, new vehicle fuel-efficiency standards, F-gas emissions reduction, and the EU Emissions Trading System). It is essential that the risks in these areas are addressed and the associated emissions reductions are delivered in full.
  - **Specific policies to deliver on Government proposals and intentions.** The Clean Growth Strategy included a range of ambitious proposals, including phasing out the sale of conventional cars and vans by 2040, upgrading the residential building stock to EPC band C by 2035, and improving business energy efficiency by at least 20% by 2030. We estimate that these could provide around a quarter (50 $MtCO_2e$) of the emissions reduction required in 2030 to meet the cost-effective path. These proposals and intentions urgently need to be turned into robust, fully funded low-risk policies.
  - **The Government should develop policies in areas of unrealised cost-effective potential. We identify that there are cost-effective opportunities to further reduce emissions**, for example a route to market for the cheapest forms of low-carbon electricity generation (i.e. onshore wind and solar), deployment of heat pumps in new build homes in the second half of the 2020s, and abatement measures in agriculture which the voluntary approach is failing to realise. Delivering emission savings in line with the cost-effective path would provide contingency for meeting carbon budgets (e.g. against delivery risks), would allow the UK to prepare for reductions beyond 80% that will be required under the Paris Agreement, and help ensure targets are met at the lowest cost.
- **Government must act now to prepare for deeper long-term emission reductions.** The legislated 2050 target for a reduction of at least 80% and the deeper emissions reductions implied by the Paris Agreement require us to prepare in earnest to achieve them. We cannot yet define the 2050 systems for carbon capture, zero-carbon transport, hydrogen or electrification of heat, but the Government must now demonstrate it is serious about future deployment. The actions required include both sector-specific and cross-cutting areas like CCS, greenhouse gas removal, and the appropriate use of sustainable bioenergy (Table 1.1).

Key messages and recommendations

Table 1.1. Key cross-cutting actions required to prepare for long-term emission reduction targets

Policy area	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/timing
Set out a clear, funded approach to deployment of carbon capture and storage (CCS) at scale. The new approach will require a programme of CCS deployment, with an initial cluster operational by 2026 and reaching 10 $MtCO_2$ per annum in 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. It should cover both energy generation and industry, with separate approaches to CO_2 capture, a new funding mechanism for industrial CCS and some sharing of risks across parties, especially where these reflect future policy uncertainty.		×	×	Deployment Pathway and review of investment and delivery models published by end 2018, and support for initial CCS deployment implemented by end 2021
An updated strategy for increasing the supply of sustainable bioenergy feedstock and using it effectively. This is important for reducing emissions where there are limited alternative options. The use of sustainable bioenergy in conjunction with CCS has the potential to remove greenhouse gases from the air. The Government's previous plans were published in 2012 and should be updated.		×		Strategy in 2019
A strategy for developing options for removing greenhouse gases from the air, alongside innovation in hard-to-treat sectors. Greenhouse gas removal (GGR) options will be needed alongside widespread emissions reductions to meet the 2050 target and beyond to achieve the long-term temperature goal of the Paris Agreement. In the Clean Growth Strategy the Government committed to developing a strategic approach to GGR technologies. Such a strategy should include: support for research, development and demonstration; support for deployment; integration into policy and accounting frameworks.		×		Strategy accompanying decision on long-term targets following CCC advice in 2019

Introduction

In this chapter we review performance in reducing emissions across the economy as a whole. We assess whether current government policies are on track to meeting carbon budgets and the 2050 target, and identify any new actions and policies that are required. We also assess developments in climate science and international progress in tackling climate change.

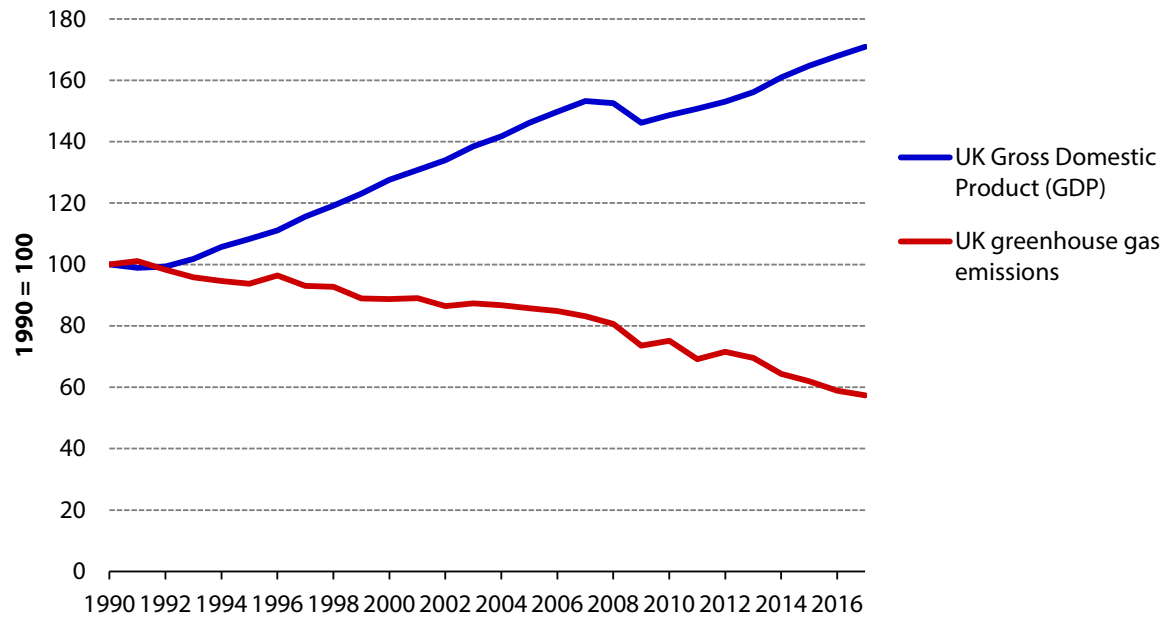
We set out the analysis that underpins our key messages and recommendations in the following four sections:

1. Economy-wide performance in reducing emissions
2. Meeting the fourth and fifth carbon budgets
3. Preparing for 2050
4. Developments in climate science and international progress in tackling climate change

1. Economy-wide performance in reducing emissions

UK greenhouse gas (GHG) emissions fell 3% in 2017 to 456 $MtCO_2e$ and have fallen 43% since 1990. Over the same period, the economy has grown by over 70% (Figure 1.1). Allowing for differences in temperatures between 2016 and 2017, emissions fell by slightly less, by 2% overall.

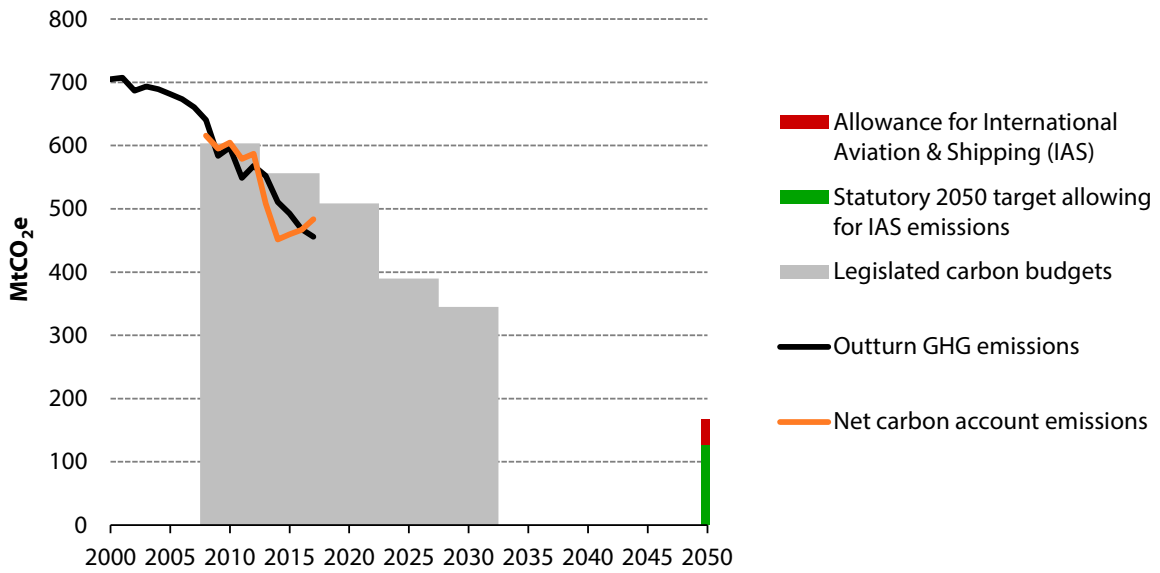
Figure 1.1. UK greenhouse gas emissions compared to GDP (1990-2017)



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; ONS (2018) *Gross Domestic Product: chained volume measures: Seasonally adjusted £m*; CCC calculations.
Notes: Series indexed to start at 100. In 2017 UK GDP was £1.9 trillion and GHG emissions were 456 $MtCO_2e$.

Under the Climate Change Act, performance against carbon budgets is measured not by actual emissions but by the 'net carbon account'. This allows for international trading of carbon permits, particularly in those sectors (i.e. power and industry) covered by the EU Emissions Trading System (EU ETS). We estimate that net carbon account emissions rose by 4% in 2017 to 484 $MtCO_2e$ (Figure 1.2). However, this rise is a result of changes in the allocation of EU ETS allowances rather than reflecting a real increase in emissions. Conversely, actual UK emissions covered by the EU ETS fell. Outside of sectors covered by the EU ETS, emissions were flat (Box 1.1).

Figure 1.2. UK GHG emissions compared to legislated carbon budgets and the 2050 target (2000-2050)



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; CCC calculations.
Notes: GHG emissions are shown on a total (gross) basis, while carbon budgets represent the emissions under the net carbon account; IAS stands for International Aviation and Shipping.

Box 1.1. The net carbon account

Under the Climate Change Act, performance against carbon budgets is measured not by actual emissions but by the 'net carbon account'. This is calculated by adding:

- The allowances allocated to the UK through the EU Emissions Trading System (EU ETS) and;
- Actual emissions from sources outside the EU ETS (i.e. the 'non-traded sector').

The net carbon account will differ from actual UK emissions as those sources of emissions covered by the EU ETS (i.e. the 'traded sector') typically will not equal the UK's share of the EU ETS emissions cap. For example, power sector emissions are covered by the EU ETS. So while actual power sector emissions have been decreasing in recent years, this reduction is not counted towards the net carbon account. Instead, it is the UK's share of EU ETS allowances that is counted.

Box 1.1. The net carbon account

The UK's share of EU ETS allowances consists of the free emission allowances allocated directly to UK installations, allowances allocated to the UK Government for auction, and an estimate of allowances allocated to new UK entrants to the EU ETS.

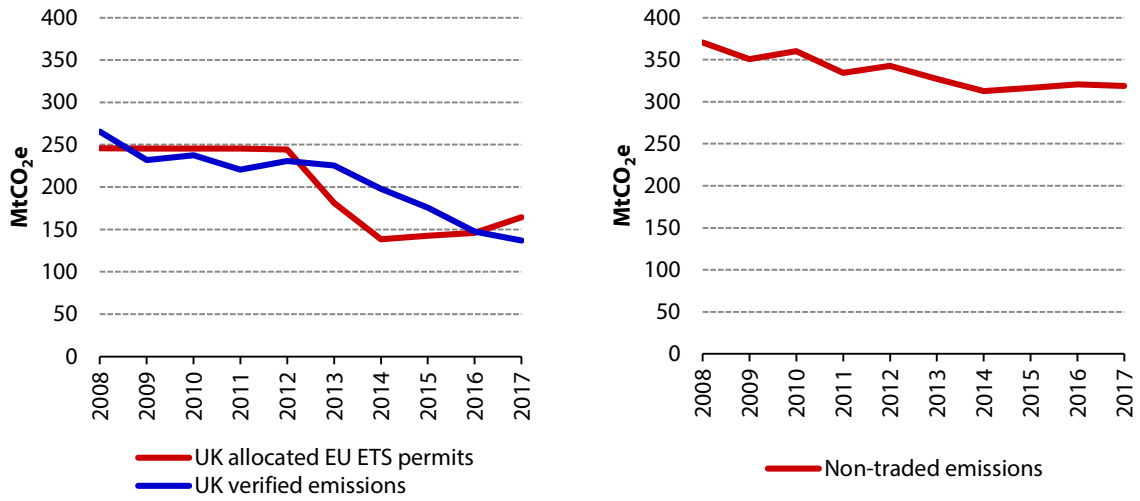
For 2017, we estimate the net carbon account was 484 $MtCO_2e$ (Figure B1.1):

- We estimate that the UK share of the EU ETS cap was 166 $MtCO_2e$.
- Non-traded emissions were 317 $MtCO_2e$.

Net carbon account emissions rose by 4% in 2017. Non-traded sector emissions were flat, meaning that this rise can be attributed to an increase in EU ETS allowances allocated to the UK (Figure B1.1). Specifically, the increase in the UK's EU ETS allocation was down to the 'backloading' policy agreed at EU-level. This policy withheld allowances from auctioning over the period 2014-16, returning to previously expected levels in 2017. So while 2017 allocations were not higher than expected, the effect of the 'backloading' policy has been to temporarily distort annual comparisons.

Given the vote to leave the EU, the UK's future role in the EU ETS is uncertain. If the UK were to no longer participate in the EU ETS then this would have implications for carbon budget accounting. We will provide further advice on this issue once there is clarity on the future arrangements.

Figure B1.1. UK GHG emissions in traded (left) and non-traded sectors (right)



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; European Environment Agency EU ETS data viewer; CCC calculations.
Notes: GHG emissions are shown on a total (gross) basis, while carbon budgets represent the emissions under the net carbon account; IAS stands for International Aviation and Shipping.

As in each of the preceding four years, the largest reduction in emissions in 2017 was in the power sector (Figure 1.3). Emissions in other sectors were flat (e.g. transport) or rose (e.g. temperature-adjusted buildings emissions) (Figure 1.4):

- Power sector emissions fell by 12%. Whilst this shows sustained progress in the power sector, the reduction is smaller compared to previous years, reflecting diminishing potential from phasing out coal generation.
- Emissions in transport remained constant compared to 2016; the transport sector now accounts for the largest share of UK GHG emissions (28%).
- Buildings emissions fell by 4% due to higher winter temperatures. However, when taking into account the effect of differences in winter temperatures to allow a like-for-like comparison, we estimate that buildings emissions actually increased by 1%.

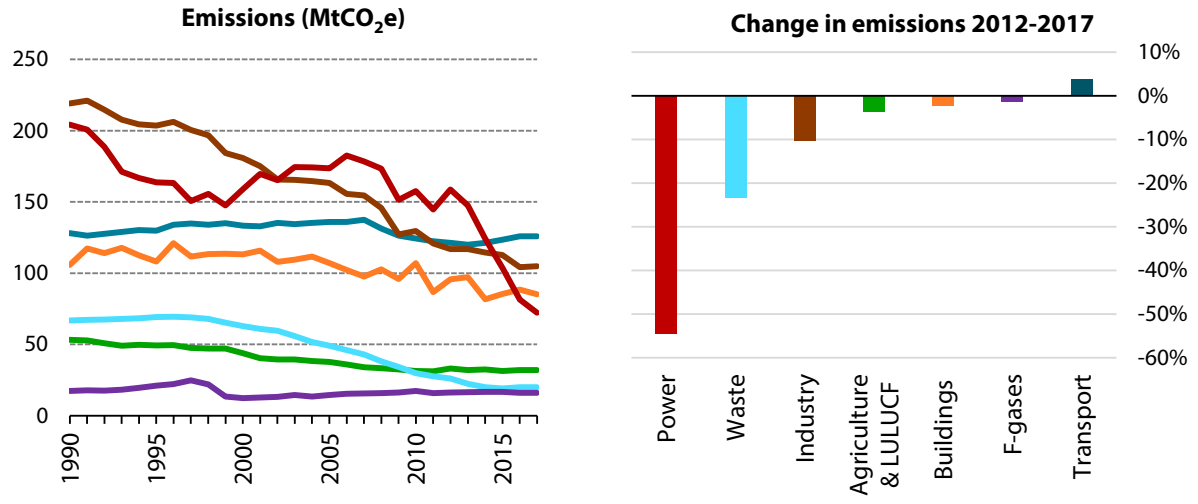
Meeting carbon budgets and preparing for 2050 will require significant progress beyond the power sector:

- The fourth and fifth carbon budgets require reductions of 51% by 2025 and 57% by 2030, relative to 1990. That implies reductions of around 10 $MtCO_2e$ every year.
- Emissions in the power sector have fallen by over 86 $MtCO_2e$ (55%) since 2012; this has contributed over 75% of the total UK reductions over that period. In the future, if all remaining coal generation was replaced by low-carbon generation, overall emissions would only fall by another 20 $MtCO_2e$ to 67% below 2012 levels. Reductions in other sectors will be required in order to meet carbon budgets.
- The waste sector has been a significant contributor to recent reductions, with emissions down 6 $MtCO_2e$ (23%) since 2012 and 47 $MtCO_2e$ (70%) since 1990. However, estimated emissions from the waste sector rose by 5% in 2016, the latest year for which figures are available, due to a reduction in the amount of methane flared at landfill.
- A 3% reduction in emissions per year is required from all other sectors, compared to 1% on average since 2012.

Economy-wide emissions have fallen rapidly whilst the economy has grown. This will not be continued without extending progress to sectors where emissions are currently increasing or staying constant.

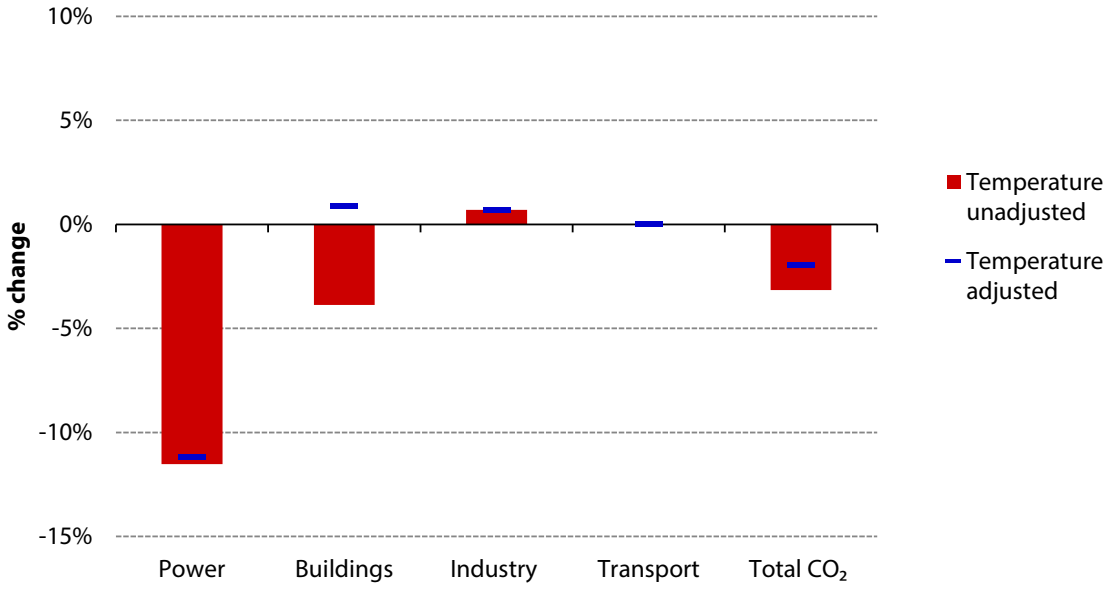
Further action to reduce UK emissions - combined with actions to reduce emissions globally through the Paris Agreement - will also reduce the emissions embodied in UK consumption (Box 1.2).

Figure 1.3. Trends in UK sectoral GHG emissions



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; CCC calculations.
Notes: The chart on the right-hand side shows changes in sectoral emissions between 2012 and 2017; buildings emissions in this chart are temperature-adjusted. 2017 emissions are provisional estimates and assume no change in non-CO_2 emissions from 2016.

Figure 1.4. Change in UK CO_2 emissions between 2016 and 2017



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; CCC calculations.
Notes: CO_2 emissions factors used for temperature adjustment are based on energy use statistics, as published in BEIS Energy Trends. Emissions for Industry and Transport are not temperature-adjusted.

Box 1.2. Consumption-based UK emissions

The internationally agreed standard for reporting greenhouse gas emissions to the UN covers emissions from activities within the UK. This approach does not include emissions embedded in the goods and services the UK imports, nor exclude those in exports; therefore it is not a good indicator of emissions related to final consumption in the UK.

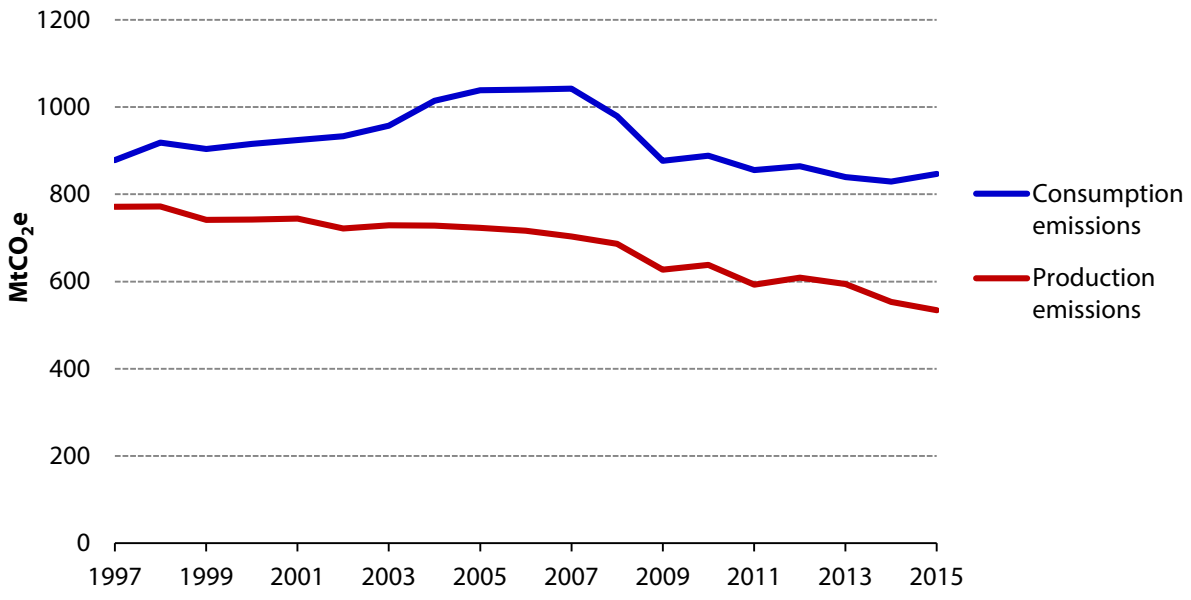
Consumption-based emissions estimates are calculated by taking production estimates, adding emissions associated with imports and subtracting emissions due to exports.

The Department for Environment, Food and Rural Affairs (Defra) publishes estimates of the UK's consumption-based emissions (Figure B1.2). Consumption-based estimates have higher uncertainty than production estimates, because they include estimated emissions from the whole supply chain of imported goods.

Comparing UK production and consumption-based emissions shows that more action is needed in the UK and globally to reduce these emissions:

- UK emissions measured on a consumption basis are higher than on a production basis. For instance, in 2015 (the most recent available data) they were 13 tCO_2e per person compared to 8 tCO_2e on a production basis.
- UK consumption emissions were rising before the financial crisis, but fell 16% between 2007 and 2009. Since then they have only decreased by a further 3%. In comparison, production emissions have fallen by 15% over the same period.
- A combination of UK and global action, as envisaged in the Paris Agreement, is required to cut both UK production and consumption emissions in the future.

Figure B1.2. UK GHG emissions on a consumption and production basis (1997-2015)



Source: Defra (2018) *UK's Carbon Footprint 1997-2015*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures.*
Notes: The chart covers the period 1997-2015 for which UK emissions measured on a consumption basis are available. It includes emissions from international aviation and shipping.

2. Meeting the fourth and fifth carbon budgets

The fourth and fifth carbon budgets (covering the period 2023-27 and 2028-32) require, respectively, 51% and 57% reductions compared to 1990 levels.[3]

Our advice on the fifth carbon budget set out the actions required across the economy to meet the budgets. The measures we have identified that would enable the fourth and fifth carbon budgets to be met include:

- **Electricity generation.** Contracts for difference **(**CfD) for a further 45-60 TWh of low-carbon electricity generation, in addition to the remaining CfD funding so that the power system has a carbon intensity of under 100 gCO_2/kWh by 2030.
- **Carbon capture and storage (CCS).** Initial projects and development of CO_2 infrastructure clusters in the 2020s, to allow deployment of CCS at scale by the 2030s.
- **Transport.** 60% of new car sales in 2030 being ultra-low emission vehicles (ULEV), potentially enabling the sale of petrol and diesel cars and vans to cease by 2035.
- **Buildings.** Substantial improvements to the energy efficiency of the building stock, plus deployment of 'low-regret' low-carbon heating such as heat pumps in new-build and properties off the gas grid, as well as low-carbon heat networks.

Ignoring international trading of carbon allowances, the latest projections suggest that this set of measures would deliver a 64% reduction in actual UK emissions by 2030 compared to 1990 levels (excluding the UK share of international aviation and shipping emissions).[4]

In October 2017 the Government published its Clean Growth Strategy, which set out their policies, proposals and intentions for meeting carbon budgets. Our assessment of that Strategy, published in January 2018 (Box 1.3), was that:

- The Government has made a strong commitment to achieving the UK's climate targets, placing the low-carbon economy at the heart of the UK's Industrial Strategy.
- The strategy includes some new policies and proposals to reduce emissions. However, these remain aspirations without clearly defined, low-risk, and funded policies in place - urgent action is needed to deliver this ambition.
- There are significant risks of under-delivery. Further risks relate to uncertainty in emissions projections (Box 1.4). Such risks need to be properly managed in order for the carbon budgets to be met.

Box 1.3. Key messages from our assessment of the Clean Growth Strategy

- **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

[3] On a net carbon account basis (see Box 1.1).
[4] The 2050 target requires an 80% reduction in greenhouse gas emissions including the UK's share of international aviation and shipping (IAS) emissions. Excluding IAS, this implies a reduction of around 85% by 2050.

Box 1.3. Key messages from our assessment of the Clean Growth Strategy

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 $MtCO_2e$ to meeting both the fourth and fifth carbon budgets on the basis of central projections.[5]
  - **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 1.4). 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.
  - **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.

Source: CCC (2018) *An independent assessment of the UK's Clean Growth Strategy*.

[5] On the basis of BEIS projections published in 2017, our assessment of the policy gap was 65 $MtCO_2e$ to each of the fourth and fifth carbon budgets. BEIS published new projections in early January 2018, which were around 50 Mt lower than the previous ones. We were unable to incorporate the new projections into our analysis in full for our assessment in January, but rather presented a range from the 65 Mt in our analysis using the earlier projections to 10 Mt, an initial approximate estimate of the impact of the new projections. For this report, we have moved fully to using the projections published in January 2018, and have incorporated these more extensively into our analysis.

Box 1.4. Uncertainty in projecting UK emissions

The Government releases an annual update of UK energy and emissions projections. From these, we use the baseline projections (i.e. projected emissions in the absence of climate policy) as part of our annual assessment of the UK's progress to meeting the carbon budgets. These can vary significantly across different editions, as a result of changes in underlying factors such as economic growth projections and fossil fuel price forecasts.

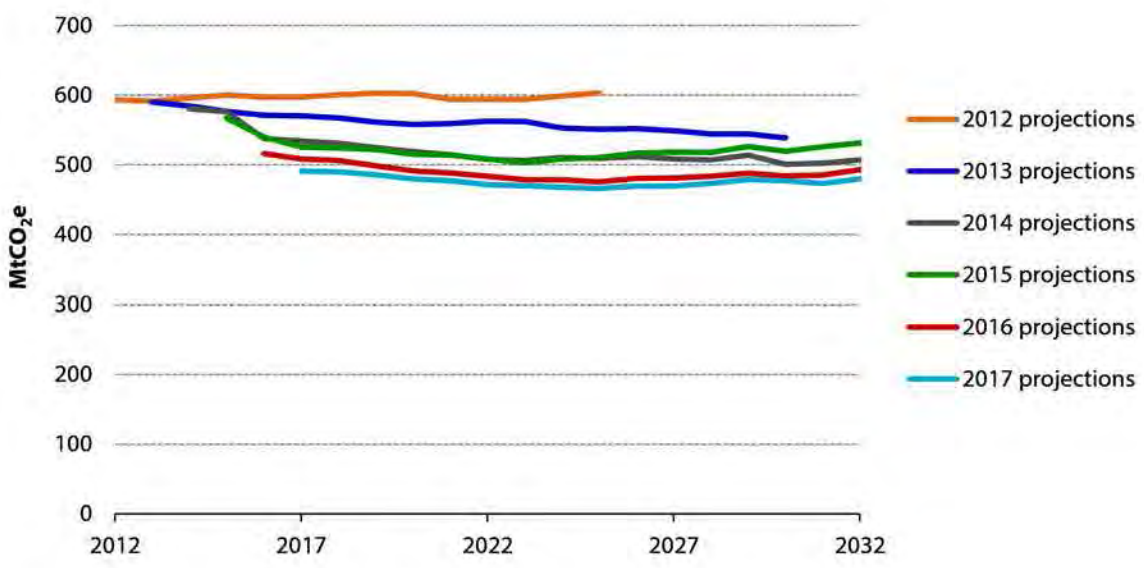
There has been a tendency for baseline projections to fall with each edition (Figure B1.4), which raises questions over whether the projection methodology is fully capturing trends relating to activities that affect emissions. There are a range of uncertainties, relating to the potential effects of recent trends and expected future trends, which may not be adequately reflected in central projections estimates, including:[6]

- **Trends in residential energy demand**, including changes to the composition of the future housing stock, changes to the use and purchase of appliances, and demographic factors.
- **Trends in industrial energy demand**, including changes in energy intensity as a result of changing structural composition of industries.
- **Trends in road transport energy demand**, including changes in car ownership and trip demand, and improved logistics in the heavy goods vehicles (HGV) sector.

In addition, the projections use a mixture of top-down and bottom-up approaches and it is not clear to what extent these are consistent.

We would like to work with the Government to extend the analysis to reflect these emerging trends more fully, so that these uncertainties could be better reflected in our assessment.

Figure B1.4. Changes in BEIS emission projections



Source: BEIS (2012-2017) *Updated energy and emissions projections.*
Notes: Central baseline projections.

[6] Cambridge Econometrics (2015) *Quantifying Uncertainty in Baseline Emissions Projections - Final report for the Committee on Climate Change.*

Meeting carbon budgets

In this section we set out our latest assessment on existing policies and the Government's new proposals. In order to assess whether carbon budgets are likely to be achieved we review Government plans to reduce emissions. We then compare these to our estimates of the cost-effective path, which embodies the set of actions we have identified as a suitable way to meet the budgets and prepare for the 2050 target.

We assess whether policies are expected to deliver emission savings, where they may fail to deliver and/or need firming up, where proposals exist but need to be developed into policies, and identify areas where there is no policy in place (Box 1.5).

Box 1.5. Criteria to evaluate level of risk in Government policies

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'. If they fail any one of the criteria and hence may not deliver then we classify them as being 'medium risk'. Proposals which are not specified in sufficient detail to be classified as policies are labelled separately as 'high risk' intentions.

Our current analysis builds on our assessment of the policies and proposals in the Clean Growth Strategy published in January 2018.[7]

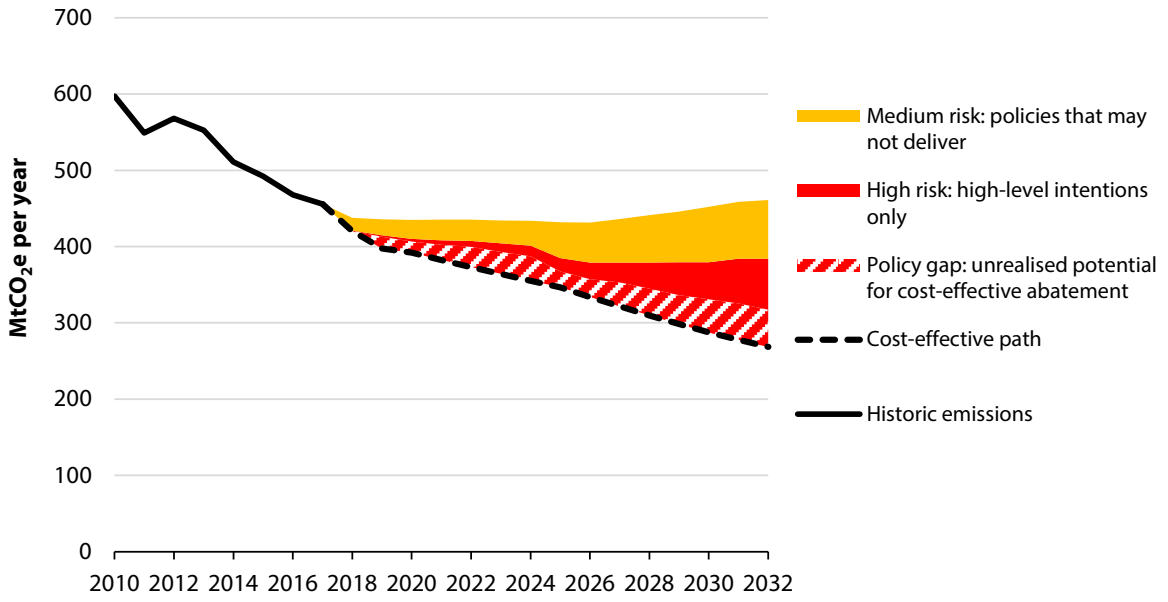
Our conclusion is that the Government's current plans and proposals are not on track to meet carbon budgets. There remain significant emission savings with delivery risks, and proposals that still need to be turned into firm, funded policies. In addition, further cost-effective potential for reducing emissions remains in a number of areas, for which there is no policy in place (Figures 1.5, 1.6):

- **Medium risk – existing policies which may not deliver.** We identify that two-thirds (75 $MtCO_2e$ in 2030) of potential emissions reductions from existing policies are at risk of under-delivery. These include savings from the delivery of low-carbon electricity generation and a wide range of policies potentially impacted by exiting the EU (e.g. energy efficiency standards for products, new vehicle fuel efficiency standards, F-gas emissions reduction, and the EU Emissions Trading System). It is essential that the risks in these areas are removed wherever possible and the associated emissions reductions are delivered in full.

[7] CCC (2018) *An independent assessment of the Clean Growth Strategy*.

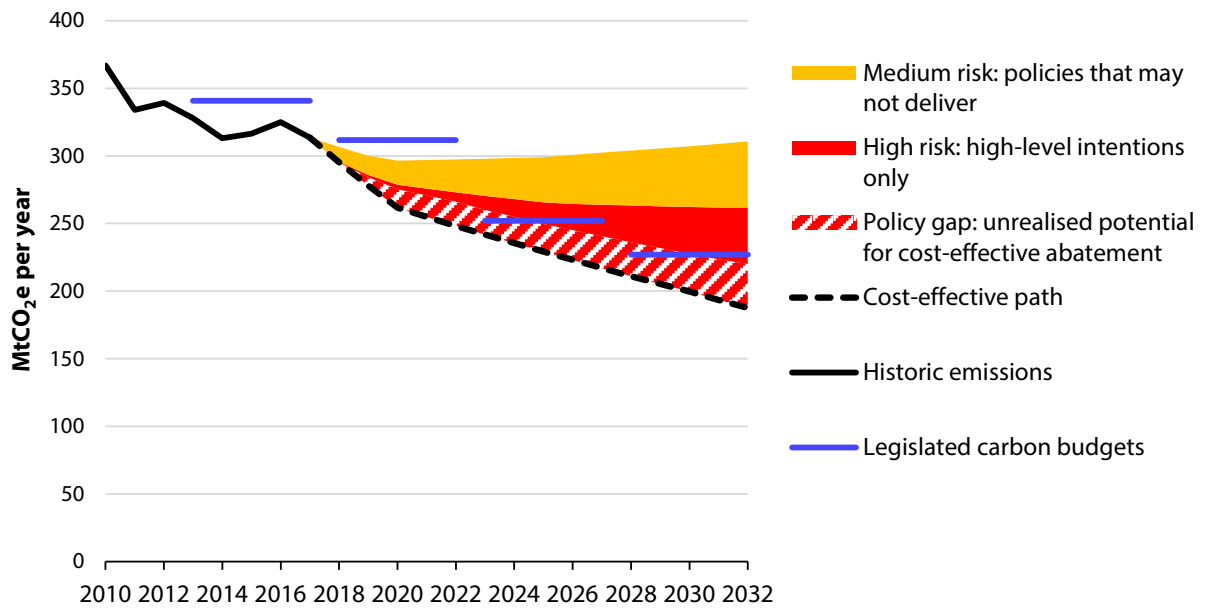
- **High-risk – proposals and intentions.** The Clean Growth Strategy included a range of ambitious proposals, including phasing out sales of conventional cars and vans by 2040, upgrading the residential building stock to EPC band C by 2035, and improving business energy efficiency by at least 20% by 2030. But it did not set out details of policies that would deliver these ambitions. We estimate that these could provide around a quarter (50 $MtCO_2e$) of the abatement required to meet the cost-effective path in 2030. Since our January assessment there have been no significant new policies announced. These proposals and intentions must urgently be turned into firm policies.
- **Unrealised cost-effective potential. There are cost-effective opportunities to further reduce emissions**, for example a route to market for the cheapest forms of low-carbon electricity generation (i.e. onshore wind and solar), deployment of heat pumps in new build homes in the second half of the 2020s, and abatement measures in agriculture which the voluntary approach is failing to realise. Delivering emission savings in line with the cost-effective path would provide contingency for meeting carbon budgets (e.g. against delivery risks), would allow the UK to prepare for reductions beyond 80% that will be required under the Paris Agreement, and help ensure targets are met at the lowest cost.

Figure 1.5. Risks around the delivery of policies at the economy-wide level



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; HMG & HMT (2009) *Building a low-carbon economy: implementing the Climate Change Act 2008*; CCC analysis.
Notes: The chart presents economy-wide emissions. Chart is on the basis of the latest Government emissions projections published in January 2018. Baseline emissions for the Power, Waste, Agriculture and LULUCF sectors have been adjusted to reflect the latest available information on energy generation and inventory accounting methods. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

Figure 1.6. Risks around the delivery of policies to meet carbon budgets (non-traded sector)



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final 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 the latest Government emissions projections published in January 2018. Baseline emissions for the Power, Waste, Agriculture and LULUCF sectors have been adjusted to reflect the latest available information on energy generation and inventory accounting methods. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path. The cost-effective path outperforms carbon budgets, so not all this gap would need to be filled to meet the legislated budgets.

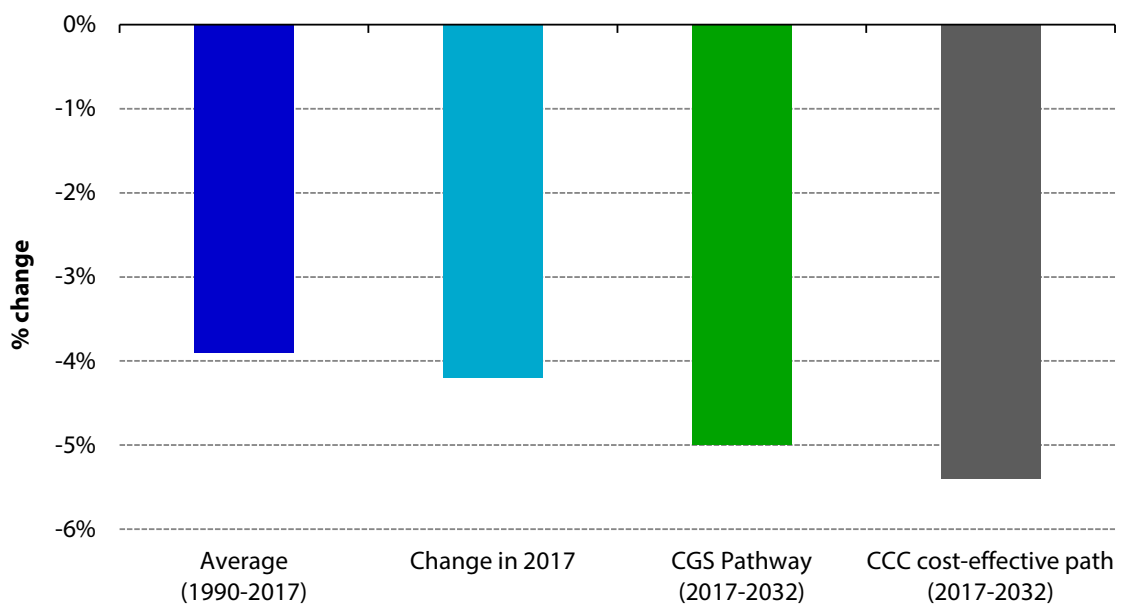
Current performance in reducing emissions

Performance in delivering existing policies was mixed in 2017 (Table 1.2). Good progress has been made in some areas (e.g. power) but there is little progress in almost all others (e.g. transport, buildings, industry, agriculture). Little progress has occurred in the five months since our January assessment of the Clean Growth Strategy.

The emissions intensity for the UK economy fell by 4% annually on average between 1990 and 2017, with a 4% reduction in 2017 compared to the previous year. In the Clean Growth Strategy, the Government stated that a 5% yearly reduction was required to 2032 to meet the fifth carbon budget. The reduction in 2017 was therefore not on track (Figure 1.7).

Table 1.2. Key outcomes (indicators) to be on track for 2030 (and latest outturn)			
Sector		**2017 indicator**	**2017 actual**
Power	Grid emissions intensity	328 gCO_2/kWh	263 gCO_2/kWh
	Total renewable generation	78 TWh	85 TWh
Buildings	At least a quarter of buildings heat from low-carbon sources by 2030	5% in 2016 (lag in data publication)	5% in 2016
	All practicable lofts insulated by 2022	545,000 per year	37,000 installed in 2017
	All practicable cavity walls insulated by 2030	200,000 per year	70,000 installed in 2017
	2 million solid walls insulated by 2030	90,000 per year	16,000 installed in 2017
Industry	Manufacturing and refining (direct) combustion emissions intensity of energy use (% vs 2012)	-9%	-3%
Land use and Forestry	Afforestation (ha/year)	15,000	6,500 (March 2017)
Agriculture	Non-CO_2 emissions ($MtCO_2e$)	38.6 (2016 indicator)	40.9 (2016 actual emissions)
Waste	Reduce landfill GHG emissions (% vs 2015)	-11.5%	+6.6%
Transport	New test-cycle car intensity of 48 gCO_2/km by 2030	111.7	121.1
	60% of new cars and vans to be electric vehicles by 2030	2.2%	1.9%

Figure 1.7. Changes in the greenhouse gas intensity of the UK economy



Source: BEIS (2018) *2017 UK Greenhouse Gas Emissions, Provisional Figures*; BEIS (2018) *2016 UK Greenhouse Gas Emissions, Final Figures*; BEIS (2017) *The Clean Growth Strategy*; ONS; CCC calculations. GDP growth rate projections are from OBR (2017) *Economic and Fiscal Outlook* and OBR (2017) *Fiscal Sustainability Report*, in line with the assumptions used in BEIS (2017) *Updated Energy & Emissions Projections, Annex M*.
Notes: Greenhouse gas intensity measures the amount of emissions produced per unit of GDP.

Further actions required

To be on track to meet the fourth and fifth carbon budgets, the Government needs to:

- Continue to deliver existing low-risk policies.
- Ensure policies with delivery risks are strengthened so that the intended emission savings occur, with risks removed wherever possible.
- Turn policy proposals and intentions from the Clean Growth Strategy into robust, fully funded, low-risk policies.
- Put in place new policies to address the remaining policy gap to the cost-effective path. This outperforms the legislated carbon budgets: aiming for this is appropriate given the ambition in the Paris Agreement, and will provide contingency for meeting the carbon budgets in case the current set of policies and proposals falls short.

Specifically, this requires turning the following proposals into firm policies:

- **Energy efficiency in existing buildings.** Concrete policies need to be published to deliver the Government's ambition on retrofit (EPC band C by 2035) - including firm proposals for able-to-pay homeowners and a delivery mechanism for the social housing minimum standards. Concrete policies are also needed to deliver the ambition on commercial and public buildings.

- **New buildings.** Standards and the associated framework for new buildings should be strengthened, to ensure they are designed for a changing climate, are future-proofed for low-carbon heating and deliver high levels of energy efficiency.
- **Business energy efficiency.** Translate the ambition to improve business energy efficiency by 20% into specific, concrete and measurable policies with clear timings and outcomes**.** This should show how the projected savings add up to 20% and any assumptions on the relative contribution of savings from different fuels and sectors.
- **Low-carbon heat.** Detailed plans should be published to phase out the installation of high-carbon fossil fuel heating in homes and businesses in the 2020s, ensuring there is no policy hiatus in 2021. Further action is needed to deliver cost-effective uptake of low-carbon heat. Cost-effective and low-regret opportunities exist for heat pumps to be installed in homes and businesses that are off the gas grid, together with low-carbon heat networks in heat-dense areas (e.g. cities) and for increased volumes of biomethane injection into the gas grid (up to around 5% of gas demand).
- **Surface transport.** In the Clean Growth Strategy, 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. Clarity and details are also required on the phase-out of sales of new conventional petrol and diesel cars and vans by 2040.
- **Carbon capture and storage (CCS).** The Deployment Pathway due to be published in 2018 must set out the Government's plans for a programme of CCS deployment, with an initial cluster operational by 2026 and reaching 10 $MtCO_2$ per annum across one or two clusters by 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. It should cover both energy generation and industry, with separate approaches to CO_2 capture, a new funding mechanism for industrial CCS, and some sharing of risks across parties especially where these reflect future policy uncertainty.
- **Agriculture and land-use.** Proposals set out in the Clean Growth Strategy regarding the development of low-emissions fertiliser and tackling endemic cattle diseases should be turned into firm policies.
- **Waste.** The Government's 2018 Resources and Waste Strategy should set out firm policies to end food waste going to landfill by 2025 at the very latest. The Strategy should also require landfilling is ended on the same timescale for other biodegradable waste streams including paper and card, wood, textiles, and garden waste.

Gaps in the policies and proposals announced in the Clean Growth Strategy, which still need to be filled, include:

- **Buildings energy efficiency.** Details need to be set out on how the overarching trajectory for improving the efficiency of the existing building stock will be delivered. In our assessment we set out an option for moving faster in upgrading 'able-to-pay' owner-occupied homes in order to reduce the policy gap. There is also potential to go further than a voluntary target for the public sector, which may not be effective in driving emissions reductions.
- **Low-carbon heat in homes, businesses and industry.** A support framework must be established for heat pumps and biomethane post-2021, as well as support for low-carbon technologies in heat networks. New build standards should be tightened in 2025 to drive uptake of low-carbon heat (including heat pumps). There is also no commitment to the use

of low-carbon heat in industrial processes. A governance framework is needed to drive enduring decisions on heat infrastructure in the early 2020s.

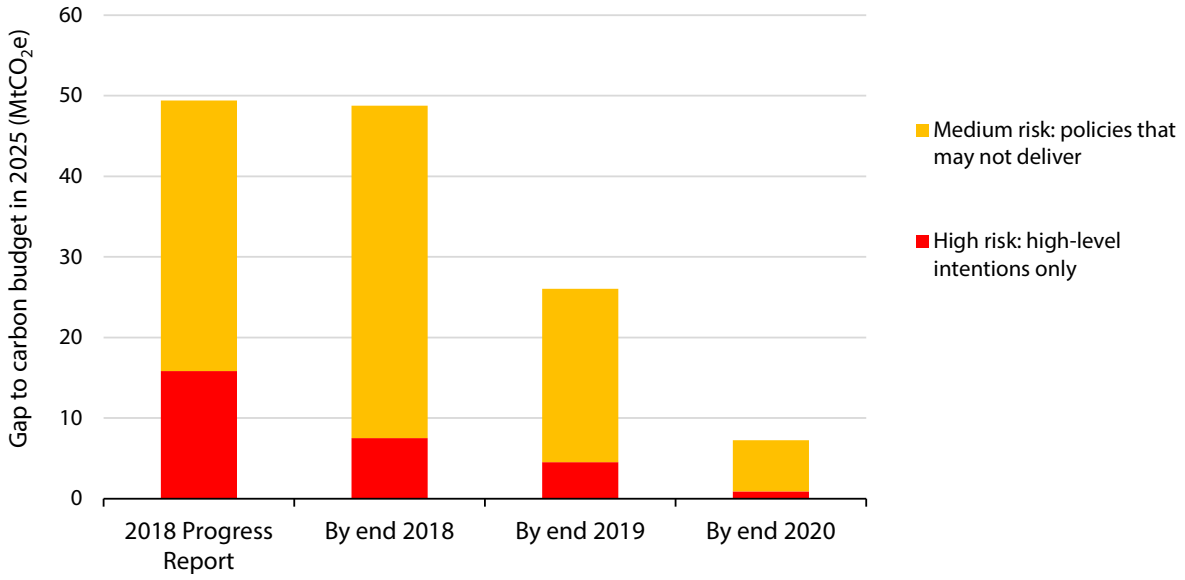
- **Surface transport.** Measures are needed to incentivise freight operators to improve logistics efficiency and shift to less carbon-intensive modes, and to increase uptake of eco-driving training and fuel-saving technologies for HGVs where cost-effective. Public transport must be incentivised, and the decline in bus usage across the UK must be addressed.
- **Power generation.** The Government's plans to decarbonise UK power generation to below 100 gCO_2 per kWh by 2030 rely to a high degree on new nuclear build and net imports across interconnectors, both of which have associated risks. These risks should be mitigated by actions aimed at improving the route to market for low-carbon electricity generation, especially low-cost options (i.e. onshore wind and solar), and by contracting for additional low-carbon generation.
- **Agriculture and land-use.** A new system of future agricultural support post-CAP should be designed. The new system should link financial support to agricultural emissions reduction and increased carbon sequestration, including afforestation.
- **Aviation.** The Government have committed to publish a new Aviation Strategy in 2019. 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.

The Government should remove risks wherever possible relating to policies to meet the fourth carbon budget by 2020 and by 2025 for the fifth carbon budget:

- Figures 1.8 and 1.9 show our assessment of the transition to 2025 and 2030 required in order to meet the fourth and fifth carbon budgets. They show the progress that government must make each year in eliminating gaps, firming up proposed policies, and eliminating delivery risks. All areas need to move to having low-risk policies.
- Taking the set of actions outlined above should lead to delivery risks around the fourth carbon budget 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 1.8).
- It will be necessary to reach the same, or greater, level of confidence regarding the fifth carbon budget by the end of 2025. Policies at risk should be firmed up and contingency options developed in case of under-delivery in some areas and/or emission projections proving too optimistic (Figure 1.9).

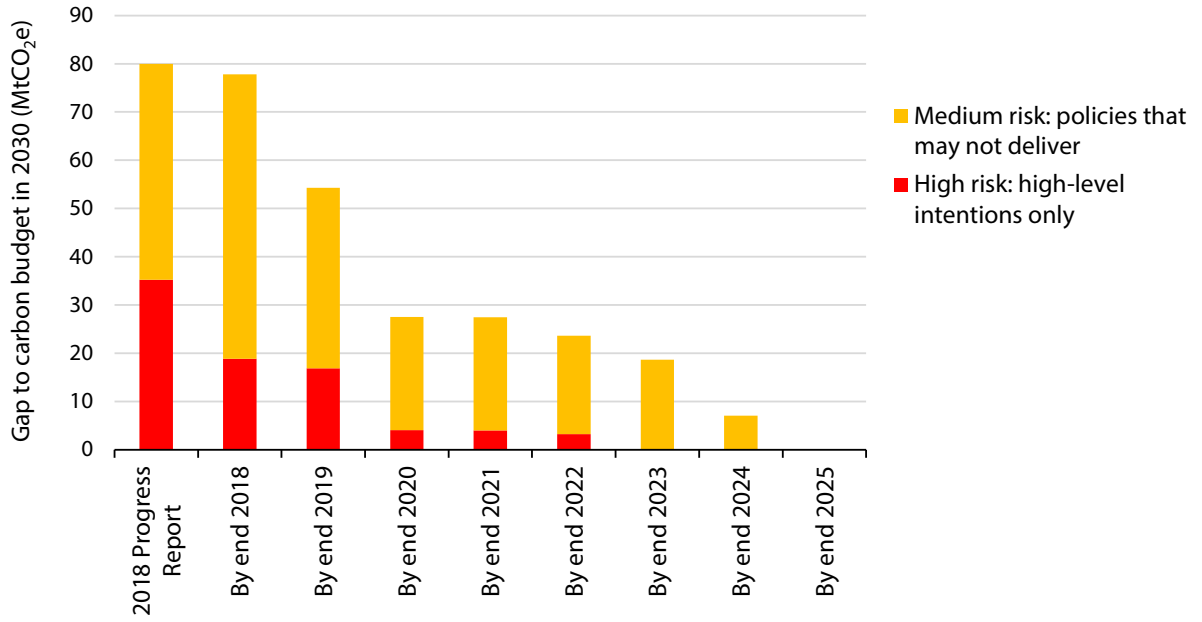
Further details on the actions necessary to remove policy risks are set out in the sector chapters of this report.

Figure 1.8. Risks around the delivery of policies for non-traded sectors in 2025, and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of when current policies, proposals and intentions should be 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 sector chapters. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period, and on the risks around 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's latest emission projections, published in January 2018.

Figure 1.9. Risks around the delivery of policies for non-traded sectors in 2030, and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of when current policies, proposals and intentions should be 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 sector chapters. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period, and the risks around 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's latest emission projections, published in January 2018.

3. Preparing for 2050

The Climate Change Act requires that UK greenhouse gas emissions must fall by at least 80% from 1990 to 2050. The carbon budgets have been set at levels consistent with this reduction. The Government must ensure that actions put in place to reduce emissions are consistent with meeting the long-term ambition of the 2050 target as well as the nearer-term targets of the carbon budgets, which currently cover the period to 2032.

As we highlighted in our assessment of the Clean Growth Strategy, there are several specific measures which require ongoing and sustained deployment (energy efficiency, low-carbon electricity generation, ultra-low emission vehicles, heat networks, low-carbon heating for buildings off the gas grid).

Furthermore, there are a number of areas which, due to the potential scale of impacts across the wider economy, need strategic development over the longer-term:

- **Carbon capture and storage (CCS).** The Committee continues to stress the importance of CCS to achieving the current 2050 target at lowest cost and being an enabler of deeper

emissions reductions beyond that. The Clean Growth Strategy stated an ambition to deploy carbon capture use and storage (CCUS) at scale during the 2030s, subject to costs coming down sufficiently. The Government's Deployment Pathway, which will build on the work of the recently-established CCUS Cost Challenge Taskforce, must set out clear plans by the end of 2018 for the development of a UK CCS industry in the 2020s. Our assessment is that CCS infrastructure roll-out and initial projects should lead to the first CCS cluster being operational by 2026 on the path to CO_2 storage volumes of around 10 $MtCO_2$ per annum by 2030, enabling higher rates of deployment that may be needed subsequently (Box 1.6).

- **Decisions on the future of the gas grid.** The Clean Growth Strategy acknowledged that more work is required to understand the combination of options (i.e. hydrogen, heat pumps and heat networks) most appropriate for the decarbonisation of heating. Widespread use of hydrogen would require repurposing gas distribution grids and deployment of CCS at scale. The Committee welcomes the Government's recent studies in this area, including on domestic hydrogen appliances, hybrid heat pumps and market and regulatory models for low-carbon gas. The announcement of £20 million of funding to accelerate the development of low-carbon hydrogen production is also a positive move. It is essential that the Government continues to develop the evidence base, particularly on safety critical aspects such as the risk of leakages from existing pipework in homes, so that a decision on the future of the gas grid can be made in the early 2020s - it is important that this timeline does not slip, given the scale of changes required by 2050.
- **Greenhouse gas removal (GGR).** GGR is not a substitute for action to reduce emissions. The Government has recently re-stated the priority that it gives to abatement of emissions. However, GGR is likely to be required to some extent globally to achieve the ambitions of the Paris Agreement. It 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 Clean Growth 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. The Government should set out their strategy for developing GGR technologies in 2019.

In April 2018, the Government announced it will seek advice from the Committee on the implications of the 2015 Paris Agreement for the UK's long-term emissions reduction targets, following the publication of the Intergovernmental Panel on Climate Change's (IPCC) Special Report on Global Warming of 1.5°C. This report is due in October 2018.

In order to keep options open for reductions beyond 80%, it is highly likely that substantial progress will be needed in all of the above areas. This would be alongside low emissions (i.e. reductions of at least 90%) from transport, buildings and power generation, and progress in 'difficult to reduce' sectors (e.g. agriculture and aviation).

Box 1.6. Deployment of carbon capture and storage (CCS)

The Committee continues to stress the importance of CCS to achieving an 80% emissions reduction at lowest cost, as well as its crucial role in enabling deeper emissions reductions beyond that. The Clean Growth Strategy stated an ambition to deploy carbon capture use and storage (CCUS) at scale during the 2030s, subject to costs coming down sufficiently.

The clear evidence base[8] shows that UK deployment of CCS is required to unlock the greatest opportunities for cost reduction (i.e. economies of scale for CO_2 infrastructure, and reductions in cost of capital by proving the technology and business model in a UK context). The Government's CCUS Deployment Pathway, which will build on the work of the recently-established CCUS Cost Challenge Taskforce, must set out clear plans by the end of 2018 to kick-start the development of a UK CCS industry in the 2020s, consistent with having the first CCS cluster operational by 2026. The Government should also publish its review of CCS delivery and investment models alongside the Pathway.

By 2050, CCS has a large potential role to play in multiple sectors, as previously identified by the CCC and others. Our scenarios for 2050 envisage a range of required CO_2 capture volumes of at least 60 $MtCO_2$, and potentially well over 100 Mt, per annum, depending on the extent of deployment of negative emissions technology, CCS use in industry and power and use of low-carbon hydrogen:

- **Bioenergy with CCS (BECCS) and other greenhouse gas removal (GGR) options.** There is an important role, both globally and within the UK, for technologies that remove greenhouse gases from the atmosphere. This allows remaining emissions in hard to abate sectors to be offset, both in meeting the 80% target and, in particular, net-zero emissions this century as required by the Paris Agreement. We have previously identified that maximising the climate benefits of sustainable bioenergy is likely to mean using it with CCS (i.e. BECCS) - our analysis suggests that BECCS in the UK could remove up to around 45 $MtCO_2$ annually by 2050.[9] Similarly, many alternative greenhouse gas removal options (e.g. direct air capture of CO_2) rely on CCS.
- **Industry.** Our current central scenario suggests that it will be cost-effective to deploy 3 $MtCO_2$ of industrial CCS by 2030, alongside energy generation projects, increasing to 16 $MtCO_2$ by 2050, including BECCS in industry. Indeed, the Clean Growth Strategy identifies that around half of the current emission reduction opportunities in industry are from CCS.
- **Power.** Though it is expected to be higher cost than renewables, CCS can still play an important role in the power sector: as a potential baseload plant if there is limited progress in nuclear, as a low-carbon mid-merit replacement for gas CCGT or producing negative emissions via bioenergy plant with CCS (BECCS). Pre-combustion gas CCS plant, producing hydrogen as a gas that can be converted to power, could also be deployed initially in the power sector, while providing optionality for decarbonisation pathways that involve hydrogen.
- **Hydrogen.** Any future decision to decarbonise heat using low-carbon hydrogen will require substantial domestic production of hydrogen. Current estimates indicate that the lowest-cost means of producing large volumes of low-carbon hydrogen is via natural gas reforming with CCS, requiring extensive capture of the carbon emissions in the process.

In order to prepare for the scaling up of CCS between 2030 and 2050, deployment before 2030 is likely to require development of at least one CCS cluster, as well as proving CCS business models. Our assessment is that deploying CCS at scale in the 2030s will require deployment of CO_2 infrastructure and initial capture projects at a level of around 10 $MtCO_2$ per annum being captured and stored by 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. This scale of deployment is likely to be the minimum necessary to keep open the option of deployment towards the upper end of possible levels of deployment by 2050.

[8] Pöyry and Element Energy (2015) *Potential CCS Cost Reduction Mechanisms;* CCSA (2016) *Lowest cost decarbonisation for the UK: The critical role of CCS.*
[9] CCC (2011) *Bioenergy Review*.

4. Developments in climate science and international progress in tackling climate change

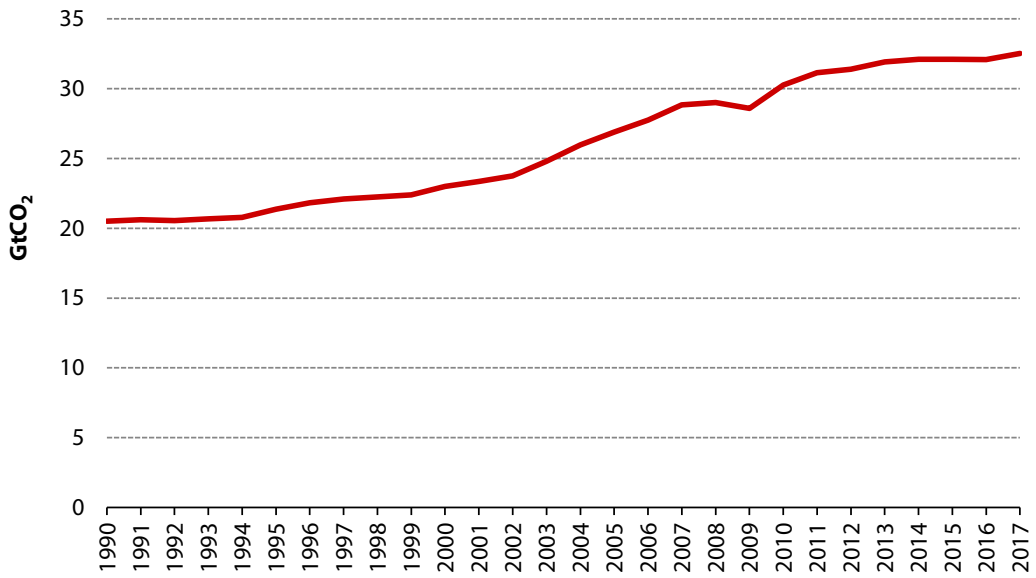
In this section we report recent developments in climate science and in international circumstances, as required by the Climate Change Act. We assess recent trends in global emissions and developments in climate change policy, including the Paris Agreement.

Global and EU emission trends

CO_2 emissions from energy use are estimated to have risen in 2017, both globally and in the EU:

- **Global CO_2 emissions from energy use and industry grew by 1.4% in 2017 to 32.5 $GtCO_2e$, after remaining flat for several years (Figure 1.10).** The increase in emissions was the result of higher global economic growth, lower fossil fuel prices, and a weakening in energy efficiency efforts. It was largely driven by an increase in emissions from China and Asia, though partially offset by reductions in some other countries (e.g. the US, UK, Mexico, and Japan).
- **EU CO_2 emissions from fossil fuel combustion also grew in 2017, by 1.8%.**[10] This particularly reflects economic growth of 2.5% in the EU in 2017. EU industrial activity grew by 3.1%, continuing an existing upward trend.[11] Average CO_2 emissions from new cars rose by 0.4 g/km in 2017.[12]

Figure 1.10. Global CO_2 emissions (1990-2017)



Source: International Energy Agency (2017) *CO_2 emissions from fuel combustion.*

[10] Eurostat Press Release (4 May 2018) *In 2017, CO_2 emissions in the EU estimated to have increased compared with 2016.*
[11] Eurostat (March 2018) *Annual rates of change for total industry, main industrial groupings and NACE divisions, calendar adjusted data, EU-28, 2005-2017.*
[12] EEA Press Release (23 April 2018) *No improvements on average CO_2 emissions from new cars in 2017.*

Observed changes in the climate system

Consistent with continued growth in global emissions from energy use, global atmospheric CO_2 concentrations continued to grow. 2017 was the warmest year on record without a substantial contribution from an El Niño event:

- **Preliminary assessments indicate annual average CO_2 concentrations of 405ppm in 2017**, with concentrations remaining permanently above 400ppm throughout the year.[13] This is around 45% above pre-industrial levels. Annual-mean atmospheric CO_2 concentrations grew by 2.3ppm between 2016 and 2017.
- **Globally, 2017 was the warmest year on record without a substantial contribution from an El Niño event.** The strong natural El Niño conditions that contributed about 0.2°C to record global average surface temperatures in both 2015 and 2016 has now subsided and had little or no influence on 2017 temperatures. Despite this, global average surface temperature in 2017 was in the top three warmest years on record.[14] The continued warmth in 2017 reflects the increasing human-induced warming of the climate system. Global average surface temperatures have now consistently exceeded 1°C above pre-industrial levels over the last few years.

In the UK, eight of the top ten warmest years have occurred since 2002. The average of the 2007-2016 decade was 0.3°C warmer than the average of the 1981-2010 climatological reference period of the World Meteorological Organization.[15]

A changing climate has impacted the planet's oceans and cryosphere, where sea level continues to rise and Arctic sea-ice observations continue to show a downward trend:

- **Global sea level continues to rise.** Recent observations indicate an increase in the rate of global sea-level rise since 1990. Sea levels around the UK are rising at a rate of around 1.4 mm per year.[16]
- **Arctic sea-ice extent observations show a downward trend.** Observations indicate a rapid and pronounced decrease in September Arctic sea-ice extent of approximately 13% per decade since 1979. A record low September sea-ice extent was recorded in 2012.

Developments in international and EU climate policy

Globally, the Paris Agreement is now in effect and parties continue to ratify it. An increasing number of countries are also committing to legislated emission targets and to phasing out fossil fuel powered vehicles:

- **Paris Agreement.** To date, 195 parties have signed the Agreement. 178 parties have ratified it, covering 88% of global emissions.[17] The 2018 Conference of Parties (COP) will convene a facilitative dialogue amongst parties, the Talanoa Dialogue. This will allow countries to take stock of progress towards the Paris Agreement's goals, ahead of the Conference of the Parties in 2019 and to inform the next round of emission pledges to be submitted by 2020.

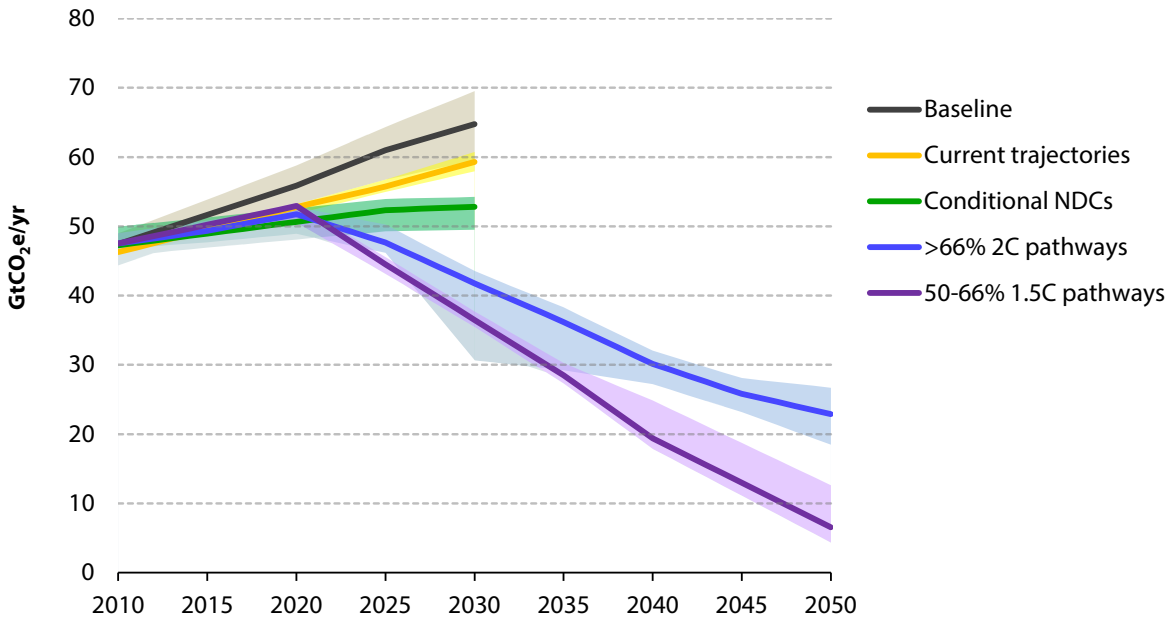
[13] NOAA, Earth System Research Laboratory Global Monitoring Division. Available at: www.esrl.noaa.gov
[14] WMO (2017) *Statement of the State of the Global Climate 2017*.
[15] Met Office (2016) *State of the UK Climate 2016.*
[16] CCC (2017) *UK Climate Change Risk Assessment 2017*.
[17] UNFCCC, Paris Agreement - Status of Ratification, available at treaties.un.org; World Resource Institute, CAIT Climate Data Explorer, available at cait.wri.org

- **The number of net-zero target commitments has increased.** In the past year several countries around the world have made a pledge to achieve net-zero targets, with a range of different timings for achieving this and with a range of different definitions.
  - Countries that committed to achieve net-zero targets include Costa Rica (by 2021); Norway (by 2030); Sweden (by 2045); and France. New Zealand has published a government consultation on adopting a net-zero target. Some of these targets cover all GHGs, while others cover CO_2 only. Varying amounts of international offset credits are permitted to be counted towards the net-zero aims.
  - The draft Climate Change (Emissions Reduction Targets) Bill in Scotland, if adopted, will set a commitment to go beyond the proposed 90% emissions reduction target for 2050 and reach 'net-zero' (i.e. defined as 100% greenhouse gas reduction) as soon as possible.
  - In January 2018 the EU Parliament voted in favour of proposals to create a net-zero target for the EU by 2050, although this is not yet a binding resolution. In March 2018 the European Council also requested that the European Commission present a strategy by the first quarter of 2019 for long-term EU GHG emissions reduction consistent with the Paris Agreement.
  - Overall, the strength of the objective varies across countries. This is due, amongst others, to the lack of a common definition of net-zero, and to the fact that countries differ in the amount of international offset credits that can be used to meet these targets.
- **Several countries and cities have announced a ban of conventional fossil fuel vehicles.**
  - The phase-out of sales of new conventional fossil fuel vehicles was announced in the Netherlands and Norway (by 2025); India, China, Slovenia, Austria, the Netherlands, Israel, Ireland (by 2030); Scotland (by 2032); and France, UK, Sri Lanka, Taiwan (by 2040).
  - Other countries including China, as well as various US and Canadian states, have adopted a Zero Emission vehicle mandate to increase the uptake of electric vehicles. Several cities have banned the use of diesel vehicles, including Copenhagen (by 2020), Paris (by 2024), and Madrid (by 2025).

Overall, latest assessments suggest current policies and pledges are still insufficient to meet the goals set under the Paris Agreement (Figure 1.11). Further new policies and more ambitious emission reduction pledges are needed internationally to close this gap.

The Committee will continue to monitor developments in international circumstances as part of work to review the implications of the Paris Agreement for the UK's long-term emissions targets.

Figure 1.11. Global greenhouse gas emissions under different scenarios and the emissions gap in 2030



Source: UNEP (2017) *The Emissions Gap Report 2017*.

Chapter 2: Power

Key messages and recommendations

Progress continued in reducing power sector emissions in 2017: emissions are down 12% on 2016 levels, 59% on 2008 levels and 65% on 1990 levels. Power sector emissions have continued to fall, while the prospects for further progress have been significantly strengthened by major reductions in the costs of renewable generation. The share of generation from low-carbon sources reached a record high of 52%, the first year that low-carbon generation has exceeded high-carbon generation. This continues the long-term trend of fossil generation being displaced by growth in renewable generation, occurring in line with CCC recommendations made in the *Power sector scenarios for the fifth carbon budget* report.

- Offshore wind prices fell to record lows in the latest Contracts-for-Difference auction. Contracts were secured at an average price of £62/MWh for projects commissioning in the early 2020s, a 60% reduction on the price of projects commissioning today. Evidence suggests that it is likely to be possible to contract onshore wind and/or solar PV at even lower costs.
- The continued fall in the costs of renewable generation means that achieving a carbon intensity under 100 gCO_2/kWh by 2030 is likely to be no more expensive than alternative, higher-carbon pathways. An early decision to pursue a lower carbon intensity outcome for the power sector therefore offers a lower-cost strategy for long-term economy-wide decarbonisation.
- Initial progress has been made on improving flexibility in the electricity system, which will help to accommodate increased shares of intermittent low-carbon generation without increasing risks to systems security whilst keeping costs to a minimum.

Notwithstanding this progress, there remain significant risks that not enough low-carbon power will be delivered by 2030 and that costs will be higher than necessary:

- **Low-cost opportunities are being missed.** Low-cost mature renewable technologies (i.e. onshore wind and solar) are the cheapest generation options and their deployment would help to cut energy bills. However, the Government currently has no plans to run further auctions for Contracts for Difference for mature technologies, which are essential to secure the high volumes of necessary low-carbon generation at the lowest cost.
- **There is currently no strategy for the development of Carbon Capture and Storage (CCS)**, which is crucial to meeting the 2050 target at least cost. Deployment of CCS in the power sector can be an enabler of wider roll-out. The publication by the Government of a Deployment Pathway should be a key step in the development of such a strategy.

Key priorities for the development of Government policy therefore include:

- **Further auctions for low-carbon generation.** Generation from committed funding for renewables and Hinkley Point C still leaves a low-carbon generation gap of 50-60 TWh in 2030. This should be filled through continued auctions for low-carbon generation alongside negotiated contracts where appropriate. Indeed, many mature renewables could be brought forward without subsidy or increases in consumer bills if further auctions are run.
- **A new strategic approach to deploy CCS at scale in the 2030s.** This will require a programme of CCS deployment across industry and energy generation (i.e. power and/or hydrogen) reaching 10 $MtCO_2$ stored per annum in 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. This must include separate approaches to CO_2 capture and the transport and storage infrastructure.
- **Development and implementation of credible contingency plans for low-carbon projects.** This should allow for alternative low-carbon generation to be brought forward, in the event of delay or cancellation to current projects, in a timely fashion and without increasing emissions.

- **Continued progress from Government, Ofgem and National Grid on flexibility options** to ensure these are rewarded for the value they bring to the system. This will mitigate any risks to system security from increased levels of variable or inflexible generation.
- **Government should actively investigate the cost reduction potential of emerging low-carbon technologies** with a large potential scale of deployment in the UK, and, where appropriate, provide R&D and demonstration and deployment support. Floating wind turbines is an example of one such technology.

Table 2.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/timing
Continue to run auctions for low-carbon power beyond the Spring 2019 Contract-for-Difference auction, sufficient to reach an emissions intensity below 100 gCO_2/kWh by 2030, including a route to market for the cheapest forms of low-carbon generation (i.e. onshore wind and solar). This should include a long-term view of future auctions to give investor confidence, help support effective supply chains, and keep costs to a minimum.		✗	✗	2019 onwards
Set out a clear, funded approach to deployment of carbon capture and storage (CCS) at scale. The new approach will require a programme of CCS deployment, with an initial cluster operational by 2026 and reaching 10 $MtCO_2$ per annum in 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. It should cover both energy generation and industry, with separate approaches to CO_2 capture, a new funding mechanism for industrial CCS and some sharing of risks across parties especially where these reflect future policy uncertainty.		✗	✗	Deployment Pathway and review of investment and delivery models published by end 2018 and support for initial CCS deployment implemented by end 2021
Develop robust contingency plans that allow for additional low-carbon generation to be brought forward in the event of delay or cancellation of planned projects, or imports of electricity below projected levels.			✗	2019
Continue progress on improving electricity system flexibility, including implementation of the 29 actions in the Government's Smart Systems Plan.	✗			Actions from Smart Systems Plan completed by 2022 alongside wider improvements.

Introduction

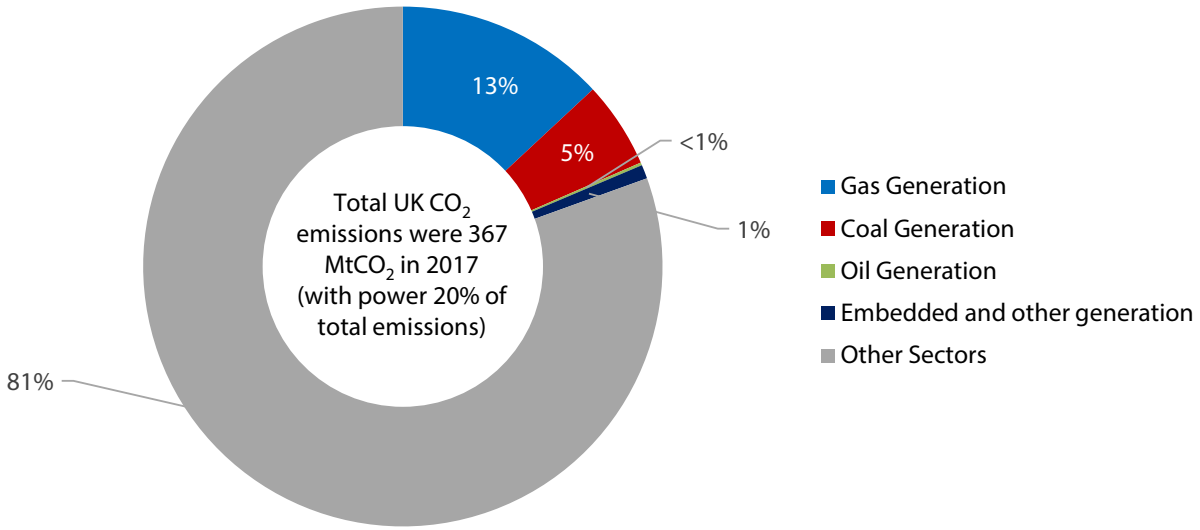
1. Power sector emission trends and drivers
2. Recent performance in redicing power sector emissions compared to required progress
3. New power sector scenarios
4. Policy implementation
5. Further actions required in the power sector

1. Power sector emission trends and drivers

Emissions trends and drivers

CO_2 emissions from the power sector fell by around 9 $MtCO_2$ in 2017, to a level of 72 Mt, representing around 19% of UK CO_2 emissions (Figure 2.1). This is a reduction of 12% on 2016 levels, 59% on 2008 levels, and 65% on 1990 levels. In 2017 electricity generation from low-carbon sources rose above 50% for the first time, providing 52% of UK based electricity generation.

Figure 2.1. Power sector emissions as a share of UK total (2017)

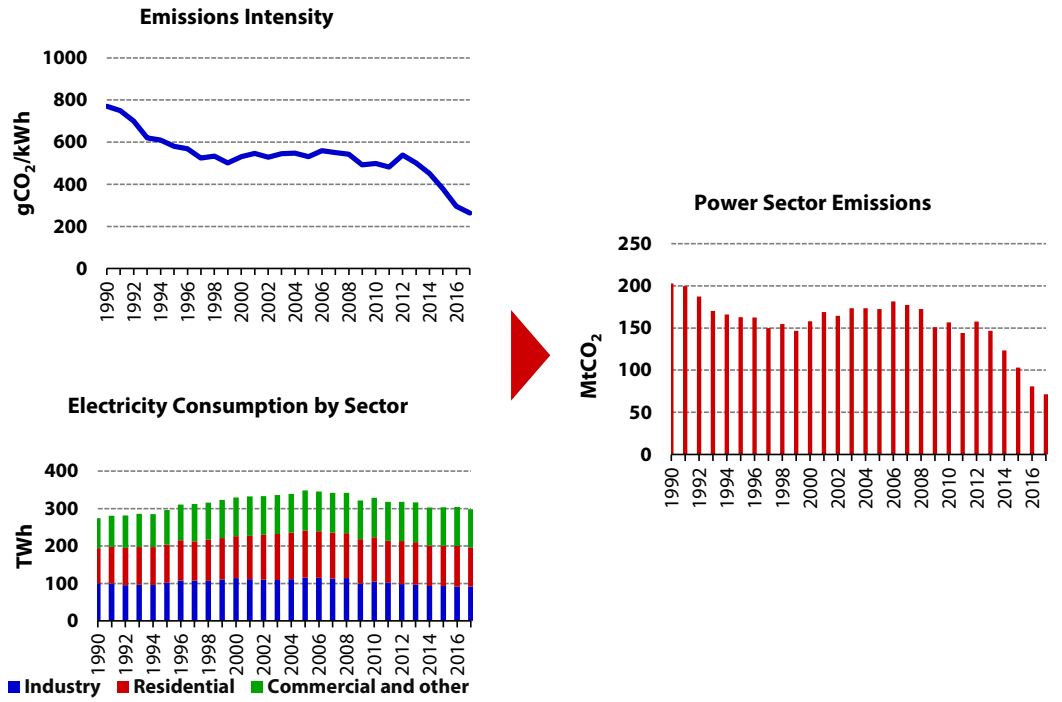


Source: CCC analysis based on: BEIS (2018) *UK Greenhouse Gas Emissions 1990-2017 (provisional)* and BEIS (2018) *Energy Trends: Table 5.1*.
Notes: Estimates of emissions from coal and gas generation are based on generation from Major Power Producers in BEIS (2018*) Energy Trends: Table 5.1*. Embedded and other generation includes municipal solid waste plants.

Reductions in CO_2 emissions in the power sector have been driven by a decrease in the emissions intensity of electricity generation, which fell by 11% to 265 gCO_2/kWh in 2017 (Figure 2.2). Demand for electricity reduced by 2% in 2017. This is reflective of a broader trend since 2012, whereby the UK power system has effectively replaced fossil generation with a combination of renewables and reduced consumption. Furthermore, the share of coal within fossil generation has fallen, with gas-fired generation remaining broadly unchanged:

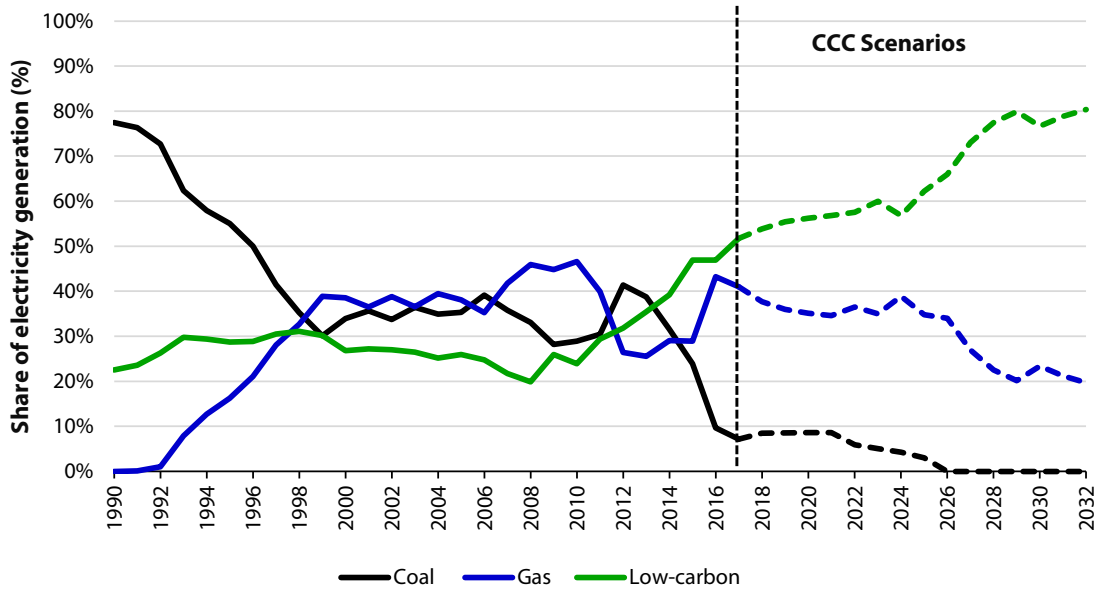
- Generation of low-carbon electricity increased in 2017 by 10% to 155 TWh, comprising 52% of UK-based electricity generation. Since 2008 the share of electricity demand met by fossil fuels has fallen as low-carbon generation has expanded, demand has decreased, total consumption has fallen and imported electricity has risen slightly (Figure 2.3):
  - Offshore and onshore wind generation increased by 12 TWh to 50 TWh in 2017 (17% of generation). This was due to both an increase in installed capacity and higher average load factors across wind farms. Higher load factors were likely driven by a combination of a return to an average wind speed year, with average wind speed increasing 5% between 2016 and 2017, and newer more efficient wind turbines coming online. Generation from other low-carbon sources, including solar, nuclear and bio-energy remained at roughly similar levels to 2016.
  - The share of electricity generated from low-carbon sources has increased from 20% in 2008 to 52% in 2017. This has been driven by a quadrupling of renewable generation between 2008 and 2017, from 21 TWh to 91 TWh. Generation from nuclear power plants has remained fairly constant over this period at around 60-65 TWh per year.
  - The share of electricity generation from fossil fuels has decreased from 79% to 48% between 2008 and 2017, with coal falling from 33% to 7% and gas falling from 46% to 41%.
  - Total electricity consumption has decreased by around 13% since 2008, despite a 5% increase in the total number of UK households. This is driven by a 20% reduction in industry consumption, 11% reduction in residential consumption and a 6% reduction in commercial and other consumption.
  - In the last two years electricity imports to the UK have decreased from an historical high of around 21 TWh in 2015 to around 15 TWh in 2017.
- In 2017 a significant part of the emissions reduction in the power sector (75%) reflected a decrease in coal generation (Figure 2.3). This reflects reduced fossil generation and a falling share of coal-fired generation within this:
  - The UK applies a tax on CO_2 emissions from power generation in addition to the price that is paid through the EU Emissions Trading System (ETS). Over 2017 the EU ETS price was broadly stable at around €6/tCO_2 (£5/tCO_2), in addition to £18/tCO_2 from the UK's Carbon Price Support. This favoured a shift away from coal towards gas, as carbon emissions from coal are over double those of gas per unit of generation.
  - Fuel prices also favoured gas-fired generation over coal-fired generation. Average gas prices in 2017 were around 31% higher than in 2016, but coal prices were on average 39% higher relative to 2016.
  - Generation from coal fell from 29 TWh in 2016 to 21 TWh in 2017 (10% of generation in 2016 to 7% of generation in 2017).
  - However, in contrast to last year, this did not result in an increase in gas-fired generation as the increase in renewable generation was sufficient to replace the reduction in coal generation. Gas generation has now returned to around 2011 levels.

Figure 2.2. Emissions intensity, electricity demand and CO_2 emissions from power sector (1990-2017)



Source: BEIS (2018) *Energy Trends*; BEIS (2018) *UK Greenhouse Gas Emissions 1990-2017 (provisional)*; CCC calculations.
Notes: Based on UK useable generation, i.e. excluding losses. Electricity consumption includes imported power.

Figure 2.3. Share of generation by source (1990-2030)



Source: CCC analysis based on BEIS (2018) *Energy Trends*; CCC (2015) *The Fifth Carbon Budget*, BEIS (2018) *Energy and Emissions Projections*.
Notes: Variability of projected generation in the CCC's scenarios reflects uncertainty of the retirement dates of existing coal and nuclear plants in BEIS's Energy and Emissions Projections scenarios.

Achievable Emissions Intensity

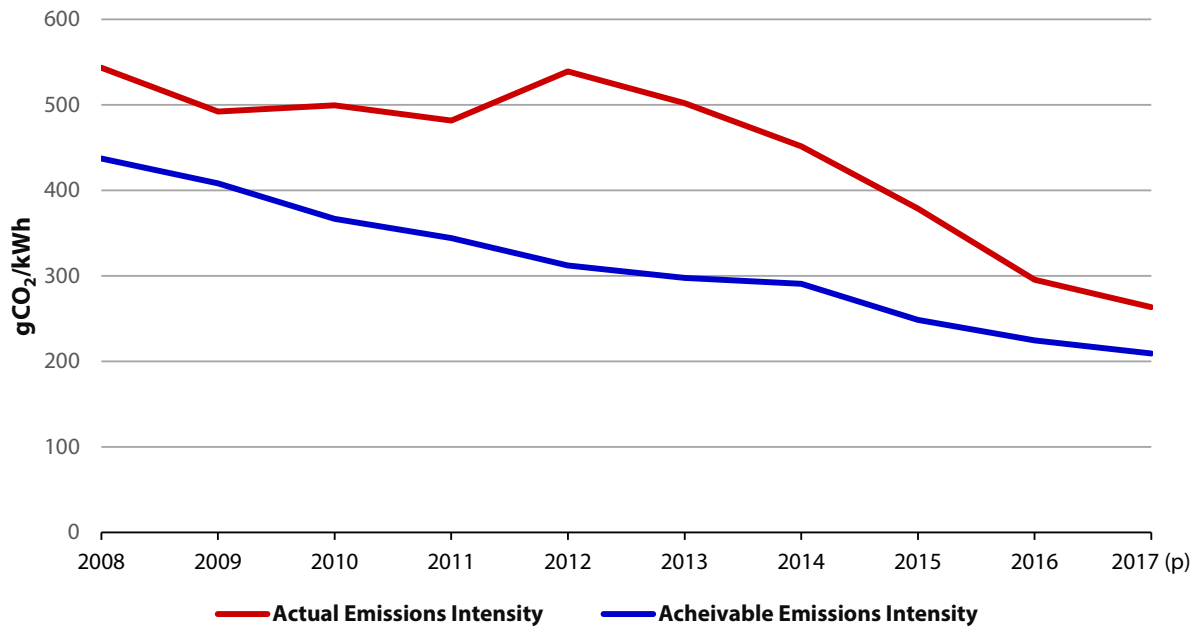
In order to identify underlying progress in decarbonising the power system we track its Achievable Emissions Intensity (Figure 2.4). This is the emissions intensity that the grid would reach if it were operated to minimise emissions by dispatching the least carbon-intensive generators first (renewables and nuclear, followed by gas and then coal).

The Achievable Emissions Intensity improved by 7% to 209 gCO_2/kWh in 2017 due to increased deployment of onshore and offshore wind, biomass and solar capacity. This represents a slowdown compared to 2015 and 2016. However, this is to be expected as a significant amount of coal has already come off of the system, and reflects the good progress that has been made in decarbonising the power sector to date.

The gap between achievable emissions intensity and actual emissions essentially reflects the level of coal generation on the system. This gap has narrowed, falling by 24% in 2017, reflecting continued declines in coal-fired generation. We expect this gap to continue to close until there is no remaining unabated coal generation on the system, by 2025 at the latest.

There is sufficient low-carbon capacity to meet over half of electricity demand in a typical year (indeed low-carbon generation met 52% of demand in 2017) and sufficient gas capacity to meet the remainder. Additional capacity may be required in a backup role to ensure system security.

Figure 2.4. Achievable Emissions Intensity (2008-2017)



Source: CCC calculations based on BEIS (2018) *Energy Trends*; BEIS (2018) *UK Greenhouse Gas Emissions 1990-2017 (provisional)*.
Notes: Achievable Emissions Intensity (AEI) is the minimum average emissions intensity that could be achieved in a year given the installed capacity, electricity demand and the profile of demand. Emissions intensity is based on UK useable generation, i.e. excluding losses and imports. This is indicative of the carbon intensity of consuming a unit of electricity in the UK. Imported electricity reduces actual UK generation and the corresponding emissions intensity but it has no effect on the achievable emissions intensity. The AEI methodology assumes lifecycle emissions for biomass of 200 gCO_2/kWh. 2017 data are provisional.

2. Recent performance in redicing power sector emissions compared to required progress

Progress indicators

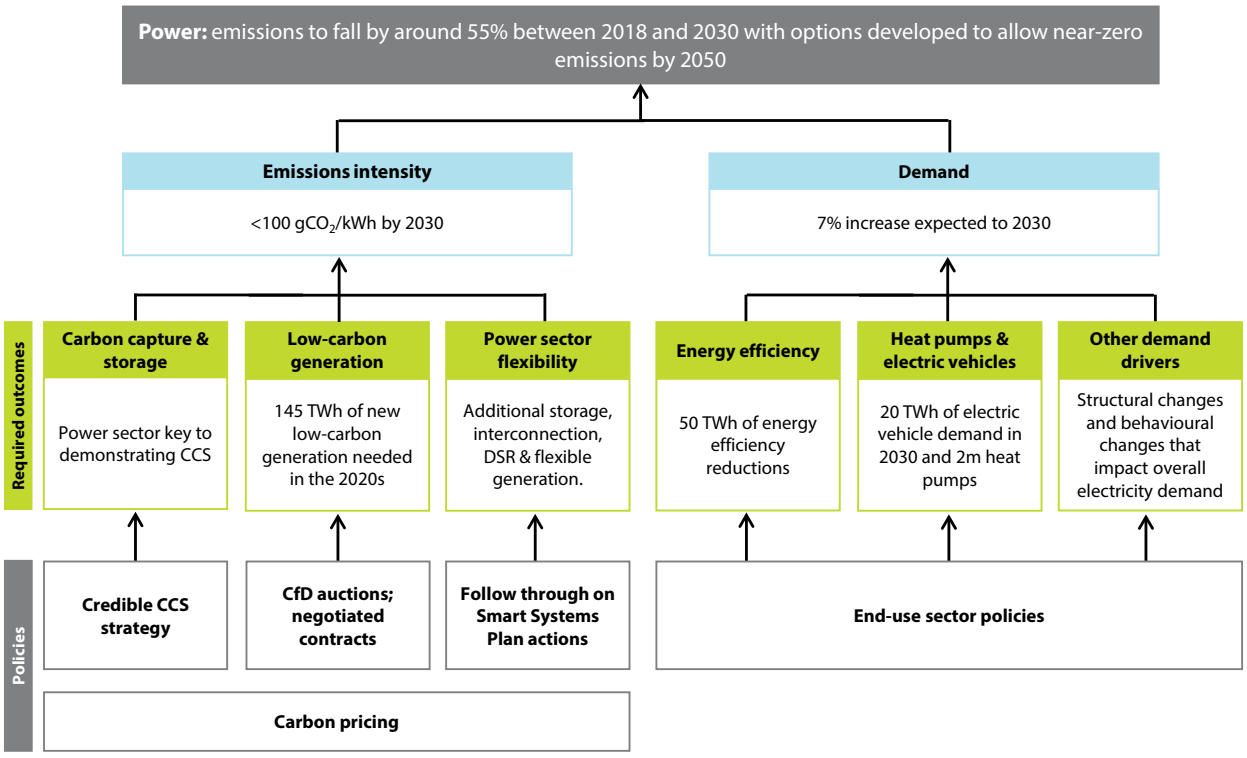
We monitor progress based on a set of indicators that reflect underlying progress in the power sector and a possible set of actions that would follow the cost-effective path for emissions reduction and prepare for the 2050 target. Our progress indicators for the power sector cover the expansion of low-carbon generation and the successful integration of low-carbon sources into the electricity system (Figure 2.5).

To further reduce emissions from the power sector requires continuing the expansion of low-carbon generation, from 52% of generation in 2017 to at least 75% of generation in 2030, at a similar rate to that seen between 2008 and 2017 (Figure 2.3). This accounts for forecast growth in demand to 2030 of around 31 TWh:

- **Low-carbon generation.** In addition to the 120 TWh of low-carbon generation we expect to be online in 2020 (and remain online to 2030), at least 130-145 TWh of low-carbon generation should be added in the 2020s to reach the 255-270 TWh of low-carbon generation in 2030, consistent with the cost-effective path for long-term decarbonisation (see section 4). Alongside up to 100 TWh of gas generation, this will result in a grid intensity of under 100gCO_2/kWh. Of the required 130-145 TWh, only 14 TWh of this has been contracted for through the latest Contracts-for-Difference auction.
  - We would expect another 70 TWh to be delivered through funding already announced for further Contract-for-Difference auctions, and through the successful delivery of the nuclear plant Hinkley Point C. This leaves an additional 50–60 TWh of low-carbon generation to be delivered in the 2020s, which would bring the total amount of low-carbon generation in 2030 to around 255-270 TWh.
  - We assume that renewable capacity retiring in the 2020s will be re-powered. If this is not the case, additional low-carbon generation would need to be contracted in the 2020s to replace the retiring plants.
  - In line with our scenarios for other sectors, we account for an increase in demand from electric vehicles (20 TWh) and 2 million heat pumps. Overall demand in 2030 would therefore be around 365 TWh.
  - Our analysis assumes that by 2030 the UK is not a net importer of electricity on an annual basis, as we do not think that it is credible to plan to achieve cost-effective decarbonisation by importing more electricity than we export (see section 4).
  - Up to around 100 TWh of generation is then required from gas-fired plants in order to meet remaining electricity demand, implying an emissions intensity of under 100 gCO_2/kWh in 2030.
- **Flexibility.** The UK's electricity system will also have to become more flexible in order to mitigate any risks to system security or increased costs that an increase in variable and inflexible generation, alongside changing demand patterns that will arise as new technology is installed in homes and businesses, may bring. In last year's Progress Report to Parliament we set out a new set of indicators against which we monitor progress in this area.
- **Policy.** As well as tracking low-carbon generation we track the investments and policy frameworks that will lead to increased low-carbon generation.

- **Carbon capture and storage (CCS).** Some of the new low-carbon generation could come from plants fitted with CCS. This technology is important to meeting the UK's 2050 emissions target at least cost and the power sector is likely to be an important element in a credible strategy for developing UK CCS infrastructure (see Chapter 1).

Figure 2.5. CCC indicators for monitoring progress in the power sector to 2030



Notes: CfD = Contract-for-Difference; CCS = Carbon capture and storage.

Progress in deploying low-carbon capacity continued in 2017, with 4.7 GW of low-carbon projects being built and 2 GW entering construction (Table 2.2). In addition 3.3 GW of low-carbon generation won contracts in the September 2017 Contracts-for-Difference auction, and will come online between 2021 and 2025. However, the amount of low-carbon capacity for which planning applications were submitted in 2017 was lower than in previous years:

- Three offshore wind projects totalling 3.2 GW of capacity won contracts at an average strike price of £62/MWh[18] in the September 2017 Contracts-for-Difference auction.[19] We expect this, and a small amount of generation from 'advanced conversion technologies' (ACTs) (0.1 GW),[20] to provide approximately 14 TWh of low-carbon generation at a cost of £176 million per year. This represents a 60% cost reduction on the price of offshore wind turbines going in the water today.

[18] In £2012.
[19] The Triton Knoll offshore wind farm (0.9 GW) won a contract at a strike price of £74.8/MWh, for delivery in 2021/22. The Hornsea Project 2 (1.4 GW) and Moray (1.0 GW) offshore wind farms both won contracts at £57.5/MWh for delivery in 2022/23. In addition, 56 MW of ACTs won a contract at a strike price of £74.8 for delivery in 2021/22.
[20] Advanced Conversion Technologies (ACTs) include standard and advanced gasification and pyrolysis, including advanced bioliquids.

- However, planning applications were submitted for only 0.9 GW of renewable generation, compared to 1.2 GW in 2016 and 2.5 GW in 2015. This reflects a slowdown of investment in renewable technologies in the UK, with investment falling by 56%[21] between 2016 and 2017. Some slow-down in investment is to be expected due to the timeline of the commissioning of low-carbon projects, and we expect this to recover to some extent as offshore wind projects come online in 2018. Moreover, we expect investment to recover further if the Government continues to run regular auctions for low-carbon power in line with our recommendations.

Reflecting this good progress we continue to expect around 130 TWh of renewable generation in 2020:

- Existing capacity would be expected to generate around 97 TWh in a typical year (it generated 91 TWh in 2017).
- We expect an additional 31 TWh of low-carbon generation to come online by 2021, 3 TWh through the Renewables Obligation (RO) and 28 TWh contracted through Contracts for Difference (CfDs).
  - Due to reductions in the Feed-in-Tariff (FiT) rates for small scale solar only 0.09 GW was deployed under the scheme in 2017. We do not expect any significant increase in FiT generation as the scheme is scheduled to close in 2019.
  - The last of the grace periods[22] for the Renewables Obligation will close on 31st January 2019. Therefore we expect an additional 0.7 TWh of onshore wind to come online by 2020 under the RO.
  - We expect another 1.5 TWh of offshore wind to commission under the RO.
  - A fourth unit at Drax is converting from coal to biomass, which we expect to be online by 2020, and will receive support under the RO. However, due to changes in support for new biomass conversions under the RO[23] we do not expect this additional biomass-fired capacity at Drax to significantly increase generation.
  - We expect 28 TWh of CfD projects to come online by 2020/21.

[21] Environmental Audit Committee (2018) *Green finance: mobilising investment in clean energy and sustainable development.*
[22] Grace periods allow generators to gain accreditation under the RO in certain circumstances after the closure of the scheme (i.e. if a certain amount of development had already been undertaken).
[23] BEIS (2017) *Consultation on controlling the costs of biomass conversion and co-firing under the Renewables Obligation.*

Table 2.2. Deployment of renewables in 2017 and expectations to 2020

Technology (% of UK Generation in 2017)	Installed Capacity in 2017 (GW)	Of which, capacity added in 2017 (GW)	Further capacity in the pipeline to 2020 (GW)	Expected capacity and generation in 2020*	CCC indicator for generation in 2020
Onshore wind (10%)	12.9	1.9	1.2	14 GW 33 TWh	30 TWh
Offshore wind (7%)	7	1.7	4.4	11 GW 38 TWh**	36 TWh
Biomass*** (9%)	6	0.2	1.5	7.5 GW 40 TWh	24 TWh
Solar PV (4%)	12.8	0.9	<1	13 GW 11 TWh	-
Hydro (2%)	1.7	0	<1	1.7 GW 6 TWh	-
Marine (< 1%)	<0.1	<0.1	<1	<0.1 GW, <1 TWh	-

Source: BEIS (2018) *Energy Trends*, Low Carbon Contracts Company (2018) *CfD Register*, BEIS (2018) *Renewable Energy Planning Database*, CCC analysis.
Notes: Load factors for renewable technologies range from around 11% for solar PV, to 80% for biomass. Wind load factors are around 30% (onshore wind) and 40% (offshore wind).
* Awarded a CfD, or expected to deploy under the Renewables Obligation. Note this includes the Neart Na Goithe offshore wind farm (0.5 GW), which has appealed against a cancelled CfD.
** We expect 2 TWh of this to be added in 2021.
*** Biomass includes biomass from: biomass conversions, dedicated biomass, energy from waste, landfill gas and anaerobic digestion.

There has been progress on broader upgrades to the UK electricity system infrastructure and flexibility that will help to accommodate this increase in low-carbon generation:

- In December 2017 0.9 GW of the 2.2 GW Western HVDC transmission link came online. The remaining 1.3 GW is expected to come online in summer 2018. This will enable more low-carbon capacity to be deployed in Scotland and is expected to reduce curtailment payments to Scottish generators for restricting their generation at times of system stress.

- Approximately 9.5 million smart meters were installed by December 2017, with 4.5 million of these added in 2017. This is part of a Government-mandated programme which is aiming to install a smart electricity and gas meter in every home (and 2 million small businesses) by the end of 2020. This is behind the original expected deployment trajectory.
- Regulatory changes are underway that involve smart meter data sharing, half-hourly settlement and smart charging standards for electric vehicles. These should promote opportunities for consumers to provide electricity system flexibility services, whilst providing adequate protection for consumers on levels of service and participation, cost and data privacy.
- In July 2017 the Government published the Smart Systems and Flexibility Plan. This aims to remove barriers to smart technologies, enable smart homes and businesses, and make markets work for flexibility. Alongside this, National Grid and Ofgem have published documents that outline their actions to level the playing field for services that provide flexibility. If addressed, we expect these actions to level the playing field and remove barriers to entry for flexibility technologies. Between the Capacity Market and ancillary services markets, we expect deployment of flexibility technologies to be in line with our recommended range to 2020 (Table 2.3).
  - National Grid followed its System Needs and Product Strategy with the Product Roadmap for Frequency Reserve and Response. This outlines the actions National Grid is taking to level the playing field for all providers of frequency response and reserve services.
  - In August 2017 Ofgem launched the Targeted Charging Significant Code Review. This focuses on reviewing embedded benefits and in particular considers reforming residual charging for transmission and distribution for both generation and demand.

Table 2.3. Required levels of flexibility providing capacity (GW)

New flexible technology requirements (GW)	Existing in 2018	Expected by 2020	Technology range by 2020		Technology range by 2030	
			Low	High	Low	High
New flexible generation	2	6	1	5	3	15
Storage	2.7	3.2	4	8	8	38
Demand-side response	1	2	3	11	4	18
Interconnection	4	8.4	8	8	10	15

Source: Pöyry and Imperial College (2017) *Roadmap for flexibility services to 2030*; CCC Analysis.
Notes: The table shows a range for total flexibility technology requirements against current and expected capacities. New flexible generation is defined as a CCGT 'H' class generator (or a generator with similar or more flexible characteristics).

Of the 13 GW of coal capacity that was online at the start of 2017, we expect only 6 GW to be online in 2020, and none to be online past 2025. This is a sharp reduction from the 20 GW of coal plant that was on the system in 2012:

- Of the 20 GW of coal plant online in 2012, 6 GW has now closed. We expect a further 7 GW to close by 2020, based on announced retirement dates and assuming that plants that have not won a capacity market contract for delivery beyond 2019 will close.
- In 2017 the Government confirmed that it will regulate to close unabated coal generation by 2025. Subsequently, in 2018, the Government announced that this would be done through the implementation of an emissions performance standard for units burning solid fuels set at 450 gCO_2/kWh. From 2025 onwards, this would only allow coal units to generate if they were capturing at least 50% of their emissions.

Despite some progress in 2017, investment prospects for many low-carbon generators remain unclear beyond 2020. The Government re-confirmed further funding for future Contract-for-Difference auctions and progress has been made on the construction of Hinkley Point C. But there has been minimal progress in bringing forward cheap mature renewables (e.g. onshore wind and solar), or CCS technologies:

- In October 2017 the Government reconfirmed its commitment to run further Contract-for-Difference auctions with up to £557 million of funding available. If similar strike prices are achieved to those in the 2017 auction, we estimate this could support around 45 TWh of low-carbon generation. This would be deployed in the mid to late 2020s.[24]
- As part of the Budget in Autumn 2017, the Government committed to targeting a total carbon price for power generation at current levels (around £24/tCO_2 at the time of announcement) until unabated coal generation is no longer on the system.
- Since signing a contract in 2016 EDF - the developer - has progressed with the construction of the nuclear plant Hinkley Point C. EDF aim to pour the first nuclear island concrete in 2019,[25] a regulator-approved milestone that indicates progress towards commissioning in the mid-2020s. Once fully operational it is expected to generate around 25 TWh of low-carbon power per year.
- In June 2018 the Government announced that it was beginning negotiations with Hitachi to support the Wylfa Newydd nuclear power plant. The proposed nuclear plant would provide 2.9 GW of capacity, capable of generating around 23 TWh of low-carbon generation. The proposed reactor design, the UK Advanced Boiling Water Reactor (ABWR), passed the nuclear regulator's Generic Design Assessment in December 2017.
- Professor Dieter Helm's independent Cost of Energy Review was published by the Government in 2017. The Review proposes significant reforms to UK electricity markets with the intention of reducing complexity and transitioning away from the Contracts-for-Difference support mechanism for low-carbon generators (see Box 2.1). The Government has subsequently launched a consultation on the proposals set out in the review.

[24] In June 2018 the Government outlined that it intends to legislate to include remote island wind in any further Contracts-for-Difference auctions for pot 2 'less-established' technologies. Alongside this there will be a tightening of the requirements for any advanced conversion technologies seeking to compete in further CfD auctions. BEIS (2018) *Contracts for Difference scheme for renewable electricity generation: Government response to consultation on proposed amendments to the scheme*.

[25] The beginning of the construction of the key nuclear reactor infrastructure.

Box 2.1. Future market reform

In the CCC's January 2017 response to the Government's Clean Growth Strategy we presented our early thoughts on the proposals in Professor Helm's review of the Cost of Energy and long-term options for market design. This acknowledged the complexity of the current arrangements, but suggested that the instruments introduced under Electricity Market Reform (EMR) were working, and there was limited case for reform.

Since then we have reviewed the literature on long-term market design options for low-carbon generation, considered the public responses to BEIS's consultation on the Helm Review, and engaged with industry, academics, investors and developers on the subject. A short summary of our conclusions is presented below, for consideration in discussions around future market design.

Overview of current UK market arrangements:

- **Electricity trading:** Wholesale electricity spot market for 30-minute periods, as well as bilateral contracts between generators/suppliers via Power Purchase Agreements (PPAs).
- **Low-carbon generation** is incentivised via long-term contracts (Contracts for Difference), which guarantee payment at a 'strike price' equivalent to the cost of the technology. Strike prices are determined via competitive auctions or bilateral negotiations between a developer and the Government.
- **Security of supply** is procured through Capacity Market one and four years ahead of time. Payments are awarded on a £/kW basis based on projected availability during system stress events.
- **System flexibility** is procured via a series of ancillary services markets by the System Operator (National Grid)
- **Carbon prices** are applied to UK-based fossil fuelled generators over 20 MW in size, set at around £25/tCO_2 until 2025.

The case for reform

The current system is working well and we do not expect its effectiveness to be materially challenged in the nearer term. Over the longer term, full reform could be a better option, but experience suggests this is a lengthy process which involves significant adaptation from market players. Any reform should demonstrate that is better than available alternatives, ensure arrangements are tailored to both present and future system needs and allow projects to access returns that reflect their value to the system.

The Helm review rightly identifies the prospect of the post-subsidy world and the importance of preparing for high penetrations of intermittent renewables, and raises important questions around improving simplicity, transparency and predictability whilst using available decarbonisation options. However the package of instruments introduced under EMR is delivering low-cost emissions reductions, whilst maintaining security of supply. The next decade of power sector decarbonisation is best dealt with by adjusting the current system in line with the principles set up under EMR, rather than a complete overhaul. There is however scope for improving the current arrangements: they currently exclude low-cost technologies and lack in transparency and visibility.

- Competitive auctions for contracts for low-carbon generation and the Capacity Market are delivering lower than expected prices, whilst the UK's carbon price support mechanism has played an important role in limiting emissions from coal power.
  - Competitive auctions for Contracts for Difference have procured around 45 TWh of low-carbon generation, at prices 40% below the auction price cap. Prices for contracts in these auctions are indicative of both competitive pressure and access to a lower cost of capital

Box 2.1. Future market reform

for developers. For example, lower prices awarded to onshore wind plant in the first of these auctions, which also had an option to receive higher revenues under the Renewables Obligation at the time, indicate access to lower costs of finance (see Newbery 2016).

  - The Capacity Market is delivering high security of supply at lower-than-expected prices. This has brought forward novel solutions such as batteries, demand-side response and peaking plant, and revealed high system security of supply margins, with large volumes of plant bidding in above the auction reserve margin. Other factors, such as generous embedded benefits for some generators, and gaps in air quality legislation have been revealed via the results of the Capacity Market, and are now being addressed.
  - Carbon pricing via the UK's Carbon Price Support mechanism - alongside other factors such as European air quality directives, fossil fuel prices and age of plant - has reduced coal generation from 32% of generation in 2008 to 7% in 2017, with 14 GW of 20 GW of coal capacity having closed, announced closure or expected to close since 2012.

- Currently, auctions are only open to 'Pot 2' technologies such as offshore wind, island wind and new bioenergy. The auction system should be extended to include lower-cost technologies, whilst increasing transparency and being used more responsively.
  - The Spring 2019 auction for Contracts for Difference is currently only open to offshore and island wind technologies, as well as some advanced conversion technologies. This excludes technologies such as onshore wind and large-scale solar power which can be brought forward without subsidy and lower consumer bills.
  - There is no visibility over how auctions will be run beyond Spring 2019. The Government should commit to regular auctions with a transparent and predictable system for setting auction volumes and reserve prices.
  - Given the risks identified in section 4 the Contracts for Difference and Capacity Market mechanisms can be used responsively if large projects or imports don't come forward, to procure both low-carbon generation and security of supply.
- Tweaks to the current system could incentivise innovation, improve cost-reflectiveness and level the playing field for low-carbon technologies. These include (but are not limited to):
  - Currently CfD generators are paid the full value of their CfD during negative system price periods, despite this being of little value to the system. Removing CfD payments in negative price periods for new CfD generators would avoid exacerbating this problem in the future.
  - Currently new-build renewables are not eligible for Capacity Market payments. Allowing renewable generators to participate in the Capacity Market would allow developers to explore opportunities for co-location alongside flexible assets, or offer security of supply across a portfolio of generation. However, we do not expect this to incentivise large volumes of low-carbon generation.
  - The ongoing evolution of ancillary service markets and network pricing has the opportunity to improve the cost-reflectiveness of the current system, by better rewarding projects for the value they offer to the system.

Source: Newbery (2016) *Towards a green energy economy?;* NERA (2017) *Offshore revolution?;* Gross R, Rhodes A, Staffell I (2018), *Is EMR working? Are Britain's electricity market arrangements fit for purpose or broken?*; UKERC (2018) *Response to the Cost of Energy Review*; Energy UK (2018) *Energy UK's Vision for the Five Year Review of Electricity Market Reform.*

3. New power sector scenarios

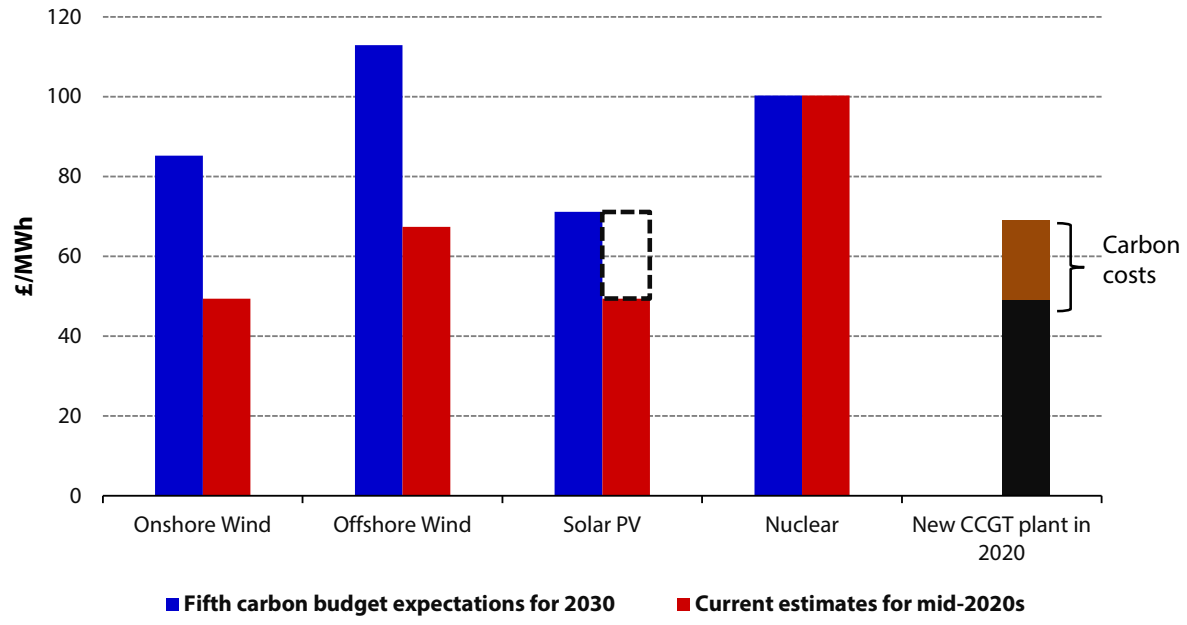
In our *Power Sector Scenarios for the Fifth Carbon Budget* report in 2015, we identified an emissions intensity of under 100 gCO_2/kWh in 2030 as the cost-effective path to the 2050 target. This was based on continuing the strong progress the UK has made in power sector decarbonisation in the 2010s with low-cost deployment of onshore wind, solar and possibly nuclear, alongside programmes of offshore wind and CCS in the 2020s, where UK deployment can be expected to be important in reducing the costs of these technologies.

Since that report, there have been developments that affect the prospects for the deployment of low-carbon capacity:

- **Renewable costs have fallen rapidly.** The most recent auctions for 'established' technologies procured contracts for offshore wind at around £62/MWh for delivery in the early 2020s - in line with prices elsewhere in Europe but 40% below where we had expected the cost of the technology would be by 2030. Although there have been no UK auctions to reveal the cost for onshore wind or solar, these are also widely understood to have fallen significantly (Figure 2.6).[26]
- **Significant delays in CCS deployment.** In November 2015, the Government cancelled the CCS Commercialisation Programme, meaning that the two initial CCS plants in our commercialisation pathway will not be delivered.
- **Limited progress in new nuclear.** The aim is for the Hinkley Point C plant to commission in 2025, but limited progress has been made with other new nuclear projects, aside from the recent announcements around the Wylfa nuclear plant. Site development and regulatory approval milestones have been passed, though formal negotiations have only just begun with one developer, raising questions over the likelihood of several new nuclear plants commissioning before 2030, beyond the Hinkley Point C project.

[26] Globally, bids have come forward to produce power from onshore wind in Colorado at £15/MWh and solar PV in Saudi Arabia at £13/MWh. See Bloomberg (2017) *Saudi Arabia Gets Cheapest Bids for Solar Power in Auction.* Evidence suggests that UK costs are also falling: Arup (2017) *Market Stabilisation Analysis*, Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*; BVGA (2018) *The Power of Onshore Wind*.

Figure 2.6. Cost reductions in low-carbon technologies



Source: CCC analysis based on BEIS (2016) *Electricity Generation Costs*; Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*.
Notes: All money in £2017, assuming an inflator of 1.083 between 2012 and 2017 and 1.046 between 2014 and 2017. The lower estimate of solar costs is equal to the costs of onshore wind from Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*, the higher bound is from BEIS (2016) *Electricity Generation Costs*.

A further reduction in the emissions intensity of power generation, to below 100 gCO_2/kWh by 2030 remains the lowest-cost path towards economy-wide decarbonisation:

- Continued power sector decarbonisation is likely to be no more expensive than alternative pathways for the power sector, such as increased gas generation paying a market carbon price in the UK or importing electricity from abroad (Box 2.2). The Government's existing plans can deliver 210 TWh of the 255-270 TWh required to reduce emissions to 100 gCO_2/kWh by 2030. A further 50-60 TWh of renewables could be deployed in the 2020s at no, or minimal, additional cost to consumers, although nuclear and CCS projects are likely to be more expensive. Successful delivery of further nuclear projects beyond Hinkley Point C or CCS projects in power could reduce this emissions intensity towards 50 gCO_2/kWh.
- Steady deployment of low-carbon technologies has the potential for significant cost reduction, with limited downside risk. As demonstrated through the price reductions for offshore wind, there may be significant cost savings to be made from deployment of many low-carbon technologies in the UK. Evidence suggests that cost reductions could be achieved for carbon capture and storage, if support for deployment is made available. This could also apply to other less-mature technologies, such as floating offshore wind. Furthermore steady deployment maintains technology pipelines and supply chains in the UK, avoiding stop-start investment.
- Electrification is a key decarbonisation option for other sectors, such as transport and heating. By 2050 we would expect substantial electrification of other sectors, such that

electricity demand could be around double today's level. Steady deployment of low-carbon capacity over the period to 2050 will initially help to decarbonise the existing power system before providing the basis for electrification of other sectors in the 2030s and 2040s.

- Early power sector decarbonisation helps to manage risks around economy-wide decarbonisation effectively, given limited progress with emissions reductions in other sectors and any potential revision of long-term emissions reductions targets following the 2015 Paris Agreement. The power sector has options available that are deployable at scale and are cheaper than abatement in other sectors.

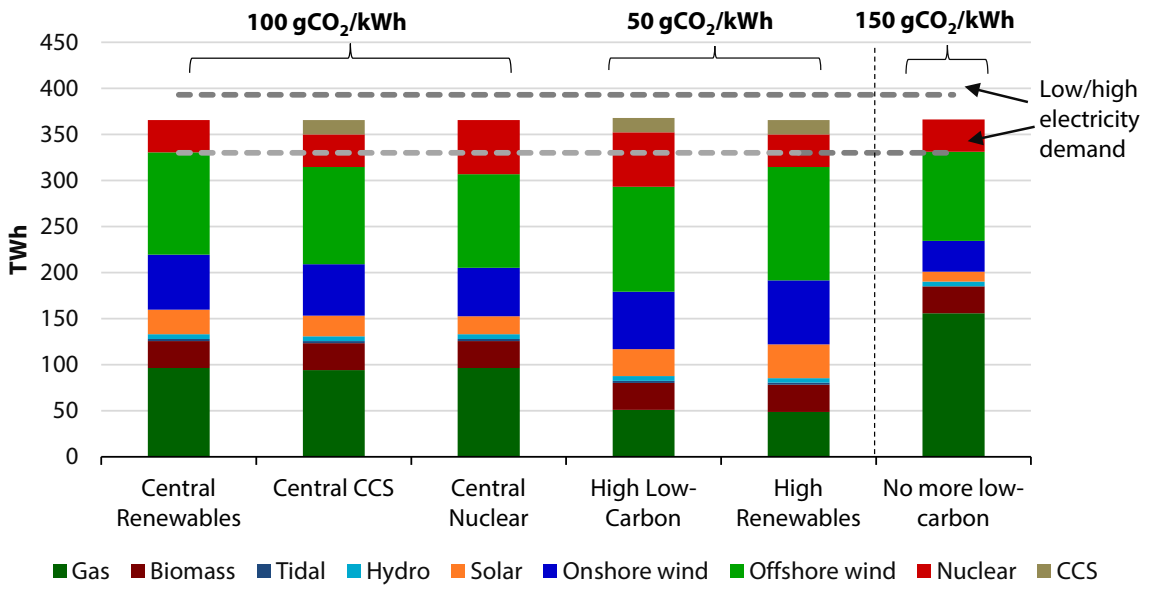
We have updated our power sector scenarios for 2030 to reflect these changes (Figure 2.7, Table 2.4, Table 2.5, Box 2.2). As in the Fifth Carbon Budget, the emissions intensity for the power sector in 2030 remains under 100 gCO_2/kWh, which should be considered an upper bound given the opportunities available, limited progress in decarbonising other sectors, and potential strengthening of targets following on from the Paris agreement.

Table 2.4. The CCC's new power scenarios

Scenario name	Description	Emissions intensity in 2030
Central Renewables	60 TWh of additional renewable generation	under 100 gCO_2/kWh
Central Nuclear	35 TWh of additional renewable generation alongside one additional nuclear plant beyond the Hinkley Point C project (25 TWh)	under 100 gCO_2/kWh
Central CCS	45 TWh of additional renewable generation and deployment of 2 GW of CCS in the power sector (15 TWh)	under 100 gCO_2/kWh
High Low-Carbon	70 TWh of renewables, alongside 25 TWh of nuclear power and 15 TWh of CCS	50 gCO_2/kWh
High Renewables	90 TWh of renewables, alongside 2 GW of CCS in the power sector (15 TWh)	50 gCO_2/kWh

Source: CCC analysis.
Notes: All scenarios assume that all current and planned renewable projects remain online in 2030 (with reduced generation from some bioenergy plant beyond 2027, and assuming only the Sizewell B nuclear plant remains online in 2030), including the Hinkley Point C project and the allocation of the remaining funding for Contracts for Difference, reaching a total of 210 TWh of low-carbon generation. The CCC's scenarios address the remaining low-carbon generation that needs to be contracted over the fourth and fifth carbon budget periods.

Figure 2.7. The CCC's new power scenarios for 2030



Notes: 'No more low-carbon' is not a CCC scenario, but is used to illustrate a higher-carbon pathway for the power sector in 2030, assuming no more low-carbon generation is deployed beyond current commitments.

Table 2.5. Capacity and generation by technology in the CCC's new power scenarios

Technology	Central Renewables (GW (TWh))	Central CCS (GW (TWh))	Central Nuclear (GW (TWh))	High Low-Carbon (GW (TWh))	High Renewables (GW (TWh))
Nuclear	4 (35)	4 (35)	7 (59)	7 (59)	4 (35)
Onshore wind	25 (60)	24 (56)	22 (53)	26 (62)	29 (70)
Offshore wind	31 (111)	29 (106)	28 (102)	31 (114)	34 (123)
CCS	0 (0)	2 (16)	0 (0)	2 (16)	2 (16)
Solar	32 (27)	27 (23)	23 (20)	35 (29)	43 (37)
Tidal	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)
Biomass	7 (29)	7 (29)	7 (29)	7 (29)	7 (29)
Hydro	2 (5)	2 (5)	2 (5)	2 (5)	2 (5)

Box 2.2. The CCC's new power scenarios

Description of scenarios

We present five new power scenarios for 2030, reflecting the falling costs of renewables, delays in CCS deployment in power and limited progress in new-build nuclear development beyond the Hinkley Point C project. The design of the scenarios reflect choices over further deployment of nuclear power beyond the Hinkley Point C project, and the role of CCS in the power sector. All scenarios reach an emissions intensity of generation of under 100 gCO_2/kWh, with scenarios achieving 50 gCO_2/kWh contingent on progress being made in integrating intermittent renewable energy into the electricity grid at acceptable cost.

- **Nuclear power.** One additional nuclear power plant beyond the Hinkley Point C project by 2030 is considered in two scenarios. If new nuclear projects were not to come forward, it is likely that renewables would be able to be deployed on shorter timescales and at lower cost.
- **CCS.** Three of our scenarios include 2 GW of CCS projects in the power sector in 2030, on the path towards 4-7 GW by 2035. Those scenarios without CCS in the power sector do not imply the absence of CCS, but rather deployment elsewhere in the economy (i.e. industry and/or hydrogen production) reaching 10 $MtCO_2$ per annum stored by 2030 (see Chapter 1).
- **Renewables.** Given cost reductions in renewables, the CCC's new scenarios envisage higher levels of intermittent renewable deployment (45-60%) than our previous Fifth Carbon Budget scenarios (40-55%). There is strong evidence that system costs for penetrations of up to 50% renewables are manageable, and emerging evidence that penetrations of 60% intermittent renewables will be technically possible by 2030, however there is a lack of evidence on the costs of these higher penetrations of renewables.
  - Previous work for the CCC and others on the costs of integrating renewable generation into the electricity system suggest that the 'system costs' (i.e. the costs of back-up capacity and other actions to balance the system) associated with renewables are around £10 per MWh of renewable generation in a system with up to 50% intermittent renewables. Experience to date suggests that these costs could be lower than previously envisaged (e.g. costs of procuring capacity in the Capacity Market have been lower than expected, falling costs of batteries and renewables).
  - The same work suggested that integration costs could rise substantially in systems with more than 50% penetrations of variable renewables. Emerging evidence suggests that systems with 60% variable renewables (or more) will be technically achievable by 2030,* and that integrating more renewables into a system with high levels of renewables reduces overall costs for consumers.** However evidence on the precise system cost implications of higher levels of renewables penetration is scarce, implying that scenarios with higher levels of renewables are only possible if progress is made in integrating renewables into the system at acceptable cost.

Electricity demand in the scenarios

Our central estimate for electricity generation required to meet the demands in our 2030 scenarios is 365 TWh, including electricity demand from 2m heat pumps and 20 TWh of demand from EVs. With accelerated uptake of EVs or heat pumps electricity demand could increase to 390 TWh; with slower-than-expected uptake and improved energy efficiency, demand could be reduced to 330 TWh.

- Scenarios with lower demand (i.e. through improved energy efficiency) imply that emissions could be lower without building additional low-carbon generation and with reduced costs to consumers.
- Scenarios with higher demand (i.e. with higher uptake of EVs and/or heat pumps) could increase the amount of low-carbon generation required to be contracted in the 2020s, in order to avoid an increase in emissions.

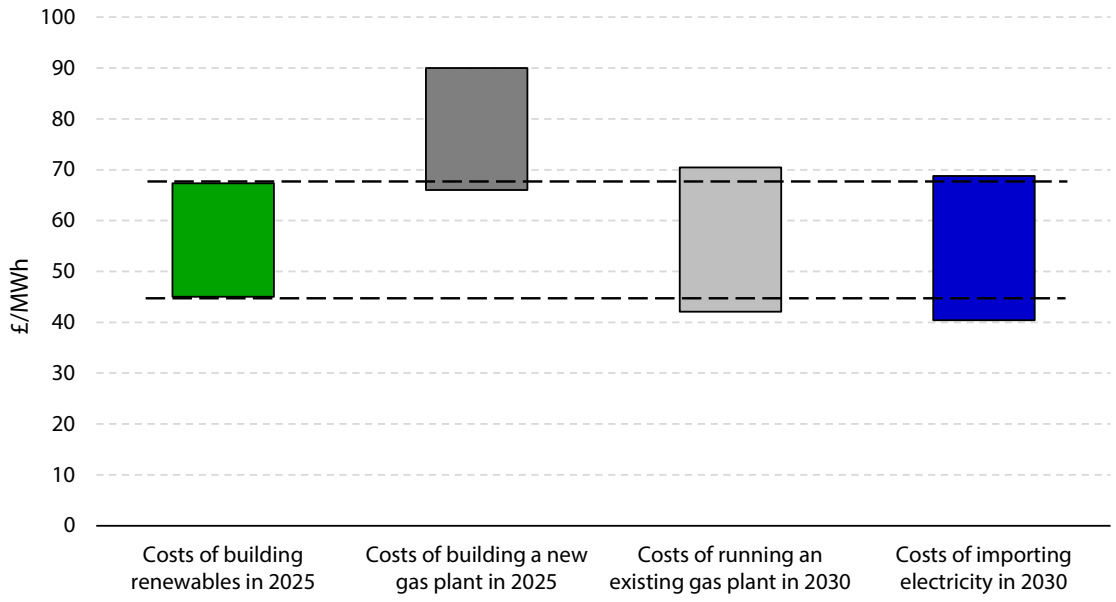
Box 2.2. The CCC's new power scenarios

Costs of scenarios

The continued fall in the costs of low carbon generation mean that further power sector decarbonisation - to under 100 gCO_2/kWh - in the CCC's scenarios is likely to be no more expensive than higher-carbon pathways for the power sector. Current prices for onshore wind, solar PV and offshore wind are between £50-67/MWh (when accounting for intermittency costs and adjusting strike prices for project lifetimes). Even if the total costs of renewables remains around £50/MWh in the mid-2020s, this would be cheaper than building a new gas plant, and in some cases running an existing gas plant, or importing electricity from Europe (see Figure B2.2). We expect the costs of running an existing gas plant and importing electricity to rise during the 2020s alongside forecast increases in carbon prices in the EU's Emissions Trading System.

We estimate that installing the additional low-carbon generation in the CCC's 2030 scenarios could be delivered at similar overall system cost to higher-carbon pathways for the power sector, with a range of around £0.5bn per year cheaper if gas prices are high and £2bn per year more expensive if gas prices are low.

Figure B2.2. Cost of building renewables vs. higher carbon technologies in the 2020s



Source: CCC analysis based on BEIS (2016) *Electricity Generation Costs*; BEIS (2017) *Energy and Emissions Projections* (Annex M); Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*.
Notes: Lower bound for renewables costs is Baringa (2017); upper bound is offshore wind strike prices from the September 2017 CfD auction, both adjusted for intermittency costs at £10/MWh. Levelised cost of a new gas plant from BEIS (2016). Projected costs of imports are estimates of marginal costs for European coal and gas plant in 2030 before accounting for interconnector tariffs. These, and gas plant operating costs, are based on CCC estimates using BEIS (2018) *Energy and Emissions Projections* (gas prices of 39 p/therm, 67 p/therm and 83 p/therm in 2030, carbon price of £39/tCO_2).

Source: NERA & Imperial College (2015) *System integration costs for alternative low carbon generation technologies*; Joos and Staffell (2018) *Short-term integration costs of variable renewable energy: Wind curtailment and balancing in Britain and Germany*.
* Vivid Economics & Imperial College Consultants (2018) *Thermal generation and electricity system reliability*;
** Aurora Energy Research (2017) *The New Economics of Offshore Wind*.
Notes: All money in £2017, assuming an inflator of 1.083 between 2012 and 2017.

4. Policy implementation

Effective policy in the power sector should allow for a steady deployment of low-carbon technologies. Technologies should be supported where they have low costs over their lifetime compared to gas generation facing a rising carbon price or where it is necessary to drive down costs of important options for the longer term, as has been seen for offshore wind and may be needed for carbon capture and storage (CCS).

As outlined in the previous section this implies moving towards a power system with an emissions intensity of under 100 gCO_2/kWh by 2030. In this section we evaluate the current and planned policies, including the policies and proposals in the Government's Clean Growth Strategy, highlighting where these policies require strengthening. We then assess the 'policy gap', where current and planned policies are not sufficient to meet the cost-effective path for economy-wide decarbonisation. Finally we highlight the risk of current policies not delivering expected low-carbon generation.

Current policy

In last year's progress report, and in our assessment of the Clean Growth Strategy, we identified risks to progress in decarbonising the power sector and made recommendations to mitigate against these. New contracts have been awarded to offshore wind projects, and the lower costs of these imply that previous funding (which has been recommitted) should deliver more low-carbon generation than previously expected. There has also been progress in developing arrangements for improving system flexibility.

We estimate that current policies could deliver around 210 TWh of the 255-270 TWh of additional low-carbon generation we estimate is required by 2030. Alongside this, we expect current policy will continue to drive the most carbon-intensive forms of generation off the system whilst supporting the increase in system flexibility required to accommodate new low-carbon generation (see Table 2.6, Figure 2.8).

In 2017 a replacement for the Levy Control Framework beyond 2020/21 was announced that allows for more support for low-carbon generation if the forecast of overall levies is falling or the support will reduce consumer bills, but it may put investment for other low-carbon projects at risk. There has been no progress in enabling deployment of mature low-carbon technologies such as onshore wind and solar, despite their low costs and the fact that running a 'Pot 1' auction could bring forward further renewable generation with little if any required financial support. No progress has yet been made on developing robust contingency plans if low-carbon projects or projected imports of electricity fail to deliver:

- The 'Control for Low Carbon Levies' document, published alongside the Budget in September 2017, will replace the Levy Control Framework from 2021 onwards. The new control allows for further support for renewables if either existing expenditure is forecast to decline or new levies will reduce consumer bills. This will allow for new contracts to be signed on a subsidy-free basis, but there may be a case for levies to be added to bills even if they are not falling (see Box 2.3). For example, if gas prices fall this will increase the overall cost of Contract-for-Difference payments but consumer bills will be lower in aggregate. Alternatively, as part of CCS deployment it may be necessary to award a Contract for Difference to a CCS in power project. If these factors are not taken into account the new controls risk undermining low-carbon investment in the power sector.

- Currently the Government has no mechanism to contract for the most cost-effective types of electricity generation. The latest estimates from BEIS and others show that onshore wind and solar are the cheapest forms of power generation, and are cheaper than new fossil-fired generation. Despite this, there are no plans to run auctions that would deliver these technologies, which evidence suggests could already be delivered on a subsidy-free basis (Box 2.3).
- An important part of a credible decarbonisation strategy is a robust contingency plan in the event that planned projects are delayed or cancelled, or projected imports of electricity to the UK under deliver. We have previously recommended that the Government should demonstrate multiple plausible pathways to achieve the necessary level of decarbonisation (i.e. reaching under 100 gCO_2/kWh) by 2030. No progress has been made in this regard.
- The Government plans to produce a CCUS Deployment Pathway at the end of 2018 which should set out the role that the power sector can play in bringing forward CCS in the UK, and present credible plans to move towards deployment.
- A diverse portfolio of low-carbon generation technologies will be required to meet increasing electricity demand towards 2050. Government should actively investigate the cost reduction potential of emerging low-carbon technologies with a large potential scale of deployment in the UK, and, where appropriate, provide R&D, demonstration and deployment support. Floating wind turbines are an example of one such technology.

Box 2.3. Subsidy-free renewables and market-stabilisation contracts

Direct payments for electricity system services from Government-backed contracts are now available to most generators in the UK through Contracts for Difference, the Capacity Market and the ancillary services markets (via the System Operator). In many cases these payments result in lower prices in the wholesale market (the so-called 'merit order effect'), reducing consumer bills. This raises questions as to what constitutes a subsidy payment.

The Committee and others have suggested using subsidy-free (or 'market-stabilisation') contracts to bring forward the cheapest low-carbon generation without subsidy. The proposals are all based on competitively offering long-term contracts for electricity generation, which ensure that developers have a secure revenue stream and are therefore able to access low-cost finance.

However, different bases have been proposed for judging the price at which a project should be considered subsidy-free. Broadly, they can be categorised as follows:

- **Social basis (£65-80/MWh in 2025).** Prices are compared to the cost of a new gas CCGT plant over the project's lifetime, adjusted to reflect the system integration (or 'intermittency') costs of renewables. Carbon is valued based on the Treasury's Green Book carbon values (e.g. £42/tCO_2 in 2025, rising to £79/tCO_2 in 2030), since these are designed to be consistent with the UK's climate targets; lower values expected in the market are effectively a subsidy to high-carbon generators.* This is the Committee's preferred definition, as first put forward in our 2015 report to Parliament, and best aligns to the Government's own guidance. Auctions could be capped at this price, and would be expected to deliver lower prices to the benefit of consumers.
- **Private basis (£45-55/MWh in 2025).** A similar definition (e.g. see Arup (2017)), based on the cost of a new gas CCGT plant but using a forecast market price (e.g. £25/tCO_2 in 2025) would align more to private interests. Arup (2016) also proposed using a forecast of wholesale electricity prices. Both are adjusted to reflect the system integration costs of renewables. Consumers should be made better off by investment in low-carbon generation below these

Box 2.3. Subsidy-free renewables and market-stabilisation contracts

prices, since they would imply lower overall system costs than investment in gas generation. In theory, some higher-priced projects could also be desirable as they would cut carbon more cheaply than expected alternatives in other sectors, but in practice there are likely to be sufficient cheaper projects available.

- **Market basis (£35-50/MWh in 2025).** A contract aiming to replicate returns available in the market (e.g. see Aurora Energy Research (2017)) would be signed at an expected 'capture price' for the technology (i.e. the price a generator gets paid in the market - a discount on the average wholesale price). Based on current price expectations, onshore wind, large-scale solar PV and offshore wind would be expected to be deployed at scale in the 2020s at these prices. However, there is a risk that some projects would be excluded even though they would reduce overall bills for consumers given the merit order effect of reducing wholesale prices.

The Government should set out its approach to auctioning subsidy-free contracts (including the basis for setting the subsidy-free price, the reserve prices that implies, the timing of future auctions and the amount of generation or capacity to be targeted) and then run auctions to award the contracts.

Recent evidence on the costs of renewables in the UK, particularly onshore wind and solar PV is limited, given the lack of auctions for these technologies. However, Baringa (2017) identified a pipeline of projects that could be deployed today, at all of the price ranges listed above. The falling costs of renewable energy internationally suggests that further cost reductions could be expected by 2025.

Without long-term contracts for electricity generation, we would not expect a sufficient volume of low-carbon generation to come forward to meet the legislated carbon targets. Although a small number of renewable projects have begun to develop without a contract the overall volume is likely to remain low given the higher risks involved (i.e. exposure to wholesale price risk when not able to access long-term contracts, or the risk of default on long-term contracts that are not backed by Government). Only one 10 MW solar farm has been developed to date, though over 500 MW is in planning, with the intention of proceeding without a Government-backed contract. Furthermore, any increase in the cost of capital as a result of the increased risks is likely to be passed onto consumers, resulting in higher bills than necessary.

Source: CCC estimates based on: Arup (2017) *Market Stabilisation Analysis*, and Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*; *BEIS (2018) Updated short-term traded carbon values used for UK Public Policy Appraisal*. Carbon Brief (2018) *Q&A: What does 'subsidy-free' renewables actually mean?*; Aurora Energy Research (2017) *The New Economics of Offshore Wind.*
* See International Energy Agency definition at IEA (2014) *Fossil-fuel subsidies – methodology and assumptions*, and evidence for Environmental Audit Committee (2013) *Energy Subsidies*.
Notes: Prices on a 'social' and 'private' basis are adjusted downwards by £10/MWh to reflect intermittency costs, and increased by £5/MWh to reflect differences between contract vs. project lifetimes.

Table 2.6. Assessment of policies to drive abatement options in the power sector

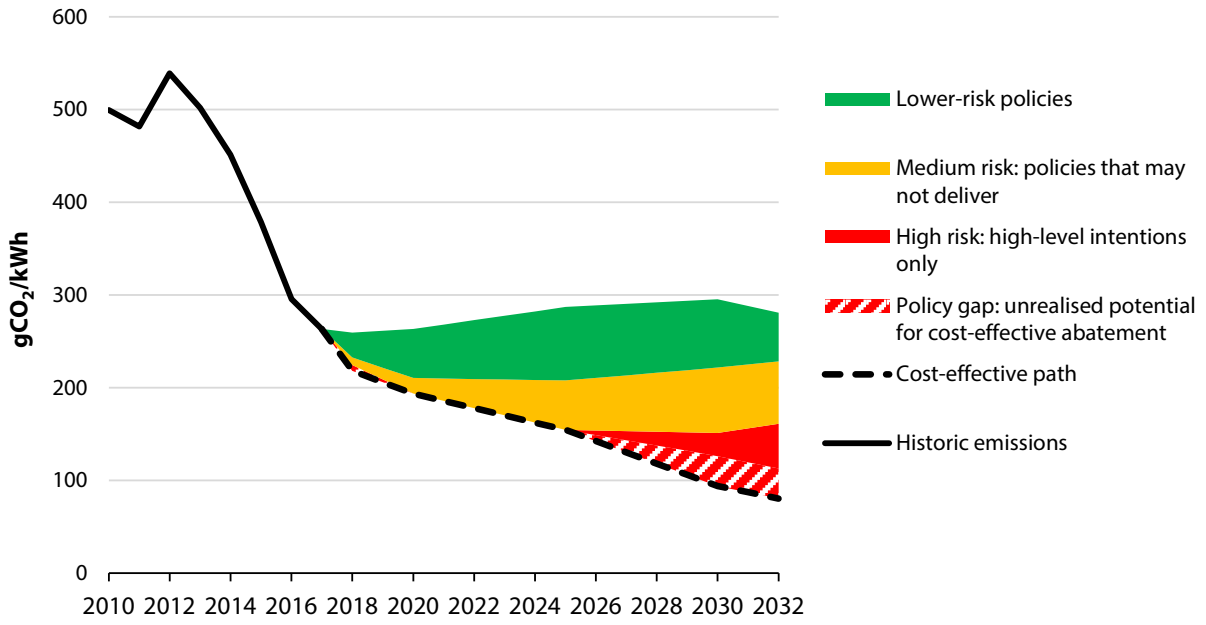
Abatement option	2017 policy	2018 updates and assessment
Contracted renewable generation (Renewables Obligation, FiTs, FIDER and first CfD allocation round)	Green — Delivery of over 130 TWh of generation per year by 2020.	Green — Although schemes are being closed early, projects have come through as planned or quicker, which should provide around 130 TWh of generation online by 2020/21.
Carbon capture and storage	Red — No policy or proposals from Government.	Red — The Government intends to publish a CCUS Deployment Pathway at the end of 2018.
Fuel switching away from coal	Green — Government committed to phasing out unabated coal by 2025.	Green — The Government announced its intention to implement an emissions performance standard which would prevent any unabated coal generation post 2025.
Nuclear - first 2 reactors at Hinkley	Amber — Contract between EDF and Government signed.	Amber — Construction of the Hinkley Point C nuclear plant is underway, however risks remain due to the scale and complexity of building a nuclear plant.
Further Contracts-for-Difference auctions for delivery post 2020	Amber — £730 million funding allocated for Contracts-for-Difference auctions, with the first of these underway.	Amber — First auction delivered, with record low offshore wind prices. The remaining £557 million funding has been re-confirmed for further Contracts-for-Difference auctions.

Table 2.6. Assessment of policies to drive abatement options in the power sector

Abatement option	2017 policy	2018 updates and assessment
A subsidy-free route to market for the cheapest low-carbon generation after 2020 (e.g. onshore and offshore wind, large-scale solar PV)	Red No policy.	Red Whilst the Control of Low Carbon Levies allows for subsidy-free renewables to be brought forward, there is currently no route to market for them.
Power system flexibility	Amber BEIS and Ofgem review and call for evidence on flexibility in the electricity market.	Amber BEIS and Ofgem committed to implement 29 actions published in the smart systems and flexibility plan. Alongside this National Grid is undertaking actions to enhance system flexibility. Continued progress in implementing these actions is required from all parties going forward.
Contingency plans for delay or cancellation of planned projects (e.g. new nuclear plants or imported electricity)	Red No policy.	Red There has been no progress on support for alternative technologies or on the development of a publicly available robust contingency plan.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower-risk policy - expected to deliver.

Figure 2.8. The policy gap in the power sector



Source: CCC analysis based on BEIS (2018) *Energy and Emissions Projections*.
Notes: Chart shows the emissions intensity of UK electricity generation, before accounting for losses. This is lower than the emissions intensity of UK based 'useable generation', which we also estimate and use as an indication of the carbon intensity of consumption. Policies to reduce electricity demand (e.g. Products Policy, Building Regulations), are covered in the relevant sectoral chapters (Chapter 3 - Buildings and Chapter 4 - Industry). We have adjusted BEIS's 'no policy' baseline to reflect actual generation in 2017. Emissions in the baseline increase beyond 2030 due to nuclear plant retiring from the electricity system.

Government projections[27] for electricity generation in 2030 includes 9% of generation from new nuclear power beyond Hinkley Point C (equivalent to two additional plants) and up to 22% of generation from imported electricity. In addition to existing and contracted low-carbon generation, and expected generation from the remaining funding for low-carbon generation (85% of generation in 2032), this leads to an emissions intensity of around 95 gCO_2/kWh by 2032. Whilst this is consistent with the Committee's cost-effective path, which considers emissions intensity below 100 gCO_2/kWh by 2030 to be cost-effective, we do not consider this pathway credible as there are significant risks associated with it:

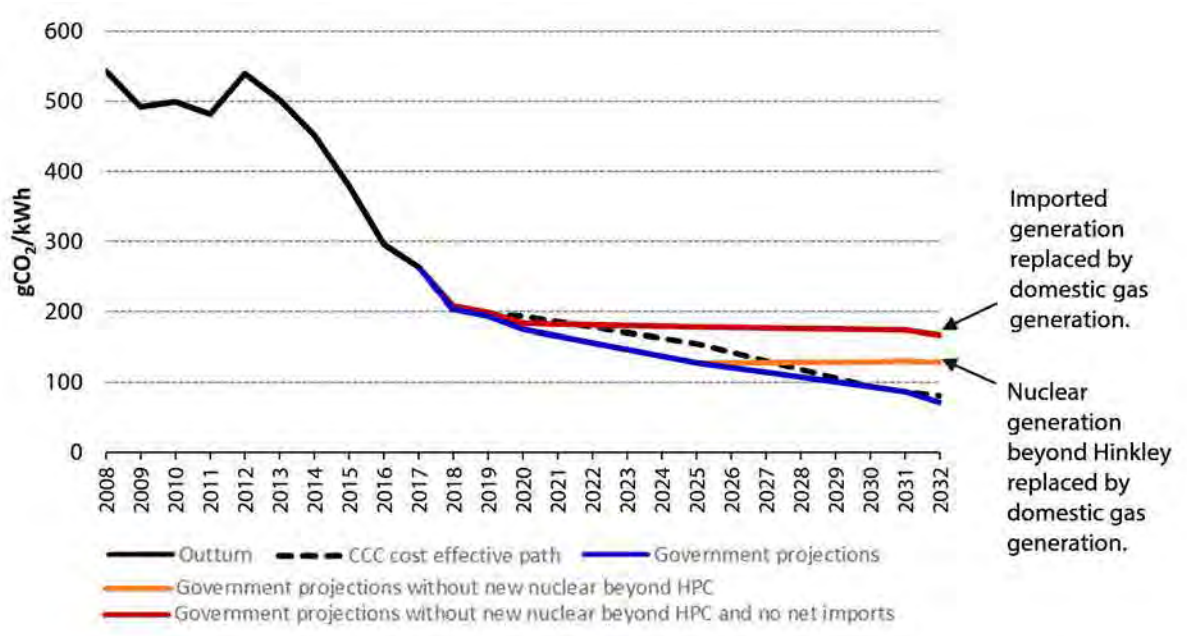
- BEIS's generation scenarios imply two new nuclear plants commissioning beyond Hinkley Point C by 2032. Delay or cancellation of these plants could – in the absence of additional contracts for low-carbon generation - lead to increased domestic gas generation in order to meet demand. Depending on how much capacity is delayed or cancelled this could increase emissions intensity by up to 35 gCO_2/kWh in 2030.
- Although the UK is currently a net importer of electricity - and emissions associated with these imports do not count towards UK territorial emissions - structural changes to European energy markets or changing fuel prices could lead to imports below BEIS's projections in 2030. This would leave the UK needing to generate more energy domestically,

[27] BEIS (2018) *Updated Energy and Emissions Projections 2017*.

which – in the absence of additional contracts for low-carbon generation - we assume would come from gas generation. This could increase emissions intensity by an additional 45 gCO_2/kWh in 2030.

A combination of these risks could increase emissions intensity from below 100 gCO_2/kWh, consistent with the CCC cost-effective path, to around 175 gCO_2/kWh in 2030 (Figure 2.9).

Figure 2.9. Risks around the emissions intensity in the Government's power sector forecasts



Source: BEIS (2017) *Clean Growth Strategy*; BEIS (2018) *Updated Energy Emissions Projections 2017*; CCC (2015) *Fifth Carbon Budget Scenarios*.
Notes: HPC = Hinkley Point C.

5. Further actions required in the power sector

In order to be on track to meet the cost-effective path for economy-wide decarbonisation the Government needs to both bring forward new policies to support low-carbon generation and develop contingencies to mitigate against the risks of planned projects failing to deliver:

- Deploying CCS at scale in the 2030s will require a programme of CCS deployment across power and industry reaching 10 $MtCO_2$ captured per annum in 2030, on the path to at least 20 $MtCO_2$ per annum in 2035, alongside a separate approach to CO_2 capture and to the transport and storage infrastructure (see Chapter 1). The power sector can play an important role in economy-wide CCS deployment, although lower renewables costs also raise the question of how much CCS is needed in the power sector alongside its use in industry, hydrogen production and greenhouse gas removal technologies.
- The Government must extend its approach to contracting low-carbon generation in order to support the deployment of 50-60 TWh of additional low-carbon generation required in the 2020s. This should include contracting mature low-carbon generation in regular auctions with adequate lead times, alongside any further negotiated contracts or CCS projects. We do

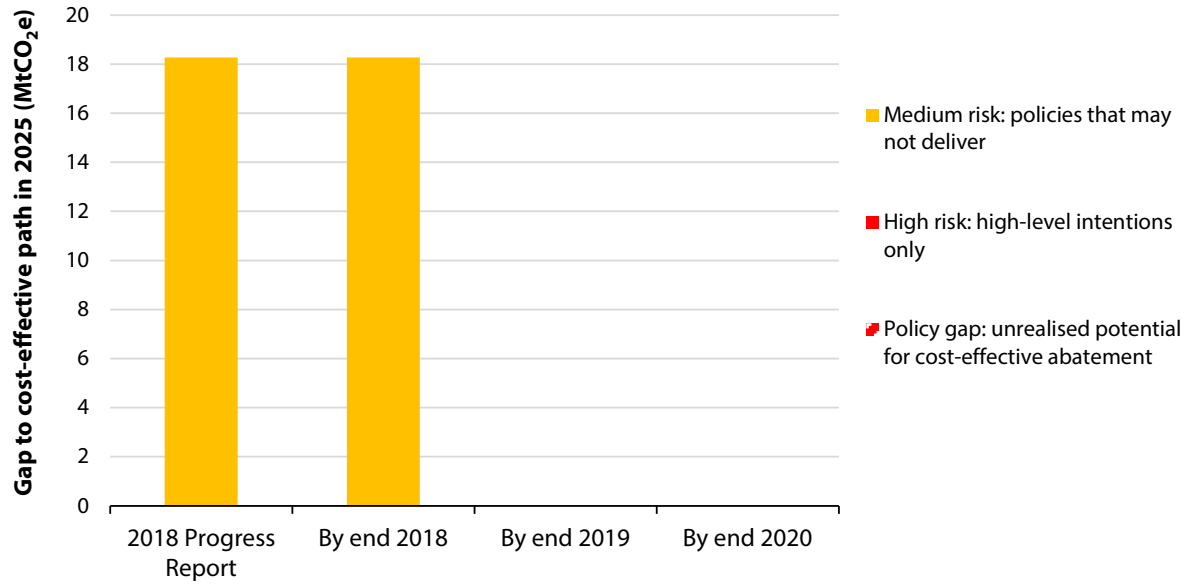
not expect that sufficient amounts of low-carbon generation can be delivered without government-backed contracts.

  - A programme of regular Contract-for-Difference auctions is required as a cost-effective approach to delivering the low-carbon generation required. A commitment to regular auctions, with auction dates published with sufficient lead-times, can provide confidence to investors that there will be a market for low-carbon generation in the 2020s. This will help to attract the necessary capital to the UK and will help to keep costs, and consumer bills, to a minimum.
  - Contracts for Difference should be offered to support the lowest-cost low-carbon generation, such as onshore wind and solar PV. These projects could be brought forward whilst benefiting consumers through lower energy bills if auctions were run with reserve prices set to give no net subsidy over a project's lifetime. Latest estimates from BEIS and others suggest that onshore wind and solar PV are already cheaper than new fossil-fired generation, as were the prices awarded to offshore wind in the latest CfD auction.
  - While auctions have proven effective in driving down costs, they could be supplemented with negotiated contracts for projects not well suited to auctions if they can be agreed at reasonable strike prices. This may apply to projects such as nuclear plants, CCS plants, or tidal lagoons that have few potential bidders or require specialised contract terms.
  - The Government must put in place a progress monitoring framework that allows for risks to delivery of low-carbon projects to be identified ahead of time. In addition, contingency plans for the delay or under-delivery of projects, such as new nuclear or imported electricity, must also be developed. These plans should allow for alternative low-carbon generation to be contracted in time to replace any under-delivery without increasing carbon emissions. A regular auctioning system could provide a route to compensate for under-delivery from other projects by increasing the amount of generation being procured through the next auction.

- Policy and regulatory changes must continue to ensure that flexibility options are rewarded in a way that reflects the value they bring to the system. This will mitigate against any risks to system security that higher levels of intermittent generation may bring. In July 2017 the Government confirmed its intention to proceed with all 29 recommendations set out in the Smart Systems and Flexibility Plan. Continued progress from Government, Ofgem and National Grid is required to achieve this aim.

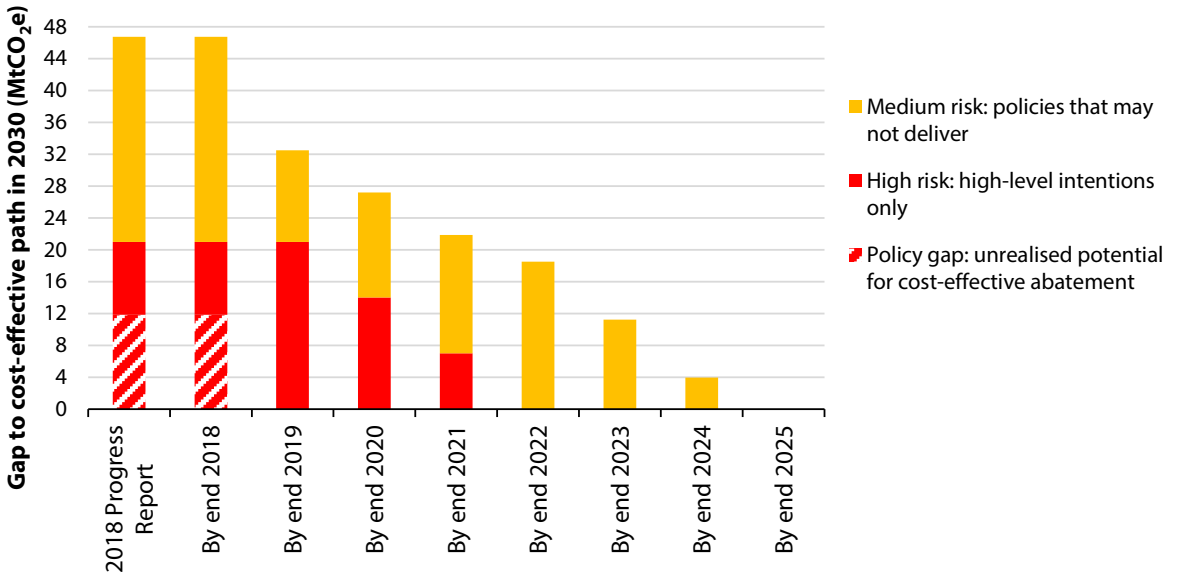
Taking the actions set out above should ensure that the delivery risks for the mid-2020s are largely removed by the end of 2020 (summarised in Table 2.7, Figure 2.10). Similarly, these actions will bring forward sufficient policies and detail to close the gap for 2030 by 2020, and remove delivery risks wherever possible associated with these policies in the first half of the 2020s (Figure 2.11). Alongside this, as outlined above, contingency plans should be developed in case planned policies fail to deliver. All together this should provide confidence and clarity that emissions reductions will be achieved sufficient to reach an emissions intensity of under 100 gCO_2/kWh in 2030, in line with the cost-effective path.

Figure 2.10. Risks around the delivery of power sector policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy Emissions Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the power sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period. Estimated generation from the remaining £557m funding for Contracts for Difference and Hinkley Point C is expected to be sufficient to close the policy gap by 2025. This assumes that Hinkley comes fully online in 2025.

Figure 2.11. Risks around the delivery of power sector policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy Emissions Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the power sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period. Estimated generation from the remaining £557m funding for Contracts for Difference and Hinkley Point C is expected to be sufficient to close the policy gap by 2025. This assumes that Hinkley comes fully online in 2025.

Table 2.7. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
Continue to run auctions for low-carbon power beyond the Spring 2019 Contracts-for-Difference auction, sufficient to reach an emissions intensity below 100 gCO_2/kWh by 2030, including a route to market for the cheapest forms of low-carbon generation (i.e. onshore wind and solar). This should include a long-term view of future auctions to give investor confidence, help support effective supply chains, and keep costs to a minimum.	2019 onwards
A new strategic approach to deploy carbon capture and storage (CCS) at scale in the 2030s. This will require a programme of CCS deployment across any of power, hydrogen or industry reaching 10 $MtCO_2$ per annum in 2030, on the path to at least 20 $MtCO_2$ per annum in 2035. This must include separate approaches to CO_2 capture and the transport and storage infrastructure.	Deployment Pathway and review of investment and delivery models published by end 2018 and support for initial CCS deployment implemented by end 2021
The development of robust contingency plans that allow for additional low-carbon generation to be brought forward in the event of delay or cancellation of planned projects, or imports of electricity below projected levels. This could, for example, be achieved through a regular and predictable approach to auctioning contracts, with a feedback mechanism to contract more should other projects be delayed.	2019
Consultation on future electricity market design. This should include consideration of technology neutrality, subsidy-free Contracts for Difference and mechanisms for re-powering.	2019
Continued progress on improving electricity system flexibility, including implementation of the 29 actions in the Government's Smart Systems and Flexibility Plan.	Actions from the Smart Systems and Flexibility Plan should be implemented by 2022, alongside the continuation of wider improvements that are already underway

Chapter 3: Buildings

Key messages and recommendations

Direct emissions from buildings fell in 2017 to 85MtCO_2e, a 4% reduction relative to 2016. This was entirely due to higher winter temperatures; adjusting for this, annual emissions in 2017 rose by around 1% relative to the previous year. This is the second successive year that temperature-adjusted emissions have increased.

Home insulation rates fell further in 2017, with only 123,000 lofts or walls being insulated. Home insulation rates are at just 5% of peak market delivery in 2012. Opportunities for cost-effective carbon and bill savings are therefore being missed. For a typical home,[28] the absence of loft insulation adds in the region of £105 a year to bills. The absence of cavity wall insulation adds around £115 a year to bills.

Around 4.5% of heat in buildings is from low-carbon sources - mostly from biomass. There has been good progress in deployment of district heat networks, though they continue to be supplied mainly by gas Combined Heat and Power (CHP) rather than low-carbon alternatives such as waste heat or large-scale heat pumps. The domestic heat pump market remains stagnant at under 1% of annual heating system sales.

Our key messages are:

- **Delivery risks and policy gap.** A limited number of firm policy commitments have been made since our January assessment of the Clean Growth Strategy (CGS). A large proportion of estimated policy savings remain at risk. Recent progress in Scotland demonstrates a strong example of an effective policy package to drive emissions reductions. Furthermore, we have identified additional cost-effective abatement opportunities in UK buildings of 6 MtCO_2e in 2030, over and above current policy ambition. These cost-effective savings are currently being ignored, but could help put us on track for meeting our commitments under the Paris Agreement.
- **Compliance and enforcement.** This should be a priority area for action, to ensure that the savings associated with existing policies and standards can be realised. The Hackitt Review recently concluded that 'what is being designed is not what is being built'. It is critical that stronger compliance and enforcement procedures, with heavy penalties where appropriate, extend beyond fire safety to building regulations and policy more widely.
- **New build.** The Prime Minister's announcement of an ambitious new programme to ensure all new homes are highly energy efficient and built with low-carbon heat by 2030 is welcome. These homes must also be prepared for a changing climate. The trajectory for tightening standards will need to be set out. A key principle should be future-proofing: new-build standards should avoid requiring later, expensive, retrofitting measures.
- **Energy efficiency improvements to existing buildings.** Energy efficiency must urgently be improved across the building stock. Current policy is failing to drive uptake, including for highly cost-effective measures such as loft insulation. Policy needs to incentivise efficient long-term investments, rather than piecemeal incremental change. Backstop mandatory requirements can support this, as in Scotland, creating policy certainty and driving innovation and growth. The shift to focusing on operational savings must be accelerated - and public reporting mechanisms remain vital tools for benchmarking public and commercial buildings.
- **Low-carbon heat.** Deployment of low-carbon heat (e.g. heat pumps and low-carbon district heating schemes) should be prioritised, with early clarity on support beyond 2021. Cost-effective and low-regret opportunities exist for heat pumps to be installed in homes and businesses that are off the gas grid, together with low-carbon heat networks in heat-dense areas (e.g. cities) and for increased volumes of biomethane injection into the gas grid (up to

[28] Defined as a 1950s 3 bed semi-detached house.

around 5% of gas demand). There remain important questions to be resolved around the current balance of tax and regulatory costs across fuels, which currently weaken the private economic case for electrification.

- **Strategic decisions in the longer term.** The current reliance on natural gas is incompatible with long-term decarbonisation. Key strategic decisions will be needed in the early 2020s on low-carbon heat for properties on the gas grid, especially those outside heat-dense areas. The main options for these properties are heat pumps and low-carbon hydrogen. A governance framework is needed now to drive decisions on heat infrastructure in the next Parliament.

We will assess the Government's plans for delivering cost-effective abatement against the following checklist:

Table 3.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/timing
A stable framework and direction of travel for improving energy and carbon efficiency, focused on real-world performance.				
Publish concrete policies to deliver the Government's ambition on retrofit (Energy Performance Certificate band C by 2035) - including a delivery mechanism for the social housing minimum standards.		×	×	2018
Address major delivery risks around the Private Rented Sector (PRS) regulations - in particular, the exemptions capping landlord contributions which severely limit the scope and impact - and set out a trajectory for tightening to Energy Performance Certificate (EPC) band C by 2030.		×		Risks to be addressed in 2018 with longer-term framework in 2019
Set out concrete policies to deliver the ambition on non-residential buildings, and address existing policy risks including tightening non-domestic PRS regulations.		×	×	2018
Introduce voluntary public sector target, followed by review and consultation on future targets, including developing options to go		×	×	2018, with review by 2019 and legislation in place

Key messages and recommendations				
further in more ambitious sectors, and finalising tighter 'Greening the Government' targets.				by 2023 for mandatory target
Continue to improve boiler standards and heating controls, including a second phase of standards.		✖	✖	Continued improvement with second phase of standards in early 2020s
Strengthen new-build standards to ensure they are designed for a changing climate, are future-proofed for low-carbon heating and deliver high levels of energy efficiency. Tighter new-build standards supporting low-carbon heat come into force.		✖		Consultation in 2018, standards announced in 2019, in force by 2020, and with further tightening by 2025
Reform monitoring metrics and certification.			✖	2021-2025
Strengthen compliance and enforcement framework so that it is outcomes-based, places risk with those able to control it, provides transparent information and a clear audit trail, with effective oversight and sanctions.		✖	✖	First half of 2019
Put in place a long-term heat networks policy framework.		✖	✖	2020
Include in the Heat Strategic Options publication detail on a governance framework to drive decisions on heat infrastructure in the early 2020s.		✖	✖	2018
Consistent price signals that clearly encourage affordable, low-carbon choices.				
Publish detailed plans to phase out the installation of high-carbon fossil fuel heating in the 2020s, ensuring there is no policy hiatus in 2021.		✖	✖	Details published by 2019
Establish support framework for heat pumps and biomethane post-2021, as well as support for low-carbon technologies in heat networks.		✖	✖	Decision on Renewable Heat Incentive successor in 2018

Key messages and recommendations				
Review the balance of tax and regulatory costs across fuels in order to improve alignment with implicit carbon prices and reflect the progressive decarbonisation of electricity.			×	2019
An attractive and well-timed offer to households and Small and Medium-sized Enterprises (SMEs) that is aligned to 'trigger points' along with simple, highly visible information, certification and installer training.				
Set out policy package for able-to-pay and address delivery risks around the Energy Company Obligation (ECO) - in particular, to retain a focus on carbon savings and timely delivery. Decision on design for home energy efficiency support from 2022-2028.		×	×	2018, with decision on future support by 2020
Implement Green Finance Taskforce recommendations around green mortgages and fiscal incentives to encourage uptake and support financing of upfront costs.		×	×	2018
Develop new policy to support SMEs (e.g. peer-to-peer networks, financial support and soft loans).		×	×	2019
Improve consumer access to data and advice, implementing the Green Finance Taskforce proposals on Green Building Passports, improving EPCs and access to data underpinning EPCs and the Standard Assessment Procedure (SAP).		×	×	2018-2020
Drive wider use of operational data for benchmarking in the public and commercial sectors by strengthening and extending mandatory public reporting of operational energy ratings, e.g. via Display Energy Certificates or equivalent (such as NABERS). Streamlined Energy and Carbon Reporting Scheme (SECR) introduced for businesses.		×	×	Performance-based labelling scheme developed and SECR introduced by 2019
Review professional standards and skills across the building and heat supply trades with a nationwide training programme to upskill the existing workforce along with an increased focus on incentivising high 'as-built' performance.		×	×	2019

In this chapter we review progress in decarbonising UK buildings emissions in 2017. We summarise the analysis that underpins our key messages and recommendations in the following five sections:

1. Buildings emission trends and drivers
2. Buildings scenarios and indicators
3. Recent performance
4. Policy implementation
5. Further actions required in buildings

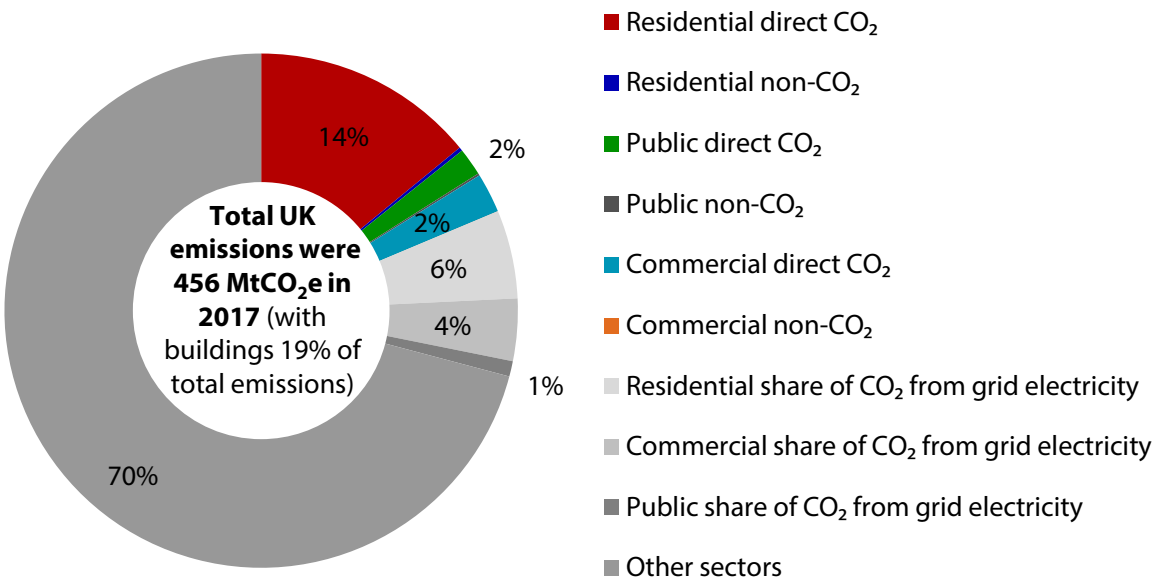
1. Buildings emission trends and drivers

Direct greenhouse gas (GHG) emissions from buildings were 85 $MtCO_2e$ in 2017, accounting for 19% of UK GHG emissions (Figure 3.1):

- Direct building CO_2 emissions were 83 $MtCO_2$ in 2017, split between homes (77%), commercial buildings (14%) and public buildings (10%).
- Buildings are responsible for 66% of UK electricity consumption, equivalent to a further 48 $MtCO_2e$ of indirect emissions. These emissions are falling due to both reductions in demand and the decarbonisation of electricity supply.
- Around 2 $MtCO_2e$ of non-CO_2 emissions (methane and nitrous oxide) were associated with buildings in 2017.

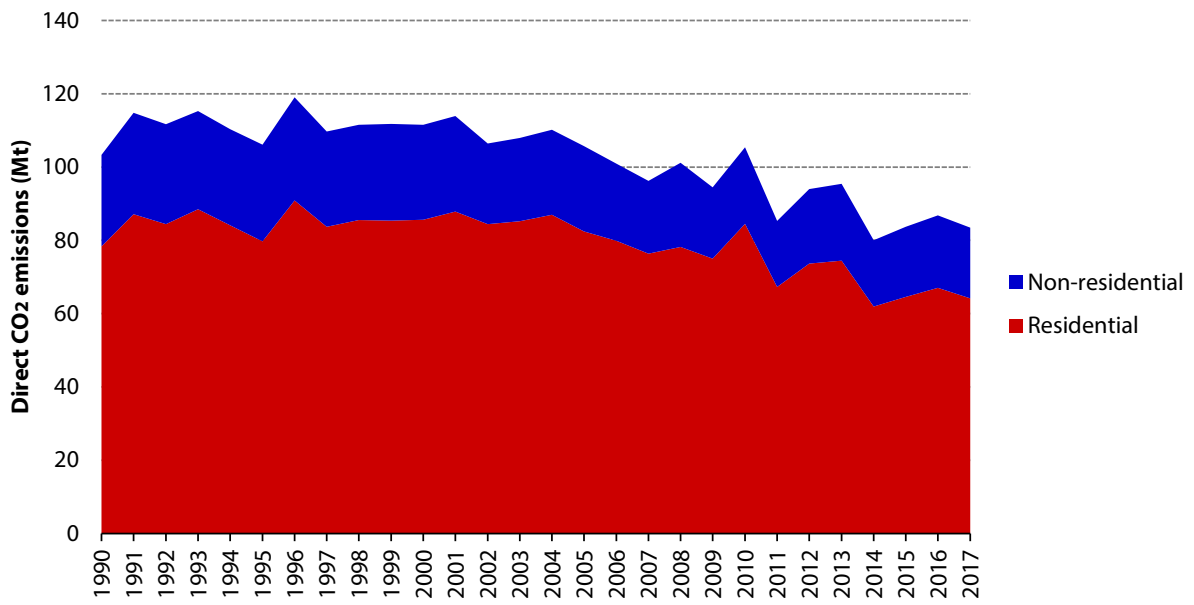
Direct CO_2 emissions from buildings fell to 83 $MtCO_2$ in 2017 (Figure 3.2). This was entirely due to higher winter temperatures: adjusting for this, annual emissions rose by around 1% (Table 3.2). This is the second successive year that temperature-adjusted emissions have risen.

Figure 3.1. Buildings emissions as a share of UK total (2017)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; BEIS (2018) *Provisional UK greenhouse gas emissions national statistics 2017*; BEIS (2018) *Energy Trends, March 2018.*
Notes: 2017 emissions are provisional. Residential, public and commercial non-CO_2 emissions round to 0% of total UK emissions, but are non-zero.

Figure 3.2. Direct CO_2 emissions from buildings (1990-2017)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; BEIS (2018) *Provisional UK greenhouse gas emissions national statistics 2017*.
Notes: 2017 emissions are provisional. Emissions data are not temperature-adjusted.

Table 3.2. Summary of buildings emissions trends

	2017 direct emissions ($MtCO_2$)		Change (temperature-adjusted)	
	Actual	**Temperature-adjusted**	**% change 2016-2017**	**Annual average % change 2009-2016**
Residential	64	71	+1%	-1%
Non-residential	19	21	+1%	0%
of which commercial	11	12	+1%	+1%
of which public	8	9	0%	-1%
All buildings	83	92	+1%	-1%

Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; BEIS (2018) *Provisional UK greenhouse gas emissions national statistics 2017*.
Notes: 2017 emissions are provisional. Figures may not sum due to rounding. Please note that the 85 $MtCO_2e$ referenced elsewhere in this section includes 2 $MtCO_2e$ of non-CO_2 emissions made up of methane and nitrous oxide.

2. Buildings scenarios and indicators

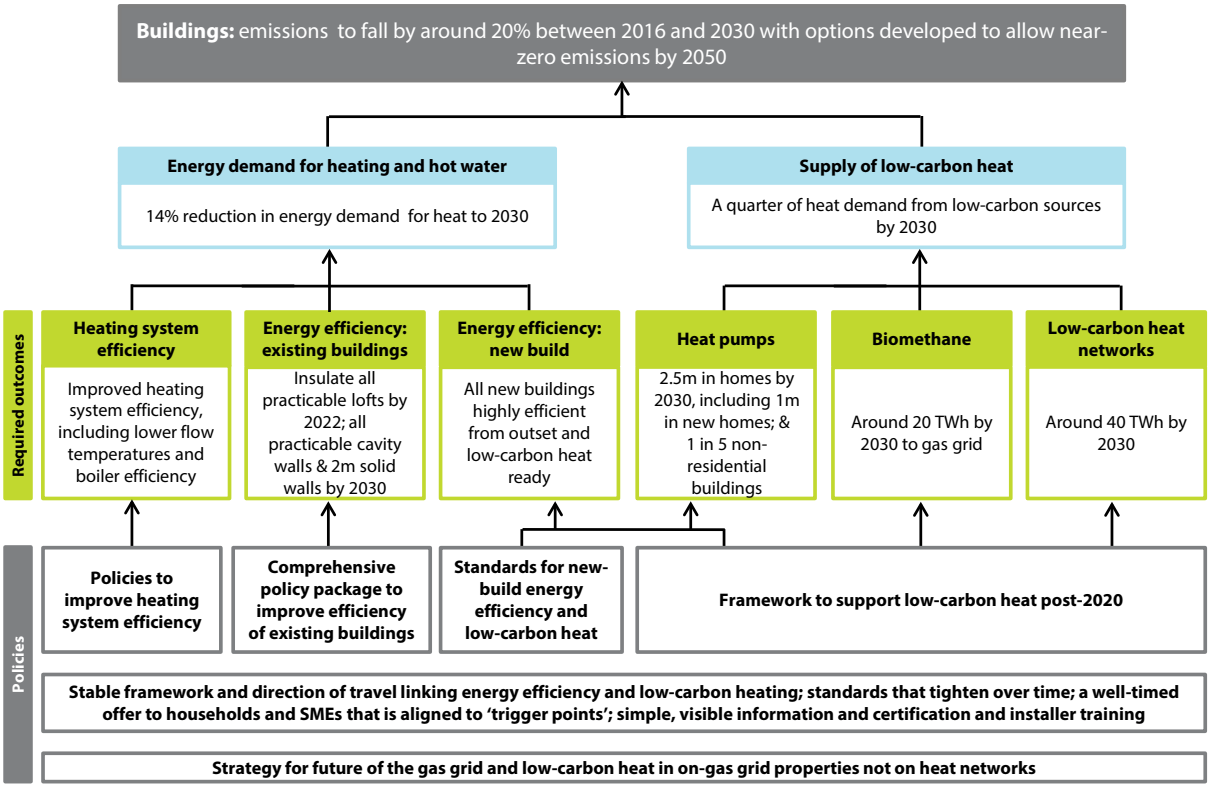
Our assessment of the least-cost pathway to the legislated carbon targets implies a reduction in emissions of 16% between 2017 and 2030.

In last year's Progress Report, we set out our framework for measuring progress in buildings decarbonisation (Figure 3.3). Our indicator framework for buildings is designed to capture changes on both ***decarbonising the supply*** by substituting fossil fuels with low-carbon electricity, fuels and heat sources ('low-carbon heat'), along with ***reducing and managing demand***:

- Our two top-level indicators track total heat demand and the supply of low-carbon heat.
- These top-level indicators are complemented by a set of supporting indicators which track the roll-out of low-carbon measures and policy indicators that highlight necessary policy development.

Our progress against these is set out in Section 3.

Figure 3.3. CCC indicators for buildings



3. Recent performance

The necessary progress is not being made in improving energy efficiency - home insulation rates are at just 5% of peak market delivery in 2012. Nor is the necessary progress being made in shifting to low-carbon heating (Table 3.3):

- Low-carbon heat deployment is at 4.5% of total buildings heat demand, which is just below our indicator. However, around 82% of this is bioenergy,[29] with 60% of low-carbon heat deployment being biomass in homes. The dominance of biomass remains an issue because this is not the long-term best use of finite bioenergy resources. Deployment of heat pumps continues to lag, with only around 18,000 units sold in 2016. Whilst delivery of heat through heat networks appears to be broadly on track, only 7% of heat in heat networks currently comes from low-carbon primary fuel sources.
- Insulation installation rates are now at their lowest in ten years, including for loft insulation despite considerable remaining potential, and even though this is a highly cost-effective measure. Following retargeting of ECO, a significant policy gap remains for households who are considered 'able-to-pay' for energy efficiency measures (i.e. not 'low-income' households).
- We do not have a set of detailed indicators on public and commercial energy efficiency due to a lack of consistent data sources, but overall measures of energy intensity (kWh/m^2 of floor space) show no evidence of underlying progress in 2016, the latest year for which data are available.

The following section considers progress in each of these areas in turn.

[29] Including biomass use in agricultural buildings, domestic wood use in biomass boilers, animal biomass and anaerobic digestion, plant biomass, sewage gas, and landfill gas. Excludes wood burnt on open fires.

Table 3.3. Key outcomes (indicators) to be on track for 2030 (and latest outturn)		
Key outcome	**2017 indicator**	**2017 outturn**
Headline indicators		
Reduce direct CO_2 from buildings by 32% by 2030, from 1990 levels*	-17%	-11%**
24% reduction in direct CO_2 from homes by 2030, from 1990 levels*	-13%	-9%**
58% reduction in direct CO_2 from non-residential buildings by 2030, from 1990 levels*	-27%	-16%**
Low-carbon heat uptake		
At least a quarter of buildings heat from low-carbon sources by 2030	5% in 2016 (lag in data publication)	4.5% in 2016
At least 2.5 million heat pumps in homes by 2030, and 300k by 2020 (critical path)	Not set on an annual basis, but average annual sales to 2020 of >30,000 needed	2016 sales of 18,000 units, with total stock of around 160,000 (lag in data)
Around 40 TWh of heat supplied through low-carbon heat networks by 2030, and 10 TWh by 2020	6 TWh of low-carbon heat supplied through district heat networks	6 TWh of district heat supplied in 2017, but only 7% of all heat networks currently use a low-carbon primary fuel source
Around 20 TWh of biomethane injection by 2030	4 TWh	2 TWh
Energy efficiency uptake		
All practicable lofts insulated by 2022	545,000 per year	37,000 installed in 2017
All practicable cavity walls insulated by 2030	200,000 per year	70,000 installed in 2017
2 million solid walls insulated by 2030	90,000 per year	16,000 installed in 2017
Notes: * Including abatement from biomethane. ** Temperature-adjusted emissions, to show underlying trend.		

Low-carbon heat

The contribution of low-carbon heat sources to heat demand in buildings is currently at around 4.5% of total buildings heat demand. However, around 82% of this is bioenergy,[30] with 60% of low-carbon heat deployment being biomass in homes:

- Burning biomass can lead to air quality issues arising from emissions of fine particulate matter and nitrogen oxides. The impact on local air quality is particularly pronounced outside rural areas.
- The use of biomass for buildings heat is poorly aligned with the longer-term best use of finite bioenergy resources, implying many consumers or businesses may need to switch to another form of low-carbon heating in the future (as competing demand drives up prices).

The domestic heat pump market remains stagnant, accounting for under 1% of annual heating system sales. For comparison, sales in the Netherlands - which has current widespread consumer access to cheap gas heating and faces the same challenge for decarbonising heat - are around three times higher on a per-capita basis.

Delivery of heat through district heat networks appears broadly in line with our indicator. However, only 7% of all heat networks use low-carbon sources as their primary fuel source (with 90% using natural gas).

Biomethane injected into the gas grid currently stands at 2 TWh, half of the contribution expected in our indicator. It is important that anaerobic digestion facilities are based very largely on waste feedstocks, in order to limit competition with food production and to minimise overall lifecycle emissions.

Demand reduction and management in homes

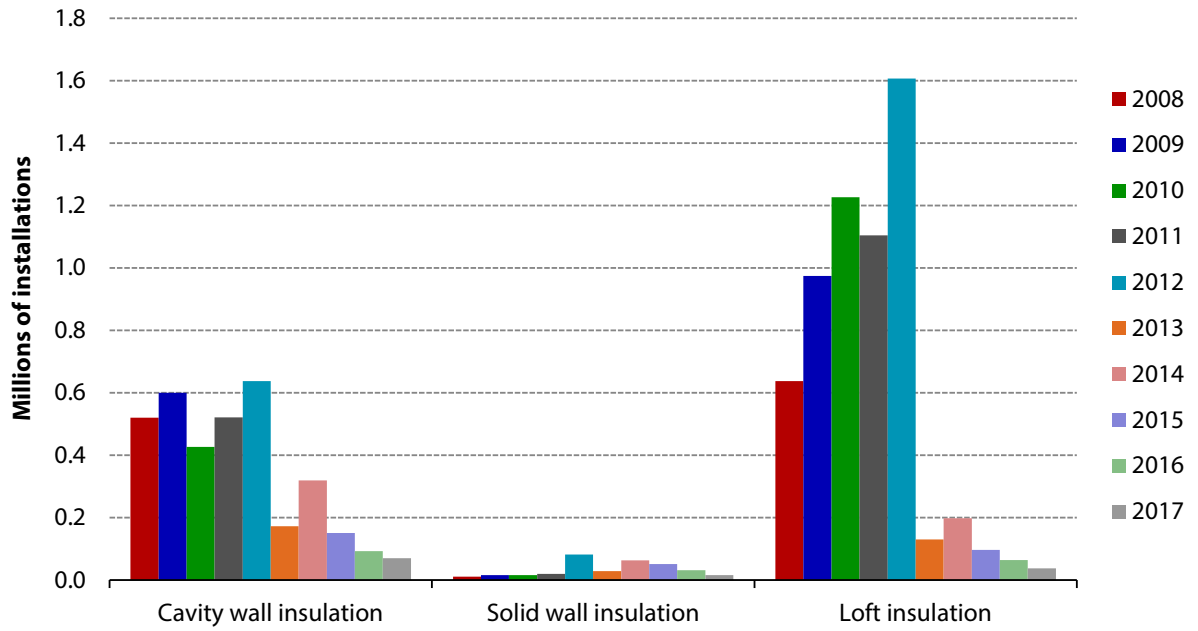
Progress in delivering insulation slowed further in 2017 from levels already far lower than those achieved up to 2012 (Figure 3.4) - home insulation rates are at just 5% of peak market delivery in 2012. Insulation measures offer highly cost-effective opportunities for carbon savings, also providing comfort and health benefits and reducing energy bills. For a typical home, the absence of loft insulation adds in the region of £105 a year to bills. The absence of cavity wall insulation adds around £115 a year to bills. The private payback is expected to be under four years for lofts and standard cavity wall insulation. These opportunities are currently being missed.

The natural replacement of older boilers can be expected to continue to deliver reductions in emissions. However there is a range of wider factors which determine efficiency, such as system flow temperatures ('return' temperatures should be no higher than 55°C for condensing boilers to work efficiently) and the degree to which systems are hydraulically balanced. Balancing can increase the operational efficiency of a heating system by at least 10% in new buildings, [31] and the same principle applies for existing buildings. More focus should be placed on monitoring and reporting actual rather than modelled performance (e.g. by using data from smart meters) to track progress.

[30] Including biomass use in agricultural buildings, domestic wood use in biomass boilers, animal biomass and anaerobic digestion, plant biomass, sewage gas, and landfill gas. Excludes wood burnt on open fires.
[31] Sustainable Energy Association research shows that most quoted energy efficiency savings from hydraulic balancing are between 10-25% for new buildings. For further detail see Sustainable Energy Association (2016) *Heating System Plus Policy Position Paper*.

Total household electricity demand fell by 3% in 2017, continuing a longer-term trend.[32] However, significant further potential remains in terms of shifting demand outside peak hours, which can unlock bill savings to consumers as well as significant system benefits. We will consider further indicators to track progress in this area in future.

Figure 3.4. Annual insulation installation rates (2008-2017)



Source: BEIS (2018) *Household Energy Efficiency National Statistics;* previous DECC publications.
Notes: Installations under Government schemes.

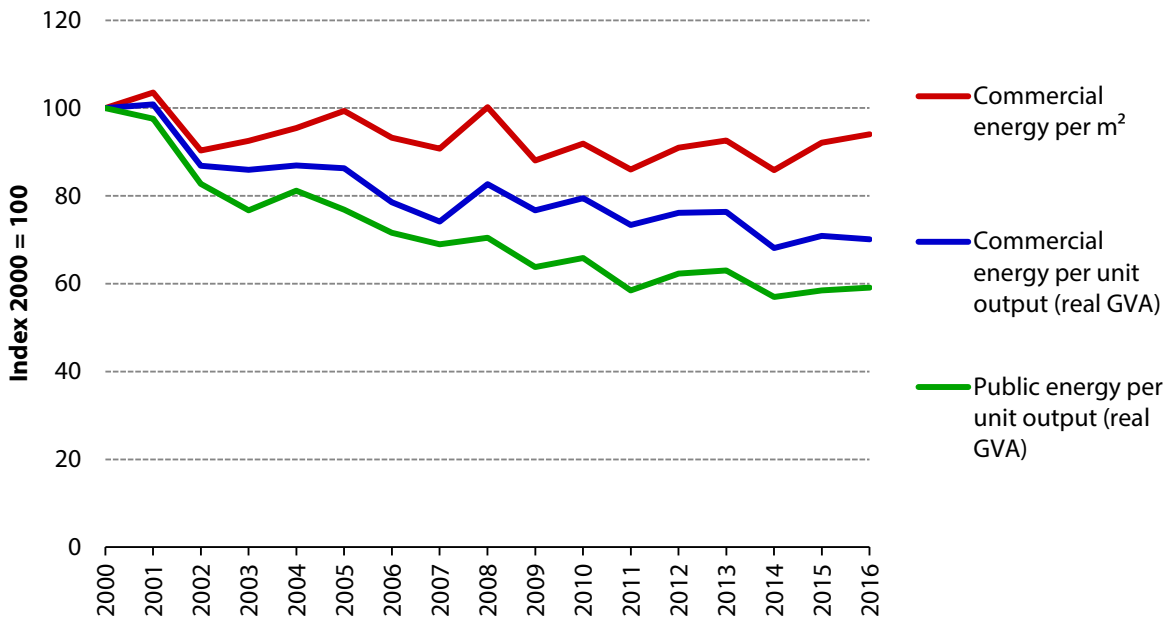
Demand reduction and management in public and commercial buildings

Progress is harder to track in public and commercial buildings, due to the huge variation in building type and lack of consistent datasets covering all buildings.

Overall measures of energy intensity show no evidence of underlying progress. Energy intensity remained broadly unchanged in 2016, the latest year for which there are available data, with slight increases in both public energy consumption per unit of output (real GVA) and commercial energy consumption per m^2 (Figure 3.5).

[32] Equivalent to a 2% fall when using temperature-adjusted data.

Figure 3.5. Energy intensity of public and commercial buildings



Source: BEIS (2017) *Energy Consumption in the UK*; VOA (2016) *Business Floor space.*
Notes: Energy consumption is final consumption across all fuel types. Consumption has been rebased from the year 2000. GVA is gross value added i.e. the value generated by any unit engaged in the production of goods and services. Separate GVA statistics are provided for commercial and public administration activities by the ONS.

4. Policy implementation

Effective policy on reducing emissions from buildings must cover:

- A stable framework and direction of travel for driving and joining up energy efficiency and low-carbon heat in existing buildings.
- New-build standards which future-proof for low-carbon heat, deliver high levels of fabric efficiency, and drive resilience to a changing climate.
- Simple, highly visible information and certification including enhanced business reporting, alongside installer training.
- Reformed support for low-carbon heat through the 2020s.
- Active preparations for strategic decisions in the early 2020s on the role of hydrogen for heat and the future of the gas grid.

The Clean Growth Strategy set out strong ambition on energy efficiency to drive down emissions from buildings (although major gaps remain on low-carbon heat). In order for these ambitions to be realised, detailed policies and measures are needed. A limited number of firm policy commitments have been made since our January assessment of the Clean Growth Strategy (Table 3.4).

Table 3.4. Key announcements in the CGS or since then

Policy area	Announcements
Energy efficiency	A key aspiration was set for as many homes as possible to reach EPC band C by 2035 where practical, cost-effective and affordable. Firm policies included a commitment to extend support for home efficiency improvements out to 2028 at the current level of ECO funding, and a new energy and carbon reporting framework for the commercial sector. Since the CGS, consultations have been published on the future design of ECO 3 and on the Private Rented Sector Minimum Standards.
New build	Government announced an intention to consult on strengthening energy performance standards for new and existing homes, and on improving the energy efficiency of new and existing commercial buildings. A commitment was made to ensure new buildings are future-proofed for low-carbon heat by 2020. In May 2018 a 'Grand Challenge' mission was announced to at least halve the energy use of new buildings by 2030, including making sure every new building in Britain uses clean heating.
Low-carbon heat	Commitments included the phase out of high-carbon fossil fuel heating in homes and businesses off the gas-grid, reform of the Renewable Heat Incentive and the build and extension of heat networks across the country. Since the CGS, the detail of the Heat Networks Investment Project has been published, the refocused RHI regulations have passed through Parliament, and new standards have been introduced for domestic boiler installations. A call for evidence on a future framework for heat in buildings has also been published.

Table 3.4. Key announcements in the CGS or since then	
Policy area	**Announcements**
Strategic decisions	The CGS announced a plan to publish initial findings and a review of evidence on the future of heat decarbonisation by summer of this year. A range of studies have since been published and £20 million of funding has been announced to accelerate the development of low-carbon hydrogen production.
Notes: This table is not intended to represent an exhaustive list of policies or announcements.	

Whilst the CGS was published on a UK-wide basis, heat and energy efficiency are partly devolved matters. The devolved administrations have a range of additional policies which go beyond Central Government policies in a number of areas. In 2016 the Welsh Government published 'Energy Efficiency in Wales', setting out a strategic direction for the decade ahead. Wales has also had a range of pre-existing schemes such as Arbed - an excellent demonstration of the broader health, affordability, wellbeing and regeneration benefits of an area-based retrofit programme. Scotland has recently published its Route Map for the Energy Efficient Scotland programme (Box 3.1). The Scottish approach represents best practice in a number of areas, including setting standards well in advance, with a regulatory backstop for owner-occupied homes, and a statutory underpinning. This provides a strong example of an effective policy package to drive emissions reductions and other outcomes, including on fuel poverty.

Box 3.1. Progress in Scotland

In March 2018 the Scottish Government published their route map and consultation on delivering an 'Energy Efficient Scotland'.

Ambition

The route map sets out an ambition to ensure all Scottish homes achieve an EPC C rating by 2040, where technically feasible and cost-effective. Since publication of the route map, the Scottish Parliament has given majority backing for proposals to bring forward these energy efficiency targets by a decade. This sits alongside commitments to maximise the number of social-rented homes achieving EPC band B by 2032 (becoming carbon neutral by 2040 as far as reasonably practical), and a detailed trajectory for private-rented homes to reach EPC C by 2030 where technically feasible and cost - effective. Finally, a target is set to bring all homes with households in fuel poverty to EPC C by 2030 and EPC band B by 2040, where technically feasible and cost-effective.

In the commercial sector, the route map commits to building on the current regulations in the Climate Change (Scotland) Act, extending them to all non-domestic buildings and requiring buildings to be improved to the extent technically feasible and cost-effective by 2040. For public buildings, an energy efficiency baseline will be established, with the aim of ensuring all public sector buildings achieve the relevant benchmark ahead of 2040 (where technically feasible and cost-effective).

While the route map contains a range of commitments around energy efficiency, it also builds on existing proposals for low-carbon heat, in particular Local Heat and Energy Efficiency Strategies (LHEES) which aim to link long-term targets and national policies with delivery of energy efficiency and heat decarbonisation on the ground.

Box 3.1. Progress in Scotland

Framework for achieving the ambition

The proposed delivery framework includes a mix of existing and new measures. These include continuing the existing programme of grants and loans, funding support for fuel poverty programmes, local authorities and LHEES, and for nationally delivered support to cover those households and businesses not covered by area-based schemes. Alongside this there is a broader framework for consumer protection, skills and training, the supply chain and quality assurance as well as assessment.

The Scottish Government is consulting on giving the proposals a legislative underpinning, in particular to set long-term standards for improved energy efficiency and heat decarbonisation (e.g. a backstop mandatory requirement for properties to meet EPC C), to place duties on Local Authorities, and to regulate district heating.

Source: Scottish Government (2018) *Energy Efficient Scotland, Energy Efficient Scotland Consultation: Making our homes and buildings warmer, greener and more efficient*.

Policy progress will be needed to deliver against Government ambition, and to meet the least-cost pathway for delivery of legally binding carbon targets. A number of existing policies have risks associated with delivery. Furthermore, a number of proposals from the Clean Growth Strategy have yet to be turned into firm policies, and there are some areas of policy for which there are no proposals. We set out below where progress will be needed.

Current policy is failing to drive uptake of energy efficiency measures in existing buildings.

Whilst broad ambition has been laid out, there are a number of significant gaps in the policy framework, and risks to current policy:

- Policies have yet to be set out to deliver the stated ambition on home retrofits (EPC band C by 2035), including for those households deemed 'able-to-pay', and a delivery mechanism for social housing minimum standards.
- In December 2017, Government consulted on setting a landlord cost cap of £2,500 for the domestic private rented sector minimum standards. Government's impact assessment estimated that a cap of £2,500 would result in only 30% of F- and G-rated private-rented homes reaching band E. This severely limits the scope and impact. More will be needed to deliver on the EPC band C by 2030 commitment. The Committee on Fuel Poverty have also stated that the current proposal would be insufficient to meet the 2020 fuel poverty strategy milestone.[33] Low levels of ambition now mean both higher running costs for renters - including many fuel poor - as well as risking higher retrofit costs in the long term (Box 3.2). Lack of consistent support can also have a damaging impact on supply chains. A recent survey by EEVS Insight and Bloomberg New Energy Finance finds that 21% of energy efficiency suppliers see policy uncertainty as their primary issue of concern.[34] Recently published results from the Low Carbon and Renewable Energy Economy Survey run by the

[33] Committee on Fuel Poverty (2018) *CFP response to consultation on Domestic private rented sector: minimum level of energy efficiency*.
[34] EEVS insight and Bloomberg New Energy Finance (2018), *Energy Efficiency trends Vol. 21*.

Office of National Statistics also show that full time employees working on 'energy efficient products' in the construction industry dropped from 67,000 in 2014 to 37,000 in 2016.[35]

- A consultation was issued in March this year, setting out proposals for ECO 3 (2018 to 2022). Whilst there are some useful proposed changes, such as the focus on actual performance and the inclusion of flexible eligibility and an in-fill mechanism,[36] proposed changes to the treatment of solid wall insulation and the treatment of supplier delays introduce further risks to the delivery of cost-effective carbon savings (Box 3.3).
- In the non-residential sector, policy has yet to be announced for the 20% energy efficiency target and existing policies have delivery risks, including the proposed weakening of requirements around Display Energy Certificates and the limited scope of the private rented sector Minimum Energy Efficiency Standard (MEES) (Box 3.4).
- The 2018 update of boiler standards, set out in the Domestic Building Services Compliance Guide, is designed to encourage bolt-on measures such as flue gas heat recovery systems, weather compensators and smart controls which can improve the efficiency of heating systems. [37] However, current boiler standards and guidance do not go far enough. Further efforts are needed to ensure boilers are installed and set according to the manufacturer's guidance. Where not properly addressed, poor installation practices can jeopardise carbon savings.

[35] Office for National Statistics (2018) *Low carbon and renewable energy economy final estimates.*
[36] 'Flexible eligibility' was first introduced in April 2017. It is a voluntary element of the scheme which allows suppliers to meet up to 10% of their ECO Affordable Warmth targets by targeting households identified by the Local Authority as eligible according to locally specific criteria. The 'in-fill' mechanism allows a certain proportion of homes which do not meet the Affordable Warmth eligibility criteria to receive ECO support for solid wall insulation if they are adjacent to other households that are eligible for ECO support.
[37] BEIS (2017) *Heat in buildings - Boiler plus.*

Box 3.2. Policy risks with the domestic Private Rented Sector standards

The 2018 Private Rented Sector standards were introduced with the stated aim of tackling the least energy-efficient properties in England and Wales - those rated F and G on their EPC.

Privately-rented F- and G-rated homes face significantly higher energy costs of keeping warm than typical households: on average over £600 per year more than E-rated PRS homes and almost £1000 more per year than the average home.[38] There is also a direct link between cold inefficient homes and poor health outcomes for tenants - the Government Impact Assessment estimates that most inefficient domestic properties are on average up to 2°C colder than the most efficient homes.

The proposed package of measures therefore risks leaving 70% of privately-rented F- and G-rated homes spending more than they need to on energy bills, and at risk of poorer health outcomes. BEIS *Fuel Poverty Statistics 2017* (2015 data) show that there are 278,000 fuel poor households living in Band F/G properties. The Committee on Fuel Poverty have highlighted that of these, 122,000 (44%) are privately rented properties.

There is also risk that a staged process of standard setting and landlord contributions will lead to incremental energy efficiency improvements at the expense of holistic whole-house solutions. Modelling undertaken by the Centre for Sustainable Energy on the fuel poor segment suggests that a tiered approach risks multiple interventions for over a million fuel poor dwellings (incurring additional costs in the process).[39] Policy should be designed to incentivise efficient long-term investments, rather than piecemeal incremental change.

Source: Statistics drawn from BEIS (2017) *Amending the Private Rented Sector Energy Efficiency Regulations - Consultation Stage Impact Assessment*; Committee on Fuel Poverty (2018) *CFP response to consultation on Domestic private rented sector: minimum level of energy efficiency*, and BEIS (2017) *Fuel Poverty Trends 2017*.

Box 3.3. Policy design issues in ECO 3

In March 2018 the Government published a consultation on proposals for ECO 3, running from 2018 to 2022.

The consultation includes proposals to reduce the (already low) minimum requirement of 21,000 solid wall insulation (SWI) installations per year to 17,000 homes being treated through SWI or achieving equivalent bill savings to SWI. The consultation also suggests this could be lowered further to just 12,000 homes pending agreement of targets in Scotland.

Not only are these requirements well below the 90,000 per annum needed to keep pace with our recommendations, but there is no requirement that measures installed as alternatives to SWI must generate equivalent carbon savings.

The proposed ECO 3 design also risks weakening expectations on timely delivery. The current proposal is that where suppliers are unable to meet their targets, rather than being considered non-compliant, they be permitted to offset up to 10% of under-delivery by delivering more under the future scheme. Aside from increased delivery risks, in carbon and bill saving terms, a measure delivered now is more valuable than a measure delivered in the future. This change would therefore further weaken the ability of ECO to contribute towards legally binding carbon targets.

Source: BEIS (2018) *Energy Company Obligation, ECO 3: 2018-2022*.

[38] BEIS (2017) *Amending the Private Rented Sector Energy Efficiency Regulations - Consultation Stage Impact Assessment.*
[39] Centre for Sustainable Energy (2014) *Meeting the proposed fuel poverty targets*.

Box 3.4. Policy risks in commercial and public buildings policy

In 2015, the Government consulted on weakening requirements for Display Energy Certificates (DECs) in the public sector. Over half of energy efficiency cost savings in commercial and public buildings to 2020 consist of low-cost measures related to energy management. However, awareness of low-carbon options and their value is generally low. In businesses, energy performance is assessed infrequently and often not discussed at senior management or board level, and so has little strategic value or salience. There is evidence that DECs promote organisational understanding and learning around how these energy efficiency savings can be realised, as well as reduced energy costs for the public sector and the tax payer.[40] Other approaches such as Design for Performance, led by the Better Buildings Partnership, point to the importance of being able to split out metered energy between the 'base building' which is the responsibility of the landlord, and additional demands (e.g. computing) which is the core responsibility of the tenant.

The current formulation of the private rented sector Minimum Energy Efficiency Standard (MEES) is limited in scope. A recent survey conducted by EEVS Insight and Bloomberg New Energy Finance found that 56% of respondents felt it included too much leeway for exemption. [41] A recent EIC report also provides evidence that a significant enforcement gap is hindering its effectiveness (considered further below).[42]

The Clean Growth Strategy proposed the introduction of a voluntary public and higher education target of 30% reduction in greenhouse gases by 2020/2021 against a 2009/2010 baseline. A voluntary target may not be effective in driving emissions reductions, particularly low-carbon heat.

Source: MHCLG (2015) *Improving the Display Energy Certificates regime for public buildings*; CCC (2015) *Letter: Response to the consultation on changes to the Display energy Certificates Regime in public buildings*; Environmental Industries Commission (2018) *Improving non-domestic energy efficiency after Brexit: the challenge and the opportunity.*

Inadequate future-proofing: Buildings being built now are not fit for 2050.

In order to avoid costly retrofit in the future, buildings must be designed to accommodate low-carbon heating options from the start, deliver high levels of energy efficiency, and be resilient to a changing climate. National standards do not yet deliver all these requirements. Standards currently vary geographically - in particular the Devolved Administrations and some Local and Regional authorities[43] have set higher levels of ambition - but the future of Local Authority standards is unclear in light of recent draft changes to the National Planning and Policy Framework.[44] The Government has made a number of commitments around standards, including its mission statement to halve the energy use of new buildings by 2030 and a commitment to consult on strengthening standards. Further clarity will be needed on the trajectory for future standards.

[40] CCC (2015) *Letter: Response to the consultation on changes to the Display energy Certificates Regime in public buildings.*
[41] EEVS insight and Bloomberg New Energy Finance (2018), *Energy Efficiency trends Vol. 21*
[42] Environmental Industries Commission (2018) *Improving non-domestic energy efficiency after Brexit: the challenge and the opportunity.*
[43] One example is the Greater London Authority. A zero-carbon target for major residential developments has been in place for London since October 2016. This target is planned to be extended to include major non-residential developments on final publication of the New London Plan. See Greater London Authority (2017) *The London Plan: Draft for public consultation.*
[44] MHCLG (2018) *National Planning Policy Framework: consultation proposals.*

Further action is needed to deliver cost-effective uptake of low-carbon heat

Recent announcements and consultations have sought to address some issues but more is needed:

- Heat pump sales continue to stagnate, most likely due to the upfront cost barrier, low awareness, the fact that the tariffs deliver lower returns for smaller properties and the relative prices of electricity and gas.
  - The introduction of the assignment of rights framework is welcome - this allows a third party investor to help fund the purchase, installation and maintenance of renewable heating system in return for RHI payments. However, it is unclear whether this will be sufficient to address upfront cost barriers. A decision on the RHI successor policy has yet to be made. International best practice indicates that upfront payments, rather than spreading returns over time, are the most effective use of limited funds to generate delivery.[45]
  - Electricity prices are high relative to gas prices, with the difference being exacerbated by the lack of a carbon price on gas and the costs of climate and social policies being loaded onto electricity bills. Further movement to carbon-reflective energy prices as electricity decarbonises would provide a greater incentive for installation of heat systems based on low-carbon electricity.
- In the CGS, the Government committed to phase out the installation of high-carbon fossil fuel heating in new and existing homes currently off the gas grid during the 2020s. In March, Government consulted on an industry-led approach to delivering this. In the absence of backstop regulation, it is unclear whether sufficient policy certainty can be provided to drive action and innovation.
- In April, Government published the main features of the Heat Networks Investment Project scheme, which requires that heat generated must be from 75% gas CHP or 50% renewable sources, recovered heat, or a combination. There remains a risk of an enduring focus on gas CHP in place of low-carbon alternatives such as waste heat and large-scale heat pumps. Government has yet to announce a policy framework to drive a sustainable heat networks market through the 2020s.
- Injecting biomethane into the grid is a way of decarbonising supply without requiring changes from consumers, although limited feedstocks mean that in practice this can only meet up to 5% of gas demand. The RHI has recently been refocused to support biomethane and biogas from feedstocks which are more consistent with cost-effective carbon abatement. There is a need to increase volumes of biomethane injection into the grid. A gap remains in support for biomethane after funding comes to an end in 2021.

A governance framework is needed now to drive key strategic decisions on low-carbon heat for properties on the gas grid - the timetable affords no slippage

The current reliance on natural gas is incompatible with long-term decarbonisation. Low-regrets actions now on low-carbon heat (e.g. heat pumps off the gas grid, low-carbon heat networks in heat-dense areas) are important in reducing emissions and preparing for faster decarbonisation later on. Key strategic decisions will be needed in the early 2020s on low-carbon heat for properties on the gas grid, especially those outside heat-dense areas. The key options are electrification using heat pumps and repurposing of gas networks to hydrogen. Approaches for

[45] For further discussion see CCC (2016) *Next Steps for UK Heat Policy*.

on-gas grid properties based on heat pumps, hydrogen and heat networks will only be realised with strong Government leadership at both local and national levels because all of these solutions will require coordination. Most consumers and businesses in a given area would need to deploy the same option in order to keep costs down.

If emissions from heating are to be largely eliminated by 2050, a national programme to switch buildings on the gas grid to low-carbon heating would need to begin by around 2030 at the latest, requiring Government decisions on the route forward by the mid-2020s. The timetable affords no slippage. The Government's Heat Strategic Options work is underway, but there is currently no governance framework for driving these decisions on heat infrastructure.

In the transition to low-carbon heating, particularly if low-carbon heat is rolled out in different parts of the UK at different times, there will be important questions to be resolved around how to pay for heat decarbonisation.

Enforcement and compliance issues pose risks for the delivery of intended carbon savings

The Environmental Industries Commission (EIC) has recently published evidence suggesting widespread compliance issues with the non-domestic private rented sector Minimum Energy Efficiency Standard (MEES) framework, and the Hackitt review has highlighted the importance of improved enforcement and compliance measures relating to building regulations (Box 3.5):

- The recent EIC report provides evidence that a significant enforcement gap is hindering the effectiveness of energy efficiency regulation.[46] For example, in relation to the private rented sector MEES, landlords of non-residential properties with an EPC rating of F or G must carry out all relevant energy efficiency improvements before letting. However, penalties for not making an EPC available are only up to £5,000, whilst penalties for non-compliance with the MEES are up to £150,000. There is evidence to suggest that compliance with EPC requirements is low and a recent Freedom of Information request by the EIC revealed a near unanimous response from all Trading Standards authorities, with the exception of one council, that fines are not being issued for non-compliance.
- There are gaps between design and the 'as built' energy performance of buildings. A report conducted by the Zero Carbon Hub in 2014 found a wide range of drivers, including overreliance of Building Control Bodies on third party information; insufficient time, knowledge or incentives to focus on energy performance in building control verification, and a lack of clarity over the documentary evidence required for Part L and Part F compliance.[47] The Hackitt review has further identified a range of issues with building regulations, including poor enforcement and sanction measures.

[46] Environmental Industries Commission (2018) *Improving non-domestic energy efficiency after Brexit: the challenge and the opportunity*.
[47] Zero Carbon Hub (2014) *Closing the gap between design and as-built performance*.

Box 3.5. Hackitt review of building standards

Following the Grenfell Tower fire in June 2017, Dame Judith Hackitt was commissioned to review building standards and safety. The review was published in May 2018, along with a commitment from Government to develop a package of regulations and guidance that is simpler to navigate but that also reflects the level of complexity of the building work.

A number of the recommendations have potential to help drive down the energy performance gap:

- **A single, more streamlined, regulatory route to oversee building standards** as part of a new Joint Competent Authority (JCA) to ensure that regulatory oversight is independent from clients, designers and contractors and that enforcement can and does take place where necessary.
- **A stronger change control process** that requires robust record-keeping of all changes made to detailed plans signed off by the JCA.
- **More rigorous enforcement powers and more serious penalties** including improvement/correction notices and prohibition notices, where failure to comply is a criminal offence; and JCA/Local Authority Building Standards powers to require changes to work that fails to meet Building Regulations.

There is a need for significant development in professional standards and skills across the building and heat supply trades, and an increased focus on incentivising high 'as-built' performance.

We consider the implications of the Hackitt Review for Government policy in Section 5.

Source: MHCLG (2017) *Independent Review of Building Regulations and Fire Safety: interim report*; MHCLG (2018) *Independent Review of Building Regulations and Fire Safety: final report.*

Our updated assessment is that the level of policy risk remains largely unchanged since our January assessment (Table 3.5 and Figure 3.6):

- A limited number of firm policy commitments have been made since our January assessment of the Clean Growth Strategy.
- A large proportion of estimated emissions savings under existing policies remain at risk.
- We have identified additional cost-effective abatement opportunities in buildings of 6 $MtCO_2e$ in 2030, over and above current policy ambition. These cost-effective savings are currently being ignored, but could help put us on track for meeting carbon budgets and our commitments under the Paris Agreement.

In the final section we set out the actions required in order to remove policy risks and deliver on the significant remaining cost-effective abatement potential to 2030.

Table 3.5. Assessment of policies to drive abatement options in the buildings sector

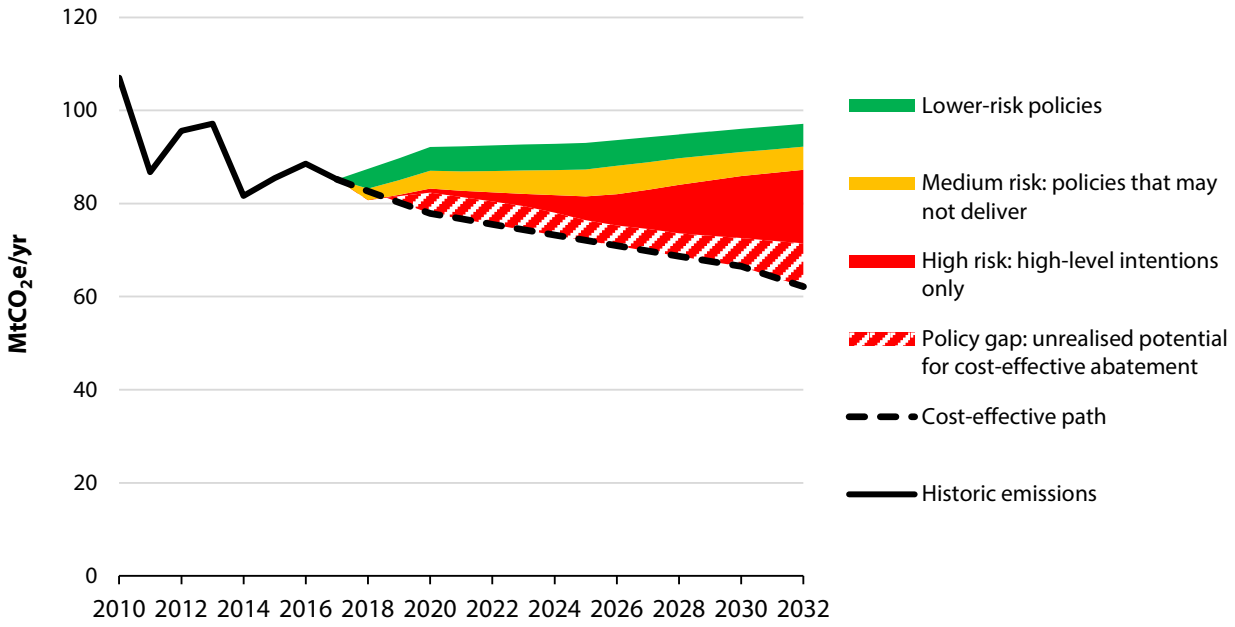
Abatement options	2017 policy	2018 updates and assessment
Building-scale low-carbon heat options in existing buildings to 2021	Amber — Renewable heat incentive funded to 2021, but does not address awareness and upfront cost barriers.	Amber — Scheme refocused. Further action needed to address upfront cost barrier and raise awareness.
Building-scale low-carbon heat options in existing buildings from 2021	Red — Further research underway on infrastructure and options.	Red — Ambition to phase out high-carbon fossil fuel heating and plan to examine measures for heat network market framework. Research on heat options underway. Policy needed, including support for low-carbon heat post-2021.
Heat networks to 2021	Amber — Outcome of first round of funding announced.	Amber — Main features of the Heat Networks Investment Project scheme published. Risks remain around focus on gas CHP in place of low-carbon sources (e.g. waste heat/heat pumps).
Hydrogen	Amber — Need for strategy.	Amber — Funding announced and research underway. Governance framework needed to drive decisions on heat infrastructure through 2020s.
Standards for new-build to drive low-carbon heat and energy efficiency	Red — No policy.	Red — Mission statement announced and commitment to consult on strengthening building standards. Policy needed.

Table 3.5. Assessment of policies to drive abatement options in the buildings sector

Abatement options	2017 policy	2018 updates and assessment
Residential energy efficiency, able-to-pay	Red — Green deal finance company sold. PRS regulations need urgent amendment. Lack of incentives for owner occupiers.	Red — Call for evidence published, and PRS consultation issued. Policy needed for able-to-pay and social housing sectors, greater ambition required for PRS.
Residential energy efficiency, low income	Amber — ECO transition April 2017 - September 2018 - reduced size and focused on fuel poverty. ECO specification unclear beyond September 2018.	Amber — Policy in place to September 2018. Consultation issued on ECO 3. Risks to be addressed around reduced focus on carbon savings and timely delivery.
Non-residential energy efficiency	Amber — Sell off GIB, CRC scheme closing in 2019 with rebalancing of CCL, and poor compliance under ESOS. PRS regulations in place along with Salix for public sector. Gap in policy for SMEs.	Amber — Commitment to drive 20% improvement in energy efficiency. Awaiting proposals and policy. Risks around existing policy to be addressed, including PRS compliance.

Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower-risk policy - expected to deliver. The assessment in this table does not map directly on to the RAG assessment in Figure 3.6. This reflects that it is an aggregate assessment for an area with a number of existing policies (e.g. non-residential energy efficiency), and in some areas no abatement is currently factored into the BEIS projections used as the basis for Figure 3.6 (e.g. mission statement on new buildings, hydrogen).

Figure 3.6. Risks around the delivery of buildings sector policies to meet the cost-effective path



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018) *2017 UK Greenhouse Gas Emissions, provisional figures*; CCC analysis.
Notes: The top of the green area in the chart represents baseline emissions, based on the latest Government emissions projections published in January 2018. Lower-risk policies have sufficient funding and ambition to deliver with reasonable confidence. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the CGS, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.
We have scaled the cost-effective path for meeting carbon budgets and long-term targets to reflect the change in BEIS baseline projections, which does not affect the level of cost-effective abatement. This means that the cost-effective path now outperforms the legislated budgets at an economy-wide level. Pursuing the actions in the cost-effective path will ensure that cost-effective abatement opportunities are realised and more ambitious long-term targets can be met, at the lowest cost for society.

5. Further actions required in buildings

To be on track to meet the fourth and fifth carbon budgets, and in order to deliver cost-effective abatement, the Government needs to remove risks from existing policies, turn proposals into firm policies and put in place new policies where needed.

In our 2016 report, *Next Steps for UK Heat Policy*, we identified a number of policy principles to support the implementation of low-carbon actions, based on evidence from three 'What Works' policy reviews and an expert advisory group. We use these as a framework below for highlighting where further work is needed. We summarise the actions needed to deliver cost-effective abatement in Table 3.6.

A stable framework and direction of travel, focused on real-world performance

Energy efficiency must urgently be improved across the building stock. **Clear forward trajectories for the evolution of standards should be set well in advance. The framework**

should deliver long-term policy certainty (e.g. through use of backstop regulation) in order to drive innovation and incentivise efficient long-term investments, **in place of piecemeal incremental change**.

Government needs to set out the level of ambition and concrete policies for delivering against its commitment on retrofit: **EPC band C by 2035**. Whilst a focus on EPC bands is pragmatic, the framework should evolve over time to ensure sufficient focus on carbon savings (rather than just bill savings) and real-world performance. A delivery mechanism and trajectory must be agreed now for the **social housing minimum standards**.

Government should address the delivery risks around the **Private Rented Sector** (PRS) regulations – in particular, the level of ambition for the PRS regulations must be raised as the current exemptions severely limit the scope and impact. Trajectories for the evolution of standards should also be set out. Setting ambitious standards for the PRS market has potential to bring much wider benefits, driving innovation in retrofit and green mortgages, and raising the prominence of energy efficiency in purchasing decisions.

Concrete policy is required to deliver the significant ambition on non-residential buildings, and address existing policy risks including **tightening non-domestic PRS regulations**. Without this, neither the planned halving of public emissions by 2030 nor the 20% business energy target are credible. There is a need to introduce a voluntary public sector target and reporting framework and consult on **future mandatory public sector carbon targets**, including developing options to go further in more ambitious sectors, and finalising tighter **'Greening the Government'** targets.

Where existing standards are in place or planned under European Law (including product standards, and requirements around Nearly Zero Energy buildings), these will need to either remain in place or be replaced with **equivalent or more ambitious regulation following UK exit from the EU**.

Consumers who buy condensing boilers must benefit from the lower bills which come with the additional efficiency of the technology, and it is the role of Government to ensure that this happens consistently. Requirements relating to **boiler standards and heating controls** should be further tightened with a second phase of standards introduced in the early 2020s:

- Recent developments in the UK standards framework to drive improved efficiency and flexibility in end-use are positive, including the proposals to mandate standards for smart appliances,[48] and the introduction of 'Boiler Plus'.[49]
- However, whilst beneficial, current boiler standards and guidance do not go far enough. Given that boilers must be installed and set according to the manufacturer's guidance, further efforts are needed to ensure installers do this correctly. It would also be straightforward for building control and/or Gas Safe engineers to check the setting on the boiler return temperature when already on-site. More focus should be placed on monitoring and reporting actual rather than modelled performance (e.g. by using data from smart meters) to track progress.

Government has made a number of commitments in relation to improving the **standards of new buildings**. It will now need to set out further detail around its recent mission statement, and strengthen standards for new buildings to ensure they are fit for 2050 and beyond. This includes making sure they are designed for a changing climate, are future-proofed for low-

[48] BEIS (2018) *Consultation on Proposals regarding Smart Appliances.*
[49] BEIS (2017) *Heat in buildings: Boiler Plus.*

carbon heating and deliver high levels of energy efficiency (Box 3.6). It also includes tightening standards in 2025 to drive low-carbon heat:

- A key principle should be future-proofing: new-build standards should avoid requiring later, expensive, retrofitting measures.
- The trajectory for tightening standards will need to be set out, including tightening in 2025 to support low-carbon heat through the installation of heat pumps in new build. Learning should be leveraged both internationally and from residential schemes such as the Welsh Government's Innovative Housing Programme.
- The framework which underpins building standards, the Standard Assessment Procedure (SAP), should evolve to focus on meeting long-term objectives.

The interactions between build costs, land prices, house prices and viability are complex, such that additional build costs need not always negatively impact viability or house prices. For instance, the 2011 Zero Carbon Homes Impact Assessment estimated that 'the additional costs of zero carbon homes will largely be passed back to landowners in reduced land value uplift'.[50] Steps can also be taken to mitigate risks, including developing market demand (e.g. raising public awareness, fiscal incentives) and minimising costs to developers through a clear and robust policy framework set well in advance.

Box 3.6. Delivering new buildings which are fit for 2050 and beyond: research on cost-effectiveness of lower-carbon new build

Earlier this year, we commissioned research to look at the cost-effectiveness of new lower-carbon and lower-energy buildings that are adapted to a changing climate. This included examining how costs vary across different combinations of measures - by building type and size - and how these costs may change over time. The work also examines approaches to standard-setting more broadly (including embodied carbon) and identifying those which have potential to represent 'best practice' in the UK context.

The emerging results support our existing recommendations on heat pump readiness, on the cost-effectiveness of low-carbon heat from mid 2020s, and on the need to integrate adaptation measures.

- Larger radiators are found to be the key measure capable of minimising the costs of retrofitting low-carbon heat in the future, with some immediate bill savings.
- Our modelling for the fifth carbon budget advice showed that heat pumps are cost-effective in the second half of the 2020s in new-build homes. Low-carbon heat networks are cost-effective now in highly heat-dense areas, with cost-effectiveness becoming more widespread through the 2020s. These findings are supported by the new modelling.
- The modelling examines passive cooling measures (inward opening windows, shutters) on top of the existing solar shading requirement. The results illustrate that more can be done, along with the benefits of designing in rather than retrofitting - in particular, the value of inward opening windows as a low-regrets futureproofing measure. In order to manage the increasing risk of overheating associated with a warming climate, the regulatory framework needs to drive developers to holistically assess and mitigate overheating risks, starting at the building design stage.

[50] MHCLG (2011) *Zero Carbon Homes Impact Assessment.*

Box 3.6. Delivering new buildings which are fit for 2050 and beyond: research on cost-effectiveness of lower-carbon new build

There is some evidence suggesting there are potential cost savings from reduced need for radiators and associated piping when moving to near Passivhaus levels of ambition. These cost savings can help offset the additional costs of building to higher design specifications.

The research on international best practice on embodied carbon outlines low-regrets steps that should be taken over the next five years to agree a common framework for the assessment and benchmarking of the carbon-intensity of construction and embodied carbon. This should include a database for lifecycle assessments/environmental product declarations for generic and manufacturer specific construction materials and products, and a standardised framework for assessment and rating. The Royal Institution of Chartered Surveyors is already undertaking work in this area.

Notes: The research is being conducted by Currie Brown and Aecom. For further detail on the scope see: https://www.contractsfinder.service.gov.uk/Notice/fc04a29c-5a7d-49e3-a0a1-50973c26f9c6

Monitoring metrics and certification should be reformed to reflect real-world performance. Early action should be taken in areas where data are already available (for instance in the non-residential sector), with expansion into the broader framework over time:

- The Government is already planning to take steps in this area, including a two-year research project to develop a new methodology for measuring the actual thermal performance of buildings.
- Fully integrating real-world performance into the metrics, certification and standards framework for new and existing buildings offers opportunities to shift mind-sets and incentives towards actual performance (in place of a compliance-focused approach), narrow the performance gap, improve enforcement and reduce energy bills and carbon emissions.

Strengthening of the **compliance and enforcement framework** will drive action and ensure that policies are able to deliver their intended carbon and bill savings. We support the principles recommended in the Hackitt review, in particular: an outcomes-based approach that sees buildings as a system; a clear model of risk ownership (with risk placed with those able to control it); transparent information and a clear audit trail; and effective oversight, inspection and sanctions underpinning the framework. It is critical that stronger compliance and enforcement procedures, with heavy penalties where appropriate, extend beyond fire safety to building regulations and policy more widely. A robust national framework for driving improved new-build standards will support a baseline level of performance across the new built stock.

There is a need for measures to be proposed to realise Government's ambition of an effective long-term market framework for heat networks beyond 2020, building on the Heat Networks Investment Project and the funding that has been allocated to 2021.

The current reliance on natural gas is incompatible with long-term decarbonisation. **Active preparations must continue for strategic decisions in the early 2020s on the role of hydrogen for heat and the future of the gas grid** (Box 3.7). We should be developing options now. A governance framework is needed to drive enduring decisions on heat infrastructure in the next Parliament. This should be within the scope of the Government's Heat Strategic Options paper scheduled for the summer.

Box 3.7. Long-term decarbonisation of heat - Imperial energy system modelling

The Committee's 2016 report, *Next Steps for UK Heat Policy*, proposed alternative pathways for low-carbon heating. It identified a set of low-regrets measures, including: energy efficiency across the stock, heat pumps off the gas grid, low-carbon heat networks in heat dense areas, low-carbon new build and biomethane injected in to the gas grid. For the remaining on-gas homes which are not in areas where heat networks are cost-effective, the main options are electrification using highly efficient heat pumps together with new generation storage heaters in smaller properties; 'greening' the gas supply (e.g. shifting to low-carbon hydrogen), or a combination. Hybrid solutions can play a role, with the bulk of heat demand met by electricity, and peak demands met by hydrogen or biomethane.

We recently commissioned Imperial College London to evaluate the technical feasibility and overall system costs of these decarbonisation pathways, across the electricity and gas systems in the UK.

The research suggests that the system costs for heat decarbonisation are broadly similar when looking across hydrogen, heat pumps and hybrid solutions. These costs are included within our previous estimates of the total costs of meeting carbon budgets (at ~1% GDP), although important questions remain around who pays and whether there may be further services which can help reduce the cost to consumers.

This study is part of a larger volume of research in this area, which includes the ongoing Freedom project hybrid heat pump trials, BEIS research on low-cost solid wall insulation, National Infrastructure Commission modelling and the Government's heat strategic options publication due in the summer.

We plan to review the implications of these for our heat decarbonisation scenarios in the context of our advice on long-term targets in 2019.

Notes: Full research report forthcoming.

Consistent price signals that clearly encourage affordable, low-carbon choices

Detailed plans are needed on the approach that will be taken to phase out the installation of high-carbon fossil fuel heating in the 2020s, ensuring there is no policy hiatus in 2021. Effective use of backstop regulation can help provide policy certainty, driving innovation and action:

- Our fifth carbon budget analysis showed that there are low-cost opportunities for replacing inefficient electric heating and cooling in offices and other non-residential buildings with highly efficient electric heat pumps. This can deliver bill savings and productivity gains as well as abatement and broader system benefits.
- Heat pumps should be a priority in homes that can be made suitable for them at low-cost (i.e. most homes with cavity walls, and a subset of solid wall properties). Hybrid heat pumps are a more appropriate solution for homes with poorer thermal performance,[51] together with small local heat networks and in some limited cases, biomass boilers. Biofuels and biomass must meet strict sustainability criteria, and consideration must be given to local air quality impacts.

[51] Particularly where they operate in electric mode for over 90% of the heat. The Freedom project is trailling hybrid heat pumps in Bridgend. For further detail on the project see Wales and West Utilities and Western Power Distribution (2018) *Freedom Project Interim Report.*

- Displacing oil heating in homes with a drop-in biofuel would not align with our advice on best use of scarce bioenergy resources as set out in our *2011 Bioenergy Review*.[52]

Deployment of low-carbon heat (e.g. heat pumps and low-carbon district heating schemes) **should be prioritised immediately, with early clarity on support beyond 2020**. Cost-effective and low-regret opportunities exist for heat pumps to be installed in homes and businesses that are off the gas grid, together with low-carbon heat networks in heat-dense areas (e.g. cities) and for increased volumes of biomethane injection into the gas grid (up to around 5% of gas demand).

A support framework should be established for heat pumps and biomethane post-2021, as well as support for low-carbon heat technologies in heat networks. Subsidies for heat pumps and other capital-intensive technologies should be rebalanced towards a capital grant, in line with international best practice:

- This would lead to higher spending upfront, but reduce overall levels of Government spend.
- It would help address the regressive nature of RHI subsidies and widen access to available funding, whilst also raising the profile of low-carbon heat across the population.
- In time, this can serve to improve consumer confidence and reduce risk premiums, ensuring greater affordability to the taxpayer and making subsidies go further. [53]

The UK could learn from approaches that combine finance for heating and efficiency measures, and the unit-cost reductions achieved through Energiesprong whole-house retrofits in the Netherlands, particularly for homes with similar build and features. This model is particularly suited to social landlords.

The balance of tax and regulatory costs should be reviewed across fuels in order to improve alignment with implicit carbon prices and reflect the progressive decarbonisation of electricity.

Current tax and regulatory costs are significantly larger for electricity than gas or oil heating, and the full carbon costs are not reflected in the pricing of heating fuels. These factors currently weaken the private economic case for electrification.

In the transition to low-carbon heating, particularly if low-carbon heat is rolled out in different parts of the UK at different times, there will be important questions to be resolved around how to pay for the decarbonisation of heat.

An attractive and well-timed offer to households and SMEs that is aligned to 'trigger points', along with simple, highly visible information and installer training

Firm proposals are needed for able-to-pay homeowners (including energy efficiency incentives, the expansion of green mortgages and a role for soft loans). **Government should address the delivery risks around ECO** – in particular, carbon savings should remain a delivery priority (including through solid wall insulation).

Access to capital is often necessary to facilitate response to standards and incentives, particularly for home owners, SMEs and the public sector. **Government should implement the Green Finance Taskforce recommendations around green mortgages, green loans and fiscal**

[52] The CCC is now planning to update its work on bioenergy, culminating in a new Bioenergy Review to be published in autumn 2018.
[53] For further detail see CCC (2016) *Next Steps for UK Heat Policy*.

incentives to encourage uptake and support financing of upfront costs (Box 3.8), using any learning from pilots to develop a robust policy framework:

- Better consideration of energy costs in mortgage-affordability calculations (e.g. through requiring typical running costs to be quoted alongside mortgage offers), and the expansion of green mortgages, could encourage the purchase of more efficient properties. Barclays have recently launched a Green Home Mortgage product which offers a 0.1% discount on mortgages for energy efficient new-build homes. Green mortgages, mortgage extensions for renovation, and green loans could also enable access to low-cost capital to support the retrofit of energy efficiency measures.
- Even where energy efficiency improvements may be financially advantageous, they are often usefully supplemented by additional fiscal incentives to encourage uptake. Fiscal incentives such as a rebalanced stamp duty, or partial subsidy, can encourage emission saving improvements that go further, sooner, than minimum standards.

This should be accompanied by a broader policy package to support SMEs (e.g. peer-to-peer networks alongside financial support and soft loans).

Improving consumer access to high-quality information and advice helps support decision-makers in the face of information failures. Those procuring and purchasing buildings should have better access to information which allows them to consider the quality of design and built performance in purchasing decisions. Monitoring, ratings and accreditation procedures could be developed to assess the quality of built performance, empowering purchasers to choose contractors who demonstrate high performance.

The Green Finance Taskforce recommendation on Green Building Passports offers potential to bring together a number of data sources to provide a holistic and long-term view of renovation needs. Alongside this there is an important role for information and advice on other steps that can be taken to manage energy use such as adjusting the configuration of heating systems and incorporating 'smart' technology. Facilitating greater consumer access to the data and assumptions underpinning SAP, EPCs, and Green Building Passports could also improve enforcement and open up potential for improved services (Box 3.8).

Building standards and the framework which underpins them should evolve to focus on meeting long-term objectives. The Standard Assessment Procedure (SAP), which underpins new-build standards and EPCs, currently uses set emission factors for each fuel.[54] In reality, emission factors for electricity are projected to decrease rapidly over time as the power sector decarbonises. This forward trajectory should be formally integrated into the framework, with improved procedures to allow for regular incremental updates.

The shift to focusing on operational savings must be accelerated - and public reporting mechanisms remain vital tools for benchmarking public and commercial buildings. Government should drive wider use of operational data for benchmarking in public and commercial sectors by strengthening and extending public reporting of mandatory operational energy ratings, (e.g. via Display Energy Certificates or equivalent). Other approaches such as Design for Performance, led by the Better Buildings Partnership, point to the importance of being able to split out metered energy between the 'base building' which is the responsibility

[54] Set out in table 12 of the Standard Assessment Procedure 2012. Whilst some future projections do exist (https://www.bre.co.uk/filelibrary/SAP/2012/Emission-and-primary-factors-2013-2027.pdf), they are high level, out of date, and are not a formalised part of the framework.

of the landlord, and additional demands (e.g. computing) which is the core responsibility of the tenant. Government should support further work in this area.

There is a need for significant development in professional standards and skills across the building and heat supply trades, and an increased focus on incentivising high 'as-built' performance:

- Developing skills domestically will not only support delivery of the UK's 2050 targets, but also help maximise the advantage for UK industry from the global shift to green growth.
  - The need to improve skills and professional standards has been widely recognised. In 2016 the expert advisory group for our 2016 report, *Next Steps for UK Heat Policy*, highlighted the need for systematic education and upskilling of the workforce, on the basis that near-zero energy new build (and whole-building retrofit) are 'far beyond the capability of the current supply chain'.
  - The 2014 Zero Carbon Hub report on the gap between design and as-built performance reiterated the importance of both skills development and appropriate consideration of skills and competency in procurement.[55]
  - Financial and reputational incentives should also be aligned to focus on 'as-built' performance, rewarding high quality workmanship. This should be integrated into Government's mission to halve the energy use of new buildings by 2030.
- A recent retrofit project in Nottingham run by Melius Homes, Nottingham City Homes and Nottingham City Council, has demonstrated the role that energy performance contracting techniques can play in driving high quality 'as-built' performance. Melius Homes' business model includes undertaking retrofits and providing contractual guarantees on the energy bills associated with designated performance levels. There is scope for similar principles to be applied to new build.

A nationwide training programme is needed to develop high professional standards and skills at all stages of buildings development, from design and construction, to operation, maintenance and retrofit.

The Government should firm up proposals and reduce policy delivery risks for the fourth carbon budget period by 2020 and by 2025 for the fifth carbon budget period (Figure 3.7 and 3.8). Table 3.6 outlines the key milestones and timings for doing so.

Box 3.8. Sir Roger Gifford's Green Finance Taskforce recommendations

The Government established the Green Finance Taskforce in September 2017 with the aim of informing and advancing policy development on green finance. Comprised of senior leaders from the financial sector, it was tasked with presenting a report to Government with policy recommendations on how to best support the finance sector in delivering the investment needed to meet the UK's industrial strategy and Clean Growth Strategy; on how to consolidate UK leadership in financing international clean investment, and on maximising opportunities for UK businesses.

The report was published in March 2018. It sets out a wide range of recommendations relevant to the delivery of carbon savings in buildings, and in particular a set of recommendations aimed to drive demand and supply for green lending products. It recommends that the Government:

[55] Zero Carbon Hub (2014) *Closing the gap between design and as-built performance.*

Box 3.8. Sir Roger Gifford's Green Finance Taskforce recommendations

- Extend 2035 EPC targets from residential properties to commercial properties by the end of 2018, and introduce a requirement for operational energy ratings from 2020.
- Introduce Green Building Passports for residential and commercial properties by 2020.
- Complete research to understand the opportunities and costs of using a range of fiscal measures to boost demand for energy efficient retrofits in 2018, and pilot fiscal measures alongside mortgage products from 2019.
- Provide short-term incentives to pump prime the green consumer loans and green mortgage markets.

The report also includes recommendations on how to boost investment in innovative clean technologies, build a green and resilient infrastructure pipeline, support local actors, and integrate resilience into the green finance agenda.

Implications for Government

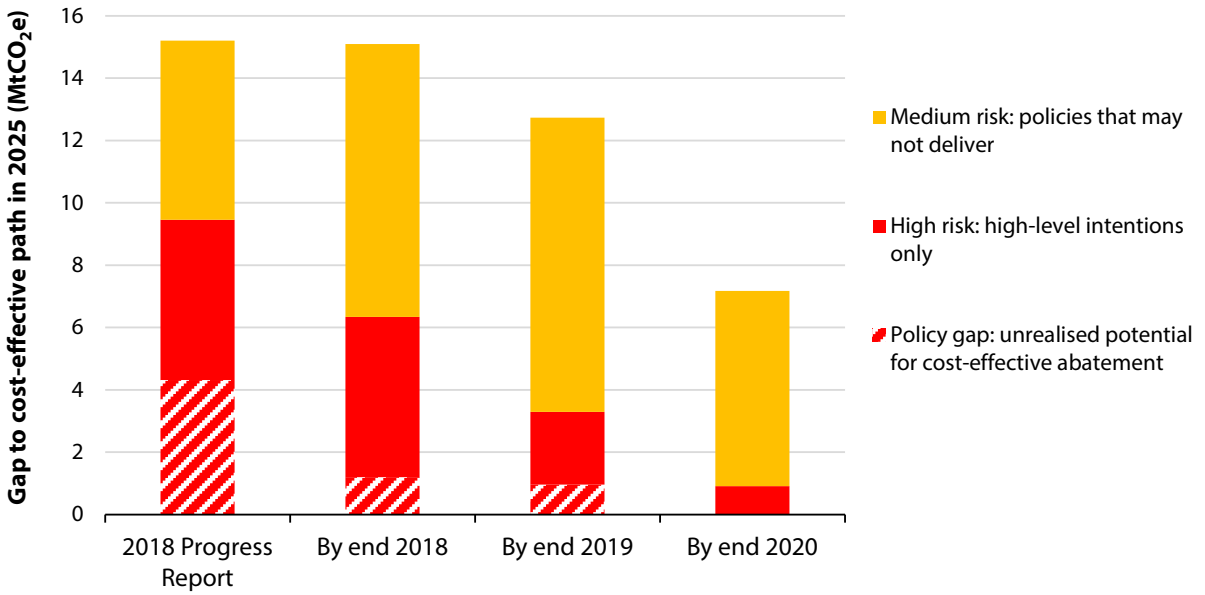
The Green Finance Taskforce has recommended that the Government introduce Green Building Passports for residential and commercial properties. Under this proposal each building would have a digital passport, transferable between building owners, which sets out a customised retrofit roadmap for the building based on fabric and operational data. The intention is to capture EPC data digitally and augment it with other data over time. This approach offers the opportunity to drive efficient incremental investments, compatible with long-term carbonisation goals. We support the recommendation that the platform be expanded to cover issues such as indoor air quality and overheating.

In addition to fabric measures, there are opportunities for carbon and bill savings to be achieved through better use of energy in buildings. Greater information provision is needed to support this. Reconfiguring heating systems (e.g. through lowering thermostat settings, lowering flow temperatures, and hydraulically balancing systems) can drive savings, as can use of 'smart' technology. Innovations in 'smart' energy systems could support low-carbon choices by increasing the focus of householders on avoiding energy waste and on comfort levels regardless of heating technology.

Greater retention and availability of the detailed data and assumptions underpinning SAP, EPCs, and Green Building Passports, as well as on the configuration of building services, would better equip homeowners to hold contractors to account where the building fails to perform as stipulated. This information could also enable the development of better services (for instance where a householder chooses to share information with an energy services provider to inform advice).

Source: Green Finance Taskforce (2018) *Accelerating Green Finance*.

Figure 3.7. Risks around the delivery of buildings policies in 2025 and when the Government should implement actions to remove those risks

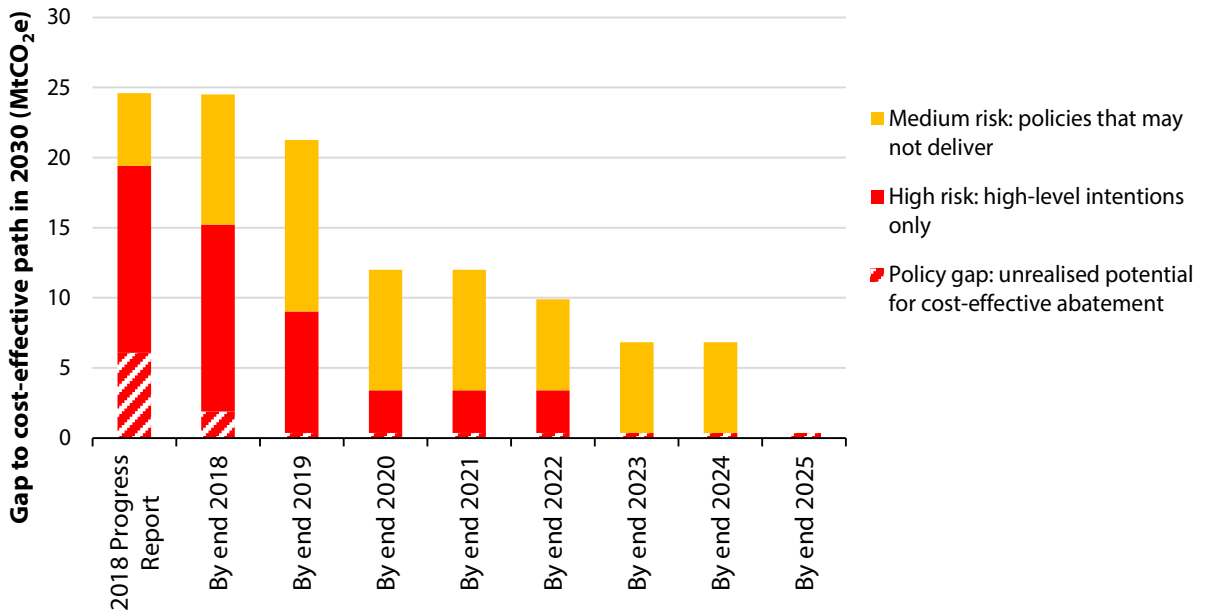


Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the buildings sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period.

We have scaled the cost-effective path to reflect the change in BEIS baseline projections, which does not affect the level of cost-effective abatement. This means that the cost-effective path now outperforms the legislated budgets at an economy-wide level. Pursuing this level of reductions will ensure that cost-effective abatement opportunities are realised and more ambitious long-term targets can be met, at the lowest cost for society.

The assessment uses Government projections for policy savings, with downward adjustments made to the savings associated with Building Regulations and Smart Meters to reflect issues around the performance gap and questions around the potential savings from smart meters. It also includes the projected savings associated with the additional actions we recommend to close the policy gap, namely moving faster on energy efficiency for able-to-pay, deployment of heat pumps in new build, support for biomethane post-2021, a mandatory target for the public sector, and support for low-carbon heat networks.

Figure 3.8. Risks around the delivery of buildings policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the buildings sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period.

We have scaled the cost-effective path to reflect the change in BEIS baseline projections, which does not affect the level of cost-effective abatement. This means that the cost-effective path now outperforms the legislated budgets at an economy-wide level. Pursuing this level of reductions will ensure that cost-effective abatement opportunities are realised and more ambitious long-term targets can be met, at the lowest cost for society.

This assessment uses Government projections for policy savings, with downward adjustments made to the savings associated with Building Regulations and Smart Meters to reflect issues around the performance gap and questions around the potential savings from smart meters. It also includes the projected savings associated with the additional actions we recommend to close the policy gap, namely moving faster on energy efficiency for able-to-pay, deployment of heat pumps in new build, support for biomethane post-2021, and support for low-carbon heat networks. Policy savings for additional actions have been calculated on a case-by-case basis, so do not sum precisely to the remaining gap. Any under delivery will need to be made up for by further savings from other policies to realise cost-effective potential through the 2020s. This could include further support for SMEs for instance.

Table 3.6. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
A stable framework and direction of travel for improving energy and carbon efficiency, focused on real-world performance.	
Publish concrete policies to deliver the Government's ambition on retrofit (EPC band C by 2035) - including a delivery mechanism for the social housing minimum standards.	2018
Address major delivery risks around the Private Rented Sector (PRS) regulations - in particular, the exemptions capping landlord contributions which severely limit the scope and impact - and set out a trajectory for tightening to EPC band C by 2030.	Risks addressed in 2018 with longer-term framework in 2019
Set out concrete policies to deliver the ambition on non-residential buildings, and address existing policy risks including tightening non-domestic PRS regulations.	2018
Introduce voluntary public sector target, followed by review and consultation on future targets, including developing options to go further in more ambitious sectors, and finalising tighter 'Greening the Government' targets.	2018, with review by 2019 and legislation in place by 2023 for mandatory target
Continue to improve boiler standards and heating controls, including a second phase of standards.	Continued improvement with second phase of standards in early 2020s
Strengthen standards for new buildings (and for new work to existing properties), to ensure they are designed for a changing climate, are future-proofed for low-carbon heating and deliver high levels of energy efficiency. Tighter new-build standards supporting low-carbon heat come into force.	Consultation in 2018, standards in force by 2020 with further tightening by 2025
Reform monitoring metrics and certification.	2021-2025
Strengthen compliance and enforcement framework so that it is outcomes-based, places risk with those able to control it, provides transparent information and a clear audit trail, with effective oversight and sanctions.	First half of 2019
Put in place long-term heat networks policy framework.	2020
Include in the Heat Strategic Options publication detail on a governance framework to drive decisions on heat infrastructure in the early 2020s.	2018

Table 3.6. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
Consistent price signals that clearly encourage affordable, low-carbon choices.	
Publish detailed plans to phase out the installation of high-carbon fossil fuel heating in the 2020s, ensuring there is no policy hiatus in 2021. This should include large heat pumps displacing resistive electric heating in offices and other non-residential buildings.	Details published by 2019
Establish support framework for heat pumps and biomethane post-2021, as well as support for low-carbon technologies in heat networks. Rebalance subsidies for heat pumps and other capital-intensive technologies towards a capital grant, in line with international best practice.	Decision on RHI successor in 2018
Review the balance of tax and regulatory costs across fuels in order to improve alignment with implicit carbon prices and reflect the progressive decarbonisation of electricity.	2019
An attractive and well-timed offer to households and SMEs that is aligned to 'trigger points' along with simple, highly visible information, certification and installer training.	
Set out policy package for able-to-pay and address delivery risks around ECO - in particular, to retain a focus on carbon savings and timely delivery. Decision on design for home energy efficiency support from 2022-2028.	2018, with decision on future support by 2020
Implement Green Finance Taskforce (GFT) recommendations around green mortgages and fiscal incentives to encourage uptake and support financing of upfront costs.	2018
Develop new policy to support SMEs (e.g. peer-to-peer networks, financial support and soft loans)	2019
Improve consumer access to data and advice, implementing the GFT proposal on Green Building Passports, improving EPCs and access to data underpinning EPCs and SAP.	2018-2020
Drive wider use of operational data for benchmarking in the public and commercial sectors by strengthening and extending mandatory public reporting of operational energy ratings, e.g. via Display Energy Certificates or equivalent (such as NABERS). Streamlined Energy and Carbon Reporting scheme (SECR) introduced for businesses.	Performance-based labelling scheme developed and SECR introduced by 2019
Review professional standards and skills across the building and heat supply trades with a nationwide training programme to upskill the existing workforce, along with an increased focus on incentivising high 'as-built' performance.	2019

Notes: This table builds on the range of actions set out in the Buildings Technical Annex, published alongside our Independent Assessment of the UK's Clean Growth Strategy.

Chapter 4: Industry

Key messages and recommendations

Based on provisional data, industry emissions rose by 1% in 2017 to 105 $MtCO_2e$ while industrial output grew by around 3%. This follows average annual emissions reductions of 3% over the period 2009-2016 and a halving of emissions since 1990. Two-thirds of the increase in emissions covered by the industry sector in 2017 was due to an increase in emissions from oil and gas production.

Industrial GHG emissions were below our indicator in 2017. This reflects outperformance of the indicator trajectory prior to 2017. The emissions intensity of industrial energy use is progressing more slowly than our indicator trajectory, highlighting slow progress on fuel-switching. Furthermore, although energy intensity is falling, it is not clear that this reflects full implementation of cost-effective energy efficiency measures, as some of the reduction in energy intensity reflects shifts in output from more to less energy-intensive sectors.

Our key messages for the industry sector are:

- **Whilst Government proposals for industrial decarbonisation policy are encouraging, the key proposals such as industrial carbon capture and storage (CCS) and the 20% energy efficiency target lack critical detail about timing and implementation, creating a major risk for industrial decarbonisation.** The Government's Clean Growth Strategy set out proposals with potential that is almost sufficient to follow our cost-effective path for emissions over the next decade. However, two-thirds of our estimate of the Government's abatement for industry in 2030 comes from proposals that do not have timelines, measurable outcomes or sufficient policy detail. This detail is required to provide a clear and credible signal of the Government's level of commitment.
- **Gaps remain in the industrial decarbonisation policy framework.** There are no clear proposals to support a switch to low-carbon fuels for industrial process heat after 2021.
- **Leaving the European Union poses a risk for carbon pricing for UK industry which must be addressed as a matter of urgency.** Price signals under the EU ETS are important in driving cost-effective emissions reduction in industry. However, the price in the EU ETS is currently too weak to act as an effective incentive for many cost-effective abatement options and uncertainty around the future of the scheme is further weakening the investment climate. The Government should engage industry closely in the development of future options for carbon pricing.
- **Effective industrial decarbonisation policy should aim to establish a strong overarching framework for driving efficient low-carbon investment decisions.** This means setting a clear direction of travel signalled well in advance, establishing a secure climate for investment, driving innovation and growth and managing carbon leakage and competitiveness risks.

To be on track for cost-effective decarbonisation, the Government needs to address the risks to existing policies, turn proposals into firm policies and put in place new policies (Table 4.1).

Key messages and recommendations

Table 4.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/ timing
Set out a clear, funded approach to industrial carbon capture and storage (CCS) at scale. The Government's upcoming CCUS Deployment Pathway should provide a clear path for industrial CCS deployment as part of an overall programme of CCS deployment that stores 10 $MtCO_2$ per annum in 2030. The Pathway should propose the delivery model to support CO_2 transport and storage infrastructure, including risk sharing, and a separate mechanism to support initial industrial CCS project(s). The support for initial CCS deployment should be implemented by the end of 2021, consistent with having the first CCS cluster operational by 2026.		×	×	Deployment Pathway and review of investment and delivery models published in 2018; support for initial CCS deployment implemented by end 2021
Translate the ambition to improve business energy efficiency by 20% into specific, concrete and measurable policies with clear timings and outcomes. This should show how the projected savings add up to 20% and any assumptions on the relative contribution of savings from different fuels and sectors.		×		Consult by summer 2018
Confirm funding and start implementation of the Industrial Energy Efficiency Scheme.		×		By end 2018
Set out plans for ensuring a continued carbon price in UK industry, in the case that the UK leaves the EU ETS. The UK should continue membership of the EU ETS, or establish an equivalent mechanism that achieves at least as much emissions reduction, on leaving the EU. This also applies to product standards.	×	×		Set out plan by spring 2019

Key messages and recommendations				
Establish an effective approach to drive sustained uptake of low-carbon heat in industrial processes and buildings. The Government should set out (a) details of the phase-out of high-carbon fossil fuel heating in businesses off the gas grid, which should include opportunities for cost-effective large-scale heat pumps (b) proposals for supporting deployment of low-carbon industrial process heat beyond 2021.			×	Proposals for high-carbon fossil fuel phase-out by in 2018; proposals for process heat in 2019
Establish an overall framework to support long-term industrial decarbonisation. The Government should publish (a) additional milestones on the timeline for the 'framework to support industrial decarbonisation', including for consulting on the framework (b) a call for evidence on the potential options for the framework including the potential design options for a mechanism to support investment in industrial decarbonisation.		×	×	Publish additional milestones and call for evidence by end 2018. Implement framework by end 2022

Introduction

In this chapter we review progress in reducing emissions from the UK industry sector and outline priorities for taking forward the policy framework to ensure that we build on this progress and meet future carbon budgets. We summarise the analysis that underpins our key messages and recommendations in the following five sections:

1. Industry emission trends and drivers
2. Industry scenarios and indicators
3. Recent performance in reducing industrial emissions compared to required progress
4. Policy implementation
5. Further progress required in the industry sector

1. Industry emission trends and drivers

Background

Direct[56] emissions from industry[57] in 2017 (105 $MtCO_2e$) accounted for almost a quarter of UK greenhouse gas (GHG) emissions (Figure 4.1). Over 90% of these direct GHG emissions were of CO_2:

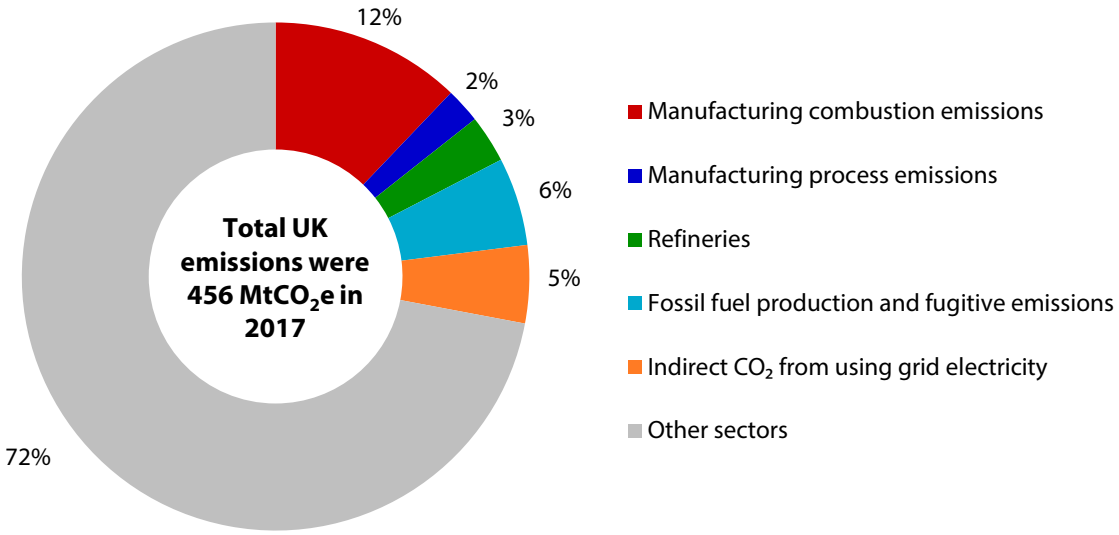
- **Manufacturing**[58] contributed 60% of industrial GHG emissions.
  - Combustion emissions, from burning fuel for the production of low- and high-grade heat, drying/separation, space heating and electricity generation for own use accounted for 85% of manufacturing emissions.
  - Process emissions from chemical reactions within industry (e.g. calcination of limestone in the production of cement) accounted for the remaining 15%.
  - The manufacturing subsectors with highest GHG emissions include iron and steel, construction, chemicals and cement and lime (Figure 4.2).
- **Refining of petroleum products, fossil fuel production and fugitive emissions** made up 40% of industrial emissions. Fossil fuel production and fugitive emissions accounted for two-thirds of this, over a quarter of which were non-CO_2 emissions.

In addition to these direct emissions, industry consumed almost a third of UK grid electricity, implying indirect emissions of 23 $MtCO_2e$, around 5% of UK GHG emissions (Chapter 2).

Industrial production and emissions are not evenly spread across the UK. For example, industry accounted for 30% of total Welsh emissions in 2016, with around half of these coming from the Port Talbot steelworks.

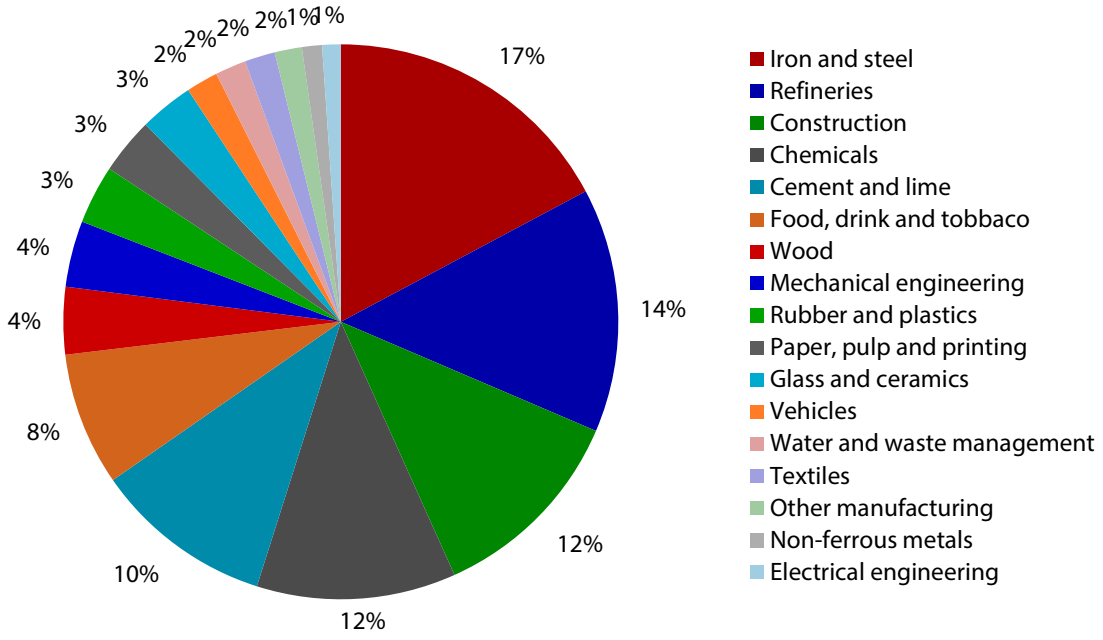
[56] Direct emissions exclude emissions from generation of electricity supplied through the grid, which are covered in Chapter 2.
[57] Industrial activity includes manufacturing, construction, water and waste management, refining of petroleum products, extraction and production of oil, gas and solid fuels and fugitive emissions (including methane leakage, venting and flaring). Industrial F-gas emissions are excluded from our industrial categorisation and covered separately in Chapter 8.
[58] For this report our definition of manufacturing includes construction and waste and water management.

Figure 4.1. Direct GHG emissions from industry and indirect CO_2 from grid electricity use as a share of total UK emissions (2017)



Source: BEIS (2018) *Provisional UK GHG national statistics*, BEIS (2018) *Energy Trends*, CCC analysis.
Notes: 2017 emission estimates are provisional. Percentage figures may not sum to 100% due to rounding.

Figure 4.2. Direct manufacturing and refining GHG emissions by industrial sector (2015)



Source: ONS (2017) *ONS Environmental Accounts.*
Notes: Percentage figures may not sum to 100% due to rounding. Based on the latest data from ONS environmental accounts, which are published each July with an 18-month lag.

Emission trends

Provisional data suggest that direct industrial GHG emissions rose by 1% in 2017 (Table 4.2) while industrial output grew around 3%. This follows average annual emissions reductions of around 3% over the period 2009-2016 and a halving of emissions since 1990 (Figure 4.3):

- Direct CO_2 emissions from industry rose by 1% in 2017, following an annual average 2% decrease over the period 2009-2016:
  - Manufacturing CO_2 emissions were flat in 2017, following a 9% fall in 2016. From 2009 to 2015, manufacturing CO_2 emissions fell by an annual average of around 2%, reflecting a combination of energy intensity improvements, structural changes to the manufacturing sector (i.e. faster growth for lower-carbon parts of the manufacturing sector) and switches to lower-carbon fuels (Box 4.1).
  - Around 80% of the fall in 2016 can be explained by a reduction in iron and steel production, which was largely due to the closure of Redcar steelworks in Teesside. Analysis suggests that the closure of Redcar was mainly due to the depressed price of steel from global overcapacity and an appreciation in the pound, rather than the cost of low-carbon policies.[59]
  - Refineries and fossil fuel production CO_2 emissions rose 2% in 2017, following an annual average 2.5% decrease over the period 2009-2016. Two-thirds of the 2017 rise can be explained by increased emissions from oil and gas production. The 2009-2016 trend can be attributed to the fall in UK fossil fuel production and refinery closures.
- Non-CO_2 emissions data are produced with a one-year lag.[60] The latest data show that 2016 emissions fell by 13% on 2015 levels, with most of the fall resulting from the closure of the UK's last large deep coal mine, which was a significant source of methane leakage. Over the period 2009-2015, these emissions decreased 6% annually on average. These reductions have been due to earlier falls in coal production, reduced leakage from the gas distribution network and the introduction of technologies to abate N_2O emissions from the production of nitric acid.
- Grid electricity consumption in manufacturing and refining fell by 0.3% in 2017, following an average annual 1% decrease over the period 2009-2016.

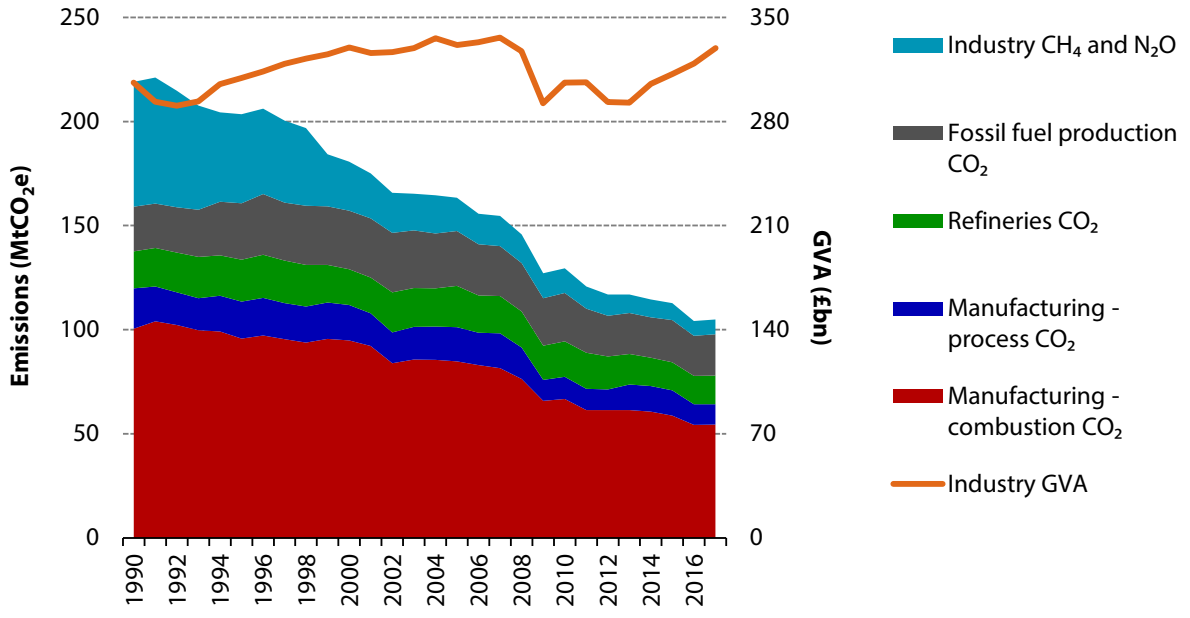
[59] CCC (2015) Technical note: *Low-carbon policy costs and the competitiveness of UK steel production* and Cambridge Econometrics (2017) *Steel – Competitiveness impacts of carbon policies on UK energy-intensive industrial sectors*.
[60] As in previous years, the official emissions statistics assume that non-CO_2 emissions for the most recent year are the same as those for preceding year (i.e. the most recent year for which data are available).

Table 4.2. Changes in industrial GHG emissions (2009-2017)

	2009-2016 average annual % change	2016-2017 % change
Manufacturing: combustion CO_2 emissions	-2.7%	+0.2%
Manufacturing: process CO_2 emissions	0.0%	-1.0%
Manufacturing: total direct (non-electricity) CO_2 emissions	-2.3%	0.0%
Refineries, fossil fuel production and fugitive direct CO_2 emissions	-2.5%	+2.0%
Total industrial direct CO_2 emissions	-2.4%	+0.7%
Total industrial direct non-CO_2 emissions	-7.2%	n/a
Total direct GHG emissions	-2.8%	0.6%
Grid electricity consumption	-1.3%	-0.3%

Source: BEIS (2018) *Provisional UK GHG national statistics*, BEIS (2017) *Digest of UK Energy statistics (DUKES)*, BEIS (2018) *Energy Trends*, CCC analysis.
Notes: The 2017 provisional estimate for non-CO_2 emissions assumes no change from final 2016 emissions.

Figure 4.3. GHG emissions from industry (1990-2017)



Source: BEIS (2018) *Provisional UK GHG national statistics*, BEIS (2018) *Final UK GHG national statistics*, National Atmospheric Emissions Inventory, ONS (2018) GDP low level aggregates, CCC analysis.
Notes: 2017 emission estimates are provisional. The 2017 provisional estimate for non-CO_2 emissions assumes no change from final 2016 emissions.

Box 4.1. Manufacturing and refining industries: decomposition analysis of combustion emissions

Decomposition of UK manufacturing and refining combustion emissions allows us to analyse the factors that contribute to a change in emissions. A change can be caused by:

- **Output effects** (e.g. recession-related emissions reduction);
- **Structural effects** (e.g. relative mix of manufacturing output moving towards less carbon-intensive sectors);
- **Switching to fuels with higher or lower direct emissions** (e.g. coal to gas, or fossil fuel to electricity); and
- **Energy intensity** (e.g. due to energy efficiency, changes in product mix within sectors, or plant utilisation).

Our decomposition analysis suggests that between 1992 and 2007 improvements in energy intensity and switching to lower-carbon fuels were the largest contributors to the reduction in direct CO_2 emissions in the manufacturing and refining sectors. Improvements in energy intensity averaged around 1.6% per year over this period and switching to fuels with lower direct emissions saved 0.6% per year. However, between 2007 and 2009 the majority of the fall in emissions occurred due to a contraction in manufacturing output, which disproportionately affected more carbon-intensive firms.

Over the period 2009-2015 there was a rise in industrial output and the fall in direct CO_2 emissions can be attributed to a structural movement towards a less carbon-intensive mix of industrial output (accounting for 25% of the change), improvements in energy intensity (45%) and changes in fuel mix (30%).

Energy intensity in this analysis is only a proxy for genuine energy efficiency improvements, since it also includes the effects of changing product mix and utilisation of plant and equipment, but it provides an indication about whether and where industrial energy efficiency is improving.

Source: CCC analysis.
Notes: The decomposition analysis uses ONS environmental accounts data, which are published with an 18-month lag. The latest results are for 2015.

2. Industry scenarios and indicators

In this section we outline what progress we expect in reducing emissions to 2030 and the indicators against which we track progress.

Cost-effective path to reducing industrial emissions

The fifth carbon budget advice published in December 2015 updated our view on the scope for reducing direct emissions in industry to around 80 $MtCO_2e$ in 2030 from 105 $MtCO_2e$ in 2017. Within this analysis we identified 13 Mt/year of abatement opportunities:

- **Energy efficiency improvement.** Improving the process of producing goods can save both emissions and energy, and thus reduce firms' costs. There are many forms of energy efficiency which are specific to each industrial sector including: energy and process management, best available and innovative technology, waste heat recovery and use, material efficiency and clustering. We identified around 5 $MtCO_2e$ of cost-effective abatement potential by 2030.
- **Bioenergy used for space and process heat.** Sustainable biomass can be utilised as a fuel or feedstock replacing current fossil fuel sources. We identified around 4 $MtCO_2e$ of cost-effective abatement potential by 2030.
- **Low-carbon electrification of space and process heat.** As electricity from the grid continues to decarbonise to 2030 and beyond, there is potential to reduce the use of fossil fuels and therefore emissions through low-carbon electrification of space and process heat, primarily through use of heat pumps. We identified around 1 $MtCO_2e$ of cost-effective abatement potential by 2030.
- **Industrial carbon capture and storage (CCS).** CCS can be applied to large industrial sites that have few alternative abatement options, such as iron and steel, refining, cement, chemicals and industrial combined heat and power (CHP). CCS could be feasible for deployment in a range of industrial sectors during the 2020s, reducing annual emissions by around 3 $MtCO_2e$ by 2030, on a path to more significant implementation by 2050.

There is likely to be further potential to reduce emissions by improving the resource efficiency of construction of buildings and infrastructure, which reduces demand for carbon-intensive products. However, to date we have not been able to include this in our quantitative assessment to 2030.

To achieve all these emissions reductions, policy must overcome a number of challenges (Box 4.2). It should aim to establish a strong overarching framework for driving efficient low-carbon investment decisions. This will mean setting a clear direction of travel signalled well in advance, establishing a secure climate for investment, driving innovation and growth and managing carbon leakage and competitiveness risks, together with a well-timed offer for SMEs to take up energy efficiency measures by making the opportunities more salient.[61]

[61] A key barrier for less energy-intensive SMEs is the immateriality of bill savings, which leads to cost-effective opportunities not being taken up. There is a role for policy in addressing this market failure. In 2016, we undertook a what works review of energy efficiency policies for businesses, published as part of our *Next Steps for UK Heat Policy* report.

Box 4.2. Challenges to reducing industry emissions

Achieving the level of abatement set out in our scenario will be challenging. It will be important to plan for investment in low-carbon measures given long project lead times, and the need for it to synchronise with the refurbishment and replacement cycles of the capital stock.

- **Refurbishment and replacement cycles.** The abatement measures that we have identified for carbon-intensive industry in the 2020s typically have long lead times. Given the difficulty of retrofitting, and to avoid missing low-carbon investment opportunities, it is important to prepare abatement in line with refurbishment cycles.
- **Capital constraints.** Many of the cost-effective opportunities in energy-intensive industry have substantial upfront requirements for capital and longer payback periods. For firms to plan and finance abatement opportunities, there needs to be a mechanism for reflecting the value of carbon (e.g. a robust carbon price) with long-term certainty.
- **Infrastructure and markets.** Some abatement will need provision of infrastructure or creation of markets outside the control of specific industries. For example, to take full advantage of the potential abatement from industrial CCS, there needs to be adequate CO_2 transport and storage infrastructure and an incentive mechanism.

Tracking progress

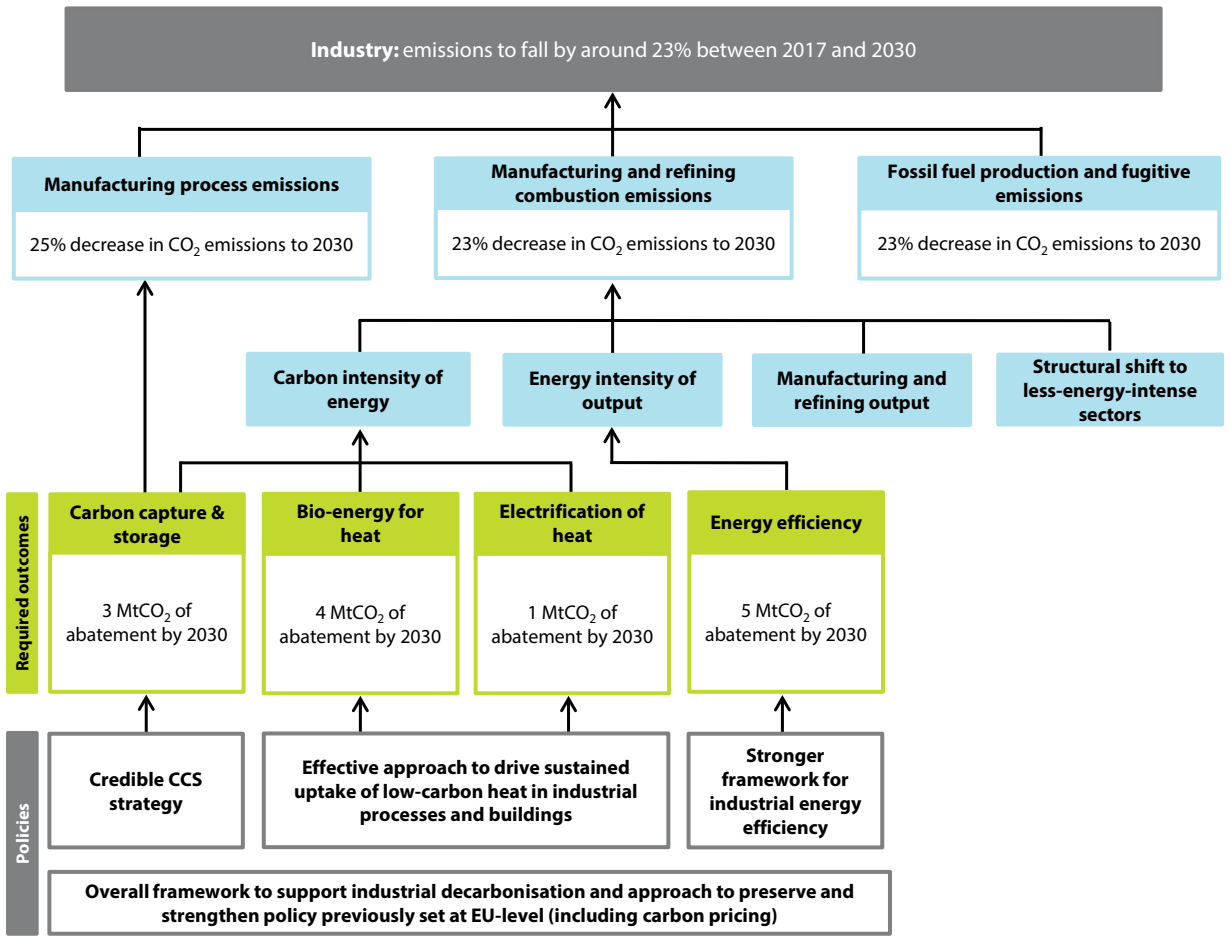
We track progress in industry against a set of indicators. These include energy and emissions pathways, actions and policies that together would deliver on the legislated carbon budgets and prepare the UK for the 2050 target (Figure 4.4):

- Progress requires improvements in energy intensity (TWh/GVA) and in the carbon intensity of energy (g/kWh). [62]
- Suitable policies on energy efficiency, CCS, bioenergy and electrification are needed to drive improvements in energy intensity and carbon intensity.
- Reductions in process emissions from the manufacturing sectors are also required through CCS.

We also track other changes, such as output and structural changes, which provide context for the indicators. We have refreshed our quantitative indicators this year to map progress against the framework in Figure 4.4. These indicators concentrate on progress in reducing combustion emissions from the manufacturing and refining sectors, because these areas were identified as having the most abatement potential in our fifth carbon budget scenarios.

[62] In these contexts, 'energy' includes on-site electricity generation, but excludes electricity from the grid. Emissions relating to grid electricity are dealt with in Chapter 2.

Figure 4.4. CCC indicators for the industry sector



Source: CCC analysis.
Notes: Manufacturing combustion emissions include on-site combustion for electricity generation, but do not include emissions associated with electricity from the grid.

3. Recent performance in reducing industrial emissions compared to required progress

GHG emissions from industry are below our indicator for 2017. This reflects that outturn emissions in 2016 were already below the indicator trajectory. Combustion emissions from the manufacturing and refining sectors are also outperforming their 2017 indicator for the same reason.

These overall reductions in UK industry emissions mask a more complicated picture of changes in the structure of the sector, energy intensity and emissions intensity, in which the emissions intensity of industrial energy use is progressing more slowly than our indicator trajectory (Table 4.3):

- The energy intensity of industrial output is ahead of our indicator. However, it is not yet clear whether this reflects full implementation of cost-effective energy efficiency measures. Some of the reduction in energy intensity will have resulted from shifts of output from sub-sectors

with higher energy intensity to those with lower energy intensity, which is not captured in our indicator. Our decomposition analysis (Box 4.1) suggests that a quarter of energy intensity improvements between 2012 and 2015[63] may be a result of shifts of GVA from more-energy-intensive subsectors to less-energy-intensive subsectors, including the closure of Redcar steelworks in 2015. Further elements of energy intensity improvements may result from shifts in GVA within subsectors, towards operation with a lower energy intensity - we are not currently able to track these changes.

- The CO_2 emissions intensity of energy use is behind both of our indicators for this measure. This suggests slow progress on fuel switching.

We intend to develop our indicators for energy intensity of output and emissions intensity of energy further in future so that we are able to separate the effect of structural changes.

Table 4.3. Key outcomes (indicators) to be on track for 2030 (and latest outturn)

	2017 Indicator (% change from 2012)	2017 Outturn (% change from 2012)
Direct industry GHG emissions	-9%	-10%
Manufacturing and refining direct combustion CO_2 emissions	-9%	-12%
Manufacturing and refining energy intensity of output	-5%	-20%*
Manufacturing and refining (direct) combustion emissions intensity of energy use	-9%	-3%
Manufacturing and refining (combined direct and indirect) combustion emissions intensity of energy use	-26%	-22%

Source: CCC analysis.
Notes: Intensity estimates based on energy and emissions from all manufacturing sectors and refining. *This reflects an increase in GVA of 14% and decrease in energy of 9%; structural effects are likely to account for a large part of this energy intensity improvement - we will review this further in future analysis.

[63] Our decomposition data ends in 2015.

4. Policy implementation

To make the necessary contributions to economy-wide emissions reduction and prepare for the 2050 target, policy for industry will need to deliver cost-effective abatement (Section 2). In this section we assess Government's progress in developing low-carbon policy for industry and outline the steps necessary for industry policy to keep the UK on track to meeting the budgets and 2050 target.

Current Government policy

The Government has implemented a number of policies for reducing emissions, aimed at encouraging energy efficiency improvements, uptake of low-carbon heat and use of bioenergy in industry. Most of these policies (Table 4.4) are focused on improving energy efficiency, with these energy efficiency policies encouraging levels of abatement that are modest compared to the levels of cost-effective abatement that we have identified for the fourth and fifth carbon budget periods. In addition to these energy efficiency policies, the Renewable Heat Incentive supports low-carbon heat uptake in industry and as the largest single implemented policy for industry, is currently expected to encourage around 2 $MtCO_2e$/year of abatement between 2020 and 2030.

In the Clean Growth Strategy (CGS) the Government announced a number of new policies and proposals that cover the industrial sector. These included:

- A proposal to improve business energy efficiency by 20% by 2030, through a package of measures to include:
  - An Industrial Energy Efficiency Scheme to help large companies install measures to cut their energy use and their bills.
  - Streamlined Energy and Carbon Reporting Framework. This policy will replace the business reporting element of the discontinued CRC Energy Efficiency Scheme, to align with mandatory annual GHG reporting for UK quoted companies.
  - Industrial Heat Recovery Programme. This £18m fund was announced to encourage investment by manufacturers to recover and reuse heat from industrial process that would otherwise be wasted.
- A proposal to phase-out the installation of high-carbon fossil-fuel heating in businesses off the gas grid during the 2020s.
- A proposal to set out a Carbon Capture Utilisation and Storage (CCUS) Deployment Pathway in 2018, establish a Cost Challenge Taskforce and CCUS Council, review the delivery and investment models for CCUS in the UK and work with initiatives in Teesside, Merseyside, South Wales and Grangemouth to test the potential for development of CCUS industrial decarbonisation clusters.
- A proposal to develop a framework to support the long-term low-carbon development of energy-intensive industrial processes, such as CCUS and electrification.
- A commitment to spend around £162m by 2021 on innovation for business and industry decarbonisation, including £100m to support industry and CCUS innovation.
  - Initially £20m was allocated for industrial fuel switching innovation and £9m for an Industrial Energy Efficiency Accelerator.

– The Government has since announced further projects coming from the £100m. These include a £15m call for CCUS innovation projects; £20m to design and construct carbon capture and utilisation demonstration projects, with a focus on industrial sites and applications; and a £20m Hydrogen Supply Programme that aims to accelerate the development of low-carbon hydrogen for industry, power, buildings and transport.

Since the CGS, there has been two developments:

- The Government has set an overall ambition for England and the rest of the UK to be a zero avoidable waste economy by 2050 by maximising the value extracted from resources, and minimising the negative environmental and carbon impacts associated with their extraction, use and disposal. This can help reduce industrial emissions through increased resource efficiency and opportunities for circular economy initiatives. Specific policies will be set out in the Resources and Waste Strategy due to be published later this year.
- The Industrial Strategy Challenge fund, announced as part of the Government's Industrial Strategy, is looking to maximise the advantages for UK industry from the global shift to clean growth.[64] This has two prongs: firstly, increasing support for innovation to drive down costs of clean technologies; and second, aligning policies, regulations, taxes and investments to grow the markets for these new innovations so that they are successfully commercialised within the UK.

Assessment of existing policy

We estimate that the combination of pre-CGS policies and the new policies and proposals in the CGS could, if delivered in full, provide sufficient industry abatement in the fourth carbon budget period to meet our industry cost-effective path and almost sufficient abatement for the fifth carbon budget period (Figure 4.5).

However, there are significant risks that sufficient industry abatement will not be encouraged because (a) the proposals remain very high level and need to be turned into firm, clear and detailed policies and (b) some of the actual policies have issues relating to design, implementation, incentives and/or funding.

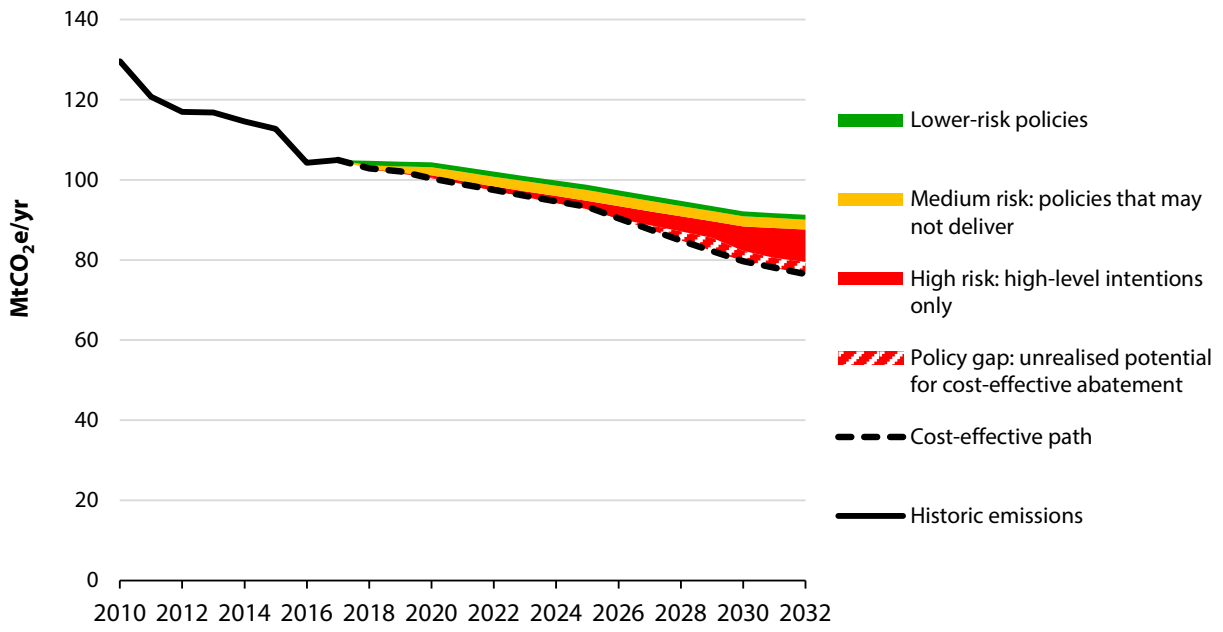
There are risks for each of our key areas of abatement: energy efficiency, low-carbon heat and industrial CCS (Table 4.4). The most significant concerns are that:

- The new proposals for industrial CCS and 20% improvement in energy efficiency lack critical detail on timing and implementation and need urgently to be turned into firm policies.
- There are no clear proposals to support a switch to low-carbon fuels for industrial process heat after 2021.

Overall, whilst the CGS was an important step towards enabling cost-effective abatement in industry, it now needs to be translated into delivery plans strong enough to support the investment required.

[64] HM Government, 2017, *Industrial Strategy, Building a Britain fit for the future*.

Figure 4.5. Risks around the delivery of industry policies to meet the cost-effective path



Source: BEIS (2018) *Updated energy and emissions projections: 2017*; CCC analysis.
Notes: Cost-effective path includes an additional 1 $MtCO_2e$ abatement in 2030 from biomethane injected into the natural gas grid. The top of the green area in the chart represents baseline emissions, based on the latest Government emissions projections published in January 2018. Lower-risk policies have sufficient funding and ambition to deliver with reasonable confidence. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

Table 4.4. Assessment of policies to drive abatement options in industry			
Abatement option		**2017 policy**	**2018 updates and assessment**
Energy efficiency		Amber There were a range of policies to support industrial energy efficiency including: CCL, CCA, EU Products Policy, ESOS, ECAs, Building regulations part L and Private rented sector regulations. CRC to close in 2019 with rebalancing of CCL. Most policies provide modest levels of abatement for industry over the period to 2032 and a number have risks of under-delivering on expected abatement.	Amber The Government's commitment to improve business energy efficiency by 2020 would likely provide around as much energy efficiency as we have in our cost-effective path. However, no new detail has yet been published about how this will be achieved, beyond the modest savings we estimate from the two new policies: streamlined energy and carbon reporting and the £18m heat recovery programme.
Low-carbon heat and use of bioenergy	To 2021	Amber RHI was funded to 2020/21 and the Government consulted on reforms. There is a risk that the RHI will not deliver the abatement projected by BEIS because of non-financial barriers to uptake of large-scale low-carbon heat projects.	Amber Refocusing of the RHI scheme is in progress and loan guarantees have been introduced to give large schemes sufficient certainty around the tariff obtained to be able to finance projects. Risks remain around whether these are sufficient to address barriers. Policy is needed to drive awareness of the scheme.
	After 2021	Red No policy	Red Ambition to phase out installation of high-carbon fossil fuel heating in business buildings off the gas-grid during the 2020s. However, the Government has set out no detail on this proposal. The phase-out does not cover industrial process heat in industry, although £20m is committed for innovation in fuel switching options.

Table 4.4. Assessment of policies to drive abatement options in industry

Abatement option	2017 policy	2018 updates and assessment
Industrial CCS	Red Funding awarded (from UK and EU funds) to a feasibility study in to a small-scale industrial CCS project in North East Scotland.	Red The Government has committed to publish a deployment pathway for CCUS in 2018, setting out the steps needed to meet its ambition of deploying CCUS at scale during the 2030s, subject to costs coming down sufficiently. However, the plans are very high level and early stage and the current £100m funding commitment is only sufficient for small scale CCS demonstration.
Cross-measure support for industrial decarbonisation	Amber The EU ETS planning for phase 4 for 2021-2030	Amber Emissions savings from the EU ETS are at risk due to the UK leaving the EU. Price signals under the EU ETS are also currently too weak to act as an effective incentive for many cost-effective abatement options. The Government has committed to develop a framework to support industrial decarbonisation, but the level of action previously set out by the roadmaps has been lost.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower-risk policy - expected to deliver. The assessment in this table does not map directly on to the RAG assessment in Figure 4.5. This reflects that it is an aggregate assessment for areas that may have a number of existing policies, such as energy efficiency.

5. Further actions required in industry

To be on track to meet the fourth and fifth carbon budgets, the Government needs to remove risk of under-delivery from existing policies, turn proposals into firm policies and put in place new policies. Specifically, this requires:

- **That the ambition to improve business energy efficiency by 20% be turned into specific, concrete and measurable policies with clear timings and outcomes.** We estimate that this proposal would deliver around a quarter of the cost-effective abatement in industry in the fourth and fifth carbon budget periods, so it is crucial that the Government provides confidence that this abatement can be delivered.
  - **Industrial Energy Efficiency Scheme.** We expect this policy to benefit business productivity and contribute a substantial proportion of the abatement to the overall 20% energy efficiency improvement policy. The Government should confirm funding and complete the development of this scheme by the end of the year, as outlined in the Clean Growth Strategy, enabling implementation to begin in 2019.
  - **Measurement.** 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 was not defined in the Clean Growth Strategy. The Government should publish the metric and baseline for the target, show how the savings from policies will add up to 20%, indicate the relative contribution from industrial process efficiency compared to buildings efficiency and indicate the relative contribution from commercial versus industrial business.
- **An overall framework to support long-term industrial decarbonisation.** The Government has committed to develop a framework to support the long-term low-carbon development of energy-intensive processes. The Government should:
  - Publish a call for evidence in 2018 on the potential options for the framework including the potential design options for a financial mechanism to support industrial decarbonisation.
  - Set out additional milestones for the period before 2022, to include a timeline for consulting on the framework.

  The framework development should not stop the implementation of nearer-term policies on CCS and should consider the interaction with the future of the EU ETS or potential successor scheme.
- **A clear, funded approach to industrial carbon capture and storage.** Industrial CCS is key for meeting future carbon targets. The Government's 2018 CCUS Deployment Pathway should provide a clear path for industrial CCS deployment as part of an overall programme of CCS deployment that stores 10 $MtCO_2$ per annum in 2030. The Deployment Pathway should propose the delivery model to support CO_2 transport and storage infrastructure, a separate mechanism to support initial industrial CCS project(s), and the allocation of risks between Government and developers, especially relating to long-term storage liabilities. Support for initial CCS deployment should be implemented by the end of 2021, consistent with having the first CCS cluster operational by 2026. The Government should also publish its review of CCS delivery and investment models alongside the pathway.
- **An effective approach to drive sustained uptake of low-carbon heat in industrial processes.** An acceleration in low-carbon heat uptake will be required over the next few

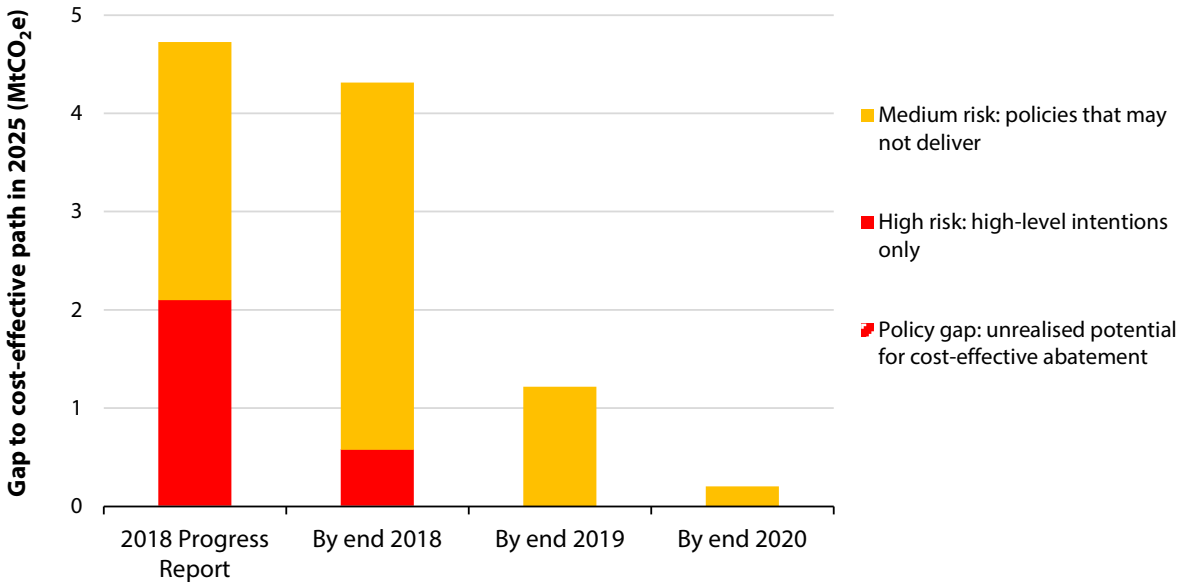
years. This will be difficult to meet without addressing barriers to uptake. Although the RHI covers some industrial process heat up to 2021, it does not cover direct firing[65] and there is no clear policy for deploying low-carbon industrial process heat beyond 2021. Policy should seek to address these gaps to ensure investment in large-scale industrial low-carbon industrial heat projects, including large industrial heat pumps. This should include consideration of a successor scheme to the Renewable Heat Incentive, reflecting lessons about the need for de-risking through long-term contracts and/or tariff guarantees for large industrial schemes (which otherwise may struggle to obtain finance).

- **Policy previously set at EU level should be preserved and strengthened in future.** The UK, alongside other Member States, has played a key role in developing EU-level mechanisms to control emissions in some areas, particularly where it makes sense to take a coordinated approach (e.g. because the relevant market is EU-wide). In areas where these EU-level mechanisms are working effectively, the UK should either remain in these schemes or replicate them at UK level:
  - **Carbon pricing.** The EU ETS has the potential to be a least-cost approach without creating competitiveness challenges for industry. The UK should either remain a part of the EU ETS or put in place equivalent mechanisms that achieve at least as much emissions reduction. The Government should engage industry closely in the development of the range of future options. Any new approaches outside of the EU ETS should not disadvantage UK competitiveness.
  - **Products Policy.** EU energy efficiency standards and labelling for products have driven up the efficiency of electrical goods on sale and removed the least efficient goods from the market. After the UK leaves the EU, the UK should maintain or replicate these policies and align with the future energy efficient products policy to avoid inefficient products with higher running costs and emissions being dumped on the UK market.
- **Energy Savings Opportunity Scheme (ESOS).** The extent to which the scheme will lead to uptake of the most cost-effective measures identified remains uncertain. The Government should assess the case for enhancing the energy use audits (e.g. through signposting to finance, follow-up support and benchmarking) and use of measured rather than modelled performance.

The Government should firm up proposals and reduce policy delivery risks for the fourth carbon budget period by 2020 and by 2025 for the fifth carbon budget period (Figure 4.6 and 4.7). Table 4.5 outlines the key milestones and timings for doing so.

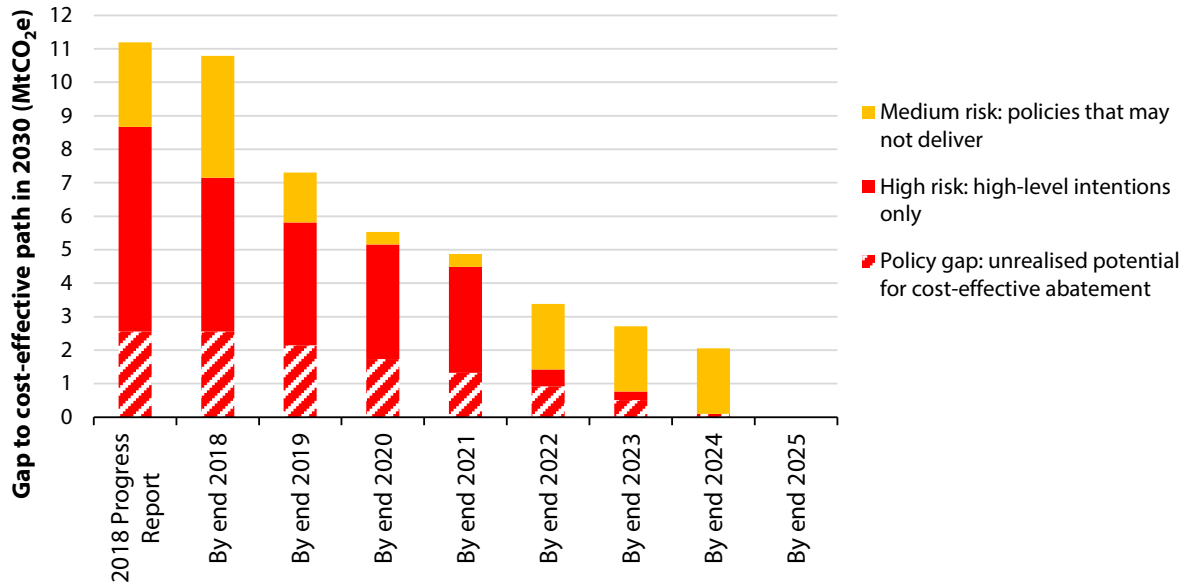
[65] Direct firing refers to direct use of heat from combustion in industrial processes, as opposed to using fuel to produce steam and hot water which is then used in industrial processes.

Figure 4.6. Risks around the delivery of industry policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*, CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the cost-effective path can be closed and how current policies, proposals and intentions are firmed up so that delivery risks are largely eliminated. This is based on an assessment of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2020. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period, and the gap to meeting the cost-effective path.

Figure 4.7. Risks around the delivery of industry policy in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*, CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the cost-effective path can be closed and how current policies, proposals and intentions are firmed up so that delivery risks are largely eliminated. This is based on an assessment of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2025. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period, and the gap to meeting the cost-effective path.

Table 4.5. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Action	Timing
Energy Efficiency	
Consult on specific, concrete policies to achieve the proposal to improve business energy efficiency by 20% by 2030. The consultation should set out: • The metric and baseline for the proposal to improve business energy efficiency by 20% • How the savings from future policies will add up to 20% and when these savings will be achieved • The relative ambition to reduce electricity use in businesses compared to other fuel use • The relative ambition for improvements in industrial process energy efficiency compared to buildings energy efficiency.	Summer 2018
Develop the Industrial Energy Efficiency Scheme, confirm funding and start implementation.	End 2018
Evaluate effect of Climate Change Assessments to inform any successor scheme for 2023.	End 2020
Introduce new streamlined energy and carbon reporting framework.	End 2019
Fund initial heat recovery project through the industrial heat recovery scheme.	End 2018
Cross-cutting industry policy	
Publish (a) additional milestones on the timeline for the 'framework to support industrial decarbonisation', including for consulting on the framework (b) a call for evidence on the potential options for the framework including the potential design options for a mechanism to support investment in industrial decarbonisation.	End 2018
Develop and implement the framework to support decarbonisation of heavy industry.	End 2022
Carbon Capture and Storage	
Publish CCS Deployment Pathway and Government's review of CCS delivery and investment models.	End 2018
Put in place a mechanism to support CO_2 transport and storage infrastructure.	End 2021

Table 4.5. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Action	Timing
Put in place a mechanism to support initial industrial CCS project(s).	End 2021
First industrial CCS project(s)/ cluster operational.	2026
Low-carbon heat	
Set out proposals for the phase-out of high-carbon fossil fuel heating in businesses off the gas grid, including a definition of 'high-carbon fossil fuel heating'. This should include consideration of cost-effective opportunities for large-scale heat pumps in industrial buildings.	End 2018
As part of the new industrial framework, set out proposals for supporting deployment of low-carbon industrial process heat beyond 2021.	2019
Carbon Pricing	
Set out plans for ensuring a continued carbon price in the UK, in the case that the UK leaves the EU ETS.	Spring 2019

Chapter 5: Transport

Key messages and recommendations

As emissions in other sectors have reduced, transport has grown as a share of overall emissions. Transport is now the largest-emitting sector of the UK economy at 126 $MtCO_2e$, accounting for 28% of UK greenhouse gas (GHG) emissions in 2017. The Government's zero emissions road transport strategy ('Road to Zero'), which will set out a plan to 2050 to reduce emissions from transport, has been delayed - although publication was initially scheduled for March 2018.

Our key messages for the transport sector are:

- **Cost-effective reductions in emissions in transport are not being delivered across almost all CCC indicators.** Emissions in domestic transport were flat after rising for three consecutive years from 2014 to 2016. Demand for travel continues to grow across cars and vans, whereas efficiency improvements have slowed. This sector is now significantly off-track from the cost-effective path in the Committee's fifth carbon budget assessment.
- **Test-cycle new car CO_2 emitted per mile has increased for the first time since records began (in 2000), increasing by 0.8% in 2017.** A decrease of 5.9% is now required every year to meet the EU 2020/21 target. The new car CO_2 intensity increase is largely due to people buying larger cars, with only a small part arising from the switch away from diesel.
- **Sales of electric vehicles (EVs) increased in 2017 to 1.9% of new cars**, slightly lower than our indicator of 2.2%. Demand for electric vehicles outstrips manufacturer supply leading to long wait times for orders, and it is likely that sales are suppressed as a result.
- **Significant risks to meeting carbon budgets remain.** Our key priorities to be addressed by the Government are:
  - Clarity about the UK regulatory approach to the EU 2020/21 new car and van CO_2 targets and proposed targets for 2025 and 2030 is urgently required. Manufacturers need to be incentivised to sell their most efficient and ultra-low emission models in the UK. When setting future targets, a measure of real-world performance of vehicles must be used alongside standardised tests to regain public trust and ensure actual emissions reductions are realised on the road.
  - Policies, including fiscal instruments, must strengthen incentives to purchase cleaner vehicles and support new car and van emissions targets. The current move to higher-emitting cars is undermining efforts to improve fleet efficiency and must be addressed.
- **Significant opportunities for people and industry could be realised in implementing policies to deliver the cost-effective path:**
  - **Opportunities to reduce demand for travel must be exploited.** Demand reduction is generally highly cost-effective and has many co-benefits. Cities and towns can take the lead in encouraging sustainable travel choices, including walking, cycling and public transport, which can improve congestion, air quality and public health.
  - **Improvements in freight logistics efficiency** such as driver training to drive more fuel efficiently can help raise productivity, but there remains a need for the regulation of the fuel efficiency of new HGVs.
  - **Policies to deliver a high uptake of EVs** to around 60% of new car and van sales by 2030 will deliver air quality improvements and clean growth opportunities for UK industry.

Existing and planned policies leave a further 33 $MtCO_2e$ reductions required in 2030 to meet our assessment of the cost-effective path to meeting the fifth carbon budget.

Key messages and recommendations

Table 5.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/ Timing
Clarity about the UK regulatory approach to the EU 2020/21 new car and van CO_2 targets is required in the event of an EU exit. If the UK is not covered by these targets, there is little incentive for manufacturers to sell their most efficient conventional and electric vehicles in the UK.		×		2019
Stretching CO_2 targets for new cars and vans are needed beyond 2020 that go further than current EU proposals. These should require a high uptake of EVs and exploit the most efficient technologies available for conventional vehicles. Flexibilities and loopholes in the current testing regime need to be removed in the transition to the new test procedure (WLTP) to restore public confidence in standards and deliver real-world emissions reduction. A real-world testing regime or actual on-road fuel consumption data should be used alongside standardised tests and quoted in sales literature.			×	2019
Policies to deliver a high uptake of electric vehicles to around 60% of new car and van sales by 2030. Barriers to EV uptake should be tackled by providing time – limited financial support and effective roll-out of infrastructure. Significant co-benefits from this measure include air quality improvement and opportunities for UK industry.		×		2018-2024
Ensure that plug-in hybrid electric vehicles deliver near-zero real-world emissions by setting a minimum range for electric drive in 2035 so that almost all trips can be completed without using the petrol/diesel engine.			×	2018

Key messages and recommendations				
Policies, including fiscal instruments, must align with new car and van emissions targets to strengthen incentives to purchase cleaner vehicles. The current move to higher-emitting cars is undermining efforts to improve fleet efficiency and must be addressed.			✖	2018
Stretching targets for CO_2 emissions reductions from new HGVs must be introduced to address the rise in emissions, as well as exploiting opportunities to improve logistics and increase uptake of eco-driving.			✖	2019
Policies to increase levels of walking, cycling and use of public transport need to be strengthened, to deliver car-km reductions of at least 5% below the baseline trajectory, to realise benefits including reduced CO_2 emissions, as well as improved public health, air quality, reduced noise, and congestion.			✖	2018
A plan for UK aviation emissions at around 2005 levels by 2050 (implying around a 60% potential increase in demand), supported by strong international policies.			✖	2019

Introduction

In this chapter we review progress in decarbonising UK transport emissions in 2017. We set out the analysis that underpins our key messages and recommendations in the following six sections:

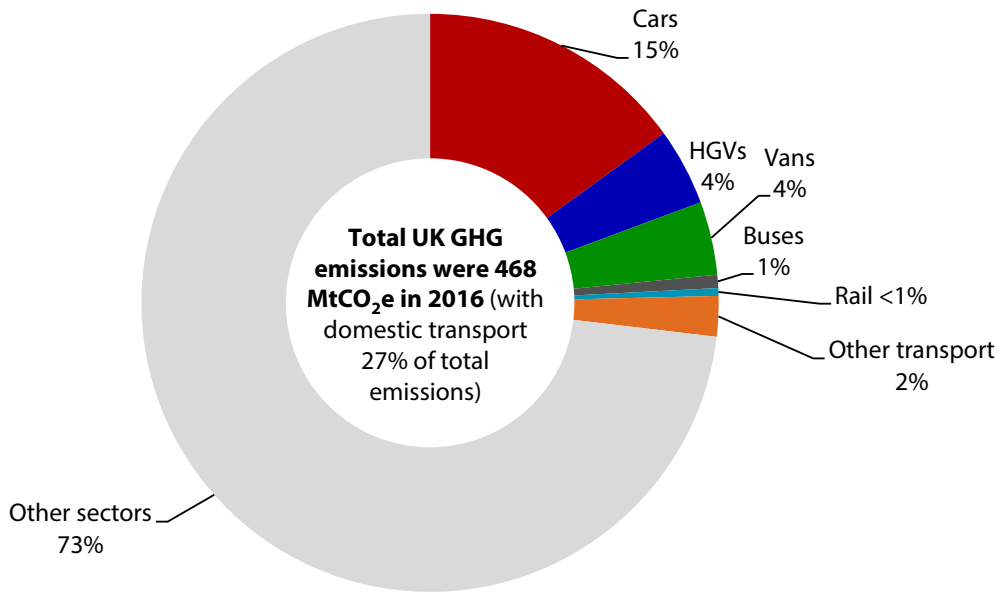
1. Transport emission trends and drivers
2. Transport scenarios and indicators
3. Recent performance in reducing surface transport emissions compared to required progress
4. Recent performance in reducing aviation and shipping emissions compared to required progress
5. Policy implementation
6. Further actions required in transport

1. Transport emission trends and drivers

Domestic transport emissions

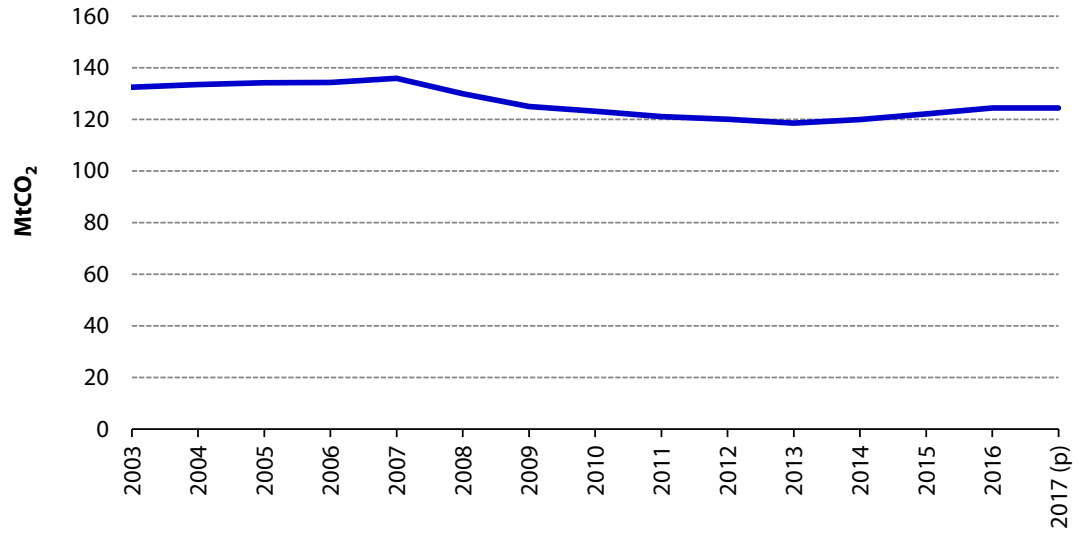
Domestic transport greenhouse gas (GHG) emissions are provisionally estimated to be 126 $MtCO_2e$ in 2017. Transport continues to be the largest-emitting sector in the UK, accounting for 28% of total GHG emissions compared with 27% in 2016. A detailed breakdown of transport emissions is only available up to 2016. Cars, vans and HGVs remain the three most significant sources of emissions, accounting for 87% of domestic transport emissions (Figure 5.1). Carbon dioxide emissions were flat from 2016 to 2017, after three consecutive years of emissions increases (Figure 5.2).

Figure 5.1. Sector emissions as a share of UK total, 2016 (GHGs)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*
Notes: Other transport includes domestic aviation and shipping, mopeds and motorcycles, liquid petroleum gas fuelled vehicles and other road vehicle engines. A detailed breakdown is only available up to 2016.

Figure 5.2. Domestic transport CO_2 emissions (2003-2017)



Source: BEIS (2018) *Provisional UK greenhouse gas emissions national statistics 2018.*

Economic context

Changes in demand for road transport are generally considered to be driven by factors such as income, population, motoring costs and manufacturing output. In 2017, the most significant change was a large rise in motoring costs which could have dampened demand across all modes. Whilst fuel costs rose this year, which will have decreased the demand for travel, the Government maintained the freeze on fuel duty, which has remained unchanged since 2010/11. The price of fuel at the pump is now 13% lower than it would otherwise have been without the freeze, with traffic growing by 4% since the freeze, leading to increased greenhouse gas emissions, poorer air quality and increased congestion.[66] Other social and economic drivers also supported an increase in demand for travel, including GDP, population growth and growth in manufacturing output, which affects demand for HGV travel (Figure 5.3).

In addition to the historical drivers of travel demand, there is also developing evidence that social trends are shifting, changing the drivers of transport demand. Recent research is summarised in Box 5.1.

[66] Professor D. Begg and C Haigh (2018) *The unintended consequences of freezing fuel duty*.

Box 5.1. Trends in demand for travel

The Commission on Travel Demand, an independent research group led by Leeds University, has recently published research showing that societal shifts in activities such as how we work and shop, changing demographics, changes in income across the population and policies which encourage urbanisation have all impacted demand for travel.

Although overall demand for travel is rising due to increased population, on a per-person basis we travel substantially less today than we did 20 years ago, making 16% fewer trips a year. If the number of trips per person per year continues to decline (DfT's Road Transport Model Scenario 3), then by 2040 miles travelled would grow by 19% (compared to 2010). In the DfT forecast we use as the basis of our central projection, miles travelled grows by 42% (DfT's Road Transport Model Scenario 1).

Younger people are travelling much less than before, with miles driven per person reducing by 20% for 17 to 34 year olds between 2004 and 2014. In 1993, 55% of 17 to 20 year old males held a driving licence. This proportion is now 33%, with the corresponding figures for women 42% to 29% respectively. This is likely to be the result of young people having less disposable income, having lower-paid and less-secure jobs and buying homes much later. They are also starting families later and increasingly communicating using social media, meeting up less in person.

Research also suggests that the later age at which people get a licence, the less they tend to drive during the rest of their life.

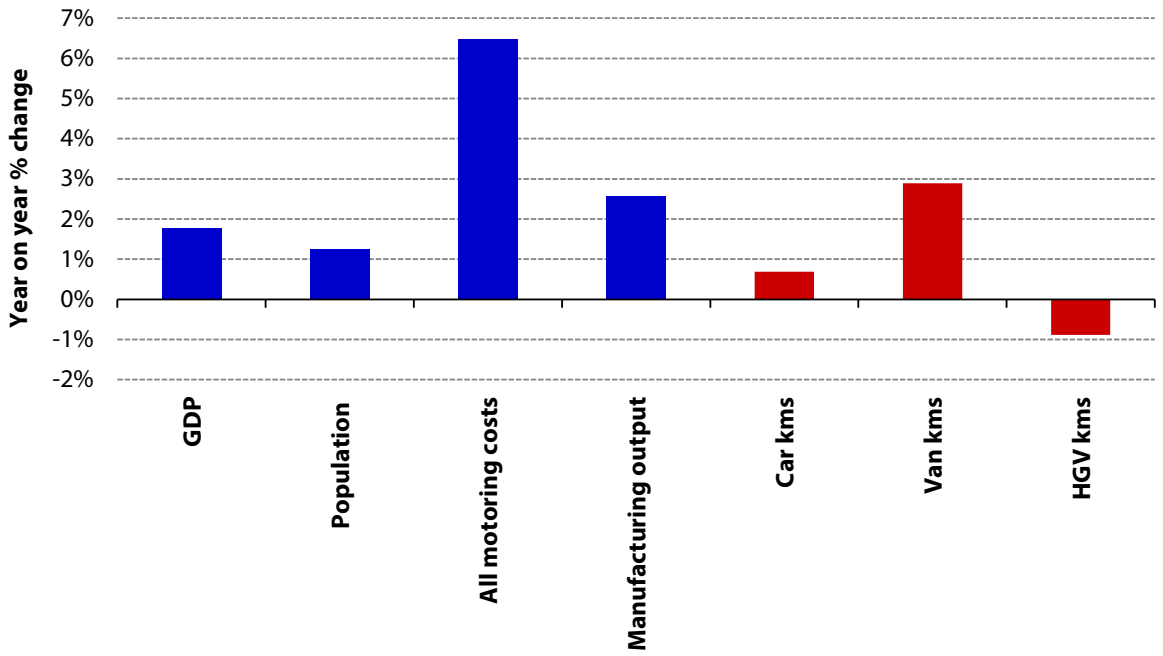
The research also emphasises the potential for shifts to public transport and cycling to replace car use where better access to these is available and where the urban area is dense enough that work opportunities, shops and leisure activities are all short distances away. In London and regional centres and towns in the South of England, there is evidence that more people are replacing their commute with cycling and public transport. Manchester and Bristol have also seen relatively constant volumes of car travel in the city centre, despite forecast growth.

Given large uncertainties in the DfT forecasts, there is potential that the predictions will substantially overestimate traffic growth and hence the need for new road infrastructure. But at least as importantly, demand is not exogenous and can be affected by policy--for example, road building can further stimulate demand. Transport for Greater Manchester is moving to a new approach, where they 'decide and provide' (use transport and land-use policy to support a vision for the area). This could lead to better outcomes than the traditional 'predict and provide' approach, where demand for car travel is forecast and roads are built to meet that demand without considering the potential impact of policy. The Norwegian Government has also asked cities in Norway to calculate what kinds of investment they would need to enable them to thrive without growing traffic levels.

By choosing to develop in a way that minimises the need for car travel, cities can deliver lower emissions, improved air quality and noise levels, better public health and reduced congestion.

Source: Marsden G. et al. (2018) *All change? The future of travel demand and the implications for policy and planning. First Report of the Commission on Travel Demand.*
Notes: DfT's Road Transport Model Scenario 1 uses a historical average for trip rates, as opposed to the extrapolated trend in Scenario 3. Both forecasts assume a positive and declining relationship between income and travel and use central macroeconomic forecasts.

Figure 5.3. Key drivers of travel and change in demand by mode (2016 to 2017)



Source: CCC calculations based on figures from the Office for National Statistics; DfT (2017) *Road Traffic Statistics.*

Surface transport emission trends

In 2016, emissions from surface transport rose 2.3% to 117 $MtCO_2e$, accounting for 93% of domestic transport emissions. In our fifth carbon budget assessment, the cost-effective path to 2050 required a 2.3% decrease in road transport emissions in 2016; instead they increased by this amount.

Emissions from cars, vans and HGVs all rose in 2016. The continued rise in road transport emissions highlights the urgent need for stronger policies to reduce emissions and moderate growth in demand for travel. The demand reduction trends noted for most age groups present an urgent opportunity to develop measures to sustain these (Box 5.1).

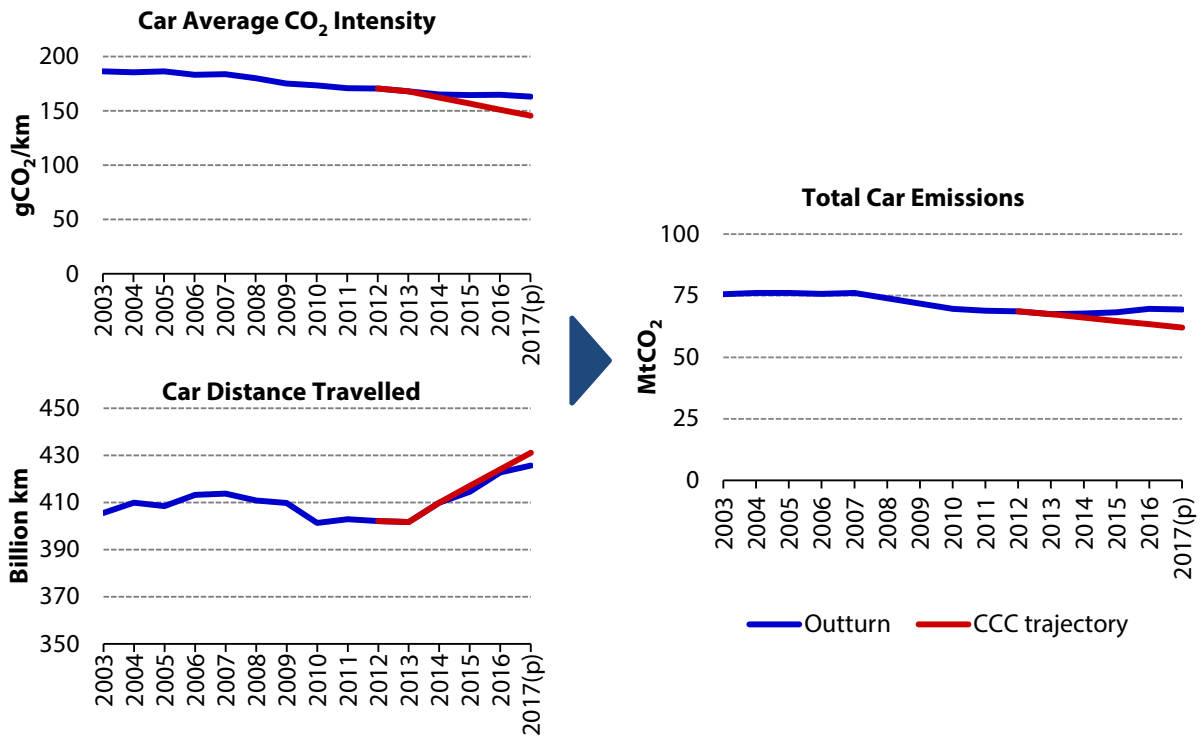
In the sections that follow, we compare emissions, demand and intensity in each mode in 2016 to our indicators, which reflect our estimates of the cost-effective trajectory to meet carbon budgets and long-term targets.

Cars

The CCC's cost-effective path for transport emissions requires a decrease of 2.1% in car emissions in 2016 (Figure 5.4). In 2016, emissions from cars increased by 2.1% to 70.3 $MtCO_2e$:

- Car-km increased by 2% in 2016, with a further increase of 0.7% in 2017.[67] This increase in demand is comparable to expectations in our indicator.
- The average CO_2 intensity of cars worsened in 2016, with an increase of 0.1%, compared to a 3.6% decrease in our indicator. Average car efficiency and biofuel usage both decreased by 0.1%.

Figure 5.4. Car emissions, demand and intensity



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016; DfT (2018) Provisional Road Traffic Statistics;* CCC analysis.
Notes: The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

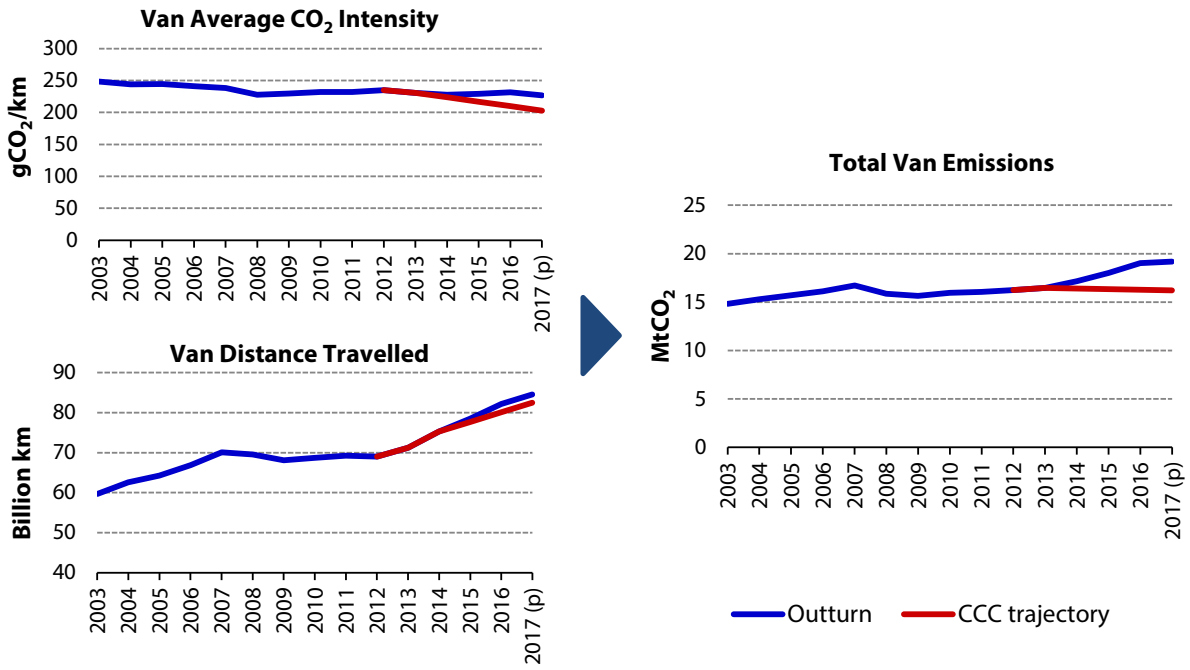
[67] The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

Vans

In 2016, emissions from vans increased by 5.5% to 19.2 $MtCO_2e$. Our cost-effective path requires a decrease of 0.4% (Figure 5.5). Demand continues to rise above projections:

- Van-km increased by 4.6% in 2016, with a further increase of 2.9% in 2017.[68]
- Van CO_2 intensity increased by 0.9% in 2016, due entirely to decreased fleet efficiency, with no change in biofuel usage.

Figure 5.5. Van emissions, demand and intensity



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016; DfT (2018) Provisional Road Traffic Statistics;* CCC analysis.
Notes: The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

Our previous reports have highlighted the rapid rise in van demand compared with other modes and that this cannot be explained by economic factors alone. Much research has highlighted the rise in internet shopping as a possible explanation for this, though the rise in van demand started before the rapid growth in internet shopping. Our estimates suggest that online retail deliveries accounted for up to 8% of van-kms in 2016; this represents less than a quarter (22%) of the growth in van-kms since 2000, when internet shopping began. Economic growth in van-dependent sectors and the rise in e-commerce in these sectors explains most of the remaining increase (Box 5.2). We set out our detailed assessment of drivers of van demand in a technical annex.

[68] The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

Box 5.2. Growth in van demand

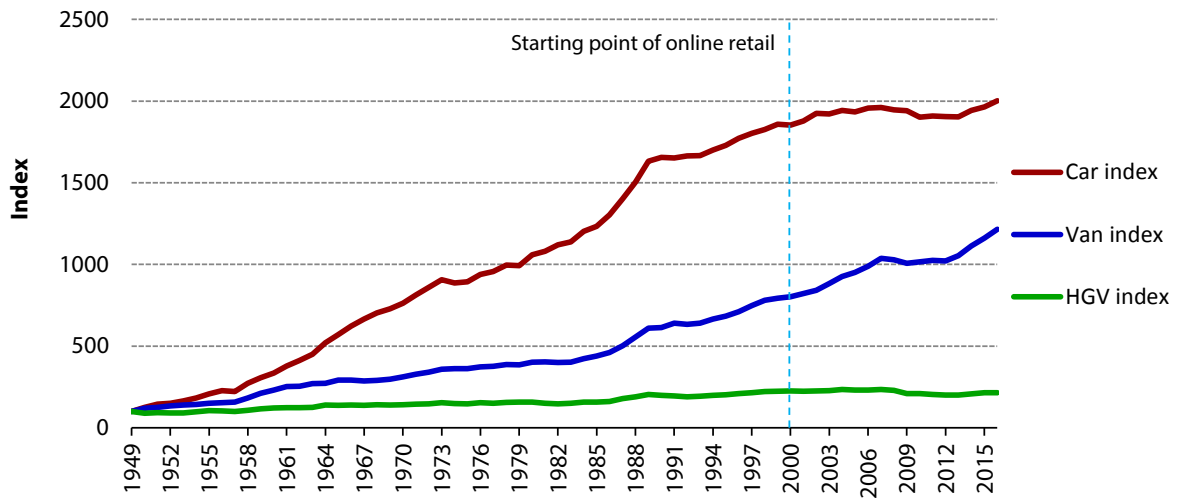
Van kilometres have been increasing for over 50 years, but there has been a pickup in the rate of growth since the mid-1980s (Figure B5.2). Aside from emissions, the growing number of vans poses issues due to congestion and noise in urban areas. A limited number of existing ULEV models are currently available to reduce emissions and improve air quality.

Our analysis identified the main drivers of van demand as the growth in online shopping, and economic growth in sectors with high van use.

The value of the online shopping market is expanding rapidly, with each household estimated to have received an average of one delivery per week in 2017. Our analysis suggests that these delivery vans account for up to 22% of the van km growth since 2000, but make up roughly 8% of van kilometres. The rise in van kilometres can also be attributed to economic growth in van-dependent sectors, such as construction, transport, utilities, ICT, wholesale, retail and food, accounting for at least 60% of the increase since 2000. If the propensity to use vans in these sectors has increased, this could account for even more of the increase. Stricter licence requirements and regulation for HGV drivers may have contributed to the van-kilometre increase, with freight shifting from small HGVs to large vans, but there is little direct evidence of this.

Further research is needed to explore options to tackle the effects of growth of van use. However, research from the Freight Traffic Control study, a consortium led by Southampton University, suggested significant savings could be made by improving logistics and freight operations in urban areas. The study highlights better targeted delivery stops and consolidation of deliveries in inner and outer city hubs as measures with the potential to reduce mileage by up to 47%. The real-world range of electric vans is improving with recently released models, and is much closer to meeting urban duty cycles.

Figure B5.2. Long-term demand trends across road transport modes (1949-2016)



Source: DfT (2017) *Road Traffic Statistics;* CCC analysis.
Notes: Base year (1949)=100.

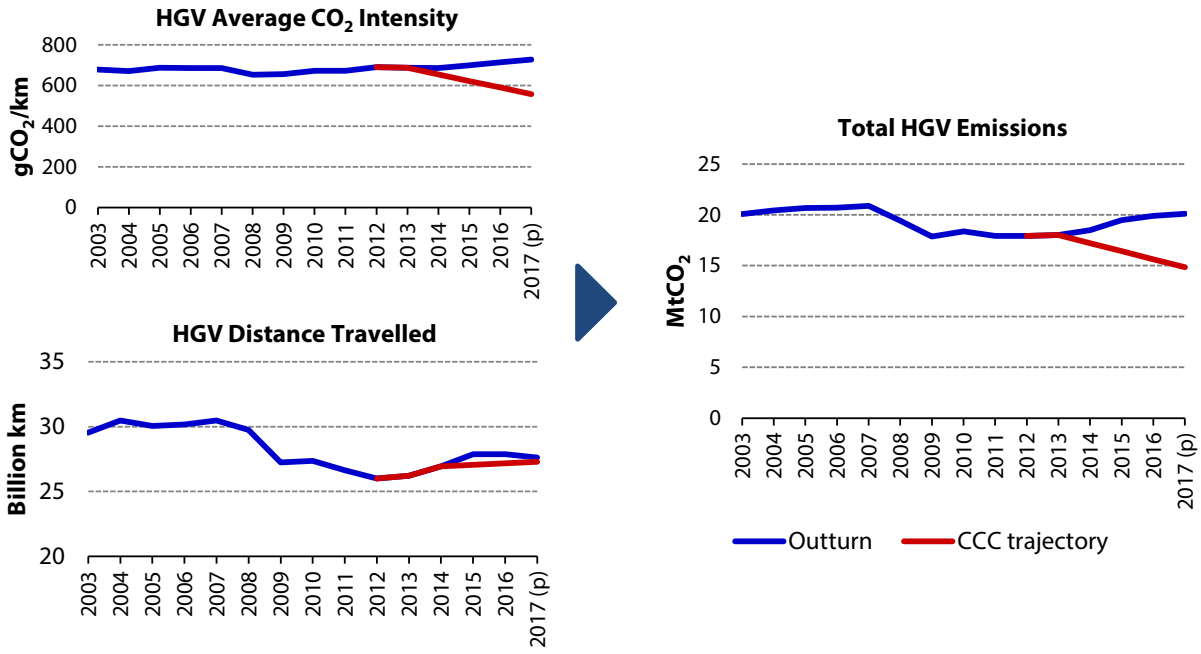
Source: see Technical Annex.

HGVs

Our cost-effective path to 2050 indicates a 4.8% decline in HGV emissions in 2016. Instead, HGV emissions increased by 2.2% to 20.3 $MtCO_2e$. This reflects a decrease in HGV fleet efficiency (Figure 5.6):

- HGV-km were flat in 2016 and decreased by 0.9% in 2017, although remaining above our indicator.[69]
- CO_2 intensity of HGVs increased by 2.1%, compared to a decrease of 5.2% in our indicator, due entirely to decreased fleet efficiency (there has been no change in biofuel usage).

Figure 5.6. HGV emissions, demand and intensity



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016; DfT (2018) Provisional Road Traffic Statistics;* CCC analysis.
Notes: The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

Aviation

Total domestic and international aviation emissions increased by 1.2% in 2016, to 35.5 $MtCO_2e$ (Figure 5.7). This was driven by a rise in international emissions (i.e. from flights from the UK to other countries). These represent the vast majority of aviation emissions and are not formally included in carbon budgets.

In 2016 the number of passengers flying rose by 7%, the number of kilometres flown by 6%, and the number of flights increased by 4%. That emissions only rose 1% suggests a range of factors are likely to have limited the increase in emissions. These could include higher load factors (e.g.

[69] The distance travelled in 2017 is calculated by extrapolating from provisional data as 2017 Road Traffic Statistics will be published later this year.

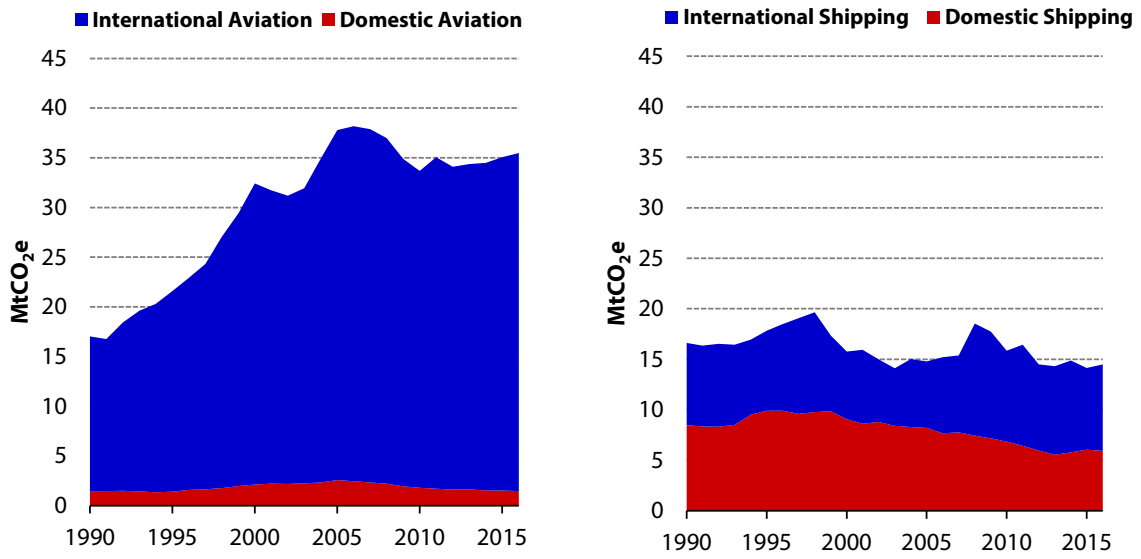
loading factors – a measure of seat occupancy – increased by 3 percentage points in 2016, and the number of passengers per flight is now 23% higher than in 2005; Figures 5.8 and 5.9), improved fuel efficiency of aircraft as new models enter the UK fleet, and/or changes in the route mix towards closer destinations (e.g. demand for short-haul flights is growing significantly faster than that for long-haul flights).

Shipping

The general trend in recent years has been for a reduction in shipping emissions; emissions are now 22% below 2008 levels. However, total domestic and international shipping emissions grew 2.5% in 2016, to 14.5 $MtCO_2e$. This reflects a 6% increase in international emissions; domestic emissions fell 2% (Figure 5.7).

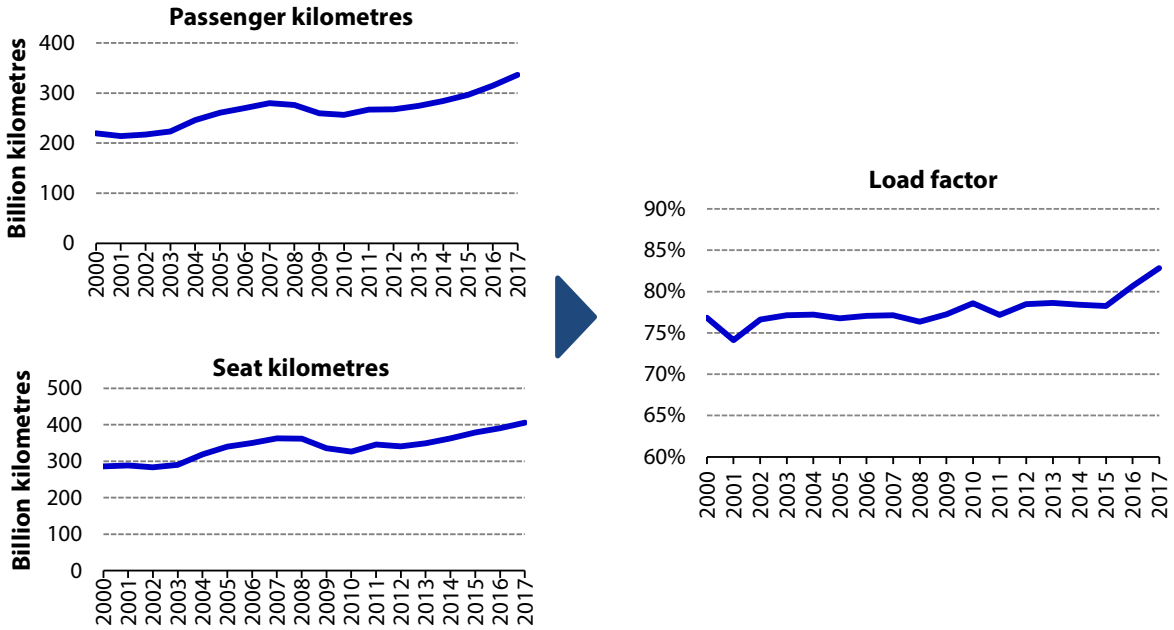
There is limited data available to explain the change in emissions. Imports of cargo fell 4% in 2016, the number of ship movements fell by 3% and the average size of ship increased by 3%. Since all of these changes would tend to suggest a decrease in emissions, other factors must have contributed to the rise in emissions. These could include increasing ship speeds, changes in fuel efficiency of ships, and/or changes in bunkering patterns (e.g. taking on more fuel at UK ports).

Figure 5.7. UK aviation (left) and shipping (right) emissions (1990-2016)



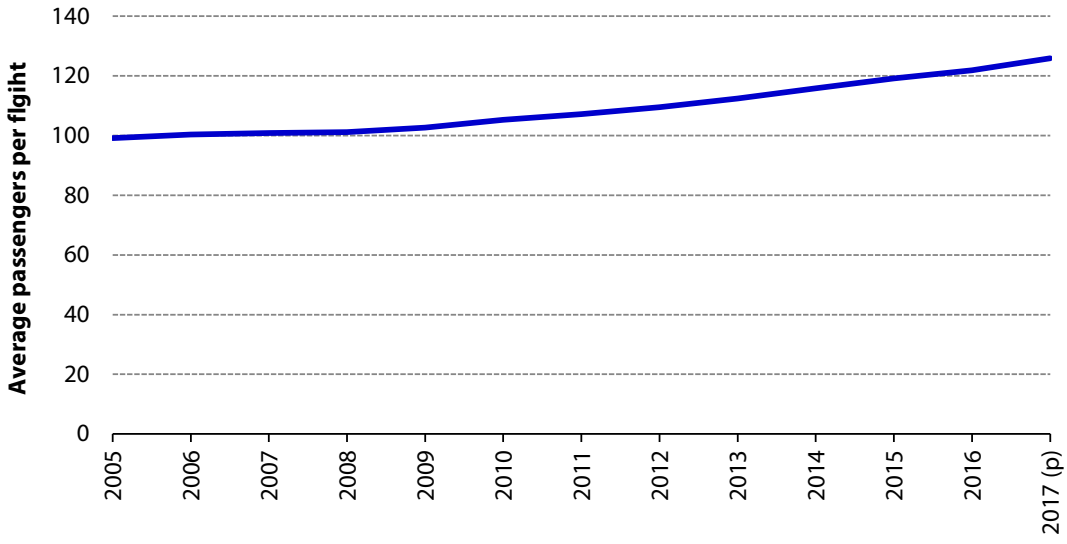
Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*

Figure 5.8. UK aviation loading factors (2000-2017)



Source: DfT analysis of CAA Airport/Airline data; CCC calculations.

Figure 5.9. UK passengers per flight (2005-2017)

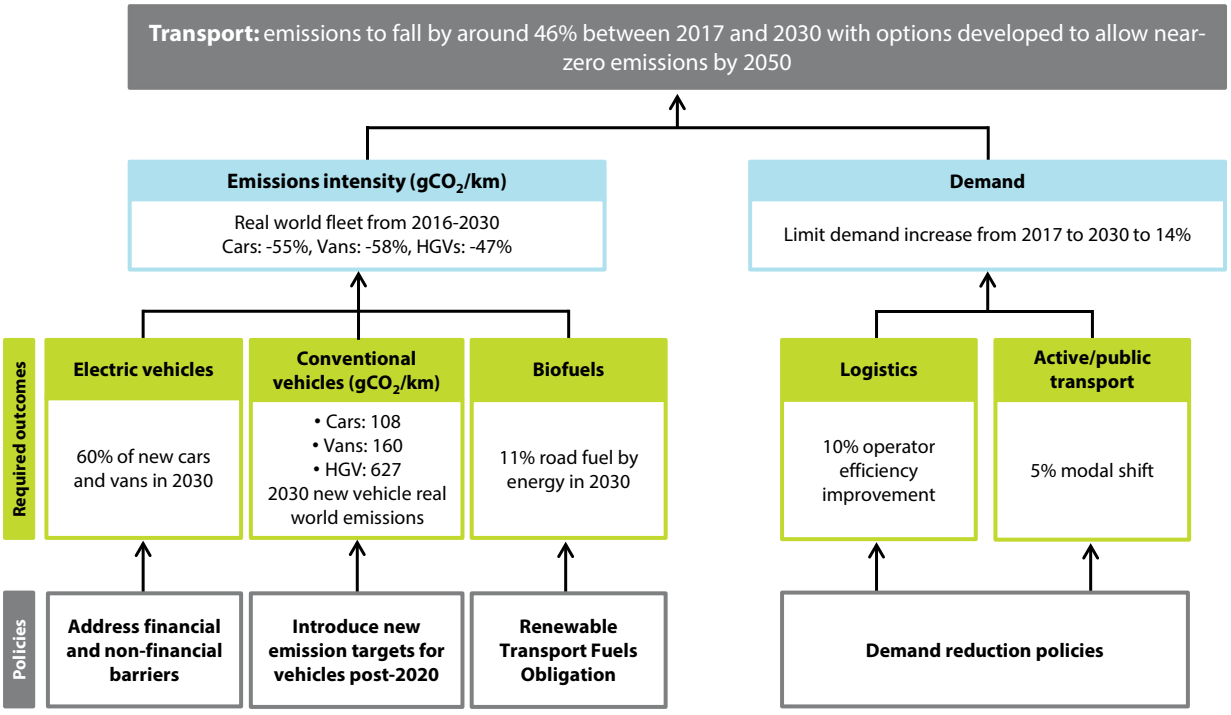


Source: CCC calculation based on CAA Airport data 2017.

2. Transport scenarios and indicators

Our assessment of the cost-effective path to meeting future emission reduction targets includes a reduction in transport emissions of 46% from 2017 to 2030. This will require improved efficiency of conventional vehicles, a major increase in the uptake of electric vehicles, measures to move goods more efficiently and to encourage the switching of travel to more sustainable modes (Figure 5.10).

Figure 5.10. CCC indicators for the transport sector



Source: CCC analysis.

3. Recent performance in reducing transport emissions compared to required progress

In this section we consider progress in developing policies to reduce emissions in surface transport, covering conventional vehicle efficiency, ultra-low emission vehicles (ULEVs), biofuels, measures to change travel behaviour and to increase freight efficiency.

Progress in reducing emissions from cars has stalled, with new test-cycle CO_2 intensity for cars increasing in 2017. The uptake of biofuels by energy is lagging behind what is required, but the Government has now legislated for increased uptake from 2018 to 2032 (Table 5.2).

Table 5.2. Key outcomes to be on track for 2030 (and latest outturn)		
Key outcome	**2017 indicator**	**2017 outturn**
Headline indicators		
Reduce road vehicle emissions by 46% by 2030, from 2010 levels	-11%	+4%
Vehicle kilometres driven 23% above 2010 levels in 2030	+9%	+8%
Supporting indicators		
New test-cycle car intensity of 48 gCO_2/km by 2030	111.7	121.1
New test-cycle van intensity of 63 gCO_2/km by 2030	169.7	165.4
60% of new cars and vans to be electric vehicles by 2030	2.1%	1.7%
11% of fuels are sustainable biofuels (by energy by 2030)	6%	2.3%

Source: CCC analysis; BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016; DfT (2018) Provisional Road Traffic Statistics;* SMMT (2018) *New Car CO_2 Report;* DfT (2017) *Vehicle licensing statistics***;** HMRC (2017) *Hydrocarbon Oils Bulletin.*

Progress in improving conventional vehicle efficiency

EU regulations on average CO_2 intensity have been in place for new cars since 2009 and new vans since 2011. The average intensity of a manufacturer's sales must reach 95 gCO_2/km for new cars in 2020/21 and 147 gCO_2/km for new vans in 2020.

For the first time since records began in 2000, average new car CO_2 intensity has risen in 2017.[70] The sector is not on track to meet the 2020/21 target (Figure 5.11):

- New cars sold in the UK in 2017 had an average test-cycle CO_2 intensity of 121.1 gCO_2/km, an increase of 0.8% since 2016.
- This deterioration is mainly due to a move towards larger vehicles. SUVs now represent 18.1% of new car sales, compared to 7.7% in 2010. If car sales of each size had remained as in 2016, then average test-cycle CO_2 intensity would have fallen by 0.8% in 2017 rather than risen.
- Diesel sales fell from 48% to 42% of the new car market in 2017, but the gap between new petrol and diesel car efficiency has reduced so this contributes a relatively small proportion of the CO_2 intensity increase.

[70] SMMT (2018) *New Car CO_2 Report.*

- The increase in the proportion of petrol vehicles sold has been offset by an increase in the proportion of alternatively fuelled vehicles sold (including conventional hybrids, plug-in hybrids and electric vehicles) from 3.3% to 4.7%. If the proportion of petrol, diesel and alternatively fuelled cars was the only change from the previous year, the average intensity would still have decreased by 0.5%.
- Even for some vehicles of the same size category and fuel type, progress has slowed with increases in gCO_2/km of vehicles in the same segment, such as the average intensity of upper medium sized diesel cars increasing from 116.9 gCO_2/km to 118.7 gCO_2/km.

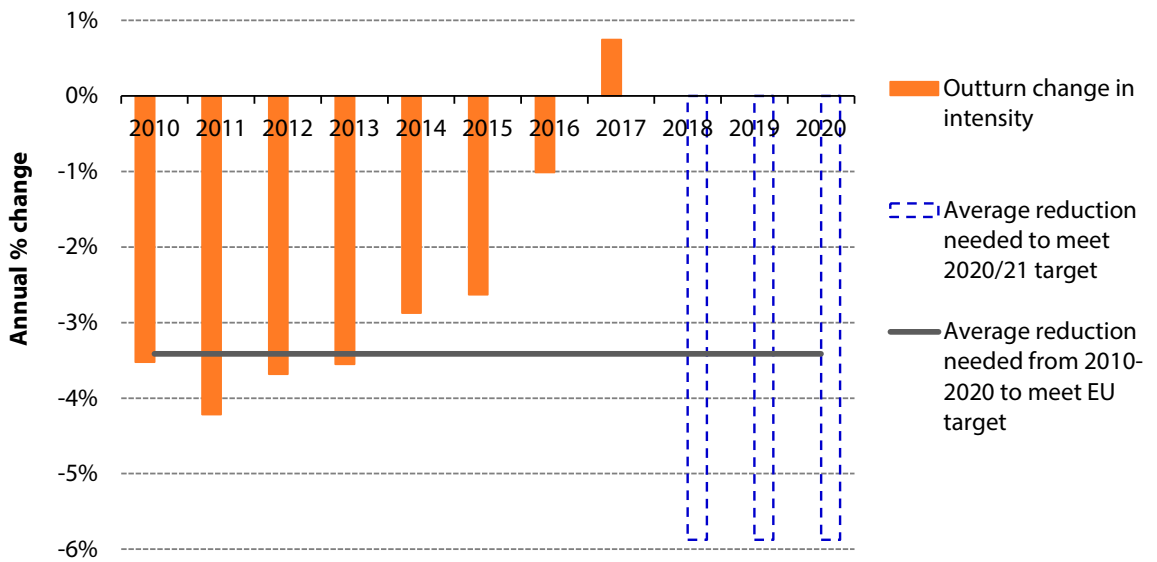
The EU-wide new car average is 118.5 gCO_2/km in 2017 and must fall by 5.4% per year in the remaining four years to meet the EU 2020/21 target of 95 gCO_2/km. UK new car CO_2 progress has been slower and so must fall by 5.9% per year in the remaining four years to reduce intensity to the same level, a rate of reduction never previously achieved in any single year.

There are stiff EU penalties for failure to comply with targets, and to avoid them, manufacturers will need to introduce more efficient models, as well as ultra-low emission models.

The shift towards purchase of higher-emitting vehicles is working against the regulations for new cars. The move towards higher-emitting cars presents a major risk to future carbon budgets and it is important that incentives to purchase lower emitting vehicles are strengthened to support new car regulations. The shift might be halted or reversed through revenue-neutral incentives (e.g. greater differentiation of Vehicle Excise Duty and changes in Company Car Tax).

If car sales of each size had remained as in 2012, average test-cycle CO_2 intensity in 2017 would be 3.2% lower, emphasising the need to incentivise customers to choose more efficient vehicles.

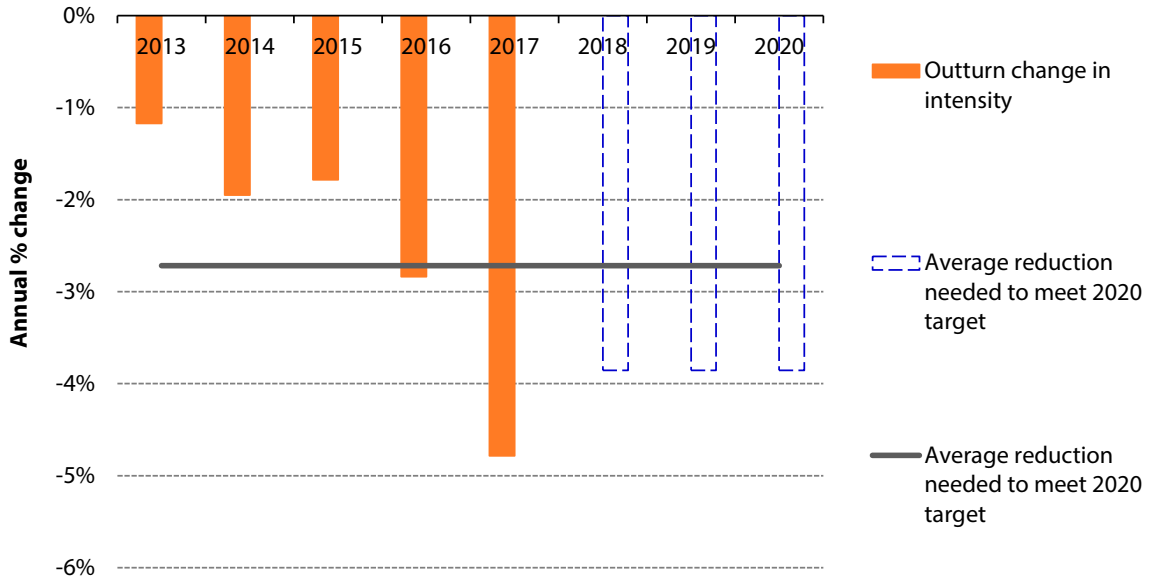
Figure 5.11. New car CO_2 intensity - recent changes (2010-2017)



Source: SMMT (2018) *New Car CO_2 Report;* CCC analysis.

There has been a significant fall in the average CO_2 intensity of new vans, decreasing by 4.8% in 2017 to 165.4 gCO_2/km. An annual reduction of 3.9% each year is required to meet the EU 2020 target of 147 gCO_2/km (Figure 5.12). This decrease has occurred in spite of an overall shift in the market towards larger vans.

Figure 5.12. New van CO_2 intensity - recent changes (2013-2017)



Source: SMMT (2018) *New Car CO_2 Report;* CCC analysis.

The gap between real-world and test-cycle emissions remains a concern. During the transition to the new test-cycle (WLTP) it is essential that flexibilities and loopholes are removed to restore public confidence and standards and deliver real-world emissions reduction (Box 5.3). A real-world testing regime or actual fuel consumption data should be used alongside the standardised tests and provided to the public to compare the performance of models.

The UK position on EU regulations on new cars and vans needs to be clarified urgently. Key risks are:

- In the context of an exit from the EU, it is not clear whether UK cars will be covered by the EU 2020/21 regulation, providing little incentive for manufacturers to sell efficient models and ULEVs to the UK market. The UK Government must ensure sales in the UK are included in the 2020/21 EU-wide target, or replace this target with equivalent domestic regulation.
- Current EU proposals for post-2020 new car and van regulations are not stretching enough given the high level of ambition for ULEV sales in the UK.
- The use of flexibilities and loopholes in the move from the existing test-cycle to WLTP needs to be addressed with the addition of either a real-world test or on-road performance monitoring of vehicles to restore public confidence and deliver real-world emissions reduction.

Box 5.3. The gap between test-cycle and real-world emissions

In 2015, the Committee commissioned research to investigate the gap between the results of the test-cycle used to measure the emissions of new cars and the actual emissions from cars driven on the roads. CO_2 emissions per km for cars were found to be 35% higher in the real world, and evidence showed that the gap was widening as manufacturers increasingly found ways to exploit the flexibilities in the existing test-cycle (NEDC). Recently, the International Council on Clean Transportation (ICCT) updated this analysis and found that the gap had increased to 42% in 2016. Manufacturers can manipulate test results by modifying tyres, illegally detecting test-cycles (and modifying engine performance) and removing parts of the car to lightweight, as well as choosing to deploy technology that operates more effectively in a test than on the road.

The EU is introducing a new test-cycle, Worldwide Harmonised Light Vehicle Test Procedure (WLTP), which reduces opportunities to cheat the test, by driving the vehicle for longer and using a wider variety of speeds and acceleration, as well as eliminating some practices that manufacturers have used to artificially lower test results (which include over-inflating tyres and choosing to test the lightest possible version of the vehicle). However, there are still measures that manufacturers can exploit, including using different tyres for testing than those available for sale, using special test drive modes and installing technologies that do not reduce emissions as effectively on the road. Use of such flexibilities further damages public trust in the testing regime.

The gap between the test-cycle and real-world driving performance for plug-in hybrids is also heavily dependent on how frequently they are charged, which will become increasingly important as they begin to represent a larger proportion of the fleet.

The EU targets for 2025 and 2030 will be set using the new test-cycle (WLTP) and are based on a percentage reduction from 2020/21. By setting a high starting point for the new regulations using WLTP in 2020/21, there is potential for manufacturers in effect to set an easier target for themselves in 2025 and 2030. The WLTP test was not designed with the assumption that manufacturers would wish to artificially inflate the reported emissions, for example, testing a non-optimised vehicle. Although the EU has designed a tool to convert between the two tests, which would enable a fair baseline calculation, manufacturers are allowed to test separately where the tool is not representative. Transport & Environment have evidence to suggest that most manufacturers intend to make use of this loophole when setting their baseline.

These flexibilities and loopholes increase the importance of reinforcing the regulation with a real-world driving test. The European Commission plans to monitor the gap between the new test and the real-world performance using fuel consumption meters, but not until 2025. The Commission could use this data to ensure that the gap does not grow further, meaning that any improvements manufacturers make to vehicles must be effective in the real world. Alternatively, they could implement a real-world driving test, as has been done for air quality testing, to reduce opportunity to manipulate the regulation.

Urgent action is required to deliver emissions reductions at a rate which will deliver climate targets, and to restore public confidence in the information provided to them about vehicle performance. The UK must make an urgent decision about the regulations and policies it will implement in this area after we leave the EU.

Source: Tietge U. et al. (2017*) From Laboratory to Road: A 2017 update of official and "real-world" fuel consumption and CO_2 values for passenger cars in Europe*; Transport & Environment (2018) *Ending the cheating: using real-world CO_2 measurements within the post-2020 CO_2 standard.*

The average CO_2 intensity of the HGV fleet is increasing, indicating that cost-effective improvements to conventional HGVs are not being made despite short payback periods on the investment. The tonnes carried per km by HGVs have increased by 9.4% in 2016, which could indicate larger vehicles are being used or an increase in logistical efficiency. Total HGV emissions per billion tonnes transported (in km) has fallen by 9%, indicating that more freight is being transported per Mt of emissions.

There is no available measure of new HGV gCO_2/km, as this is not currently regulated. The EU is introducing a Vehicle Energy Consumption Calculation Tool (VECTO) for HGVs which will improve the reporting and monitoring of CO_2 emissions from HGVs, but will need to be carefully validated by on-track testing. Manufacturers will be required to report their emissions and fuel consumption to the EU annually from January 2019.

The European Commission (EC) has recently proposed targets for a 15% reduction in emissions from trucks in 2025 and 30% reduction by 2030 from 2019 levels. We will assess if this is in line with our cost-effective path when the baseline is established in 2019. The Government should also implement measures to improve freight logistics and eco-driving as set out in its 2017 Freight Carbon Review.

Uptake of electric vehicles

Sales of electric vehicles increased in 2017 and early 2018, but are lagging slightly behind our indicator (Figure 5.13):

- 49,000 electric cars and vans were sold in 2017, representing 1.9% of new car sales compared to 2.2% in our trajectory and 0.34% of new van sales compared to 1.24% in our trajectory.[71] Electric car sales increased by 28% in 2017 compared to 2016; sales of electric vans increased by 21% between 2016 and 2017.
- 0.5% of cars sold were battery electric vehicles and 1.3% were plug-in hybrid vehicles. Sales continued to increase in the first quarter of 2018, with electric cars making up 2.0% of new car sales.

There has been a higher demand for electric vehicles than has been allowed for by manufacturers, leading to long waiting times for orders, which is likely to have suppressed sales. Volkswagen has closed ordering for the plug-in hybrid versions of the Passat and the Golf, due to the exceptionally long waiting times.

Some car manufacturers still offer no electric vehicle models within the UK, such as Vauxhall, Skoda, Seat and Fiat. Overall, however, the number of electric vehicle models available (including both plug-in hybrid electric vehicles and battery electric vehicles) has increased from 46 models in June 2017 to 54 in June 2018.[72] The number of battery electric vehicles available with over 200 miles of range (according to the NEDC test-cycle) has also increased to 5 models.

Research has found that in car dealerships across Denmark, Finland, Iceland, Norway and Sweden, dealers strongly steered customers towards petrol and diesel vehicles by dismissing electric vehicles, misinforming shoppers on vehicle specifications and omitting electric vehicles

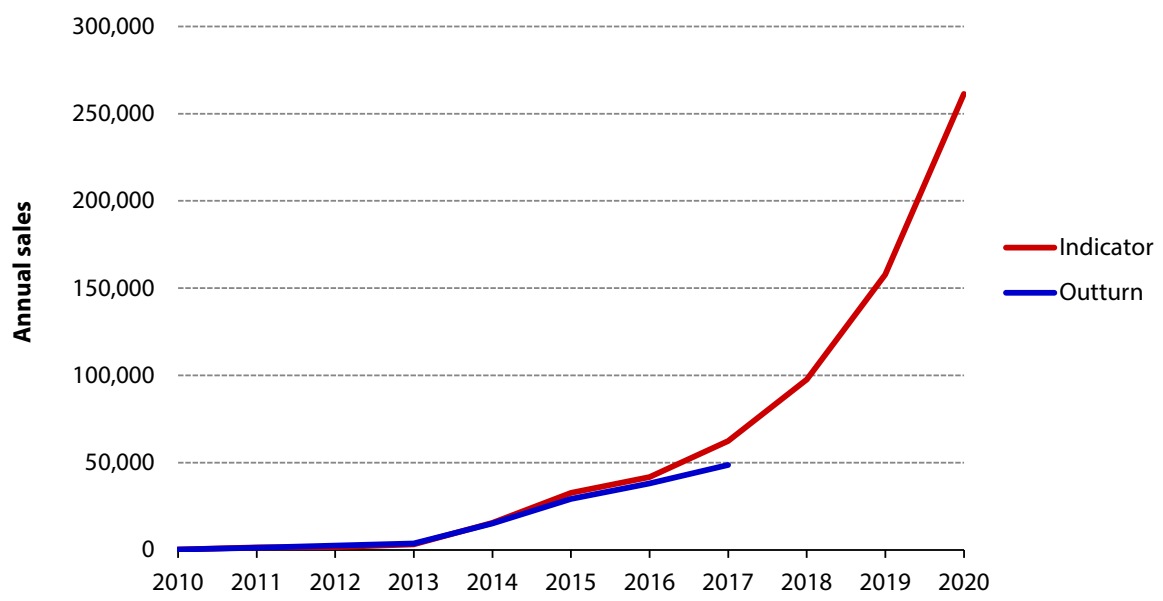
[71] DfT (2017) *Vehicle licensing statistics.*
[72] Next Green Car (2018) www.nextgreencar.com

from sales conversations.[73] It would be useful to replicate this research in the UK to establish whether the willingness of dealers to sell EVs is presenting a barrier to uptake.

An electric taxi is also now available for sale and is operating in several cities, including London, which introduced new regulations in January 2018 ensuring that all taxis licensed from now onwards must be electric, plug-in hybrid or hydrogen. London has also installed over 100 rapid chargepoints in the city to ensure electric taxi drivers can top up during the day.

Internationally, several governments have now committed to phasing out conventional vehicles between 2030 and 2040 (Table 5.3). However, while some manufacturers have announced commitments to EVs (Table 5.4), overall manufacturer ambition lags behind government commitments. It is important that plug-in hybrids sold in the UK should be capable of driving a high proportion of their journeys in zero emissions mode from 2035, in order to completely decarbonise the road transport sector by 2050.

Figure 5.13. Electric vehicle sales against our indicator



Source: DfT (2017) *Vehicle licensing statistics*; CCC analysis.

[73] Zarazua de Rubens et al. (2018) Dismissive and deceptive car dealerships create barriers to electric vehicle adoption at the point of sale. *Nature Energy, 3, 501-507.*

Table 5.3. Government commitments to the end of sales of conventional vehicles

Country	Timing
Norway	2025
India, China, Slovenia, Austria, Israel, the Netherlands, Ireland	2030
Scotland	2032
UK, France, Sri Lanka, Taiwan	2040

Source: Elbilforening (2018) *Norwegian EV Policy*; McKinsey (2017) *The future of mobility in India: Challenges & opportunities for the auto component industry*; IEA (2017) *Global EV Outlook 2016*; Government of the Republic of Slovenia (16 October 2017) *Cars with internal combustion engines to be phased out in Slovenia by 2030*; Jerusalem Post (27 February 2018) *Energy minister calls for banning diesel, gas-based cars in Israel by 2030*; NL Times (10 October 2017) *New Dutch Government's plans for the coming years*; Government of Ireland (2018) *Project Ireland 2040*; Reuters (5 September 2017) *Scotland shifts gear with green measures, national investment bank***;** BEIS (2017) *Clean Growth Strategy***;** French Government (2017) *Plan Climat***;** Parliament of Sri Lanka (2017) *Budget Speech 2018***;** Taipei Times (22 December 2017) *Cabinet to ban sales of fossil fuel-powered vehicles.*

Table 5.4. Manufacturer commitments on electrification

Manufacturer	Timing	Commitment
Nissan	2025	BEVs 50% of sales in Japan and Europe
Mercedes	2025	BEVs 15 - 25% of sales
VW	2025	EVs 25% of sales
Porsche	2030	EVs 100% of sales
Toyota	2030	EVs and conventional hybrids 50% of sales
Volvo	2030	EVs and conventional hybrids 50% of sales
Honda	2030	BEVs, PHEVs and hydrogen 15% of sales

Source: Nissan (2018) *M.O.V.E. to 2022 Midterm Plan;* Daimler (2017) *CASE Strategy*; VW (2016) *TOGETHER - Strategy 2025*; Honda (2017) *2030 Vision*; Manufacturer announcements.

With only four models currently for sale in the UK, the electric van market is lagging behind that for cars. The average 106 mile test-cycle range amounts to around 85 real-world miles, falling

short of the 120 miles needed for many urban duty cycles.[74] However, upgrades of these models with a 60% range improvement are expected over the next year, as are new, larger models such as the Mercedes eSprinter, Renault Master, and FUSO eCanter light truck.

The batteries for the new eNV2000 van will be assembled at Nissan's Sunderland plant, highlighting the opportunity for the UK to establish itself as a global leader in EV technology. Other notable projects include the Arrival vehicles (ordered by Royal Mail and UPS) being built in Banbury, and the LEVC plant in Coventry manufacturing London's low-emission taxis. The Faraday Challenge, which pledges £246 million for R&D in battery technologies, is a good example of the innovation necessary to maintain the UK's place at the forefront of green growth.

Delays among some manufacturers in supplying new EVs risks damaging the emerging market for ultra-low emission vehicles. In the context of exit from the EU, a framework to deliver improvements in new car and van CO_2 emissions (including targets for 2020/21 and 2025) is needed, to ensure there is no incentive to delay the introduction of new EVs, and deliver genuine choice to consumers.

A national charging network is essential to accelerate the roll-out of electric vehicles. The number of publically available charging points has continued to grow in 2017 and early 2018:

- The total number of publically available charging connectors of all types has increased from 12,800 in June 2017 to 16,700 in June 2018.[75]
- The rapid charger network has also expanded from 2,300 chargers in 700 locations in May 2017 to 3,500 connectors in 1,100 locations in June 2018.

The charging network must provide for two types of charging need – topping up around local regions, towns and cities whilst drivers go about their daily business and rapid charging to enable drivers to complete long inter-urban journeys above the range of their electric vehicles.[76] Both the network for local topping up and the network for long inter-urban journeys have significantly developed since last year (Box 5.4).

Box 5.4. Development of the UK's electric vehicle charging infrastructure

The Committee will set an indicator for the number of electric vehicle chargers required to support the levels of EV uptake required to meet the fifth carbon budget. Research conducted for the Committee indicated that 1,200 rapid chargers near major roads may be required by 2030 to meet current service levels, as well as 27,000 chargers around local towns and regions. Over the next year, the Committee will continue to explore the results of this modelling to understand the sensitivities of the model to the underlying assumptions, before setting an indicator in next year's Progress Report.

Classifying chargers by the need for charging they serve shows that the network has developed significantly since last year. The local 'topping-up' charging network has increased from 3,005 chargers in 2017 to 7,250 chargers this year, an increase of over 140% (see notes). Central London added the most additional chargers, installing 510 additional slow chargers, 11 fast chargers and 39 rapid chargers. Eastern Scotland and South Western Scotland also added over 250 chargers. Four areas installed less than 10 new chargers this year - East Yorkshire and Northern Lincolnshire, Bradford, Doncaster and Cardiff.

[74] Next Green Car (2018) www.nextgreencar.com
[75] Zap-map (2017) www.zap-map.com
[76] SYSTRA (2018) *Plugging the gap: An assessment of future demand for Britain's electric vehicle public charging network.*

Box 5.4. Development of the UK's electric vehicle charging infrastructure

The rapid charging network for use during long-distance journeys expanded from 457 chargers in 2017 to 619 chargers in 2018, an increase of 35%. Herefordshire, Worcestershire and Warwickshire installed the most additional chargers, with four 50kW and 26 150kW chargers being installed. Berkshire, Buckinghamshire and Oxfordshire have the most rapid chargers installed with over 100 in total, reflecting the many major roads in this area. Lancashire is likely to require the highest number of additional chargers, reflecting the importance of the M6 for journeys between the north and south of Britain, but no new chargers have been installed in the past year.

Source: Zap-map (2017); SYSTRA (2018) *Plugging the gap: An assessment of future demand for Britain's electric vehicle public charging network.*
Notes: Analysis within this box excludes Northern Ireland, as well as chargers which are not available to the public 24/7 (e.g. those located at car dealerships and workplaces).

Building EV infrastructure consistent with high take-up of EVs will require both public and private investment as well as addressing non-financial barriers. Local planning needs to enable charge points in new residential and non-residential buildings in line with the recent EU Energy Performance of Buildings Directive.

As the speed of chargers increases, available grid capacity at key locations such as motorway service areas will increasingly become an issue when installing new chargers. National Grid have estimated that to supply 50 sites with sufficient power to accommodate 350 kW chargers would cost between £500 million and £1 billion (about 60p per year per motorist).

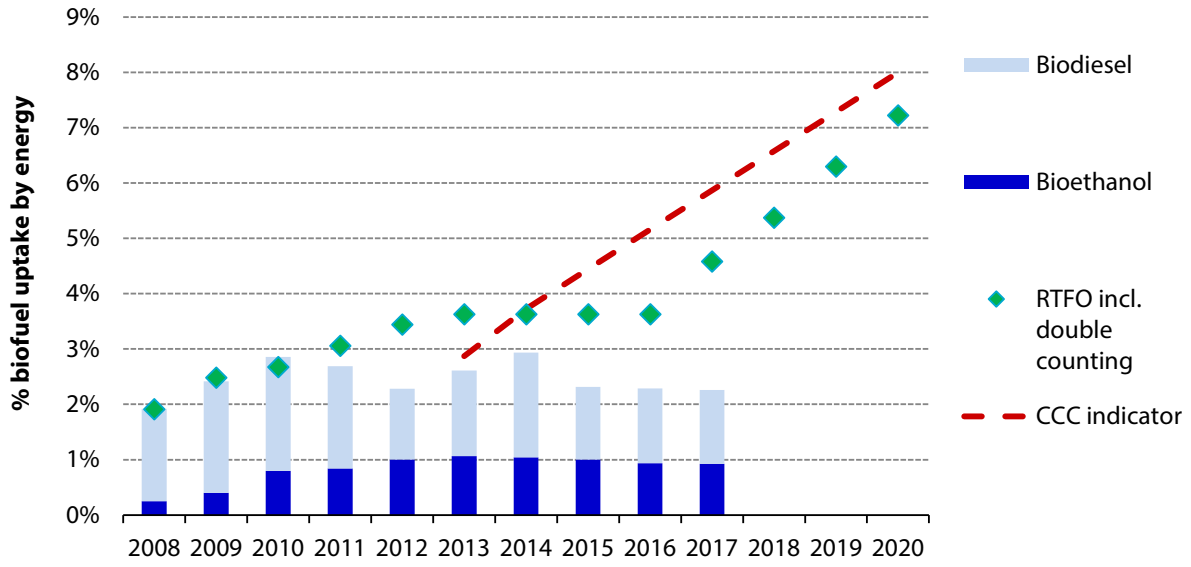
Biofuels

Biofuel uptake has reduced or remained flat in recent years (Figure 5.14):

- Biofuels share of fuel sales remained flat at 2.3% by energy in 2017.[77]
- Average GHG savings from biofuels increased to 78% (in 2016/17) from 74% (in 2015/16) by volume, excluding emissions from indirect land-use change (ILUC).
- Waste derived biofuels made up 68% of the fuels by volume in 2016/17. Waste derived biofuels are double-counted towards the Renewable Transport Fuels Obligation (RTFO) target of 4.75% by volume, so there is an increasing gap between the volume of biofuels counted towards this target (as over half the biofuels by volume are counted twice) and the energy content of these fuels.

[77] HMRC (2017) *Hydrocarbon Oils Bulletin*; CCC analysis.

Figure 5.14. Biofuel uptake from 2008-2017 by energy



Source: HMRC (2017) *Hydrocarbon Oils Bulletin*; CCC analysis.
Notes: Double counting of waste derived biofuels was introduced to the RTFO in 2009/10.

Demand-side measures

A future vision for travel demand should be an integral part of urban planning, road building and transport infrastructure development. This will help planners to grow local economies, whilst delivering reduced traffic and other benefits such as cleaner air and reduced congestion and noise.

Changing existing travel behaviour of individuals by encouraging walking, cycling and the use of public transport can help reduce emissions by reducing car use. Such behaviour change is generally highly cost-effective for individuals and governments. Businesses can also change the way they transport goods by improving logistic efficiency to reduce vehicle kilometres driven or driving more efficiently.

DfT has recently released an evaluation of the impact of the Local Sustainable Travel Fund (LSTF) which demonstrated that investment in walking, cycling and public transport represents high value for money.[78] Car use fell by 2.6% in the areas with large LSTF projects, compared to a fall of 0.3% in comparator areas. The Committee's analysis indicates that 5% of car kilometres should be switched to lower-carbon modes in 2030 in our assessment of the cost-effective way to meet emissions reduction targets. Bus usage, however, has declined by 1.9% across Great Britain from 2016 to 2017.[79] In England, in the past year to March 2018, the local bus and rail fares have increased by 2.8% and 3.1% respectively, faster than the rate of inflation (2.5%).[80]

[78] DfT (2017) *Impact of the Local Sustainable Transport Fund: Summary Report.*
[79] DfT (2018) *Bus Usage Statistics, Table BUS106a (March update)*
[80] DfT (2018) *Quarterly Bus Statistics: England Q1 (January to March) 2018.*

It is difficult to track changes in travel behaviour across the UK, as England and the devolved administrations (DAs) use different methods to collect statistics on walking and cycling. England and the DAs should work together to agree a common approach to data collection in this important area.

The number of bicycle sharing schemes has increased across the UK with new schemes in Leeds, Manchester, Sheffield and an electric bicycle sharing scheme in Derby amongst others. Recent research across 13 European cities has found that cities with large numbers of shared bicycles do not necessarily have lower car usage, unless the high availability of bicycles is accompanied by good cycling infrastructure.[81]

Cities could consider replicating Nottingham's workplace parking levy, which is an annual charge levied on all employers who provide 11 or more workplace parking spaces. All revenue is spent on transport initiatives, including doubling the size of the tram network, developing the railway station and supporting an electric bus network.

4. Recent performance in reducing aviation and shipping emissions compared to required progress

Carbon budgets currently include emissions from domestic aviation and shipping. Emissions from international aviation and shipping (IAS) are, at present, formally excluded from carbon budgets but taken into account when budgets are set (i.e. the budgets are set to be on track to a 2050 target which includes IAS emissions).

Progress agreeing global policy covering IAS emissions has been slow, but some progress has been made in recent years following the Paris Agreement. The International Civil Aviation Organisation (ICAO) made a limited start by agreeing a global offsetting scheme in 2016. In 2018 the International Maritime Organisation (IMO) took the much more ambitious step of agreeing a 2050 target to reduce shipping emissions by at least 50% below 2008 levels:

- **Aviation.** In October 2016 the ICAO agreed a global offsetting scheme for emissions from international aviation. This will require operators to purchase offset credits to cover emissions growth above 2020 levels.
  - The scheme will start in 2021, is voluntary until 2027, and currently ends in 2035. There is provision to review and extend the agreement but it does not have an explicit long-term objective or link to the goals of the Paris Agreement.
  - A range of factors are still to be agreed including the rules for monitoring, reporting and verifying emissions, and the criteria for offset eligibility. The process for this is underway at ICAO for these to be agreed before the start of the scheme.
- **Shipping.** In April 2018 the IMO took a major step forward by adopting a strategy for reducing GHG emissions from shipping. The strategy sets a long-term target to reduce emissions by at least 50% by 2050.
  - The overarching aim of the strategy is to peak GHG emissions from international shipping as soon as possible, and to reduce them by at least 50% by 2050 compared to 2008 levels. The strategy also requests member states to pursue efforts to phase out emissions completely, as part of an emissions reduction pathway consistent with the temperature goals in the Paris Agreement.

[81] Wuppertal Institute (2018) *Living. Moving. Breathing. Ranking of European Cities in Sustainable Transport.*

– The strategy sets a range of other objectives, including to reduce the carbon intensity of shipping by 40% by 2030 and at least 70% by 2050, compared to 2008 levels. It also commits to the introduction of further stages of the Energy Efficiency Design Index for new ships.

The IMO's approach has several additional elements compared to the approach adopted by ICAO for aviation:

- Long-term objectives are particularly important for investment signals in aviation and shipping, given the long lifetimes of both planes and ships. The IMO has a long-term target and link to the Paris Agreement, whereas these elements are both missing in the ICAO scheme.
- The ICAO CORSIA scheme is based on offsetting, rather than in-sector reductions under the IMO strategy.

In the context of future UK policy and infrastructure investment decisions, the Committee has previously said that an appropriate long-term assumption for government planning is for aviation emissions to be around 2005 levels in 2050 (implying around a 60% increase in demand over the same period).

The Government is planning to publish a new Aviation Strategy in the first half of 2019, including their long-term approach to climate change. The Committee will set out an assessment of what this strategy should involve around Spring 2019. This will include consideration of the potential to reduce aviation emissions over the period to 2050 and beyond, and the overall policy approach the Government should pursue (including whether the ICAO CORSIA scheme is an appropriate mechanism for formally including international aviation emissions within carbon budgets).

In its advice to Government on the fifth carbon budget the Committee recommended that international shipping emissions now be included within carbon budgets. The IMO agreement on a 2050 target for international shipping is consistent with the Committee's 2050 planning assumption, and the basis upon which the fifth carbon budget was set. It therefore reinforces the case that there is no longer any reason to exclude these emissions from carbon budgets. The Committee continues to recommend that Government should now include these emissions within carbon budgets.

5. Policy implementation

Effective policy in this sector must cover regulation to improve conventional vehicle efficiency and the supply of electric vehicles, financial incentives to support customers in choosing lower emission and ultra-low emission vehicles, action to increase walking, cycling and use of public transport and to improve freight logistics efficiency and the uptake of eco-driving measures:

- The plug-in car and van grants have been extended at their current rates to October 2018, and the Government has committed to continue the grants in some form to 2020.
- There are now several motorcycles available for sale that are eligible for the plug-in motorcycles grant, which will pay for 20% of the purchase price, up to a maximum of £1,500.
- The Alternative Fuels Infrastructure Regulation (an EU regulation) has been introduced to ensure that consumers can access charging points on an ad hoc basis without having to be part of a contract.

- The Automated and Electric Vehicles Bill is currently passing through Parliament, and will give the Government powers to require motorway services and large fuel retailers to install charging points and to ensure that all chargers are 'smart', providing grid flexibility by adjusting the rate of charge when necessary and practical for the consumer. The Government will also gain powers to mandate the method of payment for electric vehicle charging points.
- Legislation of the Renewable Transport Fuels Obligation increases biofuels targets from 4.75% by volume now to 9.75% in 2020 and 12.4% in 2030.
- The Transforming Cities Fund provides funding to improve walking, cycling and public transport links to centres of employment.
- The Government has issued a call for evidence to inform a Cycling and Walking Investment Strategy safety review, which will address the issues that cyclists and pedestrians face, or perceive, when using road infrastructure to support the Government's aim of increasing cycling and walking.
- Oxford is consulting on banning non zero-emitting cars, taxis, vans and buses from using certain areas in the city centre from 2020, expanding the zone to the whole city centre area and including non zero-emission HGVs by 2035. Other cities are considering similar measures.

However, there are areas where there are significant risks of under-delivery, where proposals from the CGS need to be turned into firm policies, and which the CGS does not cover (Table 5.5).

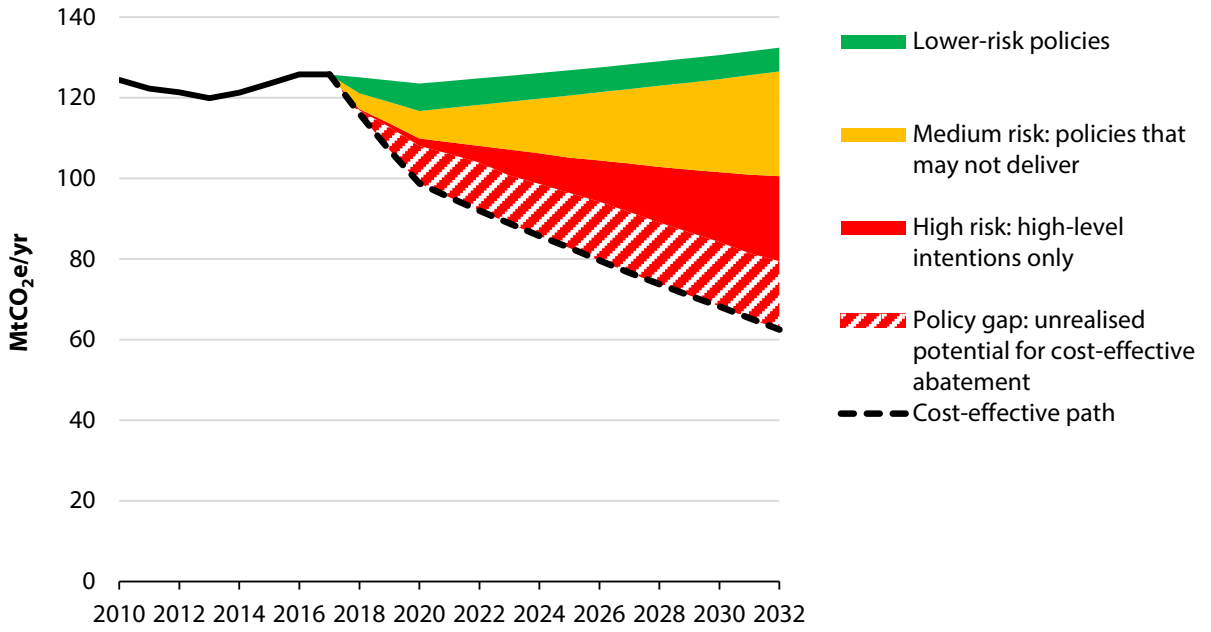
Overall, this means there remain risks to meeting carbon budgets (Figure 5.15).

Table 5.5. Assessment of policies to drive abatement options in the transport sector

Abatement option		2017 policy	2018 updates and assessment
New car/van efficiency	To 2020	Amber — EU targets and fiscal incentives in place but real-world improvements limited.	Amber — No certainty post EU-exit. Uncertainty over extent to which emissions savings will be delivered in the real world. Potential to increase incentives to buy lower emitting cars.
	After 2020	Red — EU consulting on targets but uncertain if UK will participate.	Red — EU has proposed targets which are not sufficiently ambitious. Unsure if UK intends to participate post EU-exit.
Electric vehicles	Financial incentives	Amber — Grant funding committed to 2018.	Amber — The Government has committed to grants at current levels until October 2018, and grants in some form to 2020.
	Infrastructure	Amber — Rapid network on track but little progress in developing on-street charging infrastructure.	Amber — Rapid charging network continued to grow, but some limited progress in developing on-street charging infrastructure.
Biofuels increase to 8% by energy		Amber — RTFO had been consulted on but no reported conclusions.	Green — New RTFO target now legislated.
Sustainable travel		Green — Walking and cycling investment strategy published April 2017, containing targets for increase in uptake.	Green — Transforming Cities fund providing additional funding.
HGV and freight efficiency		Amber — Freight Carbon review published Feb 2017 but little concrete action identified.	Amber — New EU HGV efficiency proposal but no clarity over UK regulatory approach.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower risk policy - expected to deliver.

Figure 5.15. Risks around the delivery of transport sector policies to meet the cost-effective path



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018) *Provisional UK greenhouse gas emissions national statistics 2017*; CCC analysis.
Notes: The top of the green area in the chart represents baseline emissions, based on the latest Government emissions projections published in January 2018. Lower-risk policies have sufficient funding and ambition to deliver with reasonable confidence. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

6. Further actions required in transport

Publication of the Government's zero emission road transport strategy has been delayed. This strategy will set out the Government's planned decarbonisation pathway in road transport by 2050, and was due to be published before March 2018. The CCC has identified the following priorities for inclusion in the strategy.

To be on track to meet the fourth and fifth carbon budgets, the Government needs to:

- **Set out a regulatory approach to new car and van CO_2 targets in 2020/21 in the context of an exit from the European Union, including punitive penalties for manufacturers who do not comply.** Manufacturers are delaying the release of more efficient models and electric vehicles to meet the targets, but there will be little incentive to sell the vehicles in the UK unless the UK remains part of the EU regulation or introduces at least as strong a regulation at a national level.
- **Announce more stretching proposals than the current EU new car and van CO_2 targets for 2025 and 2030 and reinforce those targets with a real driving emissions tests or monitoring of fuel consumption meters.** The current EU proposals are not ambitious enough given the high level of ambition for ULEV sales in the UK. There is potential for manufacturers to manipulate the test to set an artificially high baseline. As the EU targets are

now based on a percentage reduction from the baseline, this would result in less stringent targets in 2025 and 2030 (Box 5.3). The tests should be reinforced with real driving emissions testing or monitoring of data from fuel consumption meters. By reinforcing this test with real-world measurements and mandating the use of real-world data in labelling for the public, real-world emissions reductions can be achieved.

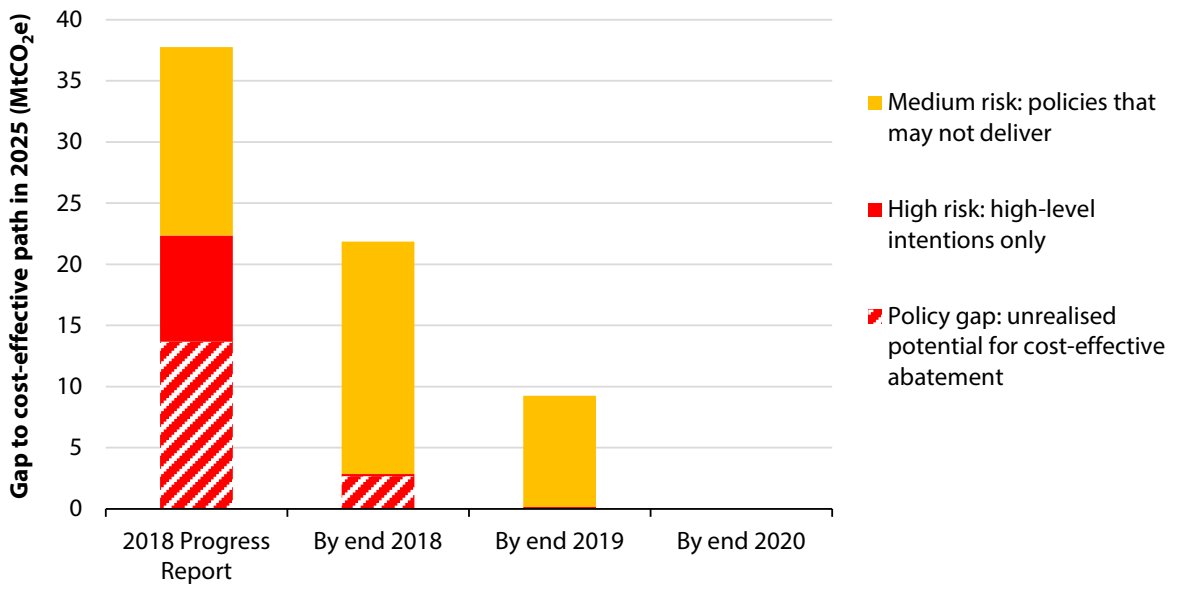
- **Increase ambition on the sale of electric cars and vans by setting stretching targets for 2030 in line with CCC indicators.** In the Clean Growth Strategy, the Government indicated that 40-70% of new car sales and up to 40% of van sales in 2030 should be electric. More ambitious targets should be set to align with the Committee's recommendation of electric vehicles representing 60% of new car and van sales in 2030. This will provide longer-term certainty for the industry and enable car manufacturers, chargepoint providers, electricity system operators and other interested stakeholders to plan for this level of uptake.
- **Ensure adequate charging infrastructure for EVs, with a focus on future-proofing new homes and improving charging provision on-street and in workplaces.** Local planning policies should require chargepoints in new buildings (both residential and non-residential) and facilitate on-street charging. The recent EU Energy Performance of Buildings Directive requires pre-cabling for all parking spaces in new residential buildings and pre-cabling for 1/5 of spaces and at least one chargepoint for new non-residential buildings. It also specifies that measures to simplify chargepoint deployment must be implemented, and regulatory barriers removed. In the context of an exit from the European Union, the UK should align with this legislation to ensure ease of charging for those without off-street access.
- **Consider the connection of chargers to the grid, and whether there needs to be additional incentives or legislation to ensure ease of access by chargepoint providers** when there are capacity restrictions on the local grid or a need to access private land in order to complete the installation.
- **Ensure that plug-in hybrid electric vehicles deliver near-zero real-world emissions by setting a minimum zero emission range requirement for plug-in hybrids that can be sold from 2035 onwards.** A sufficiently high minimum range will ensure that cars will be capable of carrying out almost all of their journeys in zero emissions mode. As the stock of cars takes around 15 years to turn over, the sale of conventional hybrids and low range plug-in hybrids after 2035 is not compatible with the Government's target of zero road transport emissions by 2050.
- **Implement stronger fiscal incentives (including vehicle excise duty and company car tax) encouraging people to buy lower emitting and ultra-low emission vehicles.** Current purchasing trends are undermining new car and van emissions targets and must be reversed. The Government's freezing of fuel duty should also be reconsidered.
- **Incentivise increased levels of cycling, walking and public transport and so moderate the increase in demand for passenger car travel.** Shifts away from car usage towards walking, cycling and public transport have been more prevalent in cities. Cities can set a vision for their future, planning for economic growth whilst reducing car traffic or holding it steady. This will entail planning new developments with sustainable travel as a priority, as well as incentives, investment in new infrastructure and communications campaigns to persuade the public to change their behaviour.
- **Set out a regulatory approach to new HGV CO_2 targets for 2025 and 2030, in line with the new proposal from the European Commission.** The European Commission has recently proposed targets for CO_2 emissions standards for HGVs. Using the new VECTO tool

to set the 2019 baseline, the targets require a 15% reduction of emissions from trucks in 2025 and a 30% reduction in 2030. In our fifth carbon budget analysis, the Committee estimated that it would be possible to improve the efficiency of new trucks by 24% between 2010 and 2030. When the baseline is established in 2019, we will assess whether this reduction is enough to meet our climate targets. Nevertheless, it is important that the UK establishes its own approach to regulation in this area.

- **Reduce emissions from freight by shifting freight from road to rail, improving logistics efficiency and uptake of eco-driving measures**. The Government should implement recommendations from its own Freight Carbon Review, including implementing communications campaigns to promote wider uptake of efficient driver changing and supporting small and medium enterprises with the costs of in-cab technologies and eco-driving courses.
- **Investigate barriers to accessing OLEV funding for ultra-low emission trucks.** Despite funding being available, manufacturers have not entered any vehicles through the approval process, resulting in no claims.

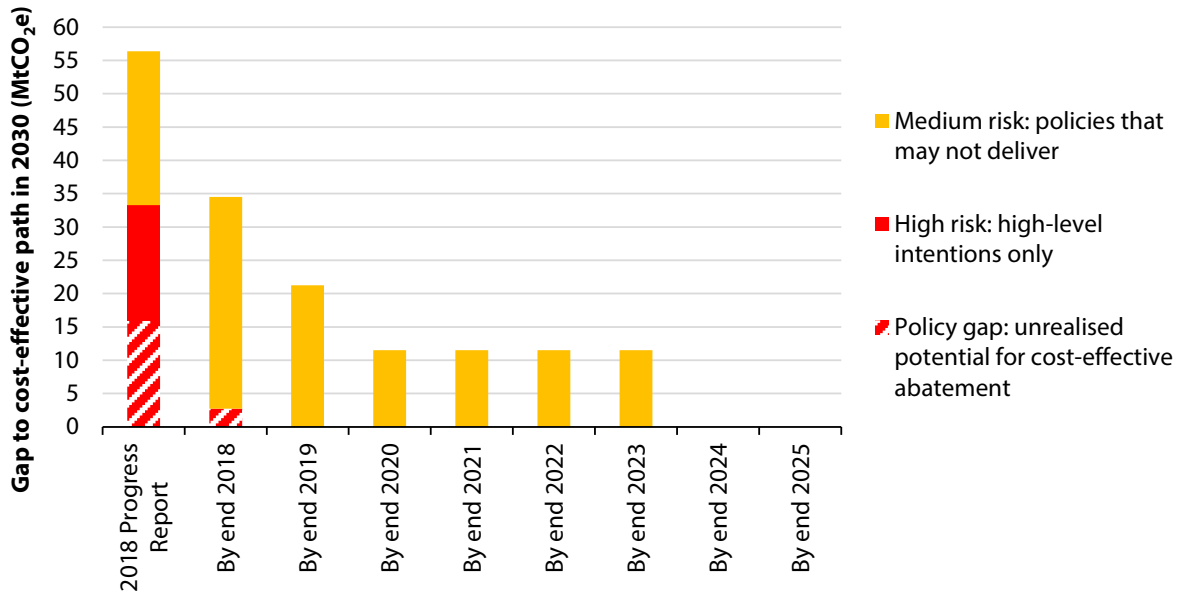
The Government should remove the policy gap for the fourth carbon budget by 2020 and by 2023 for the fifth carbon budget. Figure 5.16 and 5.17 show our assessment of how the policy gaps for 2025 and 2030 should evolve over time, when the actions listed in Table 5.6 are taken. Existing policies with delivery risks and proposals and intentions all need to become low-risk policies.

Figure 5.16. Risks around the delivery of transport policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the transport sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period.

Figure 5.17. Risks around the delivery of transport policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the transport sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period.

Table 5.6. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
Set out the UK regulatory approach to the EU 2020/21 new car and van CO_2 targets in the event of an EU exit. If the UK is not covered by these targets, there is little incentive for manufacturers to sell their most efficient and ultra-low emission vehicles here.	2019
Stretching CO_2 targets for new cars and vans are needed beyond 2020 that go beyond current EU proposals. These should require a high uptake of EVs and exploit the most efficient technologies available today for conventional vehicles. Flexibilities and loopholes in the current testing regime need to be removed in the transition to the new test procedure (WLTP) to restore public confidence in standards and deliver real-world emissions reduction. A real-world testing regime or use of actual fuel consumption data should be used alongside standardised tests.	2019

Table 5.6. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
Policies to deliver a high uptake of electric vehicles to around 60% of new car and van sales by 2030. Barriers to EV uptake should be tackled by providing time-limited financial support and effective roll-out of infrastructure. Significant co-benefits from this measure include air quality improvement and opportunities for UK industry.	2018-2024
Ensure that plug-in hybrid electric vehicles deliver near-zero real-world emissions by setting a minimum range for electric drive in 2035 so that almost all trips can be completed without using the petrol/diesel engine.	2018
Policies, including fiscal instruments, must align with new car and van emissions targets to strengthen incentives to purchase cleaner vehicles. The current move to higher-emitting cars is undermining efforts to improve fleet efficiency and must be addressed.	2018
The UK must set out an approach to the EU HGV regulation proposals in the context of EU exit or technologies with fuel savings which greatly exceed the up-front costs of technology and maintenance available today will continue to not be installed on new HGVs.	2019
Plans to increase cycling and walking must be implemented, with the most cost-effective measures being identified from the evaluation of previous funding initiatives and prioritised for roll-out.	2018-2019
Public transport must be incentivised. The decline in bus usage across the UK must be addressed.	2018
The Government must set out policies to encourage eco-driving training and logistics improvements in the freight sector, including implementing recommendations from the Freight Carbon Review. Cost-effective shifting of freight from road to rail must also be encouraged.	2018-2019
Enforcement of speed limits on major roads can reduce emissions by ensuring cars are efficiently driven and increase road safety.	2018
Announce and implement updated plans for rail electrification to achieve the full cost-effective potential over the Network Rail Control Period 6 (2019-2024)**.**	2019-2024

Source: CCC analysis.

Chapter 6: Agriculture and land use, land-use change and forestry

Key messages and recommendations

In 2016 agricultural emissions were 46.5 $MtCO_2e$, accounting for 10% of UK greenhouse gas (GHG) emissions. There has been virtually no change in agricultural emissions since 2008. The Land use, land-use change and forestry sector continued to be a net carbon sink, albeit a weaker one, sequestering over 14 $MtCO_2e$ (equivalent to abating 3% of UK GHG emissions). Stronger policies are required to meet ambition by England and the devolved administrations in these sectors to 2020 and beyond.

Our key messages are:

- **Cost-effective reductions of agricultural emissions are not being delivered.** Emissions were unchanged in 2016 and agriculture now accounts for a larger share of UK economy wide emissions (10%) than at any time since 1990 (7%). This reflects no change in agricultural emissions since 2008 and the faster pace of decarbonisation in other sectors. In 2017, 44% of farmers took no action to reduce GHG emissions, and half of farmers did not think it was important to consider emissions when making decisions about farming practices. There has been little change in these percentages over the past three years.
- **Agriculture emissions are above all our indicators.** Non-CO_2 emissions have been above our indicators for a number of years and are not on track to deliver savings of 4.5 $MtCO_2e$ by 2022 consistent with meeting carbon budgets. Delivering the savings would require an annual reduction in emissions of 1.7% between now and 2022.
- **A lack of action on forestry has led to a flat-lining of net carbon sequestration from forests over the recent past.** The ageing profile of trees has reduced the ability of forests to absorb carbon.

Significant risks to meeting carbon budgets remain:

- **Significant gaps remain in delivering agreed levels of ambition in both the agriculture and land-use sectors.** In agriculture, there is a major risk that the 3 $MtCO_2e$ in England (4.5 $MtCO_2e$ in the UK) reduction in emissions by 2022 will not be achieved.
- **In land-use, afforestation rates continue to remain well below the stated government ambition** for England and each of the devolved administrations, and the amount required to meet future carbon budgets.
- **The proposed post-CAP framework should set out policies in 2019** which link financial support to agricultural emissions reduction and increased carbon sequestration to take effect from 2022.

Significant opportunities for the sector and society could be realised in implementing policies to deliver the cost-effective path:

- **The £90m Industrial Strategy Challenge Fund aimed at transforming food production should be allocated to projects that deliver GHG emissions reduction**, in addition to government's other stated objectives. This presents an important opportunity to deliver innovation and productivity in the agriculture sector as well as emissions reduction.
- **Financial and non-financial barriers to afforestation and on-farm tree planting should be addressed.** This has the potential to deliver many co-benefits such as cleaner water, higher biodiversity and enhanced soil health.

For agriculture and forestry, existing and planned policies leave a further 5 $MtCO_2$ of reductions required in 2030 to meet our assessment of the cost effective path to meeting carbon budgets and the longer-term targets. The Government must take further action to close the gap (Table 6.1).

Key messages and recommendations

Table 6.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/ timing
A stronger framework to deliver GHG abatement is needed in agriculture to take effect from 2019. The voluntary industry-led approach has failed to meet its emission reduction targets across England and the devolved administrations.			×	Early 2019
The 2018 Agriculture Bill should set out a post-CAP framework which links financial support to agricultural emissions reduction and increased carbon sequestration to take effect from 2022.		×	×	2018
Allocate the £90m Industrial Strategy Challenge Fund to projects that deliver GHG emissions reduction in addition to government's other stated objectives. This is an important opportunity to take concerted action in agriculture in the period to the post-CAP framework.		Announced after the CGS		2018
Accelerate the rate of tree planting in the UK without delay by addressing non-financial and financial barriers**:** Act on the commitment to plant 11 million trees in England between 2017 and 2022 (equivalent to over 2,000 hectares per annum). Remove non-financial barriers to rapid afforestation. Over the longer term, develop a strategy in England and each of the devolved administrations to deliver around 20,000 hectares per year across the UK by 2020, rising to 27,000 hectares by 2024, in line with stated ambition.		× ×	× ×	2018 By 2020

Source: CCC analysis.

Introduction

In this chapter we assess current emissions trends in the agriculture and land use sectors and review progress towards meeting carbon budgets. We set out policy priorities needed to deliver the level of cost-effective abatement we have previously identified in these sectors to 2030.

We set out the analysis that underpins our key messages and recommendations in the following sections:

1. Agriculture emission trends and drivers
2. Agriculture scenarios and indicators
3. Recent performance in reducing agriculture emissions compared to required progress
4. Policy implementation
5. Further actions required in agriculture
6. The land use, land-use change and forestry (LULUCF) sector

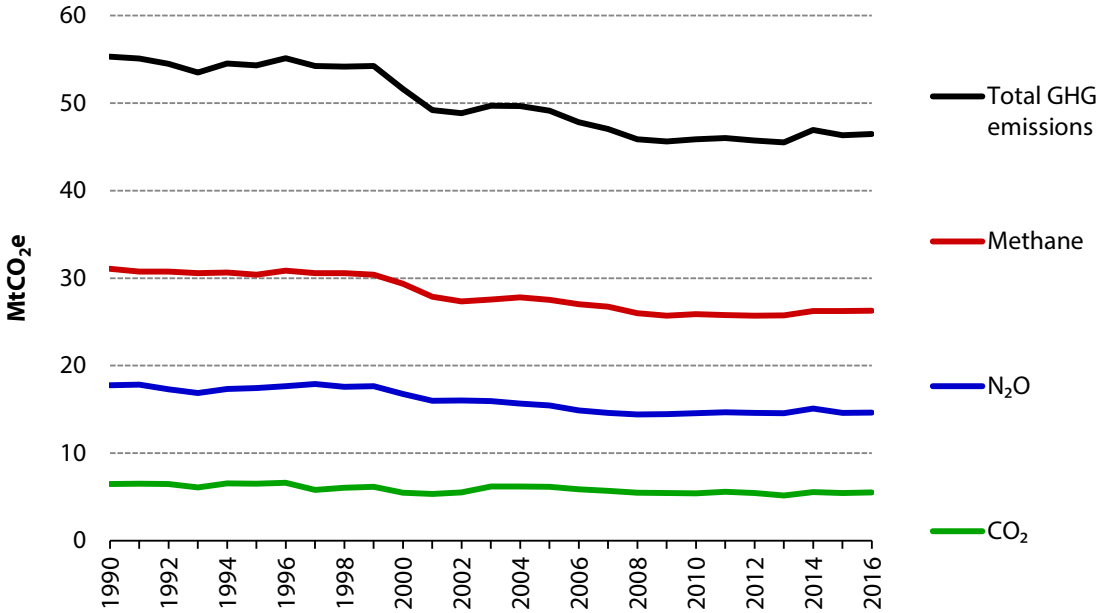
1. Agriculture emission trends and drivers

This section sets out trends in emissions from agriculture to 2016, the latest year of non-CO_2 emissions data. The whole series, from 1990-2016 has been updated with the new agriculture inventory methodology, which is now more reflective of UK agricultural conditions and practices. More than 80% of estimated emissions now use UK-specific emissions factors.

Emission trends

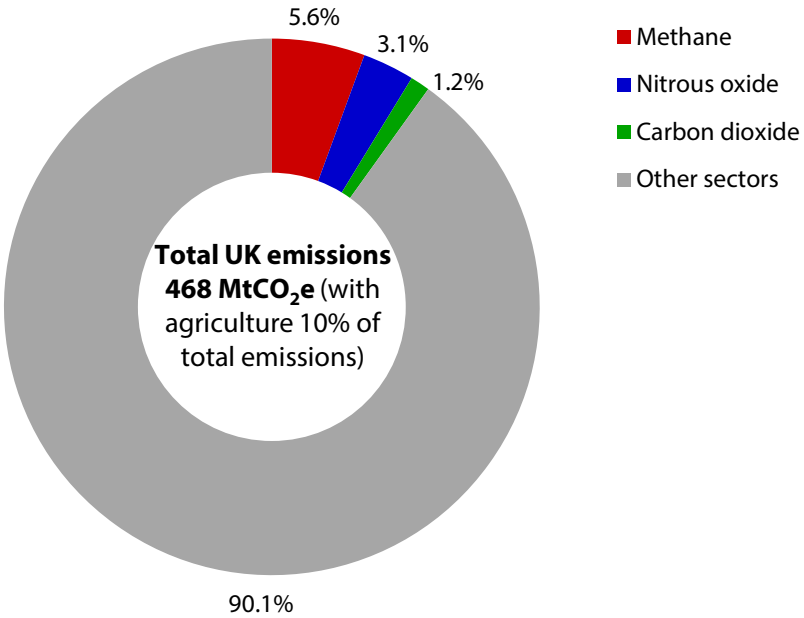
Agricultural GHG emissions were 46.5 $MtCO_2e$ in 2016, broadly unchanged from 2015. Emissions are 16% lower than in 1990, but there has been no progress in reducing emissions in this sector since 2008 (Figure 6.1). The sector now accounts for a larger share of UK economy-wide emissions (10%) than at any time since 1990 when the share stood at 7% (Figure 6.2). Deeper cuts will be required in future to meet carbon budgets.

Figure 6.1. Agriculture emissions by GHG (1990-2016)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*

Figure 6.2. Agriculture GHG emissions as share of UK total (2016)

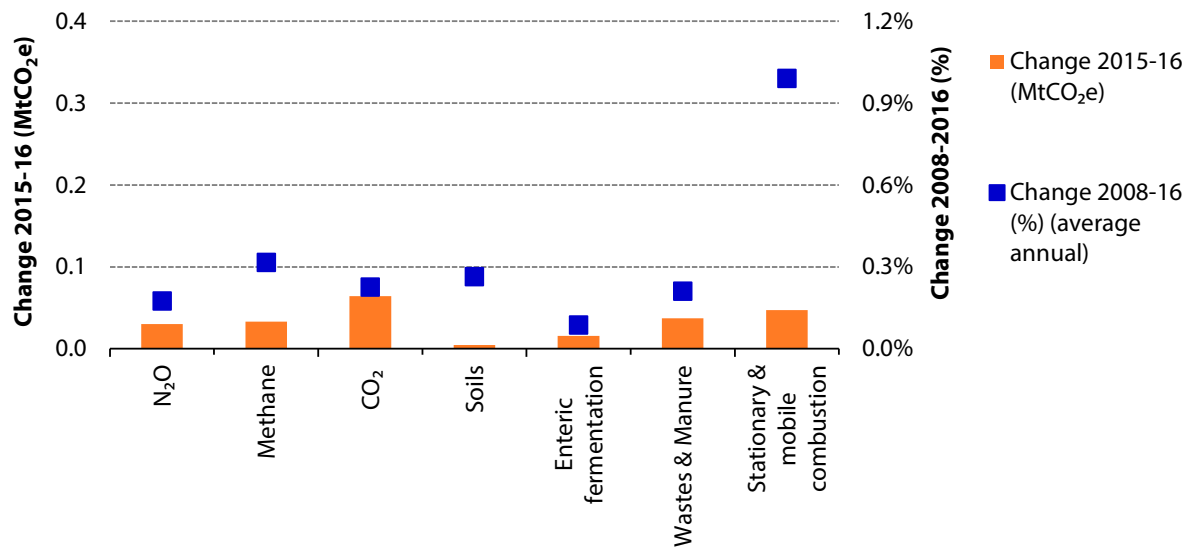


Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*
Notes: Emissions from other sectors excludes international aviation and shipping sectors.

A breakdown of emissions by gas and by source also shows little change over the past year, although emissions from most sources and gases have increased since 2008 (Figure 6.3):

- Methane accounted for 57%, nitrous oxide (N_2O) 32% and carbon dioxide (CO_2) the remaining 12%. These shares have remained broadly unchanged since 1990.
- Almost half of all agricultural emissions (47%) are due to enteric fermentation arising from the digestive process of cattle and sheep. Agricultural soils accounts for a further 24% of emissions, 16% from managing waste and manure, and a further 10% from the running of stationary and mobile machinery. These shares have been almost constant since 1990.
- N_2O and methane emissions rose by less than 0.3% in 2016, with emissions from stationary and mobile machinery increasing by less than 0.1 $MtCO_2e$ in 2016, a rise of just 1%.

Figure 6.3. Change in GHG emissions by gas and source in 2016 and 2008-2016



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*

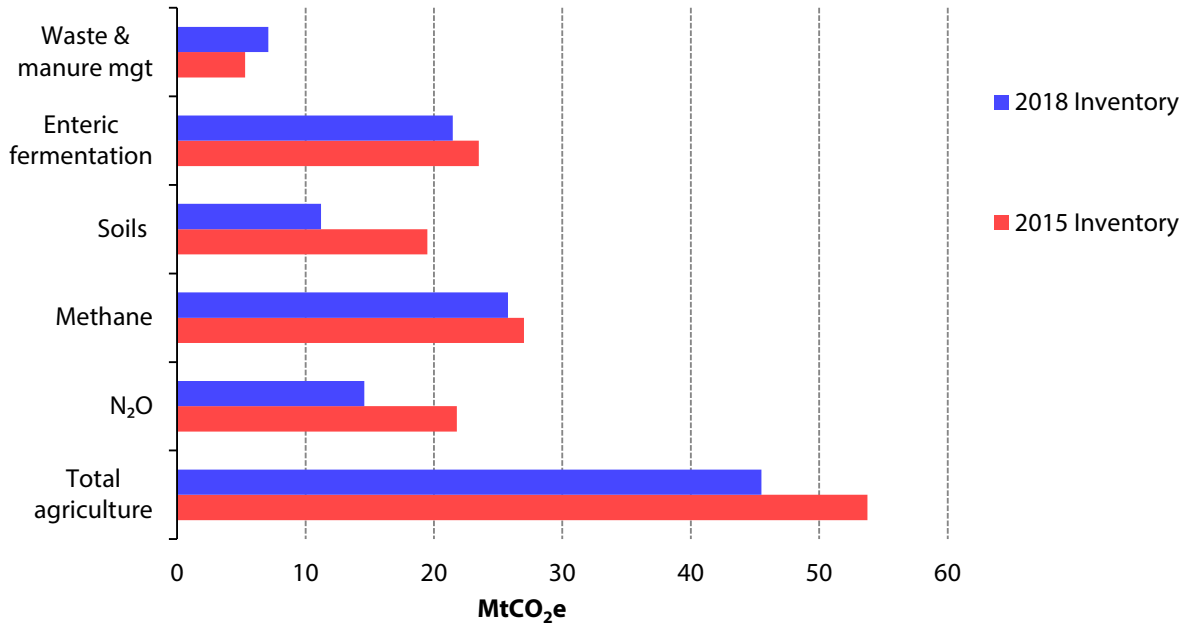
These estimates are based on the new agriculture 'Smart' Inventory, which reflects new evidence and data in estimating emissions, and has been implemented over the past three years. The main changes when comparing the 2018 and 2015 inventories for the year 2013 (the latest year that is captured by both inventories) are (Figure 6.4):

- Agriculture emissions are now estimated to be around 15% lower than in the 2015 inventory, with the trend from 1990 broadly unchanged.
- Soil emissions are now estimated to be 42% lower, largely due to revised fertiliser emissions. The trend since 1990 is broadly unchanged, although there is greater variability in the series reflecting better spatial disaggregation and taking account of rainfall and soil type.
- Methane emissions are estimated to be 5% lower, largely driven by a 9% reduction in enteric fermentation emissions, partially offset by a rise in emissions from manure management.

Over 80% of agriculture GHG emissions estimates now take account of UK-specific emissions factors. There is also greater disaggregation both spatially and temporally. A more detailed account of the 'Smart' Inventory is provided in an accompanying technical annex.[82]

We welcome the increased clarity that this extensive project has brought to the sector. However, it serves to highlight the challenge of decarbonisation in the agriculture sector and recent lack of progress. Going forward, the inventory will provide a more robust evidence base to support our assessment of emission trends and the impact of abatement measures in this sector.

Figure 6.4. 2013 agriculture emissions under the 2018 and 2015 GHG inventories ($MtCO_2e$)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; DECC (2015) *Final UK greenhouse gas emissions national statistics 1990-2013*.

Emission drivers

Given agricultural emissions have flat-lined for a number of years, it is important to understand the drivers of emissions. This includes an assessment of trends in emissions intensity, which relate emissions to levels of agricultural output and gives an indication of changes in production efficiencies.

Changes in agricultural production are helpful in understanding changes in emissions and emissions intensity. Key data on crops and livestock output are shown in Table 6.2. These highlight:

- Little change in the number of cattle and sheep and areas used for grazing livestock since 2008.

[82] CCC (2018) *Agriculture technical annex: The Smart Inventory*.

- Average meat yields produced from cattle and sheep have remained relatively constant since 2008, although milk yields have increased by 10%.
- Total crop area was in line with longer-term trends in 2016, but with slight changes by crop type, with wheat area decreasing and area for barley and oats increasing.
- Arable crop yields were in line with longer-term averages, but down from 2015.

The following section sets out the changes in emissions associated with these trends in agricultural production.

Table 6.2. Changes in key farming statistics 2016, 2015 and 2008

	2008	2015	2016
Livestock numbers (millions)			
• Beef and dairy cows	10,163	9,919	10,033
• Sheep and lamb	33,131	33,337	33,943
Grassland area ('000 ha)	11,536	11,046	11,222
Average fertiliser use on grassland (kg/ha)	55	56	56
Average dressed carcase weight (kg)			
• Steers, heifers and young bulls	349	355	351
• Clean sheep and lambs	19	20	19
Average milk yields, litres/p.a. (per dairy cow)	6,972	7,894	7,636
Total crop area ('000 ha):	4,735	4,679	4,667
• Wheat	2,080	1,832	1,823
• Barley	1,032	1,101	1,122
• Oilseed rape	598	652	562
Crop production (m tonnes)			
• Wheat	17,227	16,444	14,383
• Barley	6,144	7,370	6,655
• Oilseed rape	1,973	2,542	1,775
Crop yields (tonnes/hectare)			
• Wheat	8.3	9.0	7.9
• Barley	6.0	6.7	5.9
• Oilseed rape	3.3	3.9	3.1
Average fertiliser use on arable land (kg/ha)	137	146	141

Source: Defra (2017) *Agriculture in the UK, 2016;* Defra (2017) *British Survey of Fertiliser Practice, 2016.*

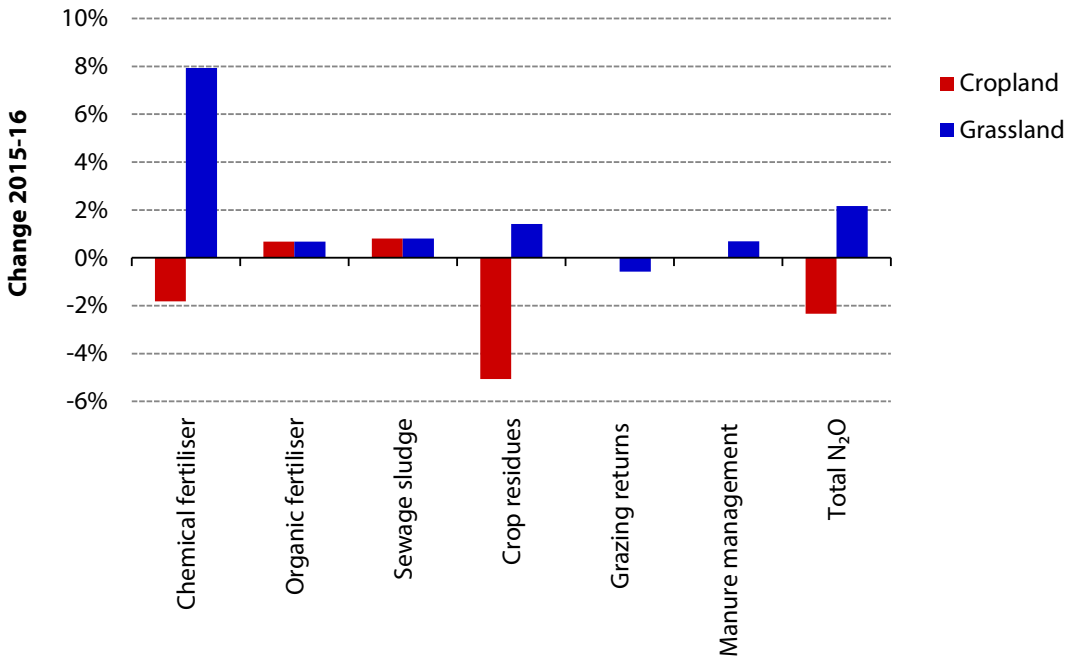
Nitrous oxide

Agricultural soils and the management of waste and manure are the two main sources of N_2O emissions in the sector, accounting for 77% and 20% respectively in 2016. When compared to 2015 and 2008:

- N_2O emissions were broadly unchanged in 2016 from 2015, but increased by 2% from 2008. Almost all of this is due to an increase in emissions from inorganic fertiliser. This reflects lower demand in 2008 when prices for fertiliser reached record highs.
- While there was no overall change in N_2O emissions compared to 2015, emissions from livestock increased (2%), while emissions from crop farming fell by over 2%. There are common sources of emissions for both farming types (e.g. use of fertiliser), and some that are specific to livestock (e.g. grazing returns from urine and dung deposited on grasslands) (Figure 6.5).

These differences and how they relate to emissions intensity of livestock and crop production is explored in more detail in the next section.

Figure 6.5. Change in N_2O emissions due to crop and livestock production (2015-2016)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; CCC calculations.

Crops

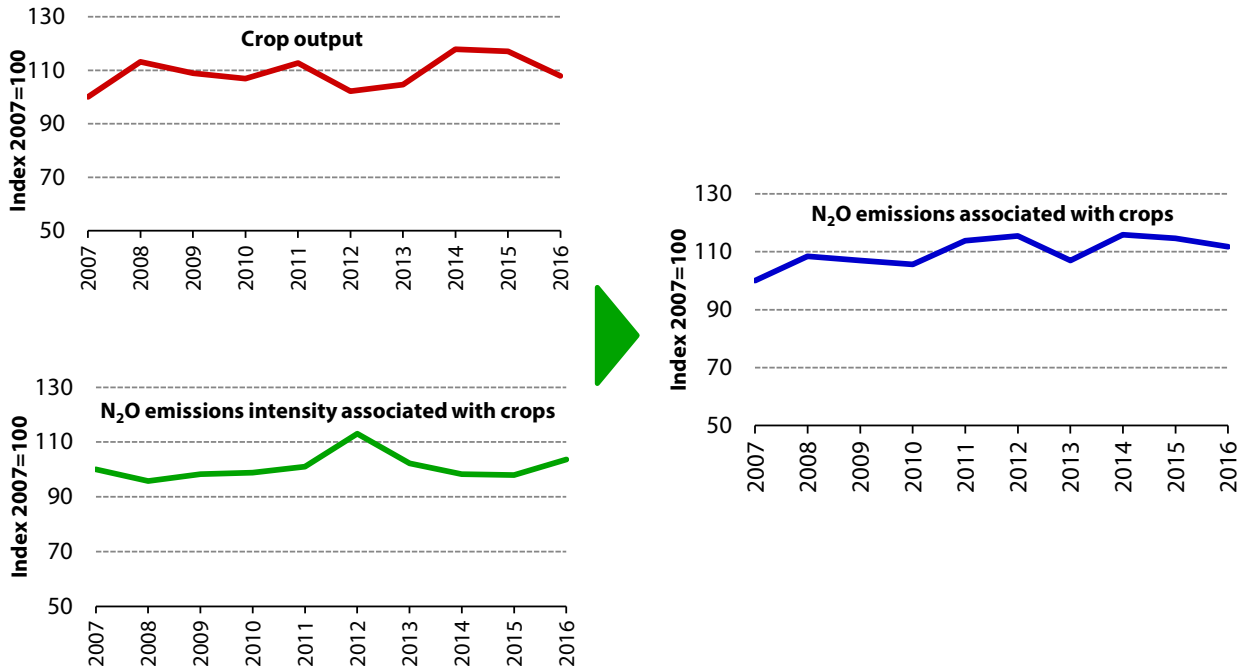
N_2O emissions were unchanged compared to 2008 with higher emissions from chemical and organic fertiliser offset by a decline in crop residue emissions. Crop output declined by 5% over the same period, which contributed to a 5% worsening of emissions intensity of output (Figure 6.6).

The worsening trend in emissions intensity continued in 2016, with output falling faster than emissions:

- Following the record harvests of 2014 and 2015, crop output declined by 8% in 2016 with yields at more typical levels.
- Crop area declined by 1% and average fertiliser application rates fell leading to a reduction in fertiliser emissions of 2%. This helped reduce overall N_2O emissions from crop production by 2%.

The 'Smart' Inventory, which takes into account fertiliser, soil texture and rainfall, is now better able to explain how N_2O emissions can vary spatially.

Figure 6.6. Crop output, N_2O emissions associated with crops and emissions intensity of output (2007-2016)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; Defra (2017) *Agriculture in the UK*; CCC calculations.
Notes: Base year (2007)=100.

Livestock

There has been a 7% improvement in the N_2O emissions intensity of livestock output since 2008 as output grew faster than emissions. Since 2008 all meat and non-meat products (e.g. milk and eggs) increased, apart from lamb (Figure 6.7).

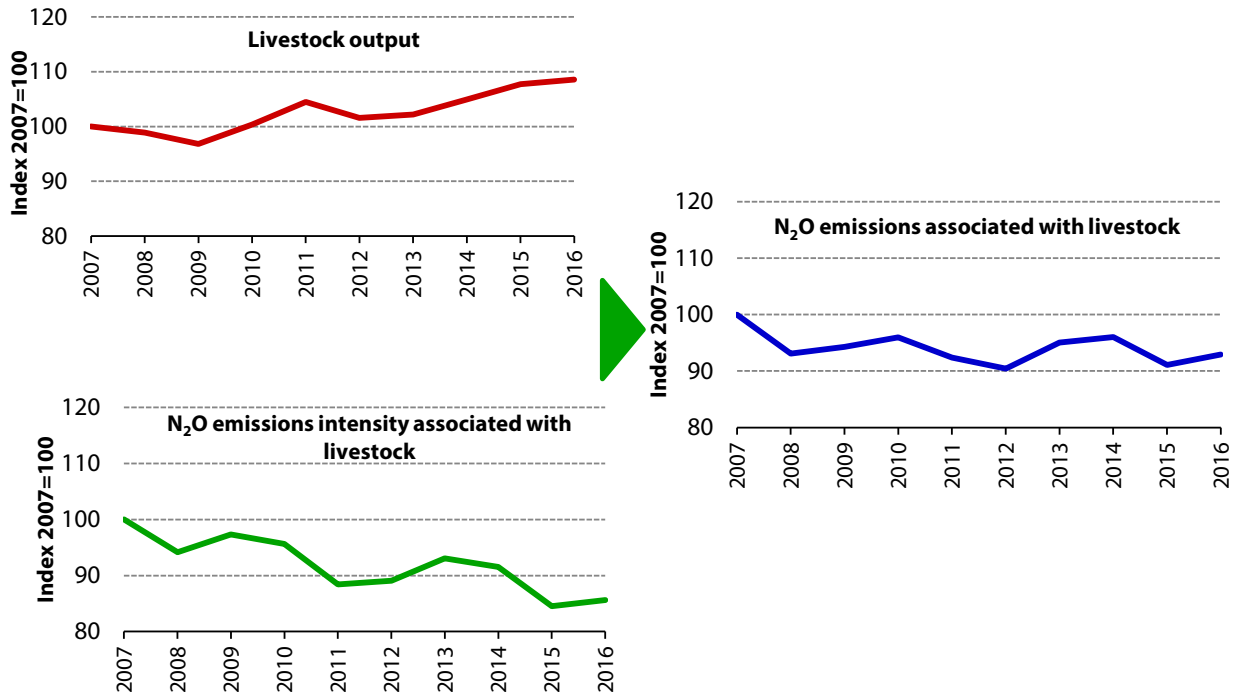
Against the longer-term trend, emissions intensity worsened by 1.5% in 2016:

- Livestock output increased slightly, but higher production of beef and pig meat was partly offset by declining milk output and lamb meat. Milk production declined by 3% following a 30-year high reached in 2015. The fall in output was due to a 3% reduction in average milk yields per dairy cow while the number of dairy cows remained unchanged.

- N_2O increased by 2% with rising manure management emissions due to higher cattle, sheep and pigs numbers, and an 8% increase in emissions from applying fertiliser to grassland partly attributable to a small increase in grassland area.

With around half of lowland grazing livestock holdings surveyed in 2017 having no nutrient management plan in place compared to 25% of dairy holdings, there is scope to improve efficient use of fertiliser on grasslands.[83]

Figure 6.7. Livestock output, N_2O emissions associated with livestock and emissions intensity of output (2007-2016)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; Defra (2017) *Agriculture in the UK*; CCC calculations.
Notes: Base year (2007)=100.

Methane

The two main sources of methane emissions are enteric fermentation arising from the digestive process of ruminants (83% in 2016), and the management of waste and manures from livestock (16%).

Between 2008 and 2016, the methane intensity of livestock output improved by 8%. This reflects a 10% increase in output, while methane emissions increased by only 1%. Sheep accounted for two-thirds of the emissions increase, associated with a 2% rise in animal numbers (Figure 6.8).

Methane intensity continued to improve in 2016, declining by 1%:

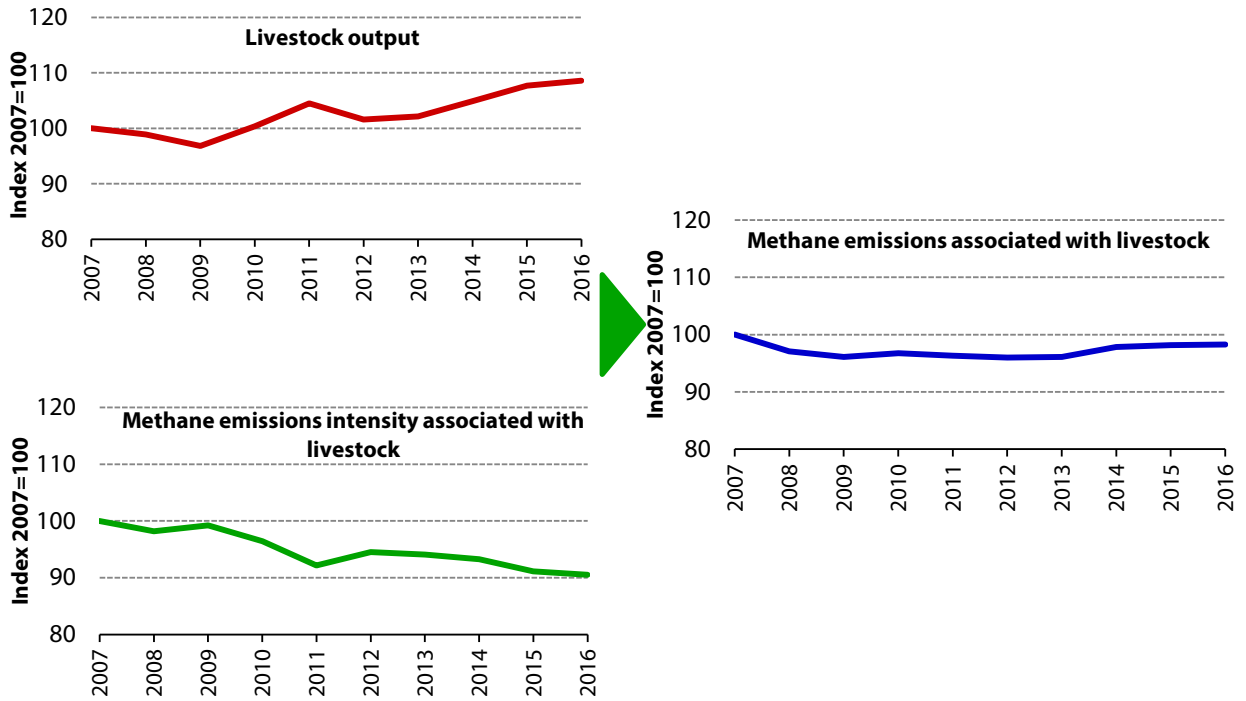
- Livestock output increased by 1% as beef and pig meat increased by 6% and 2% respectively, more than offsetting lower milk and lamb meat output.

[83] Defra (2017) *Farm practices survey, 2017*.

- Methane emissions increased marginally with a rise in cattle numbers accounting for most of this increase.

The new 'Smart' Inventory provides more granularity on the main sources of methane emissions, which will make it easier to understand the drivers of methane. For example, the inventory has different emission factors for cattle by age, breed, feed type and production system. Estimates of methane from manure management are broken down by storage type (slurry tank, lagoon etc.).

Figure 6.8. Livestock output, methane emissions associated with all livestock and emissions intensity of output (2007-2016)



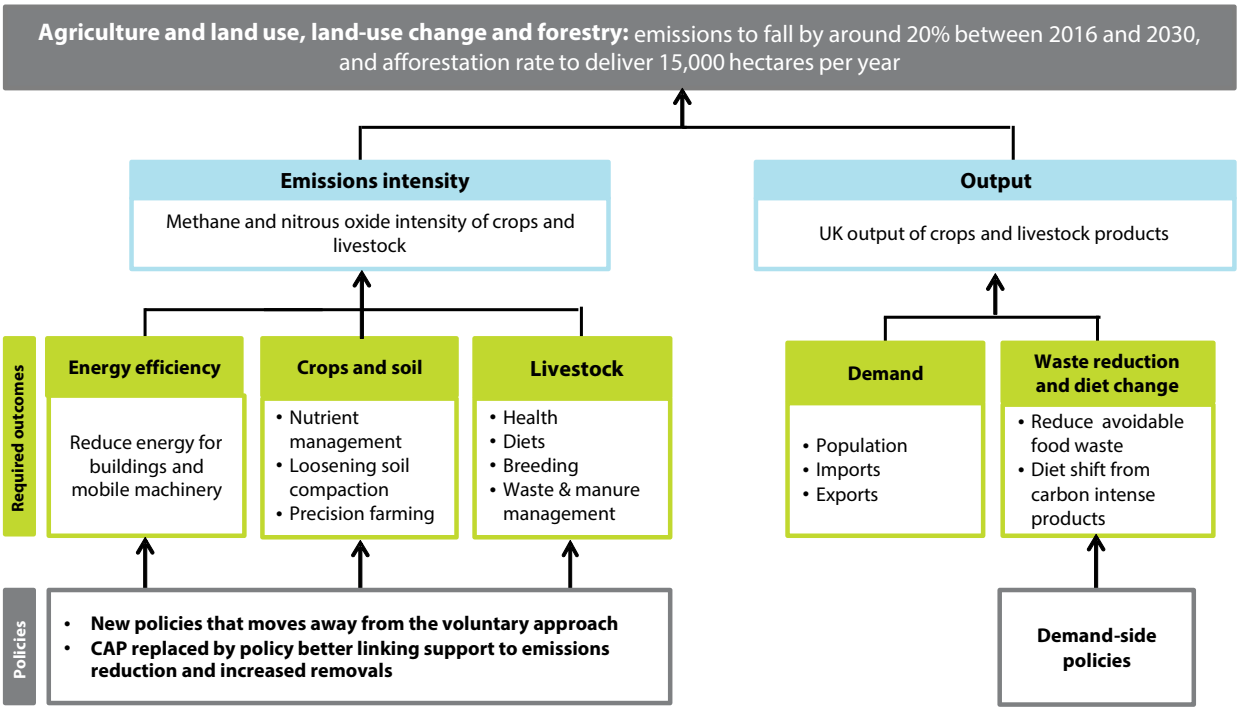
Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; Defra (2017) *Agriculture in the UK*; CCC calculations.
Notes: Base year (2007)=100.

2. Agriculture scenarios and indicators

The cost-effective path to meeting carbon budgets and the 2050 target involves a reduction in agriculture emissions of 20% from 2016 to 2030. Our analysis for the fifth carbon budget identified a set of cost-effective measures that could be deployed on-farm to abate both non-CO_2 and CO_2 emissions, saving around 7 $MtCO_2e$ by 2030. The measures cover soils and crop management; livestock diets, health and breeding; waste and manure management and energy efficiency.

We have developed an indicator framework that can be tracked to monitor progress in reducing emissions to 2030 (Figure 6.9). The completion of the 'Smart' Inventory work, which is now fully incorporated into the GHG inventory provides a firm base with which to update our indicators as part of next year's progress report. For this year, we report against our existing framework.

Figure 6.9. CCC indicator framework for the agriculture sector



Source: CCC analysis.

3. Recent performance in reducing agriculture emissions compared to required progress

Consistent with the Government's ambition to reduce emissions by 3 $MtCO_2e$ in England by 2022 (scaled up to 4.5 $MtCO_2e$ for the UK) compared to 2007, we developed a set of indicators in order to track progress in reducing non-CO_2 emissions in the agriculture sector to 2022. The indicators include trajectories for emissions reductions by gas and source (Figure 6.10).

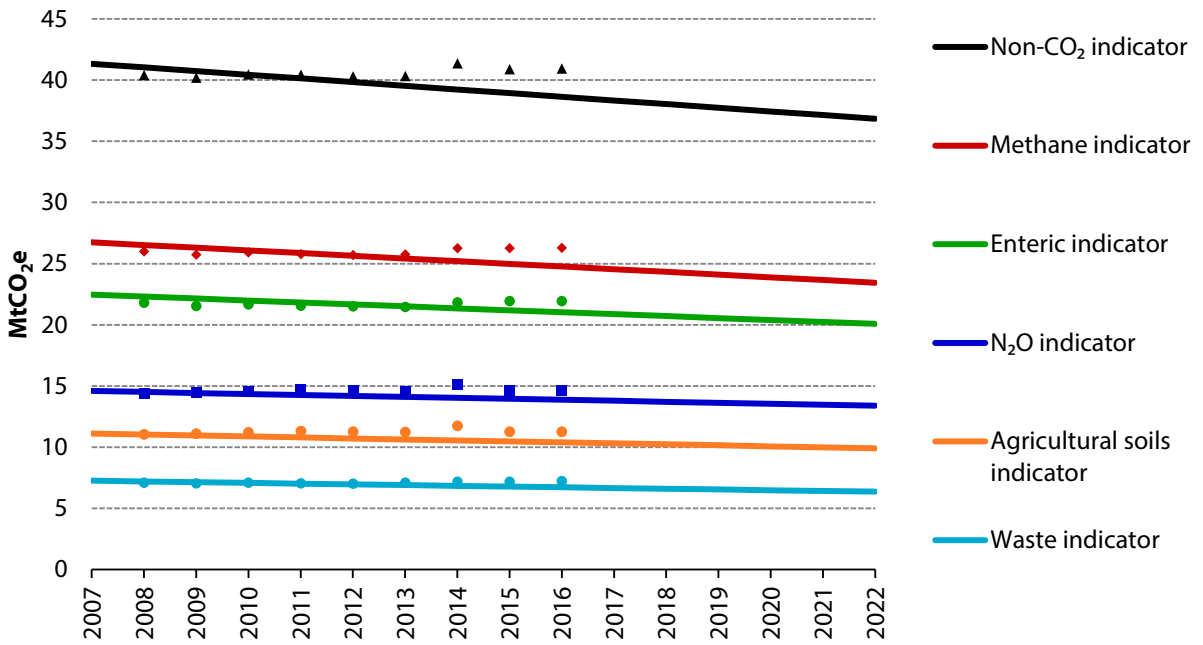
Estimated emissions by gas and source are all above our indicator trajectories:

- Non-CO_2 emissions were 2 $MtCO_2e$ (6%) higher than our indicator in 2016, the sixth year running that emissions exceeded our indicator.
- Both methane and N_2O emissions were also above their respective trajectories, each by 6%. Methane has been off-track since 2012, and N_2O since 2009.
- Outturn emissions from soils have been above the indicator in each year since 2009, with the difference rising to 0.9 $MtCO_2e$ (8%) by 2016. Enteric fermentation and waste management have both been off-track for a number of years with respective emissions 0.9 $MtCO_2e$ and 0.5 $MtCO_2e$ higher than the indicator trajectories in 2016.

Our assessment clearly indicates that the sector is not on track to achieve savings of 4.5 $MtCO_2e$ by 2022 consistent with our trajectories. Reductions of 1.7% each year will be required to achieve this.

Given this lack of progress it is important that action is taken across all countries of the UK to implement a stronger policy framework to secure emissions reductions to 2022 and beyond.

Figure 6.10. Progress against the CCC indicators for agriculture to the end of the third budget period



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016; CCC* calculations.
Note: Marker points indicate outturn data.

The voluntary approach to emissions reduction

Agricultural policy is a devolved matter, and across all countries of the UK, emissions reduction is being delivered through an industry-led voluntary approach. In England, the Greenhouse Gas (GHG) Action Plan is the sole policy mechanism in place to deliver the Government's ambition for a 3 $MtCO_2e$ reduction by 2022. The main element of this is the provision of information and advice, which focuses on improving efficiencies, while reducing emissions.

Despite all the programmes and initiatives that the GHG Action Plan has established to date, it has been impossible to appraise its effectiveness given the lack of an effective monitoring and evaluation framework. However, Defra statistics imply a lack of improvement in the sector both in terms of farmer attitudes and the take-up of mitigation practices, with almost half of farmers placing little or no importance on GHG mitigation and/or thinking their farm produced any emissions:[84]

- 49% of farmers reported that it was 'very' or 'fairly' important to consider GHGs when making decisions relating to their land, crops and livestock. Just over half of respondents placed little or no importance on considering emissions when making decisions and/or thought their farm did not produce GHG emissions.
- Overall, 56% of farmers were taking actions to reduce emissions, again little change on 2016. Of these, larger farms were more likely to be taking action than smaller farms.
- For those farmers not undertaking any actions to reduce GHG emissions, informational barriers were important, with both the lack of information (34%) and lack of clarity about

[84] Defra (2017) *Agriculture statistics and climate change*.

what to do (33%) cited as barriers by this group. 47% did not believe any action was necessary, which was unchanged on 2016.

Given the evidence of the link between GHG mitigation and improved productivity, this is a missed opportunity for farmers.[85]

The 2017 Defra Review indicated it would not introduce policy that goes beyond the voluntary approach.[86] On this basis, emission savings are unlikely to be achieved. This also puts at risk future carbon budgets.

4. Policy implementation

Since last year's progress report there have been no new policy commitments, although a number of proposals and ambitions have been announced that are relevant to reducing GHG emissions in agriculture:

- **The Clean Growth Strategy (CGS).** In its strategy to decarbonise the UK to 2032, the proposals for emissions reductions in agriculture focus on England only. The strategy set out an intention to develop low-emissions fertiliser and tackle endemic diseases in cattle. Even if these are fully implemented, they are only likely to deliver around 10% of the abatement we identified in our fifth carbon budget assessment.
- **The Health and Harmony command paper** set out Defra's proposals for the new post-CAP policy framework in England.[87] Under the new Environmental Land Management Scheme (ELM), proposals include:
  - The development of a new regulatory baseline reflecting the 'polluter pays' principle. This is expected to cover areas like the need to maintain agricultural land in good environmental condition currently required under cross-compliance rules.
  - The replacement of direct payments with public money awarded for the provision of public goods, over and above any actions set out in the regulatory baseline. Enhancing and protecting the environment is being viewed as the 'pre-eminent' public good, although there is scope for improved animal and plant health, animal welfare, and productivity to benefit too. Reducing GHG emissions and increased carbon sequestration were cited as two examples of a public good.
  - Additional mechanisms and sources of funding to incentivise farm managers and land owners to improve environmental outcomes. Examples cited included the use of reverse auctions and tendering to encourage private investment.

  Defra is expected to publish an Agriculture Bill during the summer, which will be followed by a two-period of further consultation to develop the ELM.
- **The £90m Challenge Fund.** As part of the Industrial Strategy, BEIS has set out further details of its proposed £90m investment to transform food and farming. On the technology side, the fund will focus on measures such as artificial intelligence, robotics, remote monitoring and data science, and will be allocated in tranches between 2018 and 2022. It is intended that

[85] The continuous adoption of innovative agricultural technologies in the Netherlands has enabled it to improve productivity while reducing the emissions intensity of output.
[86] Defra (2017) *The Greenhouse Gas Action Plan for Agriculture, Review 2016.*
[87] Defra (2018) *Health and Harmony: the future for food, farming and the environment in a green Brexit.*

reducing GHG emissions and improving resilience will be two of the criteria that will be used in the evaluation process.

- **The Scottish Climate Change Plan (CCP)** sets out the Scottish Government's plan to meet its emissions reduction target over the next 15 years.[88] Within agriculture, it has an ambition to reduce GHG emissions by 9% by 2032, equivalent to 0.8 $MtCO_2e$. However, delivering these savings will continue to rely on the voluntary approach with farmers being encouraged to take-up mitigation measures rather than through the use of more stringent policy mechanisms.

Our assessment is that the announcements and proposals made to date do not go far enough, for a number of reasons:

- The intentions in the Clean Growth Strategy cover only a limited set of mitigation measures, which we estimate could deliver less than 1 $MtCO_2e$ by 2030. In our fifth carbon budget assessment, we identified a range of other measures including livestock diets, livestock breeding, sheep health, improvement in waste and manure management, deployment of anaerobic digestion and energy efficiency. We estimated that this could deliver a further 6 $MtCO_2e$ of abatement savings (when scaled up to the UK) by 2030. Policies must now be developed that cover a broader range of mitigation measures.
- The reliance on a voluntary approach both for existing and future abatement across the UK (implied by the GHG Action Plan and Scottish Climate Change Plan, for example) is a key delivery risk given the lack of progress in reducing emissions in agriculture to date.
- It is essential that the Agriculture Bill to be published in the summer allows measures that reduce agricultural emissions to qualify for public money.

Our assessment of recent policy announcements is that limited progress has been made (Table 6.3). These need to be translated into delivery plans to support emissions reductions in agriculture. Until these are provided, there remains a policy gap of 44% of our estimated savings by 2030 (Figure 6.11).

Actions required to close the policy gap for the fourth and fifth carbon budgets are set out in the next section.

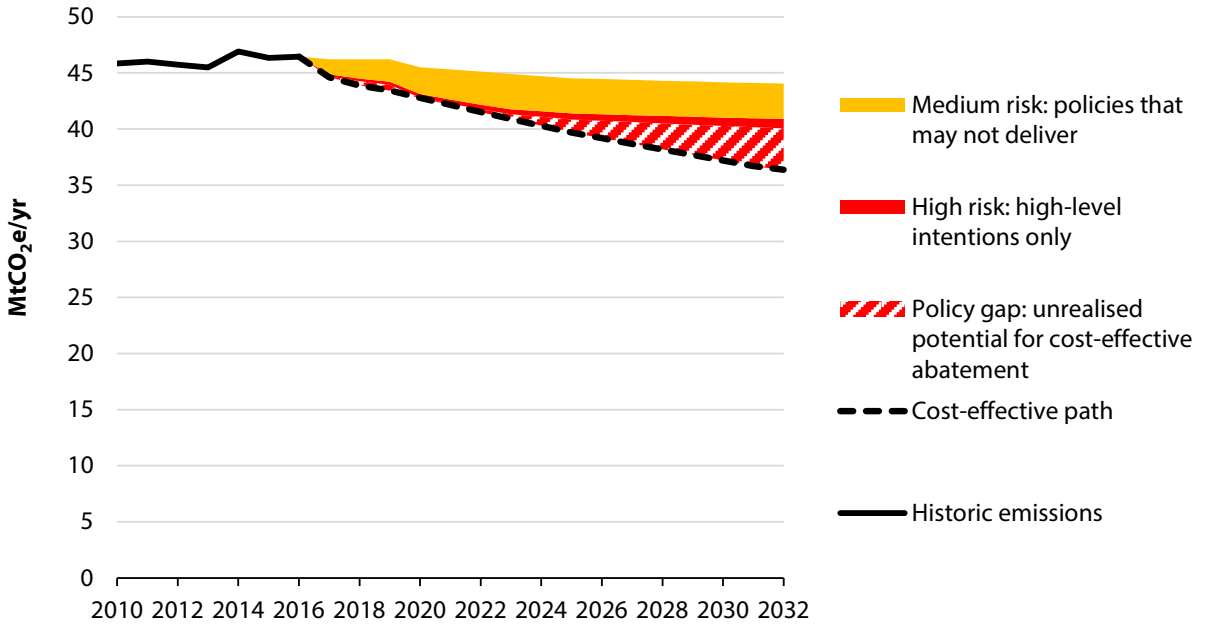
[88] Scottish Government (2018) *Climate Change Plan: Third report on proposals and policies 2018-2032.*

Table 6.3. Assessment of policies to drive abatement options in agriculture

Abatement option	2017 policy	2018 updates and assessment
Measures to 2022 aimed at reducing emissions through: • Crops and soil management • Livestock diet, health and breeding • Waste and manure management • Energy efficiency	Amber In its review of the GHG Action Plan last year, Defra stated it would not introduce new policy.	Red No policy.
Measures post 2022 aimed at reducing emissions through: • Crops and soil management • Livestock diet, health and breeding • Waste and manure management • Energy efficiency	Red No policy.	Amber Proposals to reduce emissions cover a limited set of measures outlined in the Clean Growth Strategy, and Scottish Climate Change Plan. Red New policies required for the range of other measures not covered in the Clean Growth Strategy.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower-risk policy - expected to deliver.

Figure 6.11. Risks around the delivery of agriculture sector policies to meet the cost-effective path



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016;* BEIS (2018) *Updated Energy and Emissions Projections 2017*; CCC analysis.
Notes: We have scaled the Government baseline emissions projections so that the 2016 projection matches 2016 outturn given that the inventory is based on the most up to date methodology for estimating emissions. Projections going forward change at the same percentage as given in the BEIS UEP 2017 projections. The top of the yellow area in the chart represents the scaled baseline emissions. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

5. Further actions required in agriculture

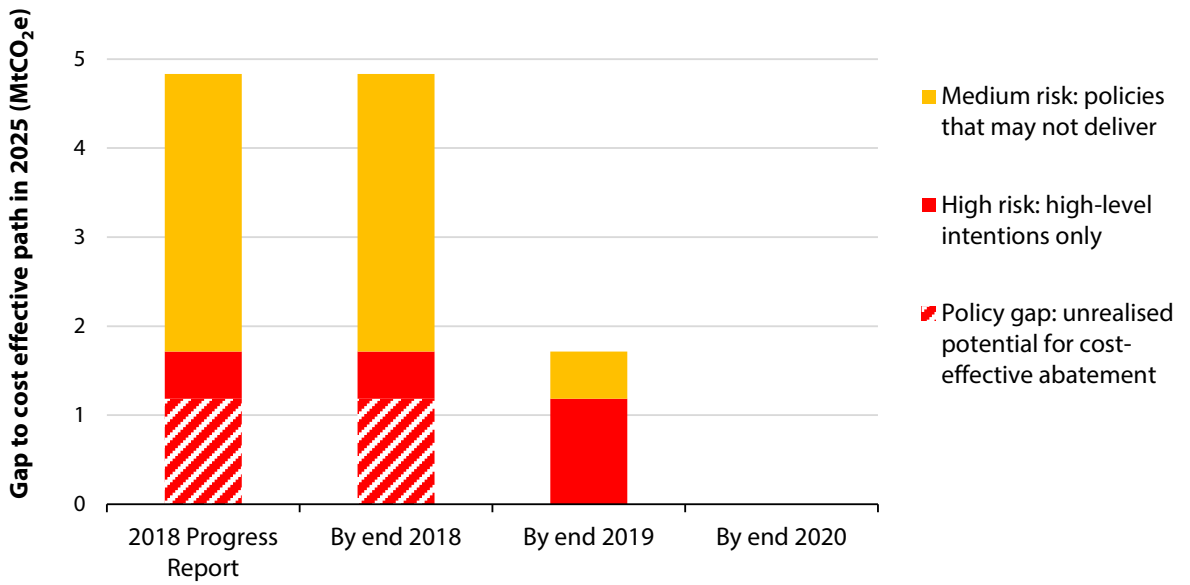
To be on track to meet the fourth and fifth carbon budgets, the Government needs to remove risks from existing policies, turn intentions into firm policies and put in place new policies:

- **A stronger framework to deliver GHG abatement is needed in agriculture.** Emissions reduction to 2022 and beyond are at risk under the voluntary-led approach in England and the DAs.
- **Low-carbon fertilisers and tackling endemic cattle diseases.** Turn proposals outlined in the Clean Growth Strategy into firm policies by 2020.
- **Develop new policies** to cover other measures that can reduce emissions in agriculture - for example, for crops and soils, sheep health, livestock diets and breeding, waste and manure management and energy efficiency. This should be addressed in developing the post-CAP policy framework that better links support more closely with emissions reductions.

- **Ensure that the £90m Challenge Fund** is allocated to projects that deliver on GHG mitigation in agriculture, as well as meeting other Industrial Strategy objectives starting in 2018. As with the £10 million of capital funding provided for peatland restoration (Section 6) emissions reduction should be a key criterion in the assessment of bids.

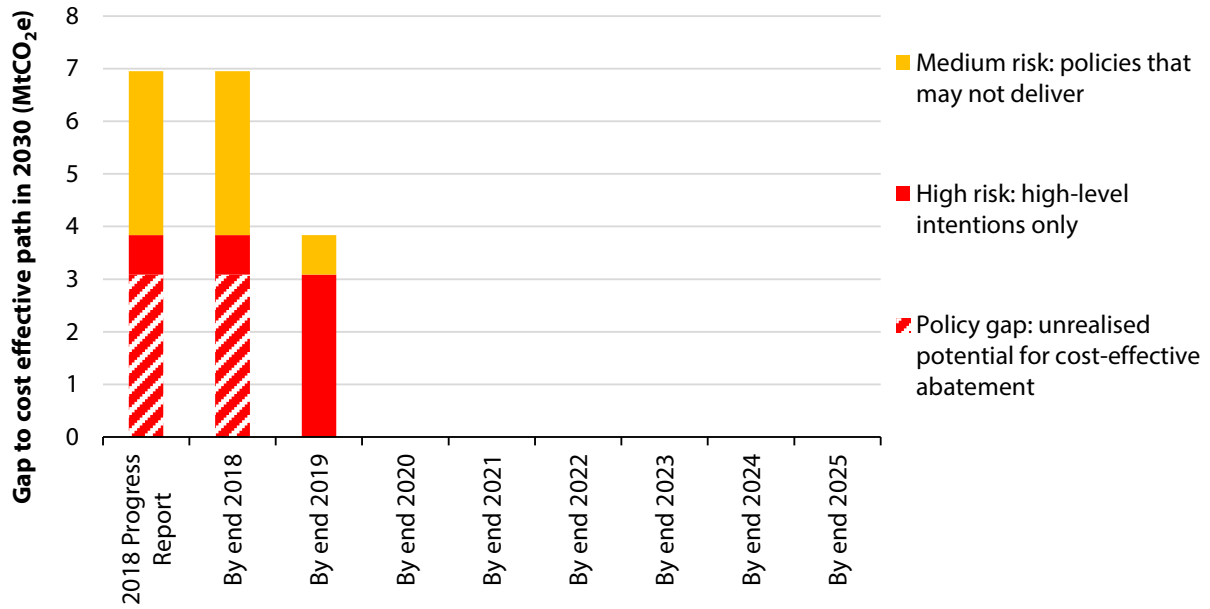
We outline the key milestones and timings for firming up policy to meet the fourth and fifth carbon budgets (Table 6.4). The Government should firm up intentions and reduce policy delivery risks for the fourth carbon budget by 2020 and by 2025 for the fifth carbon budget (Figures 6.12 and 6.13).

Figure 6.12. Risks around the delivery of agricultural policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the agriculture sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018), which we have adjusted to reflect the updated inventory methodology. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period.

Figure 6.13. Risks around the delivery of agricultural policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the agriculture sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018), which we have adjusted to reflect the updated inventory methodology. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period.

Table 6.4. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
A stronger framework to deliver GHG abatement in agriculture is needed that goes beyond the voluntary approach in England and the DAs. • For England, implement policies to safeguard the ambition to reduce emissions by 2022 that are currently at risk of not being delivered under the GHG Action Plan.	Early 2019
For Scotland, a stronger policy framework than currently committed to under the CCP to ensure it can deliver its target to reduce agricultural emissions by 0.8% by 2032	By 2020
Turn proposals in the Clean Growth Strategy to improve cattle health and low-carbon fertilisers into firm policies: • Review policies and strengthen if required.	By 2020 2023 and 2025
Design a new system of future agricultural support post-CAP: • The 2018 Agriculture Bill should set out a post-CAP framework which links financial support to agriculture emissions reduction. • Set out policies to deliver emissions reductions through a range of measures to take effect from 2022: – Crops and soil management – Livestock diet, health and breeding – Waste and manure management – Energy efficiency • Review policies and strengthen if required.	2018 2019 2023 and 2025
Allocate the £90m Industrial Strategy Challenge Fund to projects that deliver GHG emissions reduction, in addition to government's other stated objectives: • Reducing agriculture emissions should be a key criterion in evaluation of bids • Eligible measures should include precision farming for crops and livestock, improvements in animal health and diets, and enhancing nitrogen use efficiency.	2018-2022

Source: CCC analysis.

6. The land use, land-use change and forestry (LULUCF) sector

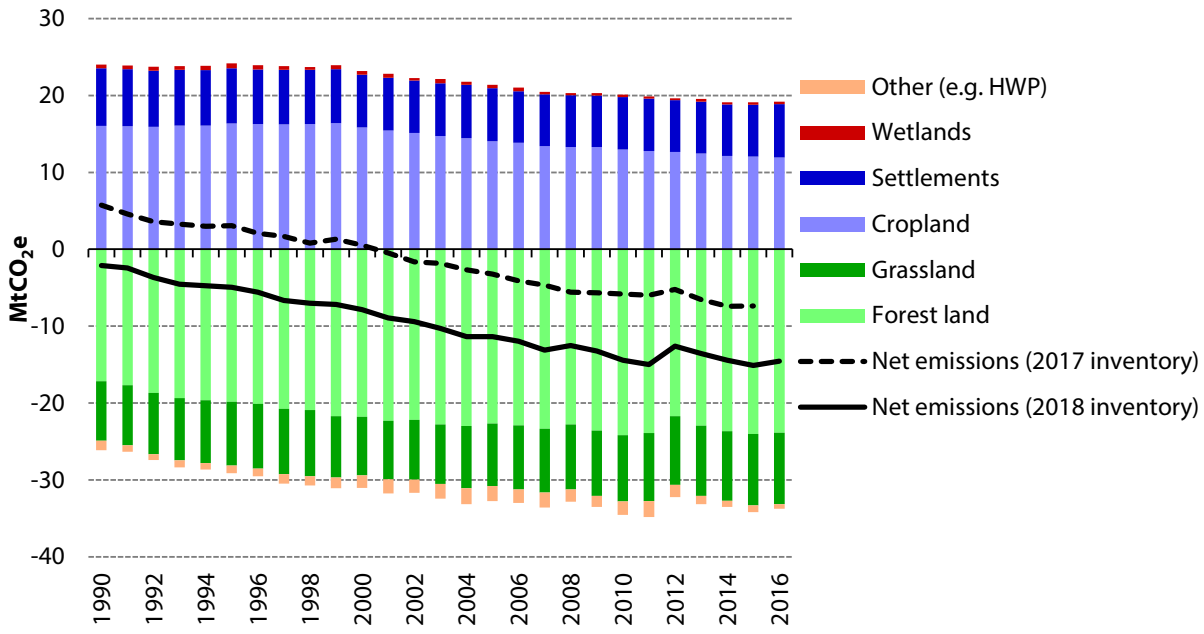
LULUCF emission trends and drivers

The land use, land-use change and forestry (LULUCF) sector captures removals and emissions arising from the use and change in use of different land types in the UK. The main land categories are cropland, forestry, grassland, wetlands and settlements. The GHG inventory also includes an additional category that captures the changes in carbon stocks of harvested wood products.

There has been a significant change in the methodology for estimating emissions in this sector since last year. This has resulted in a large increase of the estimated net carbon sink across the time series compared to the 2017 inventory (Figure 6.14):

- The net sink is larger in all years since 1990 compared to last year's inventory. For example, in 2015, the net sink almost doubled from -7.4 $MtCO_2e$ to -14.6 $MtCO_2e$.
- Under the current inventory, the sector has been a net carbon sink in each year since 1990, while last year's inventory estimated the sector becoming a net carbon sink from 2000 onwards.

Figure 6.14. LULUCF emissions and removals (1990-2016)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*

The change is mainly attributed to the inclusion of updated modelling of soil carbon stocks in newly planted and restocked woodland, which now takes account of changes in forest carbon stocks from non-forest ground vegetation. As a result of the update, estimated net sequestration from forestry increased by 8 $MtCO_2e$ (53%) in 2015 compared to the 2017 inventory.

Such large annual revisions to the inventory are a result of ongoing work being undertaken by BEIS to improve estimates of emissions and sequestration in the LULUCF sector. This is likely to continue in the future as further improvements are made, such as the development of a more accurate and repeatable way to track land-use change in a spatially-explicit way, and the inclusion of new sources of emissions not currently reported (e.g. all sources of peatland emissions). We will provide future advice on how such changes should be dealt with in carbon budgets.

Looking at changes over time, the net sink weakened by 4% (or 0.5 $MtCO_2e$) to -14.6 $MtCO_2e$ in 2016 compared to the previous year. This reverses the longer-term trend between 2008 and 2015 when net removals strengthened by an annual average of 2.4%.

The decline in the net sink in 2016 is largely attributable to settlements and harvested wood products (HWP):

- There was a 0.2 $MtCO_2e$ increase in net emissions from land converted to settlements.
- HWP cover all wood that is harvested.[89] In 2016 the net sink of HWP declined by 0.3 $MtCO_2e$, due to the volume of HWP entering the carbon pool reducing in size compared to products harvested in previous years leaving the pool as products decompose.

The sector's net carbon sink is projected to reduce further to just under -9 $MtCO_2e$ by 2030.[90] This is under a business as usual scenario within which the ability of existing forests to absorb carbon weakens due their ageing profile, and annual afforestation rates are projected to be less than 1,000 hectares between now and 2050.[91]

Recent performance in reducing LULUCF emissions compared to required progress

The main measures that could be deployed to increase the carbon sink and slow the release of emissions are planting trees and minimising carbon losses from degraded peatland and other soil types. Given that not all sources of peatland emissions are included in the inventory at present, our fifth carbon budget abatement focused on woodland creation, including the planting of trees on-farm.

Forestry

Woodland accounts for 13% of total UK land area, which is significantly below the EU average of around 35%. The level of UK woodland has increased since 1900 as a result of a steady programme of afforestation during the 20th century. However, the pace of new planting has declined dramatically in recent years, from a peak of 30,000 ha/year in the late 1980s to less than 7,000 hectares in 2016/17.

To arrest the decline, England and the devolved administrations have established targets to increase woodland creation which, if achieved, would exceed our fifth carbon budget scenario level of 15,000 ha/year in the UK:

- England has an ambition to increase woodland cover from 10% to 12% by 2060, which is equivalent to an average annual rate of around 6,000 hectares. There is a more immediate

[89] Under the inventory, the time taken for HWP to decompose and release CO_2 depends on the product type. Using IPCC default values, it is two years for paper, 25 years for particleboard and 35 years for sawn timber.
[90] BEIS (2018) *Updated Energy and Emission Projections 2017*.
[91] The BEIS business as usual scenario assumes a value of 10% of the average forest planting rate (from the 2008-2014 Rural Development Programme) out to 2050.

target to plant 11 million trees over the lifetime of this Parliament, which corresponds to over 2,000 ha/year between 2017 and 2022.

- Scotland has the most ambitious plan, which was recently strengthened under its Climate Change Plan.[92] The trajectory has annual planting rates ramping up from 10,000 hectares to 15,000 hectares by the mid-2020s which, if achieved, would deliver an increase in woodland cover from 18% of land area to 21%.
- Welsh ambition amounts to 5,000 ha/year between 2010 and 2030 and for Northern Ireland, 1,700 ha/year. However, in view of the low uptake achieved in Wales, the short-term target to 2020 has been lowered to 2,000 ha/year.

In total, if achieved, this would deliver 20,000 hectares annually by 2020, and 27,000 hectares annually by 2030. However, progress to date has been short of the ambition in all the countries with the combined level of tree planting in the UK plummeting to 5,600 hectares and 6,500 hectares in the years to end March 2016 and 2017 respectively. This compares to an annual average rate of around 11,200 hectares in the period 2011 to 2015, during the previous round of the CAP's Rural Development Programme (RDP).

In England, applications for grant funding under the current round of the RDP have been low, while additional afforestation expected from the new Woodland Carbon Fund failed to materialise until recent changes were implemented:

- **The Countryside Stewardship (CS) Woodland Creation scheme.** With £18 million available annually to deliver around 2,000 hectares each year, the new RDP's Countryside Stewardship scheme funded just 1,100 hectares during its first two years. This compares to an annual average of almost 2,000 hectares over the five years of the previous RDP. The CS has attracted criticism for having an overly bureaucratic application process that was deterring potential applicants. Recent efforts to streamline the process by Defra have addressed some of these issues, with new planting rates reaching 900 hectares for 2017/18. Defra should now ensure that the ongoing review is completed without delay and implement the required changes to boost tree planting rates to the targeted level.
- **The Woodland Carbon Fund.** Government is providing £19 million to 2020 to fund the up-front cost of large-scale productive planting. Last year we reported on the poor take-up since its launch in 2016, with only one application received by the end of 2017. In a bid to encourage more applicants, Defra has made available additional funding for ongoing maintenance, and access road provision, while reducing the planting threshold from 30 hectares to 10 hectares. These new measures are time limited to one year only, but there is a case to extend them further given that the number of applications and expressions of interest in this year reached seven by mid-May. In addition, the £19 million should be made available beyond 2020 if needed.

Defra should continue to monitor the level of applications for both schemes and, if necessary, take further action to ensure it can deliver its commitment to plant 11 million trees by 2022. It is also important for stimulating private sector investment to come forward given Defra wants the private sector to take the lead role in meeting the 12% target by 2060.

An example of public funds stimulating private investment is the plan to create a Northern Forest between Liverpool and Hull. Launched earlier this year, the ambition is to plant 50 million

[92] The Scottish Government (2018) *The Climate Change Plan, Third Report on Proposals and Policies 2018-2032 (RPP3).*

trees over the next 25 years. Defra is committing £6 million to kick-start the scheme, while the bulk of the funds is expected to come from the private sector.

Peatland

Peatlands represent a large carbon store but ongoing degradation risks significant carbon emissions. Since our last progress report, announcements have been made on restoration:

- Under this year's Climate Change Plan, Scotland is looking to restore 250,000 hectares of degraded peat by 2030. This corresponds to about 40% of the country's peat area. Policies to deliver this will focus on the provision of grants for restoration and boosting skills and know-how of land managers to deliver restoration.
- In England, the 25 Year Environment Plan, the Government's ambition to enhance England's natural environment over the next 25 years, includes the commitment to protect and restore peatland. The intent is to create a new framework that will restore peatland, and where it cannot be restored because it is prime agricultural land for example, develop sustainable management practices to minimise loss of top soils. More detail will be set out in Defra's Peatland Strategy, which is due for publication later this year.

We welcome both announcements and the development of proposals that will incentivise the restoration of degraded peat. For England, we recommend that all options are considered when assessing sustainable practices on lowland peat, including the growing of paludiculture crops.[93] In particular, the Peatland Strategy should ensure proposals to reverse the ongoing loss of lowland peat soils are set out by 2019, and target the restoration of all designated blanket bog habitats to good condition by 2030 in line with the recommendations of the CCC's Adaptation Sub-Committee.[94]

In the shorter term, £10 million of capital grants has been awarded to four projects for peatland restoration in England. The projects will restore over 6,000 hectares of lowland and upland peat, delivering an estimated annual saving of 23,000 tCO_2e. Reducing emissions was the key criteria in the evaluation of bids.

Our fifth carbon budget scenario does not include actions aimed at reducing carbon losses from peatland given emissions from all peat sources are not captured in the inventory. However, the UK has elected to include all peatland sources by 2022. While work to develop improved emission factors is complete, gaps in activity data remain and work is ongoing by BEIS to develop a new method to understand peatland condition through the use of satellite radar technology.

Policy implementation

The cost-effective path set out in our fifth carbon budget report included emissions savings of 2.4 $MtCO_2e$ by 2030 from additional tree planting (15,000 hectares a year by 2030), and the integration of trees and shrubs onto agricultural land (i.e. agro-forestry). However, policies to deliver this abatement are currently not delivering or are absent despite recent announcements (Table 6.5):

- **The proposed Environmental Land Management Scheme**, which will replace the CAP in England provides an opportunity to link the payment of public money to a range of public

[93] Crops such as blueberries, willow and sphagnum that can be grown in wet conditions such as rewetted peatland.
[94] CCC (2017) *Progress in preparing for climate change.*

goods that tree planting can deliver. This includes increasing soil carbon, enhancing biodiversity, and mitigating the risk of flooding.

- **Forestry investment zones.** These will be created to unlock private investment in England. Having completed work to identify and quantify 'low sensitive' areas suitable for planting (i.e. land which excludes specific areas such as national parks, sites of special scientific interest and high grade agricultural land), Defra and the Forestry Commission are locating suitable catchments for large scale woodland creation where targeted planting would have to deliver against a particular objective(s). This includes flood alleviation, improving water quality or the provision of a timber resource. The aim is that stakeholder engagement will attract investment from those bodies that stand to gain from the planting such as water companies, timber processors and insurance bodies.
- **In Scotland**, the tree planting ambition set out in the Climate Change Plan will be delivered through a mix of measures including forestry grants, awareness raising to get more trees on farms, and the planting of more trees on the national forest estate. However, it is unclear how this increased level of planting will be financed given no additional funding was provided in the recent Scottish budget.
- **For Wales**, the Climate Change, Environment & Rural Affairs Committee stated in their recent annual progress report on mitigating climate change, that without a 'fundamental change in approach' meeting the long-term planting target of 100,000 hectares between 2010 and 2030 was unlikely.[95] We reiterate our earlier advice to the Welsh Government that it should look to simplify and streamline the process for supporting tree planting, in order to reduce the barriers to action.[96] The Welsh Government will be responding to our advice later this year.

There is now an urgent need to turn ambition and intentions set out in the Clean Growth Strategy, the Health and Harmony command paper, and the Scottish Climate Change Plan into firm policies by 2020. Policies should address both financial and non-financial barriers.

Until this happens, there are delivery and policy risks attached to delivering emissions from afforestation (Figure 6.15):

- Savings of 2.4 $MtCO_2e$ in 2030 reflect the Committee's estimate of the cost-effective path based on annual UK afforestation rates of 15,000 hectares and the additional planting of trees and shrubs on agricultural land.
- Further savings reflect the stated ambition for afforestation by England and the DAs, equivalent to 27,000 hectares a year by 2030. Combined with our fifth carbon budget abatement estimate of 0.6 $MtCO_2e$ from agro-forestry, total savings from planting trees would reach over 3 $MtCO_2e$.

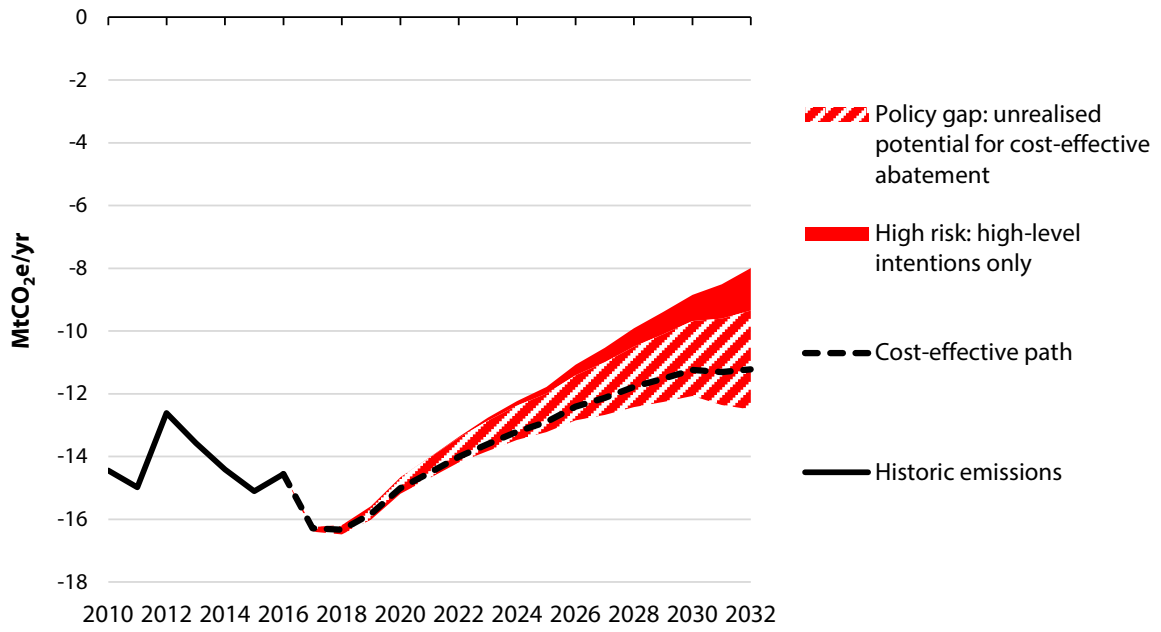
[95] Climate Change, Environment and Rural Affairs Committee (2018) *The Welsh Government's progress on climate change mitigation: annual report of Climate Change, Environment and Rural Affairs Committee.*
[96] CCC (2017) *Building a low-carbon economy in Wales-Setting Welsh climate targets.*

Table 6.5. Assessment of policies to drive abatement options in forestry

Abatement option	2017 policy	2018 updates and assessment
Afforestation	Red — Overly burdensome application process for RDP funding is impacting tree planting levels in England.	Amber — Some streamlining has seen a pick-up in rates, but the ongoing review of RDP needs to be completed, and changes implemented without delay.
Agro-forestry	Red — No policy.	Red — No change.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Delivery risk - stronger policy/implementation required. Green: Lower-risk policy - expected to deliver.

Figure 6.15. Risks around the delivery of LULUCF policies to meet the cost-effective path



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; BEIS (2018) *Updated Energy and Emissions Projections 2017*; CCC calculations.
Notes: We have scaled the Government baseline emissions projections so that the 2016 projection matches 2016 outturn given that the inventory is based on the most up to date methodology for estimating emissions. Projections going forward change at the same percentage as given in the BEIS UEP 2017 projections. The top of the red area in the chart represents the scaled baseline emissions. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. Savings under 'high risk' are based on the CCC estimates of the Scottish ambition for afforestation under the Climate Change Plan. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

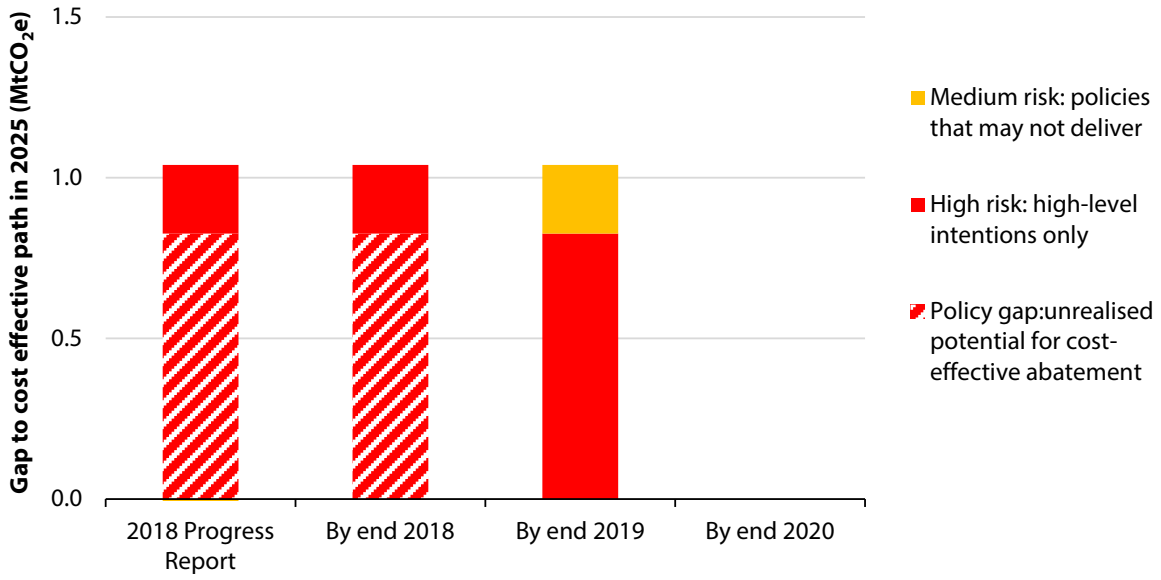
Further actions required in the LULUCF sector

To be on track to meet the fourth and fifth carbon budgets, the governments needs to turn proposals into firm policies and put in place new policies with regards to tree planting, including on-farm (Table 6.6). Specifically, this requires:

- Removing the risks associated with funding the short-term target to plant 11 million trees in England by 2022 by ensuring the ongoing review of the (CS) Woodland Creation scheme delivers a fit for purpose scheme; and retaining the recent changes made to the Woodland Carbon Fund for the duration of the scheme.
- A strategy by 2020 for accelerating afforestation rates beyond 2022. This includes ensuring the post-CAP policy framework better links support more closely with tree planting, and other land use measures such as peatland restoration.
- The Welsh Government should set out how it intends to simplify and streamline the process for supporting tree planting, while the Scottish Government should ensure proposals and policies address financial and non-financial barriers.

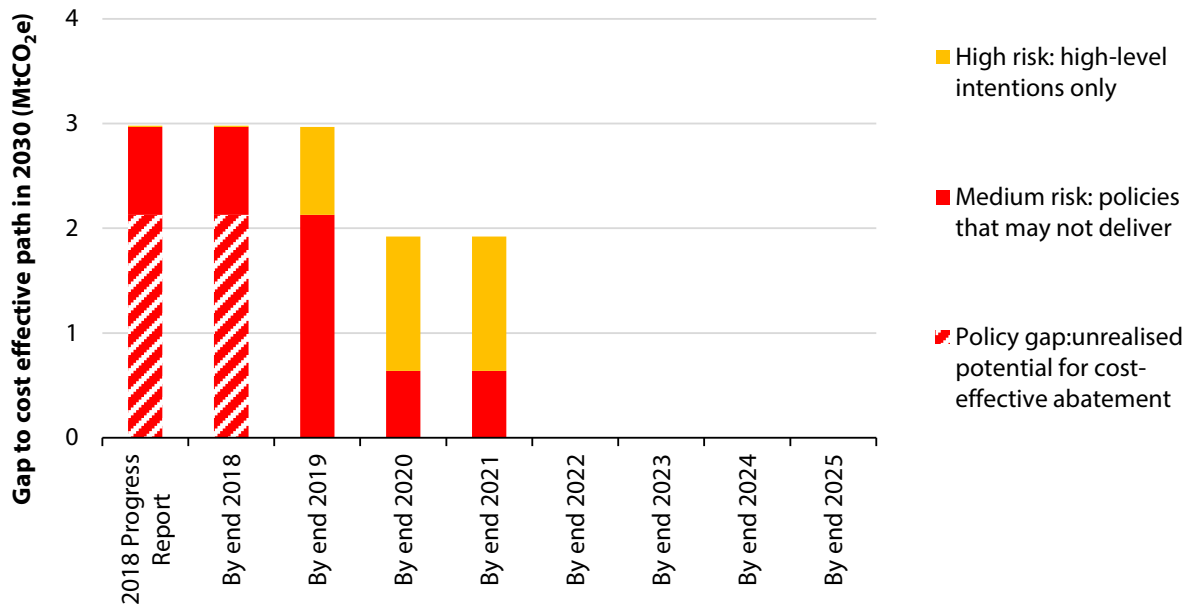
This will enable the removal of policy gap for the fourth carbon budget by 2020 and by 2025 for the fourth and fifth carbon budgets (Figures 6.16 and 6.17).

Figure 6.16. Risks around the delivery of forestry policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the LULUCF sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018), which we have adjusted to reflect the updated inventory methodology. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period.

Figure 6.17. Risks around the delivery of forestry policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the LULUCF sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018), which we have adjusted to reflect the updated inventory methodology. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period.

Table 6.6. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
Set out a post-CAP framework which includes emissions reductions and sequestration in agriculture, forestry, peatland and other land use sectors; with measures being eligible for the awarding of public money.	2019
Accelerate the rate of tree planting in the UK without delay by addressing non-financial and financial barriers to deliver around 20,000 hectares per year across the UK by 2020, rising to 27,000 hectares by 2024, in line with the stated ambition of the countries of the UK**.** This should include:	
• A coherent plan, including funding, to deliver the commitment to plant 11 million trees in England between 2017 and 2022 (equivalent to around 2,000 hectares pa).	2018
• Completing the review and implement necessary changes to the Countryside Stewardship (CS) Woodland Creation scheme, and extending changes made to the Woodland Carbon Fund to the lifetime of the Fund (2020), while ensuring any funds not allocated by 2020 can be rolled forward.	2018
• Over the longer term, develop a strategy, finalise incentives and policies in England and each of the devolved administrations to deliver 27,000 hectares by 2024 across the UK, in line with their stated ambition.	2018-2020

Source: CCC analysis.

Chapter 7: Waste

Key messages and recommendations

Emissions from waste were 19.9 $MtCO_2e$ in 2016, an increase of 0.9 $MtCO_2e$ from 2015. Waste accounts for almost 4% of total UK greenhouse gases (GHGs). They mainly comprise methane emissions from the decomposition of biodegradable waste in landfill sites.

Our key messages are:

- **Emission trends and drivers.** In 2016 waste emissions increased by 0.9 $MtCO_2e$ or 5%. Emissions have decreased by 70% since 1990. This long-term decline has been driven by reduced biological waste going to landfill, investment in methane capture technology and improved management at landfill sites. The increase in 2016 was due to a decline in the level of methane captured at landfill as methane flared decreased.
- **Indicator framework.** Landfill emissions are currently above our path for cost-effective emissions reductions to 2030. Biodegradable waste sent to landfill and methane captured are both off-track compared to our indicators.
- **England is lagging behind Scotland and Wales.** Key indicators such as the amount of recycled waste and separate food waste collection show slower progress in England than the rest of Great Britain. This is indicative of Scotland and Wales having far more ambitious targets in place, backed by required policies.

To meet long-term targets, priority actions should focus on closing the 3.8 $MtCO_2e$ gap to the cost-effective path. This comprises both the need to firm up proposals and intentions and to develop new policies. The priorities for government on development of policies are set out below in Table 7.1.

Table 7.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/ timing
Set out in the new Waste and Resource Strategy a commitment to ban the landfilling of most bio-degradable waste streams including food by 2025 at the very latest.		×	×	Set out a strategy by 2020
Explore new and innovative ways to manage emissions from landfill, including legacy sites in England.		×	Pending results of scoping study	Develop and implement cost-effective policies by 2022
Scotland to finalise and implement policies to meet the targets to reduce waste emissions as set out in its Climate Change Plan.			×	By 2018-2020
Wales to set out policy options to meet its proposed target to halve food waste by 2025.			×	By 2018

Source: CCC analysis.

Introduction

In this chapter we assess emissions trends in the waste sector and review progress towards meeting carbon budgets.

We set out the analysis that underpins our key messages and recommendations in the following sections:

1. Waste emission trends and drivers
2. Waste scenarios and indicators
3. Recent performance in reducing waste emissions compared to required progress
4. Policy implementation
5. Further actions required in the waste sector

1. Waste emissions trends and drivers

Waste emission data lags other sectors by a year, due to the longer time required to collate non-CO_2 emissions data. In this chapter, we focus on the latest emissions data for 2016. This section sets out the change in emissions from 2015 and in the recent past, and the main drivers of change.

Emissions trends

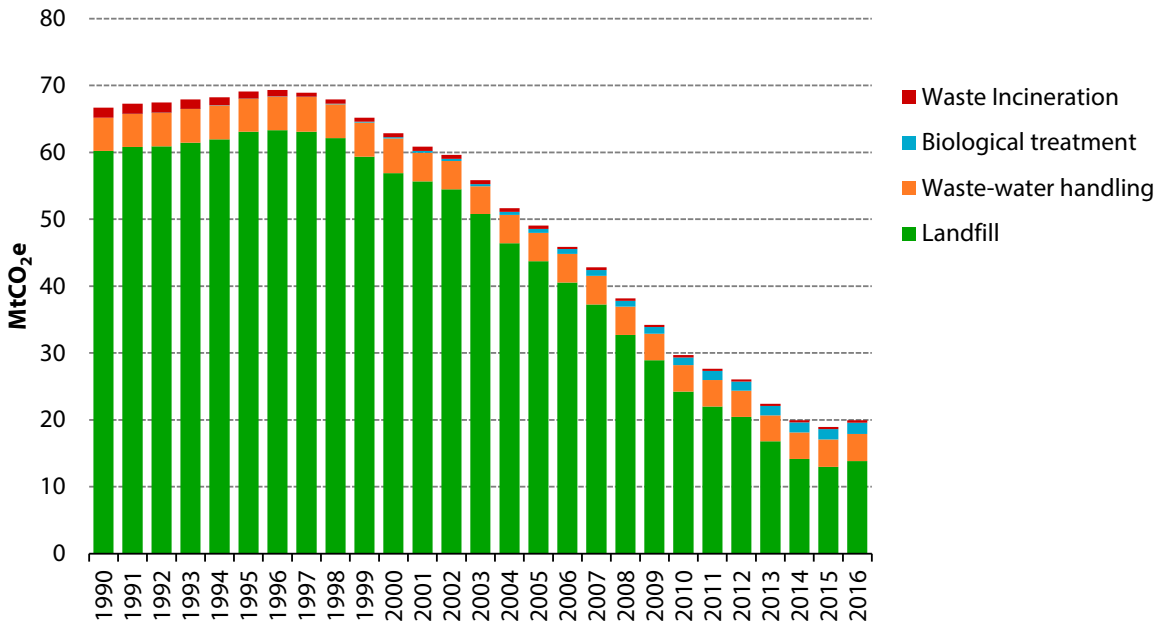
In 2016 waste accounted for 4% of total UK greenhouse gas (GHG) emissions. Waste emissions are predominantly methane (92%) which arise due to the decomposition of biodegradable waste in landfill sites in the absence of oxygen. Emissions also arise due to wastewater treatment, biological treatment and incineration of wastes (Figure 7.1).

Total GHG emissions from waste were 19.9 $MtCO_2e$ in 2016. The long-term trend in emissions has been declining, down 70% since 1990. However, this trend was reversed in 2016 with the inventory reporting a rise in emissions of 0.9 $MtCO_2e$ (5%):

- **Landfill emissions** were 13.8 $MtCO_2e$ in 2016, accounting for 69% of waste emissions and are entirely methane. Landfill emissions increased by 0.8 $MtCO_2e$ (7%) in 2016, accounting for 88% of the increase in waste sector emissions. Since 1990 they have fallen by 77% due to reductions in biodegradable waste going to landfill, investment in methane capture technology and improved management at landfill sites.
- **Wastewater treatment emissions** were 4.1 $MtCO_2e$ in 2016 and were 21% of waste emissions, the second largest source. Wastewater emissions are mainly methane (83%), with the remainder nitrous oxide (N_2O). Emissions were unchanged in 2016, but 2% higher than 2009. Since 1990 they have fallen by 18%.
- **Biological treatment emissions** arising mainly from composting and anaerobic digestion of waste were 1.7 $MtCO_2e$ in 2016, 8.5% of waste emissions. This source represents an increasing share of waste sector emissions (3% in 2009) as emissions have increased (from 1 $MtCO_2e$ in 2009), while landfill and wastewater emissions have reduced.
- **Incineration (without energy recovery) emissions** account for less than 2% (0.3 $MtCO_2e$) of waste emissions and are predominately CO_2. After an annual average 1% decrease over the period 2009-2015, incineration emissions increased by 4% in 2016.

Given their dominance in waste emissions, we focus on methane emissions from landfill.

Figure 7.1. GHG emissions from waste by source (1990-2016)



Source: BEIS (2018) *'Final UK greenhouse gas emissions national statistics 1990-2016'.*

Waste emission drivers – methane from landfill

As part of the ongoing improvement programme, revisions were made to the 2018 GHG waste inventory. These largely centred on the use of new data sources, which provide more accurate estimates of the amount and composition of waste sent to landfill from 2006 onwards.[97] The previous data was particularly unsatisfactory for commercial and industrial waste. The new data sources include the Environment Agency for England and the Scottish Environmental Protection Agency for Scotland. The revision led to minor changes of no more than ±3% in the estimates for generation of methane (pre-capture) from 2006 when comparing the 2017 and 2018 inventories.

Landfill methane emissions are not directly measured, but are estimated based on the quantity of biodegradable waste sent to landfill, assumptions on the properties of waste streams such as methane yield and decay rates, and the quantity of methane emissions avoided at landfill sites:

- **Biodegradable waste sent to landfill.** Estimates suggest that the amount of biodegradable waste landfilled increased by 2% in 2016, following an annual average 8% decrease over the period 2009-2015. The 2016 rise was largely due to a 9% increase in municipal solid waste to landfill and a smaller decline in commercial and industrial waste. Although tonnage increased, methane generation declined by 5% in 2016, as methane arising depends on all waste on the site, not just the amount deposited in the recent year.
- **Methane emissions avoided at landfill sites.** The flaring of methane to CO_2 and the capture for energy are the main abatement measures that landfill operators employ to reduce methane emissions. There is also a small amount of methane that is avoided due to natural oxidisation. Estimates suggest that 66% of methane emissions were avoided in 2016,

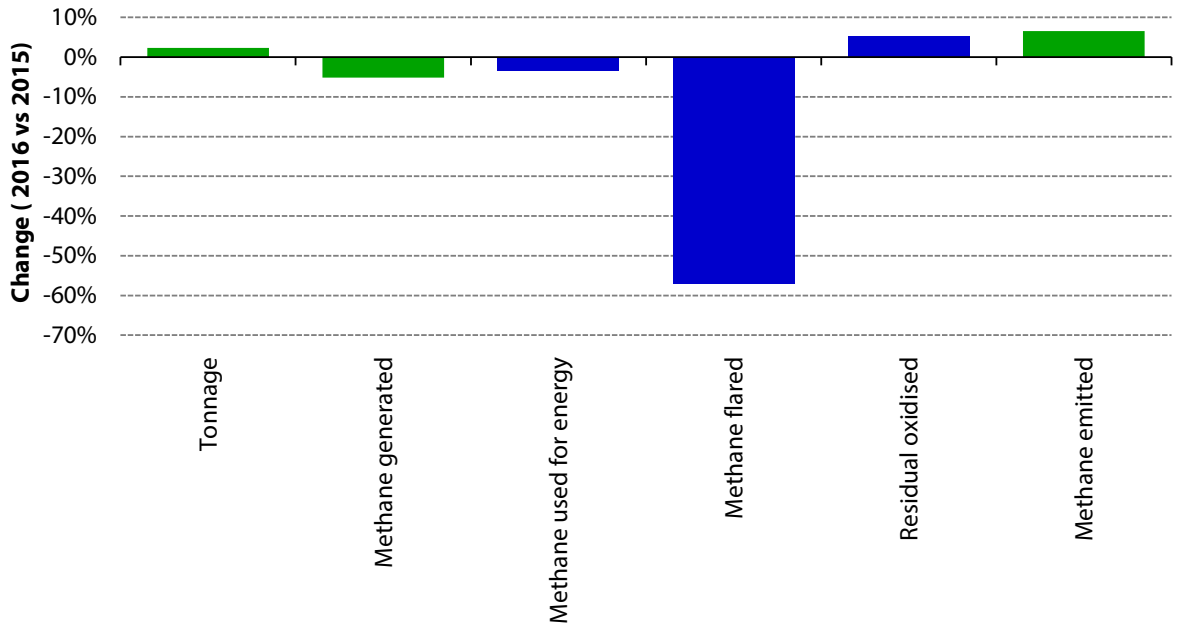
[97] The same data source was retained for the years prior to 2006 based on a report compiled and peer-reviewed on behalf of the UK Government (Eunomia, 2011).

down from 70% in 2015.[98] The decline is attributed to a 57% decrease in the amount of methane that was flared (Figure 7.2):

- The proportion of methane captured for use in energy generation rather than emitted has been rising year-on-year, reaching 58% in 2016, up from 42% in 2009.
- Flaring accounted for around 4% of the methane avoided at landfill sites in 2016, a sharp decline on the record highs of 10% reached in the two previous years. The decline is explained by a more than 50% drop in the average quantity of methane flared per site in England, with levels falling to an average of 454,099 m^3 methane in 2016.
- Residual methane that is oxidised at the landfill site is estimated to average 4% in 2016, up from 3% in 2015.

As a consequence of the reduced level of flaring, the estimated amount of methane emitted from landfill increased by 7% in 2016, reversing the declining long-term trend (Figure 7.3). Without a clear explanation of why the amount of methane flared should have fallen, there is some question about this result. Ricardo, who compile the inventory are investigating the levels of methane flaring in conjunction with the Environment Agency.

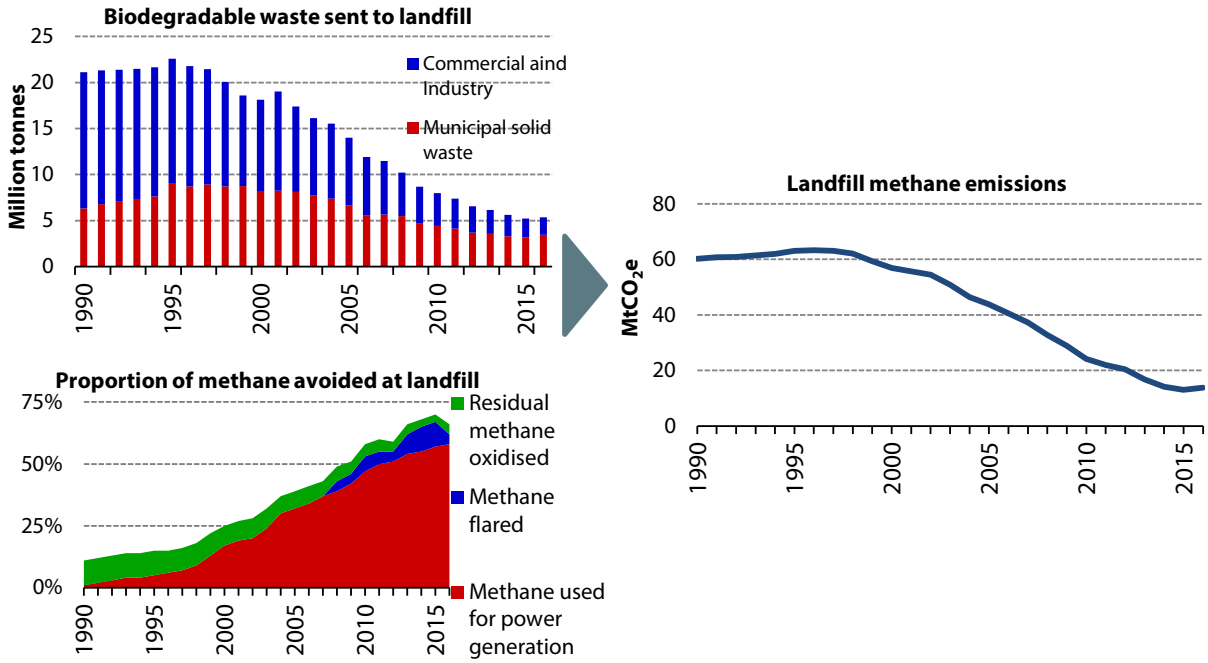
Figure 7.2. Change in biodegradable waste landfilled, methane generated, methane avoided and methane emitted (2016 vs. 2015)



Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016*; Ricardo Energy and Environment (2018) *UK national inventory 2018: Annexes.*

[98] Ricardo Energy and Environment (2018) *UK national inventory 2018: Annexes.*

Figure 7.3. Biodegradable waste, methane emissions avoided at landfill sites and methane emissions from landfill (1990-2016)



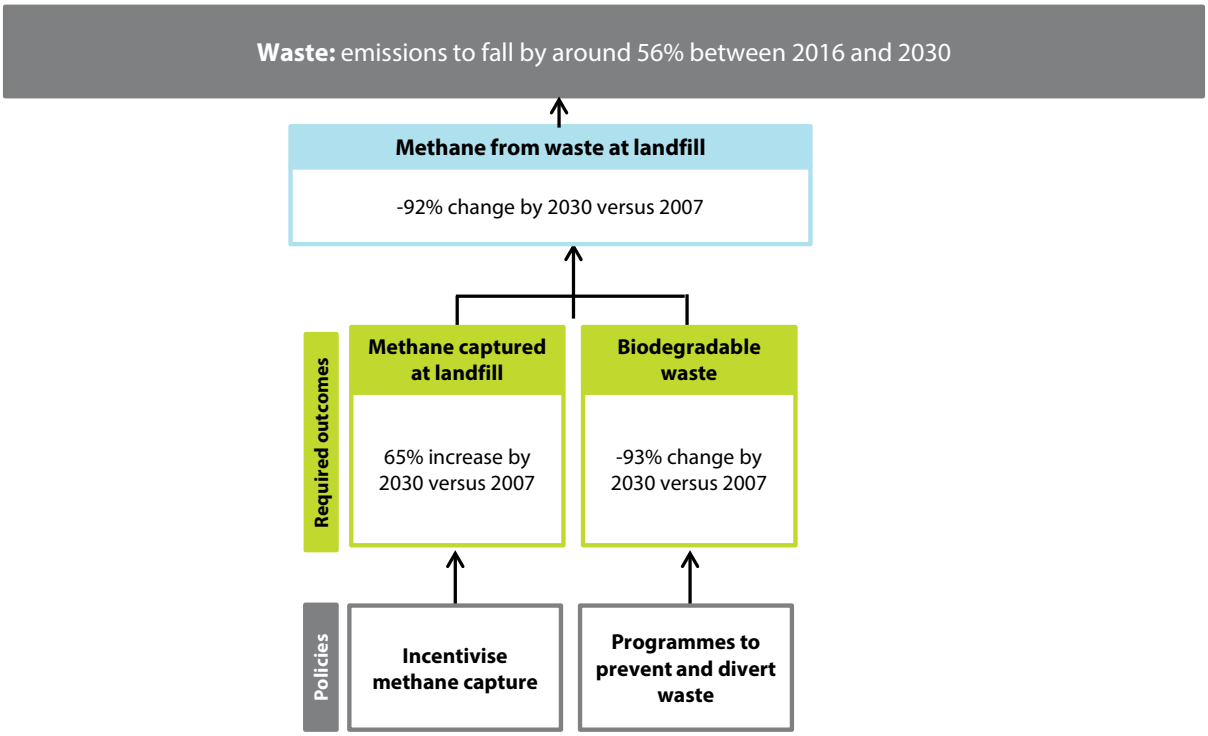
Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016.*
Notes: Biodegradable waste and proportion of landfill methane not avoided do not equal landfill methane emissions. Emissions also depend on methane yield from waste.

2. Waste scenarios and indicators

Our assessment of the cost-effective path to meeting carbon budgets and the 2050 target includes a 56% reduction in waste emissions between 2016 and 2030. Our analysis for the fifth carbon budget focused on opportunities to reduce methane emissions from landfill. We estimated that measures to prevent and divert biodegradable waste streams from landfill could reduce emissions by 4 $MtCO_2e$ by 2030.

To track progress in delivering abatement savings we have developed an indicator framework, which focuses on reducing biodegradable waste going to landfill and increasing the share of captured methane at landfill (Figure 7.4). These indicators track progress both in terms of emissions reduction and also the required policy action to drive the abatement. We report on progress against these indicators in the next section.

Figure 7.4. CCC indicators for the waste sector



Source: CCC analysis.

3. Recent performance in reducing waste emissions compared to required progress

In this section we set out the opportunities to further reduce waste emissions and progress in developing policies to deliver these.

Our indicators reflect a scenario in our fifth carbon budget advice of prevention or diversion of five biodegradable waste streams (food, paper/card, wood, textiles and garden waste) from landfill, across the UK by 2030.[99] As estimated in the latest inventory, progress in reducing emissions from waste reversed in 2016 as landfill emissions and the amount of biodegradable waste sent to landfill increased, while the proportion of methane captured at landfill decreased. All the key indicators are off-track for 2030 (Table 7.2).

[99] CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget.*

Table 7.2. Key outcomes (indicators) to be on track for 2030 (and latest outturn)		
Key outcome	**2016 indicator (Change from 2007)**	**2016 outturn (Change from 2007)**
Reduce landfill GHG emissions by 92% by 2030 from 2007 levels	-71%	-63%
Reduce biodegradable waste sent to landfill by 93% by 2030 from 2007 levels	-61%	-53%
Increase the proportion of methane captured at landfill to 65% in 2030 from 2007 levels	+65%	+62%

Source: BEIS (2018) *Final UK greenhouse gas emissions national statistics 1990-2016;* CCC analysis.
Note: The CCC indicator for the proportion of methane at landfill reaches 65% by 2016.

Emissions reduction has occurred through a combination of information and voluntary programmes to prevent waste, a landfill tax to divert waste from landfill and investment in methane capture technology:

- **Waste prevention.** There is a potential to reduce food waste further. The amount from households that is deemed to be avoidable or under the revised definition 'edible', reached 5m tonnes in 2015 according to estimates from the Waste Reduction Action Programme (WRAP).[100] Voluntary initiatives to reduce food waste include the *'Love food hate waste'* campaign which provides advice and tips to consumers, while *'Courtauld 2025'* is targeting a 20% reduction in waste arising across the food supply chain from producer to consumer.
- **Diversion of biodegradable waste from landfill.** There is significant potential to divert biodegradable waste away from landfill and towards recycling, composting, anaerobic digestion (AD), mechanical biological treatment (MBT) and incineration with energy recovery. The Landfill tax has been the key driver of progress to date. The tax has increased year-on-year to meet targets set by EU Directives to reduce biodegradable waste going to landfill and incentivise methane capture at landfill sites. By April 2017 it had reached £86.10/tonne in England compared to £84.40/tonne a year earlier.
- **Landfill methane capture or flaring.** Methane capture at modern landfill sites is over 80% and can reach as high as 90%. These sites will play a bigger role as legacy emissions from older (and less efficient) landfill sites decline.

Faltering progress in 2016 may reflect more widely on the loss of momentum in waste management with evidence showing that recycling rates have plateaued, which is most apparent in England:

- **Household recycling rates.** There was a small increase in UK household recycling rates to 44.6% in 2016 from 40.2% in 2010. At this pace, meeting the EU target for the UK to recycle at least 50% of household waste by 2020 will not be achieved. A disaggregation by country reveals similarly low rates in England. In contrast, a concerted policy drive in Wales, including

[100] WRAP (2018) *Household food waste: restated data for 2007-2015*. This report restates previously published estimates which have been reinterpreted using the most recent international definitions and classifications relating to food waste.

the introduction of statutory targets and better separate waste collections, has boosted recycling rates from 44% to 56.7% during the same period. Wales is on course to meet its statutory target to recycle 70% of waste by 2025.

- **Separate food waste collection.** There is still no legal requirement on English local authorities to introduce separate food waste collections, which means that food waste collected separately remains a very small proportion of total waste collected, only 1.6% in 2016. Around two-thirds[101] of English local authorities offer food waste collections, although a third of this is mixed in with garden waste. This is lower than in Scotland and Wales where more ambitious action has resulted in much higher collection rates:
  - Over 80% of households in Scotland have access to food waste collection. This equates to around 1.95m households, up from just over 0.5m households in 2013.
  - All local authorities in Wales collect separate food waste.

Aside from actions in Scotland and Wales, there may be lessons to learn from experience in other countries. A combination of regulation and innovative measures has, for example, led to a transformation of food waste awareness and collection in South Korea (Box 7.1).

The Government has acknowledged that more needs to be done to encourage local authorities to increase food waste collection. Details on how to do so are expected to be outlined in the new Resource and Waste Strategy, which should be published later this year.

It is imperative that the policy framework, particularly in England, is strengthened, and that not only is separate food waste collection offered by local authorities as standard, but that more is done to encourage people to make use of it.

Box 7.1. Food recycling policy in South Korea

Food waste has long been a significant problem in South Korea, especially as its traditional food requires a large number of small dishes. Over the last two decades the South Korean government has launched various programmes aiming at raising awareness. These include:

- A recycling programme, established in 1998 and revamped in 2004, demanding the collection of food waste in residential areas and from other sources such as restaurants.
- A ban on food waste going to landfill in 2005.
- A co-operative waste reduction programme between government departments and different sectors such as hotels, restaurants and schools. They were encouraged to use fewer small side-dish plates and adopt waste saving strategies such as 'no-leftover days' and eco-friendly menus.
- A volume-based food waste fee system introduced in 2010, e.g. 'pay-as-you-throw' solutions and food-waste bins with magnetic card-readers for use by households when disposing of their waste, with a monthly weight-related fee.

The mix of food waste reduction measures have had a large impact on raising consumer awareness and on the environment. Food recycling rates rose from 2% in 1995 to 95% in 2009, and food waste going to landfill has decreased drastically. Food waste is being turned into compost, livestock feed and biomass and biofuels. The mix of policies involving regulations and standards with voluntary measures is highly successful; it is an approach that is transferrable and scalable to European regions.

Source: Innovation seeds (EU) http://www.innovationseeds.eu/success-stories/success-stories.kl

[101] WRAP (2015) *Local Authority Scheme Data 2017/18.*

4. Policy implementation

Policy has been successful in making deep cuts in waste emissions over the long term, but continued progress will need further actions throughout the waste chain (i.e. through waste prevention, separation, diversion from landfill and avoidance of methane released at landfill sites).

Waste management is a devolved issue, with England and each of the devolved administrations developing waste strategies and legislating waste measures. Since last year's progress report there have been no new policies. However, a number of proposals and ambitions have been announced.

The Clean Growth Strategy (CGS)

Although the Government's CGS set out the strategy for decarbonising all sectors of the UK economy through the 2020s, proposals for emissions reductions in waste focused on England only:

- **An overall ambition for England and the rest of the UK to be a zero avoidable waste economy by 2050** by maximising the value we extract from our resources, and minimising the negative environmental and carbon impacts associated with their extraction, use and disposal.
- **Work towards no food waste entering landfill by 2030** by supporting local authorities to introduce separate food waste collection and encourage people to make use of it.
- **Explore innovative ways to manage emissions from landfill, including legacy sites.** Defra is exploring methods to manage the aftercare of sites that have closed, and that will close in the future and still require management of the waste. A scoping study to understand the scale of the issue with regards to legacy sites is due to be published this year.

Specific policies will be set out in the Resources and Waste Strategy. This is intended to deliver on the ambition set out in the 25 Year Environment Plan, to work towards eliminating all avoidable waste by 2050.

Devolved administrations

In the DAs, proposals are far more ambitious than in England:

- **Scotland:** The Climate Change Plan (CCP) sets out the Scottish Government's plan to meet its emissions reduction target over the next 15 years.[102] It expects waste emissions to fall by 52% during the period, which equates to abatement of 0.6 $MtCO_2e$ by 2032. This level of reduction is consistent with our fifth carbon budget estimates from Scottish specific waste policies. Achieving these savings is based on delivering the following targets:
  - Phasing out the landfilling of biodegradable municipal waste by 2021, and reducing all waste sent to landfill to 5% by 2025.
  - A 50% reduction in food waste by 2030.
  - Increase recycling of waste to 70% by 2050.
  - Where possible, emissions from closed landfill sites will be captured.

[102] Scottish Government (2018) *Climate Change Plan: Third report on proposals and policies 2018-2032.*

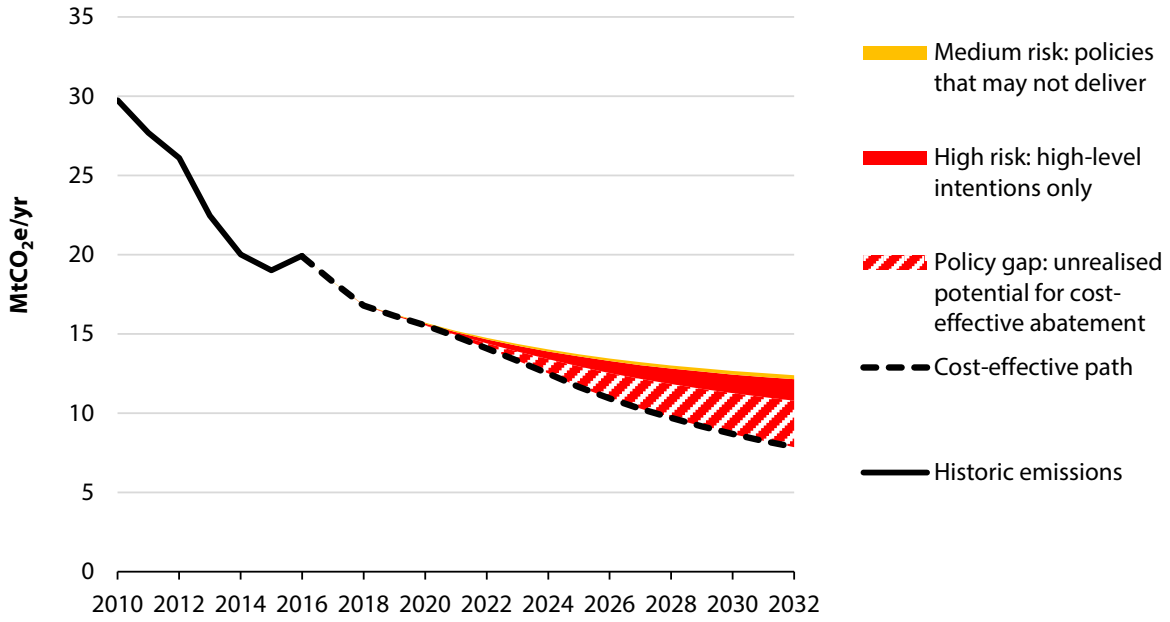
The plan is to use a mix of policies with possible regulation requiring businesses and local authorities to ban biodegradable waste going to landfill.

- **Wales:** An updated waste strategy for Wales is due later this year. This is expected to set out a new target beyond 2025 that goes further than the current statutory target to recycle 70% of waste by 2025, which Wales is on course to meet. As part of this, there will be a consultation on a target to halve food waste by 2025. WRAP is currently scoping out options on what the food waste target could cover (i.e. all food waste or just inedible food waste) and the baseline for each option.

The high-level intentions outlined in the Clean Growth Strategy and Scotland's Climate Change Plan only account for an estimated 30% of potential savings we estimated in our fifth carbon budget assessment by 2030, equivalent to 1.2 $MtCO_2e$. Of this, 0.65 $MtCO_2e$ can be attributed to our estimate as to how much the banning of food waste to landfill could deliver, and the remainder is derived from Scotland's waste reduction target set out in the Climate Change Plan.

Even with the development of firm policies to meet those intentions, a policy gap of around 2.6 $MtCO_2e$ remains to the cost-effective path (Figure 7.5).

Figure 7.5. Risks around the delivery of waste policies to meet the cost-effective path



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018*) Final UK greenhouse gas emissions national statistics 1990-2016*; CCC analysis.
Notes: The top of the yellow area in the chart represents baseline emissions (based on the latest Government emissions projections published in January 2018), which we have adjusted to reflect the latest inventory method. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'. We have assessed emission reductions from proposals and intentions that were included in the Clean Growth Strategy, which are included as 'high risk'. There remains potential for cost-effective emissions reduction, which we include as the 'policy gap' to the cost-effective path.

Wastewater treatment

Abatement from sources of waste emissions other than landfill are not currently included in our cost-effective path, but we will consider potential savings from other waste sources in the future. Water companies are already deploying measures to reduce waste emissions by improving the efficiency of the processes used for treating sewage sludge. Plans by Thames Water to roll out an advanced energy recovery pyrolysis process in the next few years could result in a step-change in the amount of energy that can be captured, which could result in a further fall in methane emissions (Box 7.2).

However, estimates of methane emissions in this sector are uncertain due to the use of IPCC default emissions factors, which tend to be higher than country specific ones and limitations in available UK data. Estimates are likely to be too high and further work is needed to improve the accuracy of measuring wastewater emissions and potential future emissions savings.

Box 7.2. Treatment of sewage sludge in the waste water sector

All water companies have a licence condition to treat sewage sludge (e.g. by anaerobic digestion (AD)), and it is the treatment process which is main source of emissions in the waste water sector:

- Conventional AD captures about 40% of the potential methane, and the remainder is emitted as fugitive emissions on site, and from the digestate that is produced as a co-product as fertiliser for farms.
- Use of thermal hydrolysis AD captures a further 10% of potential energy, and therefore more biogas is produced and less methane emitted.

Plans in place by Thames Water to build and test its first pyrolysis plant could deliver higher capture rates. The company sees this as a 'world's first' and a step-change for the treatment of sewage sludge, which will be heated up to 800°C in the absence of oxygen to produce a fuel gas that is hydrogen rich. To prove the process, a three-year pilot at Crossness sewage plant, processing sewage sludge from over 450,000 people, is due to be commissioned later this year.

Source: Thames Water.

5. Further actions required in the waste sector

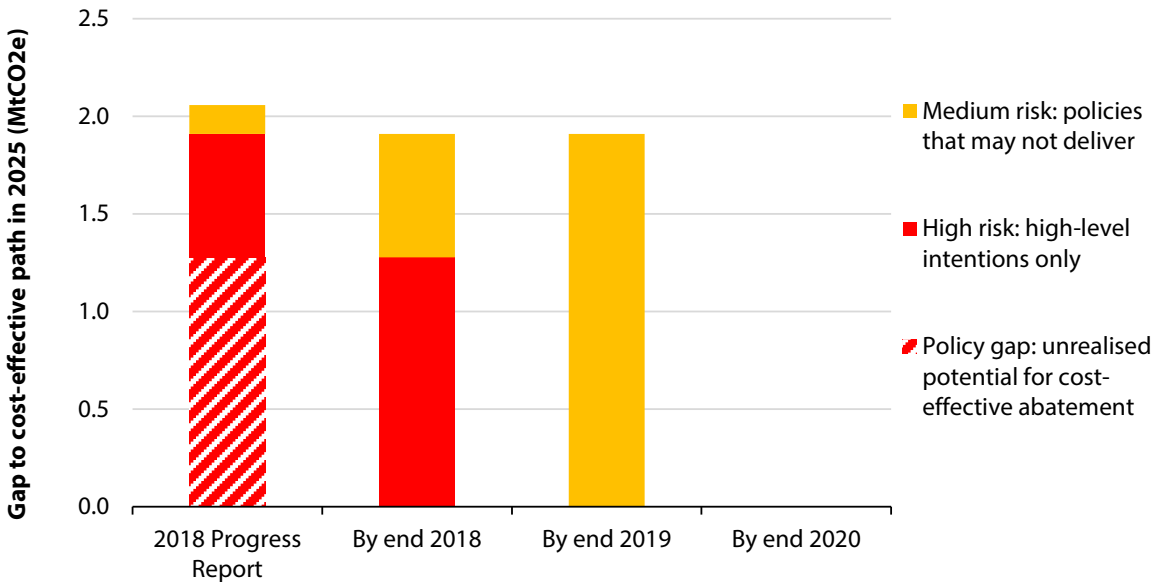
To be on track to meet the cost-effective path for carbon budgets and long-term targets, the Government needs to turn proposals into firm policies and put in place new policies (Table 7.3). Specifically, this requires:

- **Mandating a landfill ban of most bio-degradable material no later than 2025.** Ban five waste streams - food, paper/card, wood, textiles and garden waste - from going to landfill. This requires setting out a commitment in this year's Resources and Waste Strategy, and specific strategies on how to reduce each of the five waste streams from households and businesses by 2020.
- **Managing emissions from legacy sites.** The scoping study this year will seek to quantify the size of the problem, and potential methods to deal with after care. Pending the results of the study, field trials to ascertain the viability of methods should be conducted soon after to identify cost-effective abatement.

- **Scottish Climate Change Plan.** Develop policies to meet the targets to reduce waste emissions as set out in its Climate Change Plan.
- **Wales proposed target to halve food waste by 2025** should outline policy options to deliver this as part of its updated waste strategy to be published later this year.

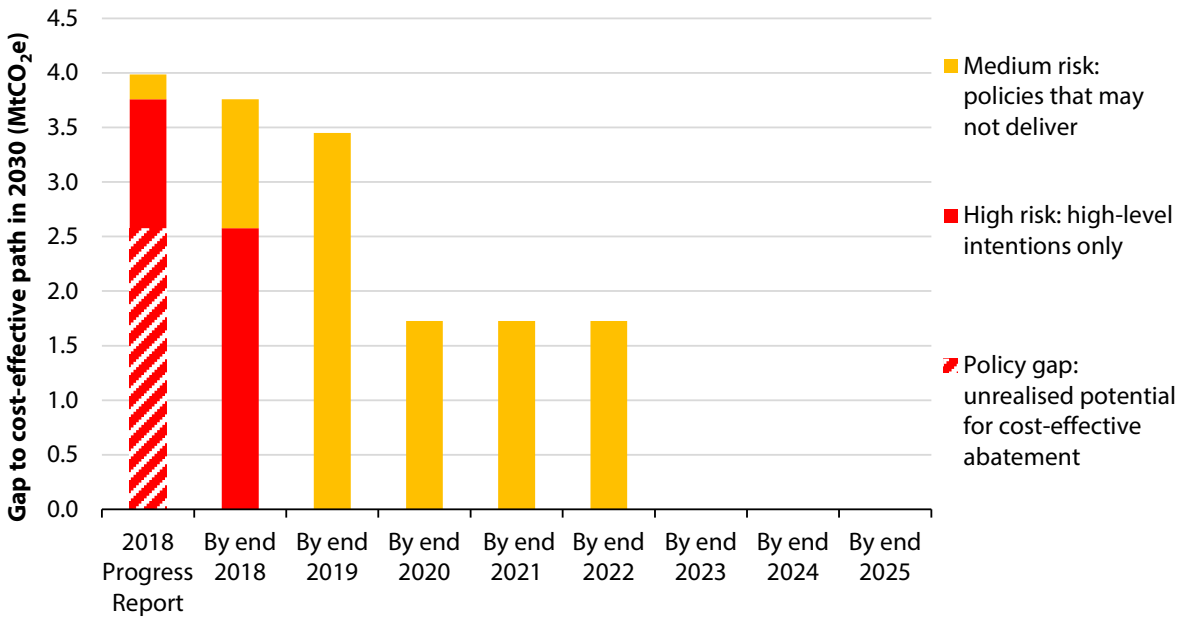
The Government should remove the policy gap for the fourth carbon budget by 2020 and by 2025 for the fifth carbon budget. Figures 7.6 and 7.7 show how our assessment of the policy gaps for 2025 and 2030 should evolve over time. Existing policies with delivery risks, policy proposals, and further new policies all need to become low-risk policies.

Figure 7.6. Risks around the delivery of waste policies in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections* 2017; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the waste sector need to be firmed up in order to close the gap to the cost-effective path by 2020. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2020, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period.

Figure 7.7. Risks around the delivery of waste policies in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how current policies, proposals and intentions for the waste sector need to be firmed up in order to close the gap to the cost-effective path by 2025. The chart is based on an assessment of the current status of policies, proposals and intentions, and the potential actions required to strengthen policy by 2025, using the latest Government emissions projections (January 2018). The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period.

Table 7.3. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key action required	Timing
In England, ban the landfilling of most bio-degradable waste streams including food by 2025 at the very latest: • Set out the commitment • Defra to publish specific strategies to meet the commitment for each of the main bio-degradable waste sources	2018 By 2020
Explore new and innovative ways to manage emissions from landfill from legacy sites • Publish scoping study • Pending scoping study, initiate field trials/further research to assess best methods in management and aftercare • Pending the results of field trials/ further research, develop and implement cost-effective policies	2018 2019 By 2022
Scottish Climate Change Plan Scotland to finalise and implement policies to meet the targets to reduce waste emissions as set out in its Climate Change Plan, covering: • Phasing out the landfilling of biodegradable municipal waste by 2021, and reduce all waste sent to landfill to 5% by 2025 • A 50% reduction in food waste by 2030 • Increase recycling of waste to 70% by 2050 • Where possible, emissions from closed landfill sites will be captured	By 2018-2020
Wales Set out policy options to meet its proposed target to halve food waste by 2025 in this year's updated waste strategy.	2018

Source: CCC analysis.

Chapter 8: F-gases

Key messages and recommendations

Fluorinated gases (F-gases) accounted for around 3% of total UK greenhouse gas emissions in 2016. While F-gas emissions come from various applications, they are mainly used as refrigerants in air conditioning and refrigerators, and are typically released due to leakage from appliances. F-gas emissions are reported with a one-year lag compared to sectors where CO_2 is the main source of GHG emissions.

Our key messages for the F-gas sector are:

- **F-gas emissions fell by 4% in 2016,** which is short of the 6% fall in emissions indicated in our existing cost-effective path to meeting carbon budgets and long-term targets.
- **There is cost-effective potential to reduce F-gas emissions further and faster than the pace of the existing EU F-gas Regulation.** Last year, we recommended that the Government should review cost-effective opportunities to exceed regulatory minimums on F-gas abatement. Since then, we have commissioned a study which shows there is cost-effective potential to go beyond the ambition of the F-gas Regulation.
  - There is modest potential to reduce refrigeration and air conditioning emissions further and faster than the EU F-gas Regulation. This potential lies in deploying equipment that can use low- Global Warming Potential (GWP) refrigerants (e.g. hydrocarbons or CO_2), replacing the high-GWP refrigerants in some existing equipment and reducing leakage rates further.
  - There are alternatives available to metered-dose inhalers that use high-GWP propellants. These alternatives maintain the clinical effectiveness of existing inhalers and alternatives are already more widely used in most other European countries. Abatement from using these alternatives is estimated to be cost-effective. It would be feasible and cost effective to switch to 50% low-GHG inhalers by 2022 and to reduce emissions from metered dose inhalers by at least 90% by 2027.

To be on track to meet the fourth and fifth carbon budgets and enable all cost-effective abatement, the Government needs to address the delivery risks to the F-gas Regulation presented by leaving the EU and create policy to enable further and faster F-gas abatement in line with the available cost-effective opportunities (Table 8.1).

Key messages and recommendations

Table 8.1. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Key actions required	Committed to in Clean Growth Strategy	In Clean Growth Strategy but more detail required	New policy required	Actions/ timing
Continue the UK's inclusion in the EU F-gas Regulation, or develop equivalent or stronger legislation in the UK.		×		Spring 2019
Publish a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives. The Government should publish a plan to achieve the cost-effective abatement that goes beyond the ambition of the existing F-gas Regulation. This should: • Set out an approach to reduce emissions from refrigeration and air conditioning further and faster than the ambition of the F-gas Regulation, in line with the cost-effective potential identified in our new analysis. • Set out an approach to enable 50% of inhalers to be low-GHG by 2022 and to reduce emissions from metered-dose inhalers by at least 90% by 2027.			×	Set out approach by spring 2019

Introduction

In this chapter we review progress in reducing F-gas emissions at domestic and international levels, as well as existing evidence on opportunities to reduce F-gas emissions further and the expected level of reduction by 2030. We summarise the analysis that underpins our key messages and recommendations in the following five sections:

1. F-gas emissions trends and drivers
2. F-gas scenarios and indicators
3. Recent performance in reducing F-gas emissions compared to required progress
4. Policy actions
5. Further progress required in the F-gas sector

1. F-gas emissions trends and drivers

Background

F-gas emission levels were around 16 $MtCO_2e$ in 2016, accounting for 3% of total UK GHG emissions (Figure 8.1). F-gas emission levels are 7% below 1990 levels.

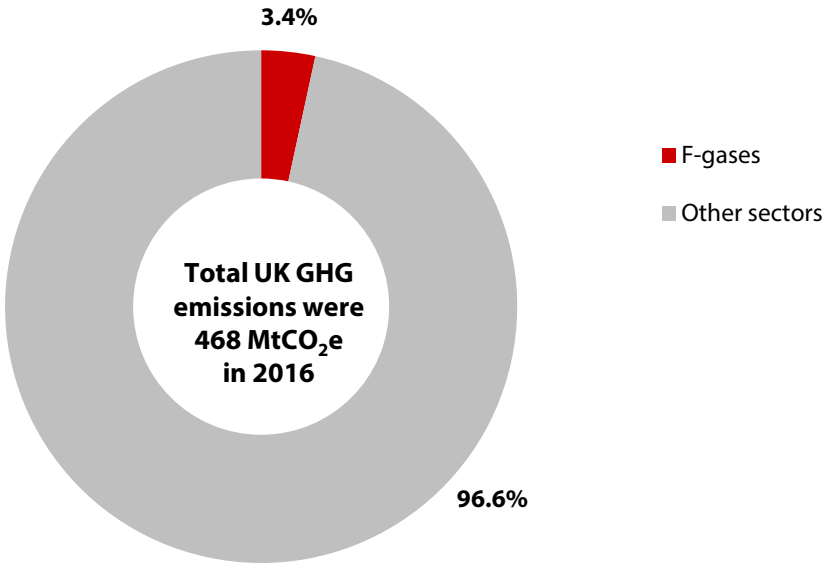
The main source of emissions is the leakage of F-gases from refrigeration and air-conditioning systems, which have mainly used hydrofluorocarbons (HFCs) since the use of ozone-depleting chlorofluorocarbons (CFCs) was phased-out. Other F-gas emissions come from aerosols, metered-dose inhalers, which are applied for respiratory disorders (e.g. asthma), and fire-fighting equipment.

F-gases are released in small amounts. However, they are very effective at trapping heat and some of them will remain in the air for many centuries after their release. As a result, they have a relatively high climate impact per molecule, which is reflected in the high Global Warming Potentials (GWPs) used in international emissions accounting. The four reported F-gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3):

- **HFCs** (95% of total emissions) are used in refrigeration, air-conditioning appliances, aerosols and foams, metered-dose inhalers and fire equipment. They are emitted during the manufacture, lifetime and disposal of these products and can stay in the atmosphere for up to 270 years.
- **SF_6** (3%) is mainly used in insulation for electricity networks, magnesium casting and military applications. It stays in the atmosphere for around 3,000 years.
- **PFC** emissions (2%) result mainly from the manufacture of electronics and sporting goods. They are also a by-product of aluminium and halocarbon production. Their lifetime in the atmosphere ranges from 2,600 to 50,000 years.
- **NF_3** emissions are currently very low and result from semi-conductor manufacturing. NF_3 stays in the atmosphere for around 700 years.

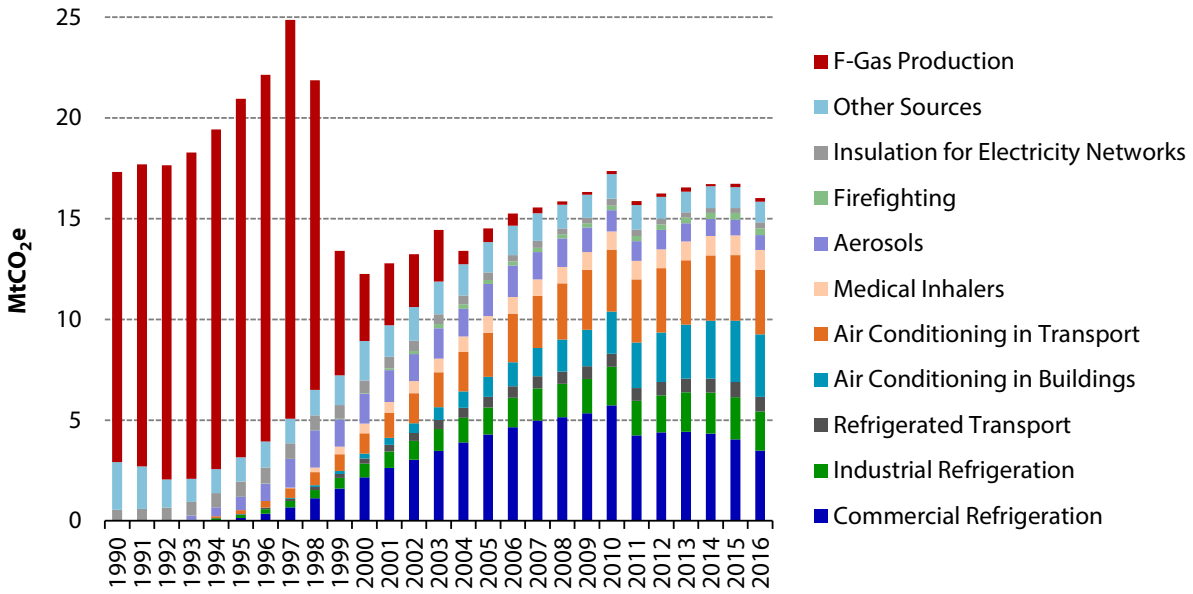
Total F-gas emissions peaked in 1997, reaching 25 $MtCO_2e$, when 80% of emissions were due to F-gas production. Between 1997 and 2000, F-gas emissions dropped significantly as a result of the fitting of abatement equipment to the plants producing F-gases. Since 2001, F-gas emissions have been slowly rising again, mainly because of increasing use in air conditioning and refrigeration appliances (Figure 8.2).

Figure 8.1. F-gas emissions as share of UK total GHGs (2016)



Source: CCC analysis, National Atmospheric Emissions Inventory (NAEI).

Figure 8.2. GHG emissions from F-gases by source and type of gas (1990-2016)



Source: CCC analysis, National Atmospheric Emissions Inventory (NAEI).

Emission trends

In 2016, F-gas emissions fell 4%, following average annual growth of 0.4% between 2009 and 2015. The main driver of 2016's fall was the 2014 EU F-gas Regulation. The preceding rise was driven by increasing demand for F-gases in refrigeration and air conditioning, although this was partially offset by the 2006 EU F-gas Regulation:

- **Stationary refrigeration (35% of the total).** The main source of F-gases fell by 12% between 2015 and 2016, driven by the 2014 F-gas Regulation. Emissions reached a peak of 7.9 $MtCO_2e$ in 2010 and showed an average 3% reduction over the period 2009-2015. The decline after 2009 is likely to be the result of the 2006 EU F-gas Regulation.
- **Air conditioning**[103] **and refrigeration in transport (25%).** These fell by around 2% in 2016. This followed average annual growth of 2% between 2009 and 2015.
- **Air conditioning of buildings (19%).** These have been growing strongly recently: a 2% increase in 2016 following 9% annual average growth over the period 2009-2015, driven by increased demand for air conditioning.
- **Metered-dose inhalers (6%).** These are medical aerosols used to dispense drugs used for lung diseases such as asthma. Emissions from metered-dose inhalers increased by around 1% in 2016, following annual average increases of 2% over the period 2009-2015.
- **Aerosols (5%).** These decreased by around 7% in 2016, in line with annual average falls over the period 2009-2015.
- **Firefighting, foams, insulation for electricity networks and other (11%).** These rose by around 5% in 2016, following annual average increases of 2% over the period 2009-2015.

In summary, while emissions from air conditioning of buildings and medical inhalers continued to increase in 2016, as a result of continued increases in demand, emissions from air conditioning in transport and all refrigeration started or continued to fall because of the 2014 EU F-gas Regulation.

[103] Air-conditioning systems for cars, light commercial vehicles, trucks, buses, coaches, trailers and railcars.

2. F-gas scenarios and indicators

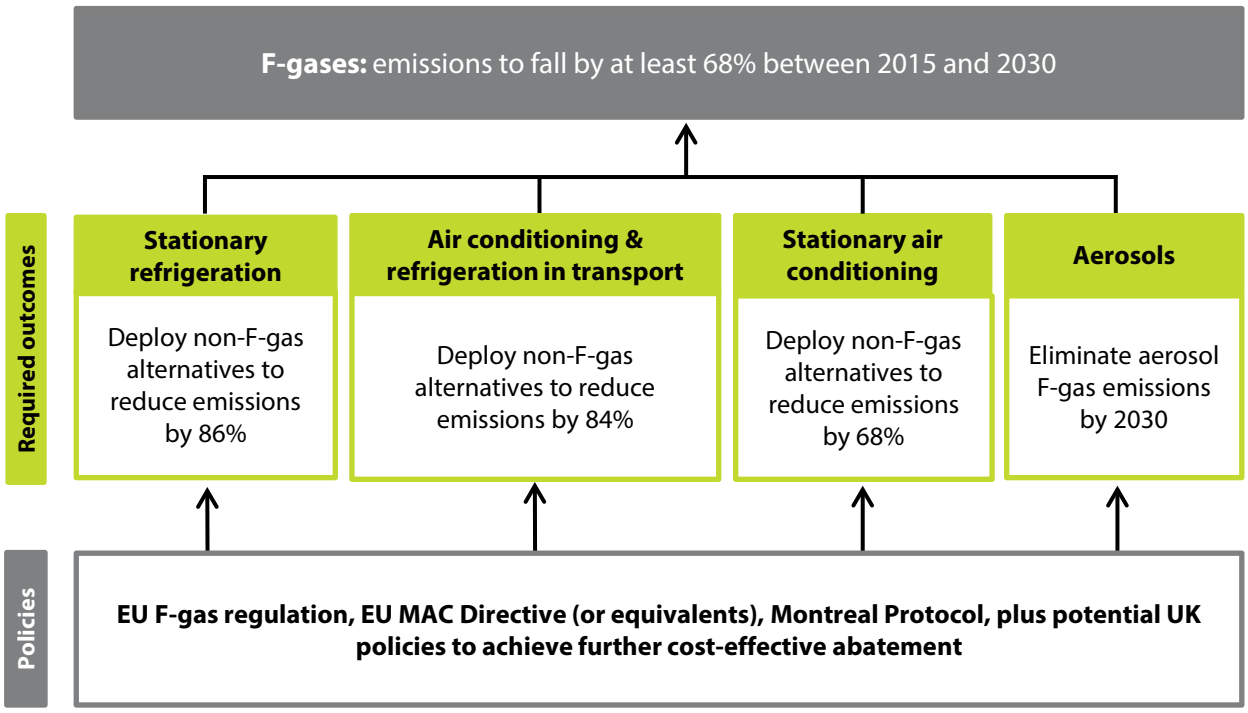
This section outlines the existing indicators against which we track progress. It also details our plan to set out a new cost-effective path, based on new evidence, against which we will track progress in next year's progress report.

Indicators for tracking progress on reducing F-gas emissions

Reducing F-gas emissions cost-effectively to 2030 will require the use of alternatives to F-gases in most applications. For most of these cases the alternative technologies are already available, while a small number of the alternatives need further development to be commercially viable.

We have an existing framework of indicators for changes to emissions in line with the central scenario from our fifth carbon budget advice, as well as expected policy drivers for this change (Figure 8.3).[104] These changes reflect our understanding of the impacts of EU F-gas Regulation, which provides significant cost-effective reductions to F-gas emissions. In this scenario, F-gas emissions fall from around 16 $MtCO_2e$ in 2016 to around 5 $MtCO_2e$ in 2030. We track progress against these indicators below (Section 3).

Figure 8.3. CCC indicators for the F-gas sector



Source: CCC analysis.
Notes: Indicators to be updated based on our new analysis for the 2019 Progress Report.

[104] For more detail see CCC (2015) *Sectoral Scenarios for the Fifth Carbon Budget*, Chapter 7, p. 210.

Updated cost effective path for future tracking in the 2019 Progress Report

This year we commissioned work to inform our assessment of the available and cost-effective opportunities to reduce UK F-gas emissions (Box 8.1). This assessment will inform the development of a new cost-effective path against which we will track progress from the 2019 progress report onwards. The initial analysis shows that there is more cost-effective potential than we had accounted for in our existing path to meeting carbon budgets and long-term targets. This includes faster abatement from the refrigeration, air conditioning and heat pump sectors and new abatement from medical inhalers. We plan to publish the new path in our upcoming Long-Term Targets report in 2019.

Box 8.1. New analysis of cost-effective abatement in the F-gas sector

In February 2018 we commissioned Ricardo and Gluckman Consulting to investigate the potential to reduce F-gas emissions further and faster than the existing F-gas Regulation. The work has considered the cost of abatement measures, non-financial barriers and potential rates of uptake. The results from this work show that:

- There is cost-effective potential to reduce F-gas emissions further and faster than the pace of the existing EU F-gas Regulation.
- There is modest potential to reduce refrigeration and air conditioning emissions further and faster than the EU F-gas Regulation. This potential lies in deploying equipment that can use lower-GWP refrigerants (e.g. hydrocarbons or CO_2), replacing the high-GWP refrigerants in some existing equipment with lower-GWP refrigerants, and reducing leakage rates further.
- In the small-medium building air-conditioning market, ultra-low-GWP non-flammable replacement refrigerants are not available at present and industry has not started to develop these refrigerants. However, experience in the car air-conditioning market suggests that there could be potential to develop these alternative refrigerants.
- There are alternatives available to metered-dose inhalers (MDIs) that use high-GWP propellants. These alternatives maintain the clinical effectiveness of existing inhalers. The potential alternatives include dry-powder inhalers and MDIs with a low-GWP propellant. Indeed, dry-powder inhalers are already used more than MDIs in most European countries. For around 20% of MDI sales, the low-GHG alternative is cheaper (i.e. there is no cost of abatement). It would be feasible and cost-effective to switch to 50% low-GHG inhalers by 2022, from current levels of around 25% and to reduce emissions from metered dose inhalers by at least 90% by 2027 from 2016 levels.
- The cost of abating emissions from the insulation of electricity networks appears high, with current technology.

We will publish further detail shortly in the report entitled 'Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment'.

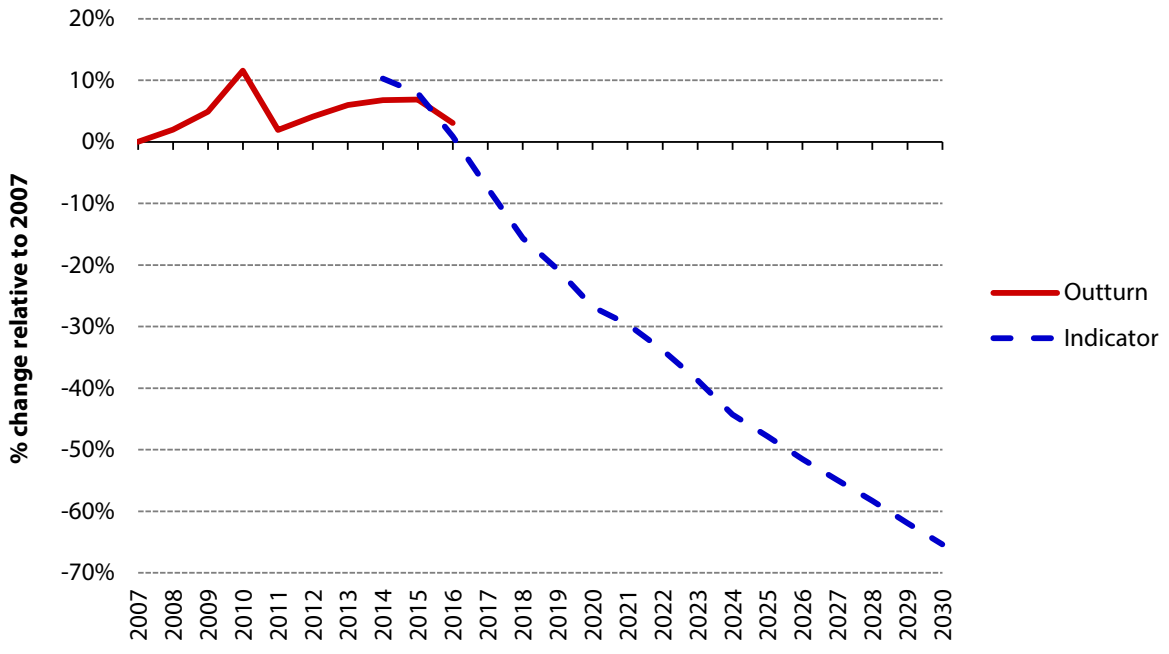
Source: Ricardo and Gluckman Consulting (2018) *Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment.*

3. Recent performance in reducing F-gas emissions compared to required progress

The level of F-gas emissions in 2016 was above our indicator trajectory for meeting carbon budgets (Figure 8.4). This was because emissions from stationary refrigeration and aerosols fell at slower rates than our indicator for these sources (Table 8.2). Emissions from air conditioning and refrigeration in transport, and stationary air conditioning were all at levels in line with our indicator pathways.

The slower overall progress with F-gas emission reductions shows that 2016 reductions are behind those projected under existing policy by the Government. This includes slower progress in HFC emissions reductions, which are being phased down by the EU F-Gas regulation. We do not have clear evidence to explain the slower progress on HFC emissions, but the impact of the EU F-gas Regulation may have been less than expected because: F-gases were stockpiled before the start of the F-gas Regulation, so that there is more F-gas in the market than projected; or UK-based companies are retaining a higher proportion of their F-gas quota than expected or are buying quota from EU-27-based countries; or there has been higher leakage from the appliance stock this year, which will subsequently be offset by lower leakage in later years.[105] We will continue to monitor progress in this area; this initial slower progress raises a concern that the UK will not achieve the emissions reductions projected by the Government.

Figure 8.4. F-gas emissions indicator trajectory (2007-2030)



Source: CCC analysis, National Atmospheric Emissions Inventory

[105] Since the F-gas Regulation limits the amount of F-gases placed on the market rather than the amount emitted at a point in time.

Table 8.2. Key outcomes (indicators) to be on track for 2030 (and latest outturn)

Indicator	2016 indicator (change on 2007)	2016 outturn (change on 2007)	2030 indicator (change on 2007)
Total F-gas emissions	+1%	+3%	-65%
Stationary refrigeration emissions	-17%	-16%	-87%
Air conditioning and refrigeration in transport emissions	+23%	+23%	-80%
Stationary air conditioning emissions	+122%	+122%	-29%
Aerosol emissions	-55%	-46%	-100%

Source: NAEI, CCC analysis.

4. Policy implementation

Effective policy on F-gases should aim to bring forward the cost-effective abatement outlined above (Section 2). In this section we set out and then assess the Government's policies on reducing F-gas emissions.

Current policy

There are three main policies to drive reduction in F-gas emissions. These are the 2014 EU F-gas Regulation, the Mobile Air Conditioning (MAC) Directive and the Kigali Amendment to the Montreal Protocol:

- The 2014 EU F-gas Regulation came into force in the UK in January 2015. It introduced a number of new measures and strengthened the measures in 2006 EU F-gas Regulation:
  - It caps the amount of HFCs that producers and importers are allowed to place on the EU market.[106] The initial EU-wide cap in 2015 matched the average level of F-gases placed on the market between 2009 and 2012. Subsequently it was cut by 7% in 2016 and then a further 30 percentage points in 2018. The cap is to be incrementally cut every three years until reaching a 79% cut by 2030 from 2015 levels. Some uses of HFCs are exempted from the regulation, including their use in metered-dose inhalers, military equipment and manufacturing of semiconductors.
  - The regulation introduces bans for some new equipment. These bans cover areas including domestic and imported refrigerators and freezers or air-conditioning systems. For example, domestic refrigerators and freezers have not been allowed to use refrigerants with GWP above 150 from 2015.[107]
  - The regulation introduced a new ban for the maintenance and servicing of existing refrigeration appliances, the ban applying to refrigeration containing HFCs with a GWP above 2,500 from 2020.
  - The regulation also strengthens existing obligations in terms of leak checking and repairs, F-gas recovery and technician training.
- The MAC Directive focuses on emissions from air conditioning in new cars and vans, and has been in force since 2011. Since 2017, it has required all new cars and vans to use substances with a GWP less than 150.
- The Kigali Amendment to the UN Montreal Protocol sets out pathways for developed and developing countries for controlling the production and consumption of HFCs, similar to the EU F-gas Regulation. Under the amendment HFCs in developed countries will be reduced through incremental targets up to a cut of 86% by 2036. These plans are less stringent than the EU F-gas Regulation up to 2034, after which the Kigali Amendment targets are currently more ambitious. This may not remain the case as the EU plans to consider an extension of the ambition of the F-gas Regulation beyond 2030 in 2022. The UK ratified the Kigali Amendment in November 2017 and the amendment will take effect in January 2019.

In addition to these policies, emissions of PFCs from aluminium production are priced, under the EU Emissions Trading System.

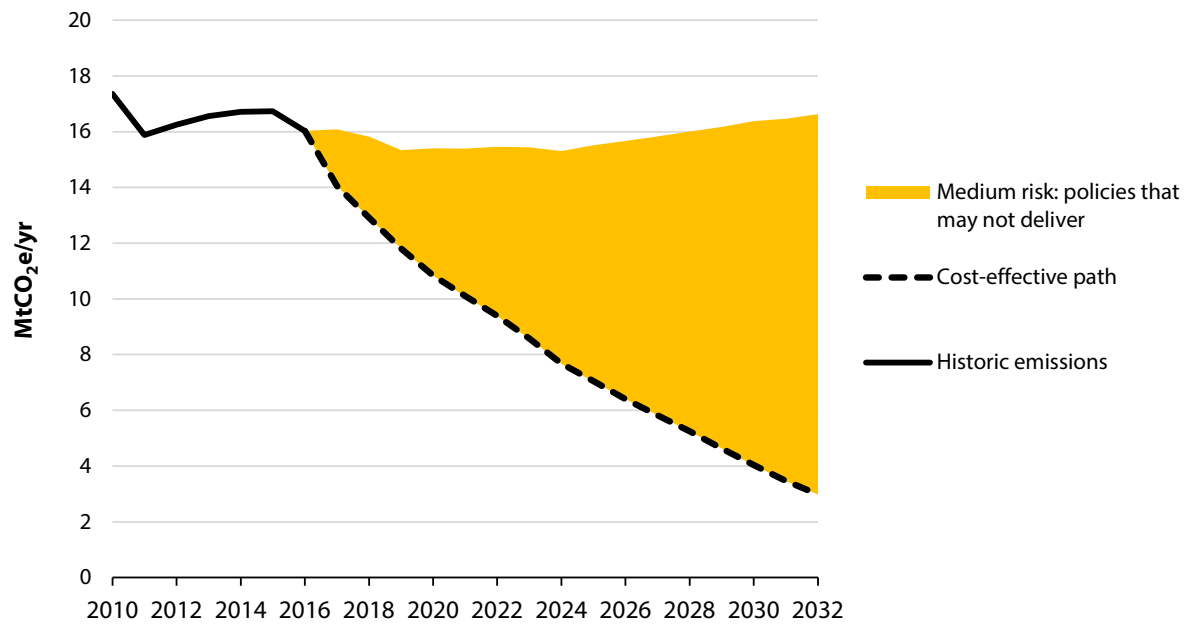
[106] It does not place a direct cap on the level of F-gas emissions.
[107] Annex 3, EU (2014) *Regulation no. 517/2014 on fluorinated greenhouse gases*.

Policy progress

Current policies will provide sufficient abatement to meet our existing cost-effective pathway for emissions reduction if they deliver as projected by the Government (Figure 8.5). This year's successful ratification of the Kigali Amendment provides some weaker back-up to the F-gas Regulation. However, there is a continuing risk that this abatement (from the F-gas Regulation) will not be delivered in full as a result of the UK's plan to leave the EU (Table 8.3).

Furthermore, there has been no Government progress on seeking opportunities to exceed EU regulatory minimums on F-gas abatement, where evidence suggests cost-effective and comparable alternatives exist, as we have recommended in recent reports. Our new analysis has identified clear cost-effective potential to go further and faster than the F-gas Regulation and we outline these areas for further policy progress below (Section 5).

Figure 8.5. Risks around the delivery of F-Gas policy to meet the cost-effective path (2010-2032)



Source: BEIS (2018) *Updated Energy and Emission Projections 2017*; BEIS (2018) *2017 UK Greenhouse Gas Emissions, provisional figures*; CCC analysis.
Notes: The top of the chart represents baseline emissions, based on the latest Government emissions projections published in January 2018. Emission reductions from existing policies that we judge to have significant delivery risks (e.g. insufficient funding) are rated 'medium risk'.

Table 8.3. Assessment of policies to drive abatement options in F-gases		
Abatement option	**2017 policy**	**2018 updates and assessment**
Phasedown in the use of HFCs in refrigeration, mobile and stationary air conditioning.	Amber 'Repeal Act' would convert 2015 F-gas Regulation in UK, but would require amendment in order for regulation to achieve intended outcome.	Amber A European Commission assessment of the F-gas Regulation suggests that it was broadly working in 2015, its first year of implementation.[108] The Government has stated that the UK will continue to follow the same phase-down schedule as the current EU regulation, either through the EU system or by establishing a separate UK quota system.[109] There are two clear risks associated with this (a) the EU law is not transferred into UK law effectively (b) the Environment Agency may not be able to establish a separate UK quota system in time for the UK leaving the EU, especially if the UK does not remain in the EU scheme for a transition period.
Cost-effective reduction in F-gas emissions beyond the ambition of the 2014 EU regulation.	Red No policy.	Red No policy.
Source: CCC analysis.		

5. Further actions required in the F-gas sector

To be on track to meet the fourth and fifth carbon budgets and enable all cost-effective abatement, the Government needs to address the delivery risks to F-gas Regulation presented by EU Exit and create policy to enable further and faster F-gas abatement in line with the cost-effective opportunities available.

[108] Report from the Commission assessing the quota allocation method in accordance with Regulation (EU) No 517/2014.
[109] House of Commons Environmental Audit Committee (2018) *UK Progress on Reducing F-gas Emissions.*

Specifically, the Government should:

- **Continue the UK's inclusion in the EU F-gas Regulation, or develop equivalent or stronger legislation in the UK.**
  - We expect the Government to have achieved this by the planned date for the UK to leave the EU, in 2019. This should remove the delivery risks to meeting our existing cost-effective paths (Figures 8.6 and 8.7), although there will be a gap to our updated cost-effective path, unless stronger targets are adopted.
  - The Government and Environment Agency should rapidly prepare for implementation of a UK only F-Gas Regulation, in readiness for the UK leaving the EU.
- **Publish a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives.** The Government should publish a plan to achieve the cost-effective abatement that goes beyond the ambition of the existing F-gas Regulation. This should:
  - Set out an approach to reduce emissions from refrigeration and air conditioning further and faster than the ambition of the F-gas Regulation, in line with the cost-effective potential identified in our new analysis.
  - Set out an approach to reduce emissions from metered-dose inhalers by at least 90% by 2027 and an approach to enable 50% of inhalers to be low-GHG by 2022, in line with the recommendation by the House of Commons Environmental Audit Committee (Box 8.2).
- **Investigate ways to support the development of low-GHG technologies for the small-medium air conditioning sector.**

Table 8.4 summarises the set of milestones for enabling the UK to be on track to meet the fourth and fifth carbon budgets and enable cost-effective abatement.

Box 8.2. Environmental Audit Committee report

The House of Commons Environmental Audit Committee published a report on UK progress on reducing F-gas emissions in April 2018. The report made a number of recommendations:

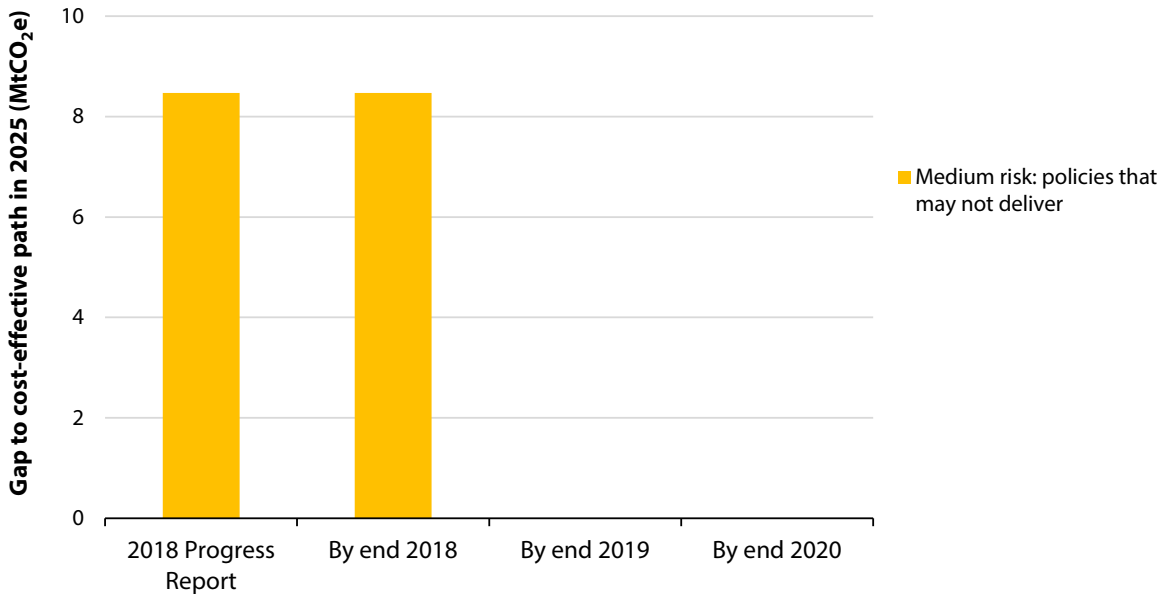
- "The Government must enforce existing F-gas rules to phase down the use of HFCs and meet the UK's legally binding carbon budgets. The Government must ensure that adequate resources are allocated to monitoring illegal activities, especially online, and that only qualified persons handle F-gases."
- "[L]ow GWP inhalers should be promoted within the NHS unless there are specific medical reasons for not doing so. Promotion should include raising awareness of low GWP inhalers and training amongst NICE, the medical community and patients. The NHS should set a target that by 2022 at least 50% of prescribed inhalers are low GWP. It should publish annual progress reports. We were disappointed to find that so few MDIs are disposed of responsibly. We therefore recommend that the Government should work with medical professionals, pharmacists, the pharmaceutical industry and patients to significantly improve the recycling of MDIs; this makes both environmental and economic sense. The Government should ensure that by 2020, at least 50% of MDIs are recycled. The Government should publish annual data showing progress in reaching and exceeding this target."

Box 8.2. Environmental Audit Committee report

- "The Government should ensure that heat pumps use low GWP refrigerants. The Government should reform the Renewable Heat Incentive schemes so that they encourage the deployment of heat pumps that use low GWP refrigerants, and that by 2020 all publicly-funded heat pump projects use low GWP refrigerants. It should publish annual data indicating which gases are being used in heat pumps so that Parliament and the Committee on Climate Change can track performance in this area."
- "The UK should seek to remain part of the EU's quota system. This will not prevent the UK Government from being more ambitious in its efforts to reduce F-gas emissions through the measures outlined above. If, however, the Government decides to leave the EU system, it must set out concrete proposals showing how it will be able to achieve more progress on F-gases."
- "If the UK leaves the EU's F-gas system, and devolved powers are repatriated to the UK, there could be policy divergence across the UK, which could lead to additional red tape and costs for business."
- "The Government needs to outline a timetable for its negotiations with the devolved Administrations on how F-gases will be managed after we leave the EU."

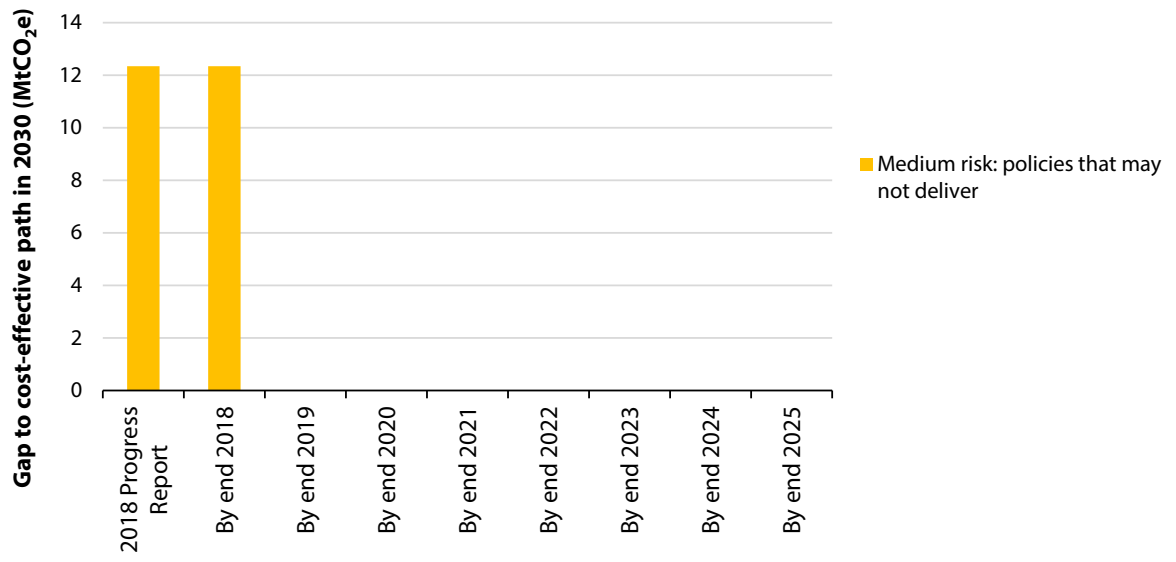
Source: House of Commons Environmental Audit Committee (2018), *UK Progress on Reducing F-gas Emissions*.

Figure 8.6. Risks around the delivery of F-gas policy in 2025 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emissions Projections 2017*, CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the cost-effective path can be closed and how current policies, proposals and intentions are firmed up so that delivery risks are largely eliminated. This is based on an assessment of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2020. The chart focuses on annual emissions in 2025, the middle year of the fourth carbon budget period, and the gap to meeting the cost-effective path.

Figure 8.7. Risks around the delivery of F-gas policy in 2030 and when the Government should implement actions to remove those risks



Source: BEIS (2018) *Updated Energy and Emissions Projections 2017*, CCC analysis.
Notes: This chart reflects the Committee's detailed assessment of how the remaining gap to the cost-effective path can be closed and how current policies, proposals and intentions are firmed up so that delivery risks are largely eliminated. This is based on an assessment of the current status of policies, proposals and intentions, and the potential to strengthen policy by 2025. The chart focuses on annual emissions in 2030, the middle year of the fifth carbon budget period, and the gap to meeting the cost-effective path.

Table 8.4. Key actions required to remove risks around policy delivery and close the gap to the cost-effective path

Action	By when
Continue the UK's inclusion in the EU F-gas Regulation, or develop equivalent or stronger legislation in the UK.	Spring 2019
Publish a plan to restrict the use of F-gases to the very limited uses where there are currently no viable alternatives.	Spring 2019

Chapter 9: Devolved administrations

Key messages and recommendations

The devolved administrations have an important role to play in tackling climate change. Their actions contribute to meeting their own domestic targets for reducing emissions, as well as the UK's overall progress towards carbon budgets. In this chapter, we highlight progress on emission reductions in each main sector in each of the devolved administrations.

Emissions data for each devolved administration is produced one year later than the UK-wide data. In this chapter we use the recently published data for 2016, unlike the rest of the Progress Report which is mainly based on 2017 data.

Scotland, Wales and Northern Ireland together accounted for 22% of UK emissions in 2016 (8%, 10%, and 4% respectively), while they account for 16% of the UK's population and 13% of economic output measured by GVA.

The Scottish Government published its Climate Change Plan in February 2018 detailing how it plans to meet its existing targets to 2032. It has also published the Climate Change (Emissions Reduction Targets) (Scotland) Bill, which includes a 2050 target for a 90% reduction on 1990 emissions. The Committee provided advice on the Bill in March 2017 and December 2017, and will assess the policies and proposals in the final version of the Climate Change Plan as part of our Scottish Progress report in September.

The Committee provided advice to the Welsh Government on the design and level of the emissions targets and carbon budgets under the Environment Act (Wales) in April and December 2017. These targets will be placed in legislation later this year, after which Welsh Ministers are required to publish a report setting out their proposals and policies for meeting them.

In June 2018, the Department for Agriculture, Environment and Rural Affairs in Northern Ireland requested the advice of the Committee on future actions that may help achieve emissions reductions by 2030. The scope and timescales of this advisory report will be confirmed later this year.

Powers are fully or partially devolved in a number of areas relevant to emissions reductions, with some variation by nation. Key areas of devolved powers include transport demand-side measures, energy efficiency, aspects of power policy, waste, agriculture and land use. The devolved governments also have important roles implementing UK policy (such as renewable energy deployment) through the provision of additional incentives and in areas such as planning consents.

Progress in reducing emissions is mixed across the devolved administrations. Significant reductions are largely confined to the Scottish power sector, while transport emissions are on an upward trend:

- In **Scotland,** emissions fell by 11% in 2016, largely due to the closure of the Longannet coal-fired power station. Waste emissions continued to fall, but there was considerably less progress in reducing emissions in other sectors. Transport emissions have risen for three consecutive years, while very little progress is apparent in agriculture and non-residential buildings.
- In **Wales**, emissions increased by 5% due to a large increase in emissions from power generation. This was partially offset by a reduction in industry emissions, while emissions in other sectors were broadly flat. Transport emissions have risen for three consecutive years. Welsh emissions have risen gradually since 2009.
- In **Northern Ireland**, emissions increased by 1%, despite reductions in the industry sector. Emissions increased in the power sector, and were broadly flat in the other sectors.

Introduction

In this chapter we review progress in the devolved administrations in 2016, and report on changes in emissions in each nation and in the different sectors of the economy.

The analysis that underpins our key messages and recommendations is set out in the following sections, starting with an overview section, followed by emission trends and progress towards targets, and then sections on each sector.

Discussion of policies in devolved areas is covered in the relevant sectoral chapters.

1. Devolved administrations overview

The devolved administrations have an important role to play in tackling climate change. Their actions contribute to meeting their own domestic targets for reducing emissions, as well as the UK's overall progress towards carbon budgets. They have fully or partially devolved powers in a number of areas relevant to emissions reduction. These vary by nation, but will become increasingly important as powers are devolved further in the coming years.

Key areas of devolved responsibilities currently include transport demand-side measures, energy efficiency, agriculture, land use, and waste. The devolved administrations also have important roles in implementing UK policy (such as renewable energy deployment) through the provision of additional incentives and their approach in areas such as planning policy.[110]

The devolved administrations have adopted a range of emission reduction legislation, targets, policies and strategies for reducing emissions and monitoring progress:

- **Scotland** passed its own Climate Change (Scotland) Act in 2009, which set a long-term target to reduce emissions of greenhouse gases (GHGs)[111] by at least 80% in 2050 relative to 1990, with an interim target to reduce emissions by 42% in 2020. Secondary legislation set a series of annual emission reduction targets to 2032. The Scottish Government published a draft version of its Climate Change Plan in January 2017, setting out initial policies and proposals to meet the targets to 2032. Following comments from a range of stakeholders, including the Committee in our Scottish progress report in September 2017, the Scottish Government made significant changes to the Plan for the final version published in February 2018.

  The Climate Change (Emissions Reduction Targets) (Scotland) Bill will change emissions targets from a net to actual basis and set a target of a 90% reduction on 1990 levels by 2050. The Committee advised on the design and levels of the targets in the Bill in March 2017, and provided supplementary advice in December 2017 on how to cope with challenges presented by anticipated inventory changes over the next few years. The Climate Change Bill and Plan both include commitments to annual monitoring of progress on emissions reductions and policy implementation.

- **Wales** passed the Environment (Wales) Act in 2016. This sets out its approach to addressing climate change. Together with the complementary Well-being of Future Generations Act, the Environment Act provides for the setting of emission reduction targets to 2050, including at least an 80% reduction from 1990 levels in 2050, and five-year carbon budgets. The Committee provided advice on the design of Welsh carbon targets in March 2017,[112] and on

[110] Energy policy is fully devolved to the Northern Ireland Executive.
[111] Including emissions from international aviation and shipping.
[112] CCC (2017) *Advice on the design of Welsh carbon targets.*

the level of carbon budgets in October 2017.[113] The Welsh Government will set emissions targets and carbon budgets in legislation by the end of 2018.

- **Northern Ireland** has a draft Programme for Government that contains indicators for future emissions reductions. The Committee reported on the appropriateness of a Northern Ireland Climate Change Act in January 2016114. The Department for Agriculture, Environment and Rural Affairs has requested the advice of the Committee on future actions that may help meet a range of emissions targets by 2030. Further details will be confirmed later this year.

2. Emission trends and progress towards targets

The latest UK emissions data are for 2017, except for non-CO_2 gases, but the latest data available for the devolved administrations are for 2016. This section analyses the change in emissions from 2015 to 2016 and the longer-term trend between 2009 and 2016.[115]

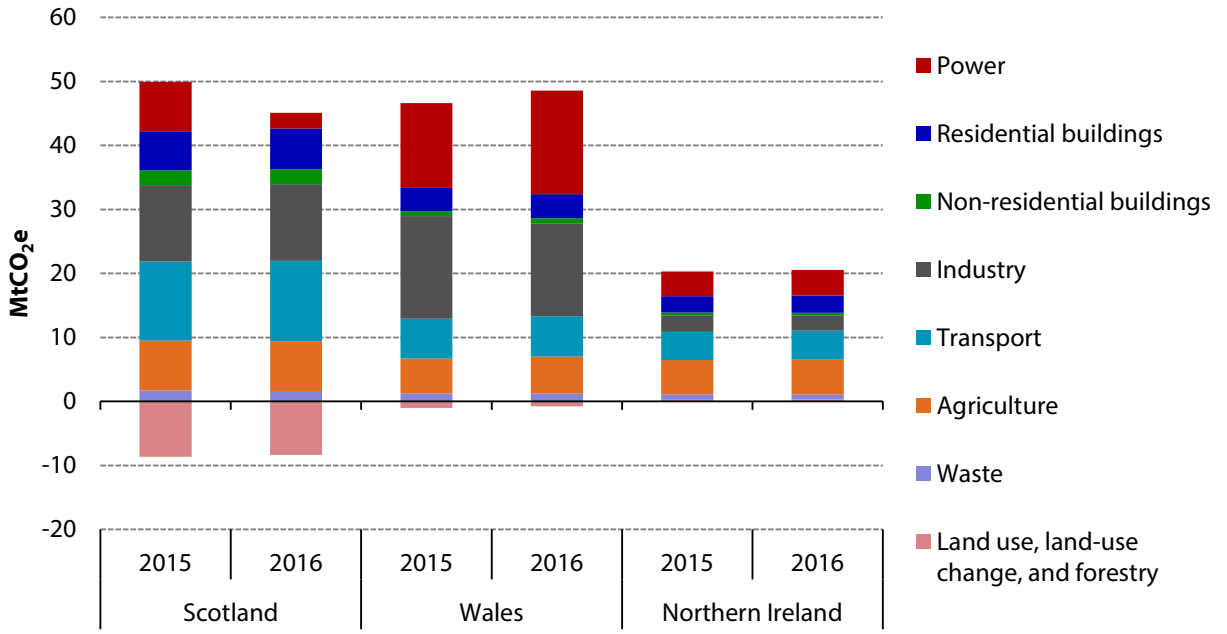
Scotland, Wales and Northern Ireland accounted for 22% of UK emissions in 2016 (respectively 8%, 10% and 4%), while they account for 16% of the UK's population and 13% of economic output measured by GVA.

Trends in emissions vary considerably across the devolved administrations (Figure 9.1):

- Scottish emissions fell 11% in 2016, with an average annual decrease of 5.0% between 2009 and 2016
- Welsh emissions increased by 5%, with an average annual increase of 1.4% between 2009 and 2016
- Northern Irish emissions increased 1.3% with an average annual decrease of 0.2% between 2009 and 2016.
- These compare with a reduction in greenhouse gas emissions of 5% in 2016 for the UK as a whole, with an average annual decrease of 3.1% between 2009 and 2016.

[113] CCC (2017) *Building a low-carbon economy in Wales - Setting Welsh carbon targets.*
[114] CCC (2015) *The appropriateness of a Northern Ireland Climate Change Act – 2015 update.*
[115] Unless stated emissions data do not account for trading in the EU ETS and do not include emissions from international aviation and shipping.

Figure 9.1. Greenhouse gas emissions in devolved administrations by sector (2015 and 2016)



Source: NAEI (2018), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2016.*

Scotland is on track to meet its own 2020 target, but neither Wales nor Northern Ireland are on track to meeting their current near-term targets (Table 9.1). The Committee has advised Wales on its statutory target for 2020:

- In **Scotland**, total emissions fell by 11% to 36.8 $MtCO_2e$ in 2016 mainly as a result of further falls in power sector emissions. Scotland met its annual target for 2016. Scottish emissions, excluding international aviation and shipping (IAS) fell 51% between 1990 and 2016, the largest reduction in the UK:
  - There were strong falls in 2016 in emissions from the power sector (-68%), largely due to the closure of the Longannet Power Station in March 2016. We would expect a further fall in 2017 to reflect a full year without coal generation.
  - There were moderate falls in the land use, land-use change and forestry (LULUCF) sector (-3%) and the waste sector (-5%), whilst industry and agricultural sectors remained flat.
  - There was a moderate increase in emissions from residential buildings (+3%) and non-residential buildings (+3%) and from the transport sector (+2%).
  - Emissions on the 'net' measure used under Scotland's existing emissions targets[116] rose by 1.0 $MtCO_2e$ in 2016, due to a slight rise in actual Scottish emissions outside the EU ETS (mainly transport and buildings), together with an increase in Scotland's share of allowances in the EU Emissions Trading System.[117] For 2016, the Net Scottish Emissions Account (NSEA) was 41.5 $MtCO_2e$, well below the annual target of 44.9 $MtCO_2e$.

[116] 'Net' emissions are calculated under the Net Scottish Emissions Account (NSEA), taking into account non-traded emissions, surrendered units and Scotland's assigned EU ETS cap (known as the specified amount).

[117] Scotland's share of EU ETS allowances increased in 2015 relative to 2016, due to an increase in the total number of allowances being auctioned at EU level, which reflects the timing of the 'backloading' initiative.

- In **Wales**, total emissions increased by 5% to 47.8 $MtCO_2e$ in 2016. This follows falls in emissions in 2014 and 2015. Emissions have fallen 14% since 1990.
  - In 2016, there was a general trend of small increases for most sectors with the overall rise in emissions (2.2 $MtCO_2e$) largely driven by the increase in power emissions (2.9 $MtCO_2e$) and partially offset by a fall in industry emissions (-1.5 $MtCO_2e$)
  - Emissions increased in a number of sectors: agriculture (+5%), non-residential buildings (+5%), residential buildings (+2%) and transport (+2%). The size of the land use carbon sink also decreased by 22% to 0.8 $MtCO_2e$.
  - Only the industry sector (-9%) had falling emissions in 2016, largely driven by an 11% reduction in emissions from Port Talbot. Emissions in the waste sector were flat.
  - Between 2009 and 2016 emissions from power rose by an average of 5% per annum, whilst emissions from industry were unchanged.
  - Wales currently has an existing non-statutory target to reduce greenhouse gas emissions by 40% from 1990 levels by 2020. In 2016, emissions were 14% lower than in 1990 (compared to 41% for the UK). On the basis of progress to date, the 40% target by 2020 is very likely to be missed.
  - In December 2017 the Committee recommended the level for a statutory 2020 target under the Environment (Wales) Act for a 27% reduction from 1990 levels (or 32% if the Aberthaw coal plant closes prior to 2020). The Welsh Government will set emissions targets and carbon budgets in legislation by the end of 2018.
- In **Northern Ireland**, emissions in 2016 increased by 1.3% to 20.6 $MtCO_2e$. Northern Ireland's target requires a lesser emissions reduction than the Scottish and Welsh targets, in part reflecting the larger share of its emissions from difficult to reduce sectors (especially agriculture). The changes in sectoral emissions were small, with some increases and some falls:
  - Emissions in 2016 fell in the industry (-9%), waste (-3%), and non-residential buildings sectors (-6%).
  - Emissions in 2016 rose in the power (+5%), transport (+2%), land use (+6%), residential buildings (+5%) and agriculture (+3%) sectors.
  - Northern Ireland has a target to reduce emissions in 2025 by at least 35% compared to 1990 levels. In 2016, emissions in Northern Ireland were 16% below their 1990 levels. Northern Ireland Executive projections suggest that progress is falling short of what is required in order to meet the 2025 target.[118]

Overall, emissions in the devolved administrations were collectively 32% below 1990 levels in 2016. The differences across the nations in part reflect the relative importance of different sectors at the devolved level.

[118] DAERA (2018) *Northern Ireland Greenhouse Gas Projections Update.*

Table 9.1. Devolved administrations targets and progress

	Targets: reductions from 1990 baseline	Emissions change 1990-2016	Relative change in emissions 2015-2016	Average annual emissions change 2009-2016
UK	35% by 2020	-41%	-5.0%	-3.1%
Scotland	56% (actual emissions) by 2020 42% (net) by 2020	-49% (actual) -45% (net)	-10.3% (actual) +2.5% (net)	-4.7% (actual) -4.0% (net)
Wales	27% by 2020 (CCC recommendation) 40% by 2020 (existing non-statutory target)	-14%	+4.8%	+1.4%
Northern Ireland	35% by 2025	-16%	+1.3%	-0.2%

Source: NAEI (2018), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990-2016.*
Notes: The latest UK emissions data considered elsewhere in this report are for 2017, but the latest data available for the devolved administrations are for 2016. These data (unless stated) do not account for trading in the EU ETS. The Net Scottish Emissions Account (NSEA) adjusts actual emissions to account for trading in the EU ETS.The Scottish targets and emissions to date include Scotland's share of international aviation and shipping (IAS) emissions, as these are included in the measure of Scottish emissions under the legislated targets. This explains the difference between the 49% reduction on 1990 emissions presented here and the 51% reduction excluding IAS presented earlier. IAS emissions are not included for Wales, Northern Ireland and the UK as a whole. The 2020 targets are expected to change in Wales and Scotland. In Wales, the Environment (Wales) Act 2016 requires Wales to legislate a statutory 2020 target by 2018. In December 2017, the Committee recommended that the level of such a 2020 target should be a 27% reduction on 1990 levels, or 32% reduction if the Aberthaw coal plant closes before 2020. The Scottish Government has introduced a new Climate Change Bill, which includes a new 2020 target of reducing actual Scottish emissions by 56% as recommended by the Committee.

The recently published emissions data contain significant revisions to the greenhouse gas inventory methodology in the forestry, shipping, agriculture and waste sectors (Box 9.1). Whilst these changes do not affect the trends reported here, which use the latest methodology for all years reported, they mean that the latest data are not directly comparable to those published in previous years. They can also make legislated targets easier or more difficult to meet.

Our advice to the Scottish Government in December 2017[119] recommended a methodology to adjust emissions data to a 'GHG Account' on a consistent basis to that used for the legislated targets. As the latest emissions data for the devolved administrations were published on 12 June, we have not had sufficient time to consider the suitability of the latest inventory as the 'base inventory' used to assess whether the existing legislated targets are met. We will provide further advice on this shortly.

[119] CCC (2017) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework*.

Box 9.1 Revisions to the latest Greenhouse Gas Emissions Inventory

Inventory improvements are designed to increase the transparency, accuracy, consistency, comparability, and completeness of the inventory. Changes to the emissions inventory published in 2018 mainly affected the forestry, shipping, agriculture and waste sectors:

- **Forestry.** Methodological changes have increased the estimated forestry carbon sink. These largely reverse the changes made in the inventory published in 2017, which caused the forestry sink to be underestimated. This has resulted in an increase in the magnitude of the sink from forest land across the time series, which has affected estimates of emissions in Scotland in particular.
- **Shipping.** Improvements to the methodology for estimating emissions, now partly based on GPS data rather than fuel sales, has resulted in an increase in the estimates for gas oil and fuel oil used. This has led to revisions in estimated emissions from domestic navigation and fishing vessels.
- **Agriculture.** Incorporation of the smart inventory changes at UK level are reflected for the devolved administrations, generally leading to slightly lower estimates of agriculture emissions.
- **Waste.** Improved models specific to waste composition in each of the devolved administrations have now been developed, leading to recalculations across the time series.

As we highlighted in *Quantifying Greenhouse Gas Emissions*,[120] estimates of Scottish emissions are more uncertain (±10%) than those for Wales (±3%), Northern Ireland (±7%) or the UK as a whole (±3%). This is reflected in the magnitude of the revisions to estimated emissions for the devolved administrations.

- **Scottish** emissions have been revised to a significantly greater extent than for the UK as a whole or the other devolved administrations, due to the importance of its shipping and forestry sectors:
  - The estimate for Scottish emissions in 1990 is largely unchanged, due to offsetting changes. LULUCF emissions in 1990 have been revised down by 2.6 $MtCO_2e$, while shipping emissions have been revised up by 2.7 Mt (+25%). Including offsetting revisions to waste (+7%) and agriculture (-7%), the overall revision to estimated emissions for 1990 is a reduction of 0.1 Mt (-0.2%).
  - For 2015 emissions, the estimate of the LULUCF sink has been revised upwards by 5.8 Mt. This is offset to a degree by an increased estimate of shipping emissions by 1.6 Mt (+15%). The overall revision to total emissions for 2015 is a decrease of 4.4 Mt (-10%).
  - Previous inventory changes have tended to affect estimates for both 1990 and more recent years in similar ways (Figure B9.1), often leaving the percentage change against 1990 emissions largely unaffected. However, inventory changes in both 2017 and 2018 have had a much larger net impact on more recent years than on 1990, resulting in large movements in estimated percentage reductions on 1990 levels.
  - Accordingly, although last year's data indicated that total Scottish emissions had fallen by 39% between 1990 and 2015, this is now estimated at 44% following the inventory change.
- The inventory changes affect estimates of 1990 **Welsh** emissions more than those for recent years:
  - Emissions in 1990 are now estimated to be 1.2 $MtCO_2e$ smaller than the estimate made in 2016. This is driven by a 1.2 Mt increase in the LULUCF sink estimate, and offsetting revisions in transport (+5%), agriculture (-5%), and waste (-3%).
  - The emissions estimate for 2015 emissions was revised downwards by 0.1 $MtCO_2e$ (-0.2%). An increase in the estimate of the LULUCF sink of 0.7 Mt was offset by upwards revisions in industry of 0.4 Mt and smaller revisions in other sectors.

[120] CCC (2017) *Quantifying Greenhouse Gas Emissions*.

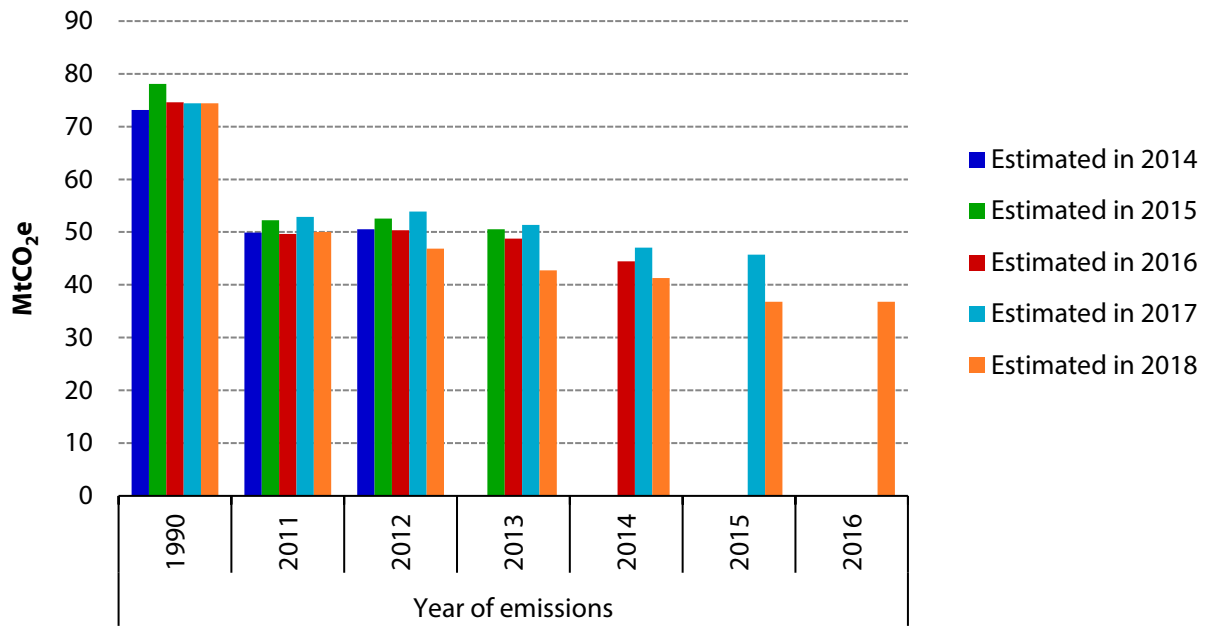
Box 9.1 Revisions to the latest Greenhouse Gas Emissions Inventory

  - As a result, last year's estimate that Welsh emissions in 2015 were 20% below those in 1990 has now been revised to 18%.

- For **Northern Ireland** the inventory changes revised emissions downwards in all years.
  - Estimates for 1990 are marginally more affected than emissions in 2014; the revised emissions estimates for 1990 are 2.8% lower whilst the 2015 emissions estimate is 1.8% lower.
  - The revision is driven mostly by changes to LULUCF emissions (0.4 $MtCO_2e$ decrease in both 1990 and 2015) and agriculture (0.7 $MtCO_2e$ decrease for 1990; 0.5 $MtCO_2e$ decrease for 2015). On last year's estimates, emissions in 2015 were 18% below 1990 levels; as a result of the revision this reduction is now estimated to be 17%.

Further revisions to the greenhouse gas inventory methodologies are anticipated over the coming years. We provided advice to the Scottish Government in December 2017 on how to handle this under the new Scottish target framework.[121]

Figure B9.1. Revisions to Scottish emissions estimates between inventories published in 2014-2018



Source: NAEI (2014), NAEI (2015), NAEI (2016), NAEI (2017), NAEI (2018).
Notes: The chart shows how revisions to the greenhouse gas inventory affect estimates for previous years.

Source: NAEI, CCC analysis.

[121] CCC (2017) *Letter from Lord Deben to Roseanna Cunningham MSP advising on Scottish climate target framework.*

3. Power sector

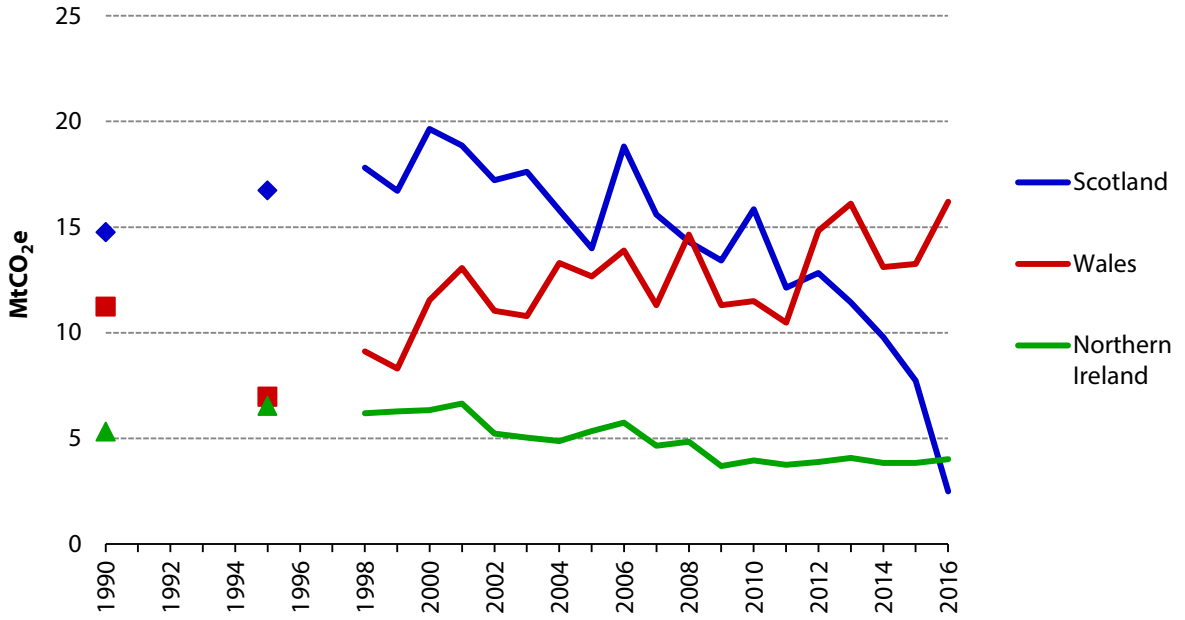
Emissions, drivers and electricity generation trends

Progress in the devolved administrations is mixed. Power sector emissions decreased by 68% in Scotland whilst increasing in Wales (22%) and Northern Ireland (5%) in 2016 (Figure 9.2).

- In **Scotland**:
  - Emissions decreased to 2.5 $MtCO_2e$ in 2016 with an average annual decrease of 21.4% between 2009 and 2016. Power sector emissions accounted for 6% of total Scottish emissions, having decreased by 83% between 1990 and 2016.
  - Overall generation decreased by 11%. Coal generation in 2016 was 78% lower than in 2015, due to the closure of the Longannet Power Station in March 2016. The decrease in electricity production from coal was partially offset by increases in gas and nuclear generation (+63% and +11% respectively).
  - Renewable generation decreased by 10% as a result of lower average wind speeds in 2016, though still made up 43% of all generation in Scotland, up from 42% in 2015 (Figure 9.3).
- In **Wales**:
  - Power sector emissions rose to 16.2 $MtCO_2e$ in 2016, accounting for 34% of total Welsh emissions. They are 44% higher than 1990 levels, having increased by an average of 5.3% from 2009 to 2016.
  - Overall generation rose 12%. Gas generation increased by 52% and accounted for the majority (63%) of generation in Wales. There was a 12% increase in hydro pumped storage generation and a 1% increase in renewables.
  - Coal generation decreased by 10%, and nuclear generation ceased in 2016 as Wylfa Nuclear Power Station, which generated 3.9 TWh in 2015, closed permanently on 30 December 2015.
- In **Northern Ireland**:
  - Emissions increased to 4.0 $MtCO_2e$ in 2016, with an annual average increase of 1.2% between 2009 and 2016. Emissions were 24% lower than 1990 levels. The sector accounts for 20% of total Northern Irish emissions.
  - There was an increase in gas generation (7%) in 2016 which already makes up the largest share (50%) of total generation. There was also a 4% increase in renewable generation.

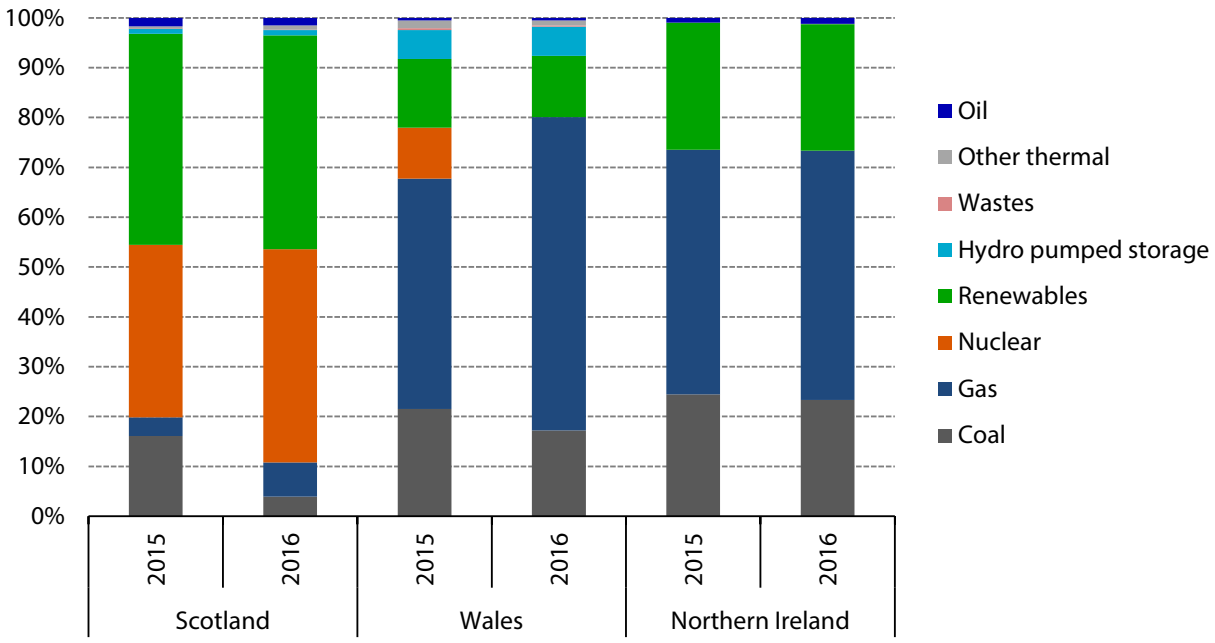
At the UK level, emissions decreased by 21% in the power sector between 2015 and 2016 with an average annual decrease of 9% per year between 2009 and 2016. Overall, power sector emissions in the devolved administrations were 27% below 1990 levels in 2016.

Figure 9.2. Power sector emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Figure 9.3. Proportion of generation by fuel in Scotland, Wales and Northern Ireland (2015 and 2016)

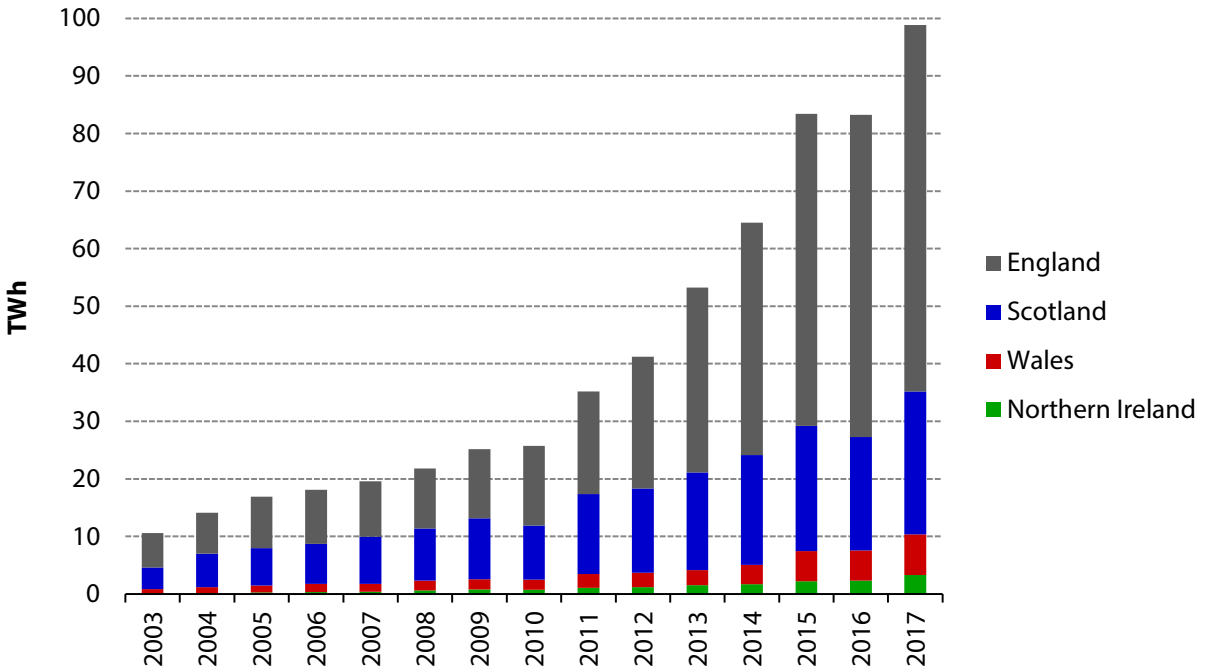


Source: BEIS (2017) *Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2016.*

Trends in renewable electricity

Renewable electricity generation in Scotland, Wales, and Northern Ireland increased by 29% in 2017, the most recent year for which data are available, compared to a UK-wide increase of 19%. This increase is due to continued renewable capacity growth across the devolved administrations (Figure 9.4) and an increase in wind load factors.

Figure 9.4. Renewable electricity generation in the UK (2003 - 2017)



Source: BEIS (2017) *Energy Trends 6.1 Renewable electricity capacity and generation.*

In 2017 the devolved administrations together accounted for 36% of UK renewable generation:

- **Scotland** accounted for 25% of UK renewable generation in 2017.
  - Renewable capacity increased by 13% from 2016, whilst generation increased by 26% to 25 TWh.
  - Scotland has a target for the equivalent of 100% of gross electricity consumption in 2020 to be met from renewables. In 2016 the share was 54% (down from 60% in 2015), due to a UK-wide average reduction in wind speeds compared to 2015.
- **Wales** generated 7 TWh of renewable electricity in 2017, accounting for 7% of the UK's renewable generation. Renewable capacity increased by 10% from 2016, whilst generation increased by 34%.
  - Wales met its target[122] to produce 7 TWh from renewables by 2020 and is likely to exceed this target by 2020 if renewable capacity continues to grow.

[122] Technical Advice Notes are advice to developers and decision-makers. TAN 8 in Wales provides guidance on land-use planning in relation to renewable energy and sets a target for renewable generation.

- In September 2017, the Welsh Government announced its ambition to generate 70% of its electricity consumption from renewable energy by 2030.

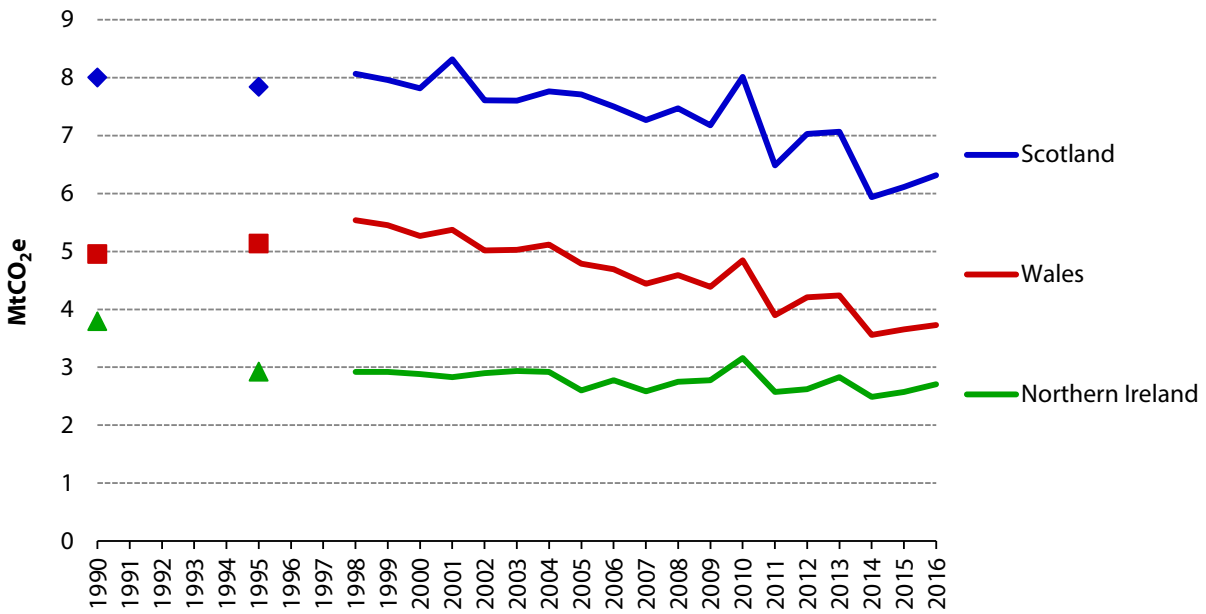
- **Northern Ireland** accounts for 3% of the UK's renewable generation, generating 3 TWh in 2017. Renewables capacity increased by 36% from 2016, whilst generation increased by 42%. It has a target to produce 40% of electricity consumption from renewables by 2020. In 2017 the share was 34.8%, up from 25.4% in 2016.
  - Wind continues to dominate renewable generation, accounting for 77% of all renewable generation in 2017.
  - Northern Ireland Renewables Obligation (NIRO) was closed in 2016 for new small-scale onshore wind (up to 5 MW) projects.

4. Buildings

Emissions from residential buildings

Direct residential emissions across the devolved nations increased by 3.4% in 2016 (Figure 9.5). This was in line with a 3.6% increase in residential emissions at UK level.

Figure 9.5. Residential emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: This chart presents out-turn data, not adjusted to account for differences in winter temperatures across years. No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Winter temperatures in 2016 were higher than the 20-year average in both Wales and Northern Ireland, though Scotland was colder than average:

- In Scotland, emissions from residential buildings accounted for 16% of total emissions and emissions were 22% lower than 1990 levels. They increased by 3%, following a 17% decrease in 2014 and a 3% increase in 2015.
- In Wales, emissions from residential buildings accounted for 8% of total emissions and were 25% lower than 1990 levels. They increased by 2% in 2016, following a 16% decrease in 2014 and a 3% increase in 2015
- Emissions from residential buildings in Northern Ireland accounted for 13% of total emissions, and emissions were 29% lower than in 1990. They increased by 5% in 2016.

Low-carbon heat

The main GB support scheme for low-carbon heat is the Renewable Heat Incentive (RHI). This provides payments to those who generate and use renewable energy to heat their buildings. Out of all RHI-accredited installations up to December 2017, Scotland had 21% of non-residential capacity and 20% of residential capacity, whilst Wales had 9% of non-residential and 7% of residential capacity. This reflects Scotland and Wales' larger share of off-grid homes. The majority of domestic RHI accreditations from Scotland and Wales were in properties off the gas grid (86% and 84% respectively, compared to 72% in GB overall).

Scotland has implemented further policies to encourage the uptake of renewable heat:

- In 2016, an estimated 1.7 GW of renewable heat capacity was operational in Scotland, producing an estimated 3.8 TWh of useful renewable heat.[123] This represents a 13% increase in capacity but an 11% reduction in heat generated from renewable sources compared to 2015. This reduction in renewable heat output was primarily due to changes at a small number of large non-domestic sites (sites with a capacity of 1 MW or more).
- In 2015, Scotland generated 5.4% of its non-electrical heat demand from renewable sources. It is estimated that in 2016 between 4.8% and 5.0% of non-electrical heat demand came from renewable sources.

In **Wales**, heat generation from biomass boilers, heat pumps, and biogas is increasing. This is largely due to the non-domestic RHI for farm and commercial activities:

- In 2016, Wales had an estimated 0.5 GW of renewable heat capacity which produced an estimated 1.8 TWh of renewable heat.
- 67% of this renewable heat capacity was biomass boilers. An additional 133 MW of capacity was installed through nearly 1,000 projects in 2016.

To support the development of low-carbon heat in **Northern Ireland**, the Executive introduced its own RHI and Renewable Heat Premium Payment (RHPP) schemes, both of which are now closed. The scheme is currently subject to a public inquiry into its design, governance, implementation and operation, and cost control mechanisms.

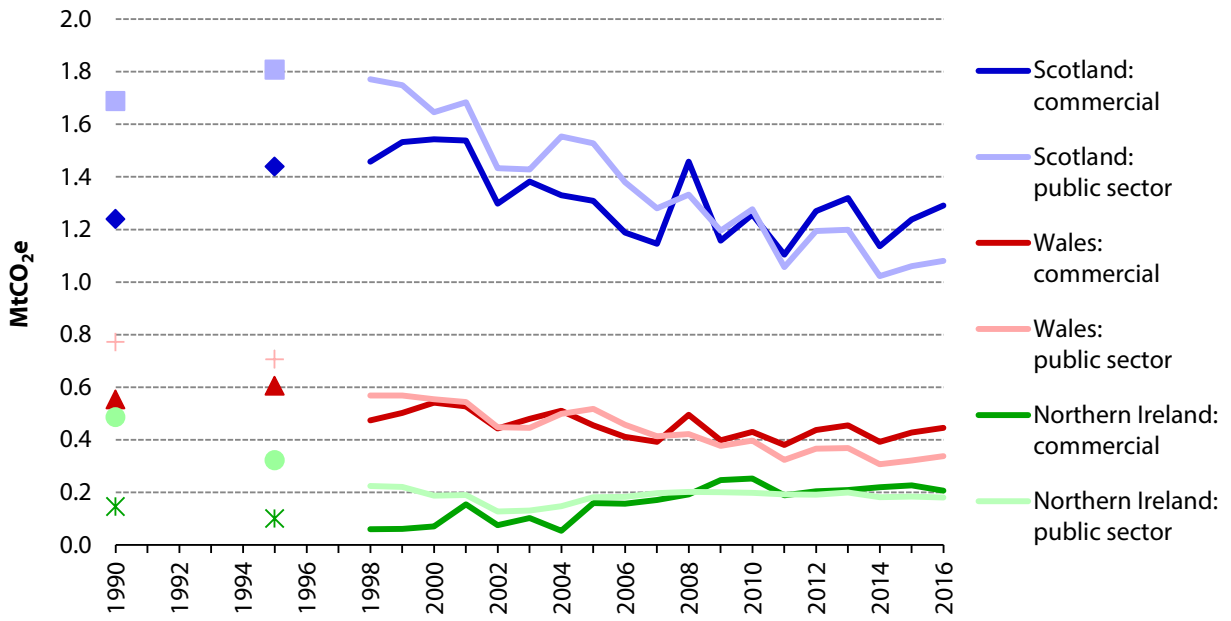
[123] Renewable heat technologies include biomass, biomass CHP, heat pumps, energy from waste, and solar thermal.

Non-residential buildings

Emissions from non-residential buildings fell in Northern Ireland but rose in Scotland and Wales in 2016 (Figure 9.6):

- In Scotland, emissions from non-residential buildings rose by 3%, with emissions from commercial buildings increasing by 4% and those from the public sector increasing by 2%. The non-residential buildings sector accounted for 6% of total Scottish emissions in 2016.
- In Wales, emissions from non-residential buildings increased by 5%, although this sector accounted for only 2% of total emissions in 2016. Emissions from commercial buildings increased by 4% and those from the public sector increased by 5%.
- In Northern Ireland, emissions from non-residential buildings decreased by 6%. This was due to a 9% decline in emissions from commercial buildings and a 2% decrease in emissions from public sector buildings. The non-residential buildings sector accounted for 2% of Northern Ireland emissions in 2016.

Figure 9.6. Non-residential buildings emissions in Scotland, Wales and Northern Ireland (1990-2016)



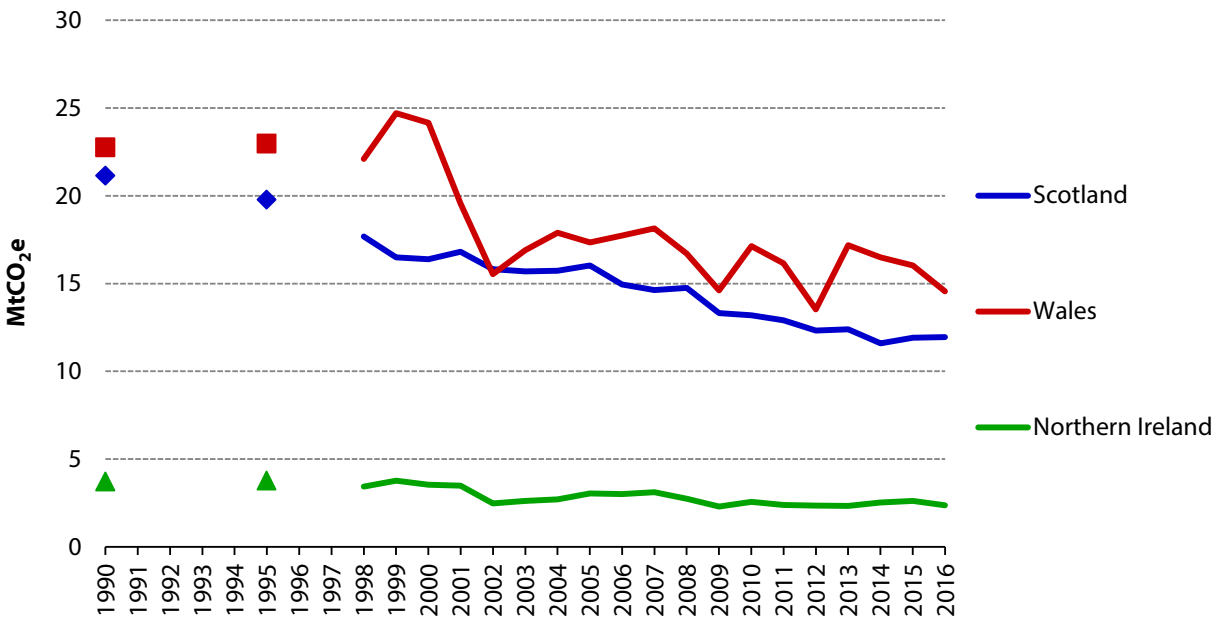
Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

5. Industry

Direct emissions from industry decreased in Wales and Northern Ireland in 2016, whilst they remained broadly flat in Scotland (Figure 9.7), in the context of an overall 7% fall at UK level:

- In Scotland, emissions from industry increased by 0.3% in 2016, and have decreased at an average of 1.5% per year between 2009 and 2016. Emissions from the sector accounted for 31% of total Scottish emissions and have decreased 44% since 1990.
- In Wales, emissions from industry decreased 9% in 2016 to 14.6 $MtCO_2e$, but have remained broadly flat between 2009 and 2016, growing at an average of 0.1% per year. Industry emissions in 2016 were 36% lower than 1990 levels, and accounted for 30% of total Welsh emissions. Industry makes up a particularly large share of total emissions in Wales, mainly due to the Port Talbot steelworks. In 2016, EU ETS verified emissions for Port Talbot steelworks decreased by 11% (0.83 $MtCO_2e$) on 2015 levels, similar to the overall fall in Welsh industry emissions.
- Emissions from industry in Northern Ireland accounted for 12% of total emissions in 2016 and decreased by 9%, with an annual average increase of 0.5% between 2009 and 2016. They are 36% lower than in 1990.

Figure 9.7. Direct industry emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

The devolved administrations have little control over industrial policies for emission reductions which are largely reserved and operate at the UK/EU level (Chapter 4). Policies include the EU

ETS, Climate Change Levy (CCL) and Climate Change Agreements (CCAs), and the Renewable Heat Incentive (RHI).[124]

The devolved administrations all offer interest-free loans for small and medium-sized enterprises (SMEs) for energy efficiency or resource efficiency projects, through Resource Efficient Scotland in Scotland and Carbon Trust in Wales and Northern Ireland.

6. Transport

Overview

Demand-side measures such as road maintenance, cycling, and bus policies are devolved matters. Supply-side transport policy remains reserved, although devolved administrations can support these (e.g. through provision of electric vehicle charging infrastructure).

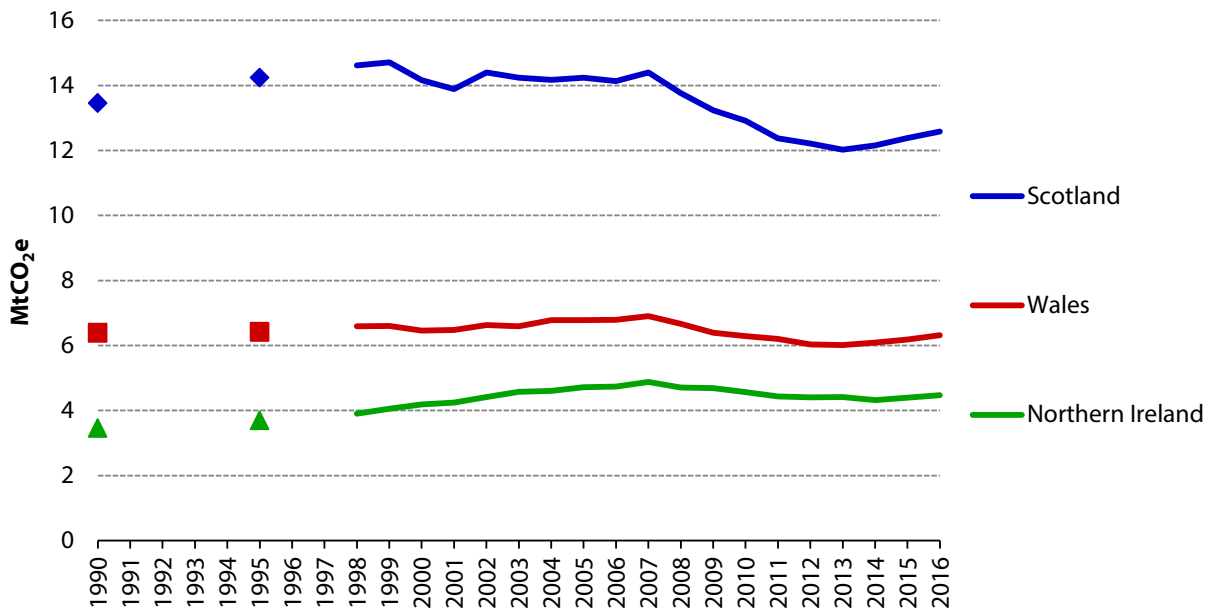
Emissions trends and drivers

Emissions from transport increased by 2% across the UK in 2016, a change that is also present across the devolved administration from 2015 to 2016 (Figure 9.8):

- In **Scotland**, transport emissions increased by 1.6% in 2016, the third consecutive annual increase, to 12.6 $MtCO_2e$. This is 7% below the level in 1990. Transport emissions account for 33% of total emissions in Scotland in 2015, higher than the UK share (27%).
- In **Wales**, the transport sector accounts for a smaller share (13%) of overall emissions. Emissions from transport increased in 2016 by 2.0%, the third consecutive annual increase, with an annual average decrease of 0.2% between 2009 and 2016. Welsh transport emissions are 1.2% lower than in 1990.
- In **Northern Ireland**, transport emissions increased by 1.9% in 2016, with an annual average decrease by 0.7% between 2009 and 2016. Transport emissions in 2016 were 29% higher than in 1990. Emissions from the sector were 22% of overall Northern Irish emissions in 2016. The increase in emissions since 1990 largely reflects an increase in car ownership rates in Northern Ireland, which are now comparable with the UK average.
- The increase in emissions from the transport sector largely reflects an increase in annual vehicle-kilometres across the devolved administrations (Table 9.3).
- There were small decreases in new-car efficiency from 2016 to 2017. This was the first UK-wide decrease in efficiency in two decades, and was driven by market trends towards larger vehicles and a significant fall in diesel registrations[125]. The efficiency of new cars is driven by EU legislation towards achieving the EU's 2020 target of 95 gCO_2/km by 2020.
- The increase in vehicle-kilometres in 2016 in Scotland and Wales (2.3% and 2.2%) was in line with the GB average over the same period (2.2%).

[124] See CCC (2017) *Energy Prices and Bills Report 2017* and Cambridge Econometrics (2017) *Steel – Competitiveness impacts of carbon policies on UK energy-intensive industrial sectors.*
[125] SMMT (2018) *New Car CO_2 Report*.

Figure 9.8. Transport emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: *NAEI (2018).*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Table 9.3. Change in traffic vehicle-km in 2016 and new-car efficiency 2017

	Road traffic	Heavy Goods Vehicles	Cars	New car test-cycle efficiency 2017	Target for 95 gCO_2/km by 2020 on track?
Scotland	2.3% increase	0.5% increase	2.0% increase	120.1 gCO_2/km (0.1% increase from 2016)	No, but slightly more efficient than UK average (121.0 gCO_2/km)
Wales	2.2% increase	2.0% increase	0.8% decrease	120.3 gCO_2/km (0.6% increase from 2016)	No, but slightly more efficient than UK average (121.0 gCO_2/km)
Northern Ireland	N/A	N/A	N/A	119.4 gCO_2/km (0.6% increase from 2016)	No, but best efficiency in UK

Source: Scottish Government (2017) *Scottish Transport Statistics No 36*, Welsh Government (2017) *Road Traffic in Wales 2016*, The Society of Motoring Manufacturing and Traders Limited (2018).
Notes: Vehicle-km data for Northern Ireland are not available after 2014. Road traffic calculations for the NAEI inventory apply trends from DfT data for Great Britain to Northern Ireland.

Progress developing electric vehicle markets

There has been an increase in electric vehicle (EV) sales at the UK level since 2010, although this is from a low base and has been largely driven by sales in England (which represented 92% of the total UK sales in 2017). Sales of electric vehicles in Scotland accounted for 5% of UK sales in 2017, with Wales at 2% and Northern Ireland 1%. These shares were lower than the proportion of overall vehicle sales (8% Scotland, 3% Wales and 2% Northern Ireland in 2017).

The proportional growth of EV sales in the devolved administrations were faster than in England in 2017. English EV sales grew by 24%, compared to larger proportional increases in Scotland (67%), Wales (34%), and Northern Ireland (31%):

- In Scotland, 1.2% of car sales were EVs in 2017, up from 0.7% in 2016 (compared to 2.1% in England).
- In Wales, 1.0% of car sales were EVs in 2017, up from 0.7% in 2016.
- In Northern Ireland, 1.1% of car sales were EVs in 2017, up from 0.8% in 2016.

Scotland, Wales and Northern Ireland have continued to make progress developing infrastructure and markets for electric vehicles following on from Plugged in Places funding from the Department for Transport (DfT):

- At the beginning of June 2018, there were 2,548 public charging points across Scotland (15.3% of total UK points), 737 more than in June 2017, an increase of 41%.[126]
- As of June 2018, Wales has 557 charging points, a share of 3.4% of UK charging points. This represents an increase of 43% since June 2017
- Northern Ireland has 470 charging points as of June 2018, a share of 2.8% of UK charging points. The number of charging points in Northern Ireland grew by 3% in the last year.

Changing travel behaviour

The main lever to influence emission reductions from transport in the devolved administrations relates to infrastructure and service provision, actions to improve transport planning and the support of behaviour change. Measuring success and outcomes in changing behaviour is inherently difficult, as the overall impact is small in comparison with other drivers of vehicle-kms and demand. Vehicle-kms have been rising in Scotland and Wales, and across the UK, since 2013.

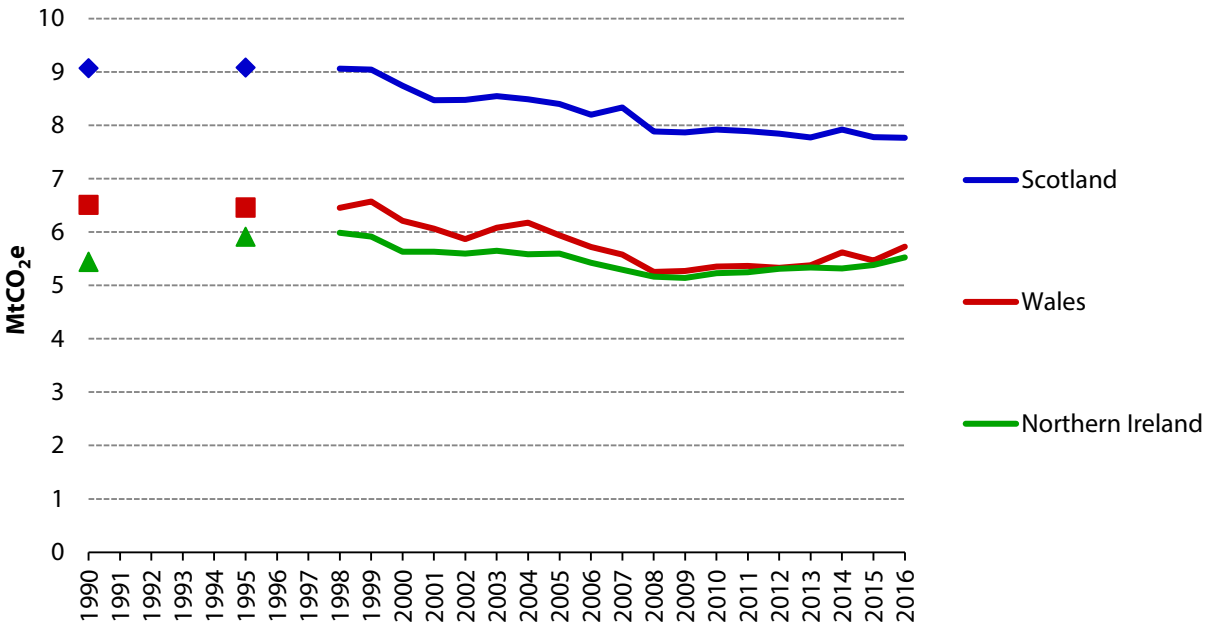
[126] https://www.zap-map.com/statistics/

7. Agriculture and land use

Agriculture emissions and drivers

Emissions from agriculture did not change significantly for the UK as a whole in 2016. There were similar changes in Scotland, but emissions increased in Wales and Northern Ireland (Figure 9.9).

Figure 9.9. Agriculture emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Historically, there has been considerable uncertainty over emissions from agriculture and this uncertainty had limited the scope for significant new initiatives in agriculture. Work on the UK-wide Smart inventory was completed last year and is expected to reduce this uncertainty in future. The updates are now fully incorporated into the GHG inventory at UK and devolved administration levels. Despite this uncertainty around the level of emissions, the trend of emissions over time is generally more robust.

Agriculture in the devolved administrations is more important for emissions, and for the economy, than for the UK as a whole. This is especially the case for Northern Ireland where 2016 emissions were 27% of the total compared to 20% in Scotland, 12% in Wales and 10% at a UK level. In 2016:

- In Scotland, agricultural emissions did not change significantly in 2016 (-0.2%), with no overall change between 2009 and 2016, although they have reduced 14% since 1990.
- Emissions from agriculture in Wales increased by 5%, with an annual average increase of 1.2% between 2009 and 2016, and were 12% below 1990 levels.
- In Northern Ireland, emissions from agriculture increased by 2.7%, with annual average increases of 1.0% between 2009 and 2016, and are 2% lower than they were in 1990.

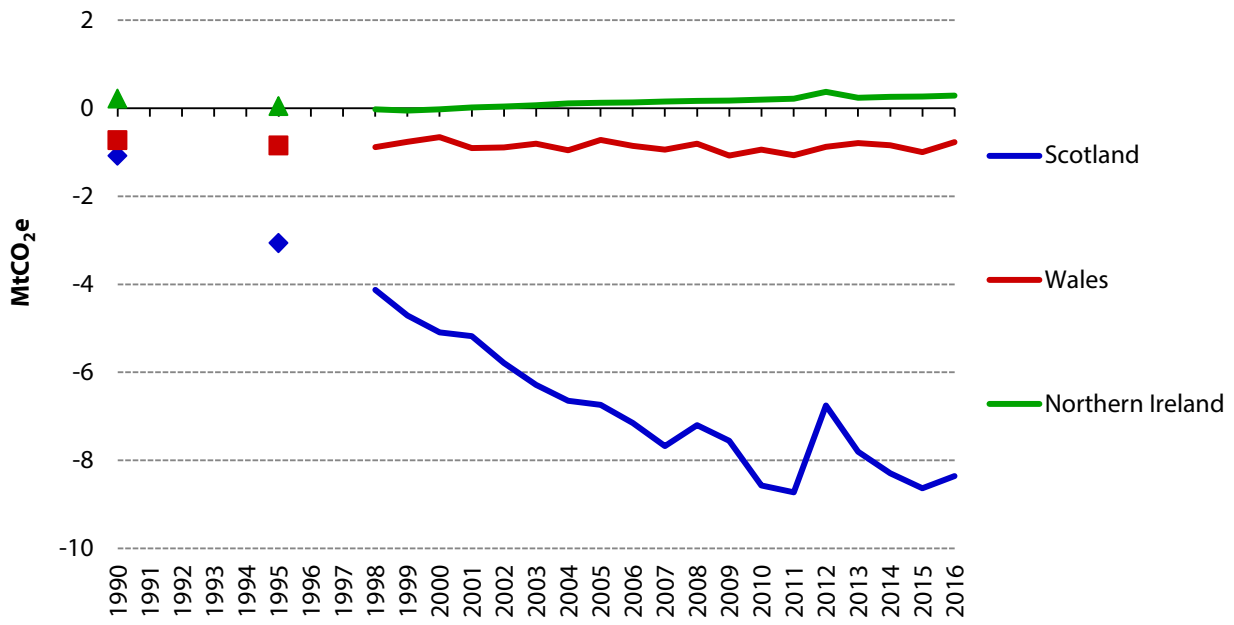
Emissions from forestry and land use

Forestry and land use are devolved matters. The size of the carbon sink from the land use, land-use change and forestry (LULUCF) sector was affected by inventory changes (Box 9.1), so the figures in this report are not directly comparable to those in previous reports.

In Scotland, the size of the carbon sink from the land use, land-use change and forestry (LULUCF) sector decreased by 0.3 $MtCO_2e$ between 2015 and 2016, whilst in Wales the sink decreased by 0.2 $MtCO_2e$ (Figure 9.10). In Northern Ireland, the LULUCF sector is a net emitter, and emissions from this sector did not change significantly, decreasing by 0.02 $MtCO_2e$

- In Scotland:
  - The size of the carbon sink decreased to 8.4 $MtCO_2e$ in 2016, from 8.6 $MtCO_2e$ in 2015. However, the size of the sink increased between 2009 and 2016 by an annual average of 0.1 $MtCO_2e$. In 1990, the sink was significantly smaller at 1.1 $MtCO_2e$. The carbon sink in Scotland represents 57% of the UK's total LULUCF sink.
  - New tree planting rates increased in 2016/17 by 4% to 4,800 hectares (ha). This followed a decrease of 39% in 2015/16. Scotland has the largest share of new planting in the UK at 74% in 2016/17 and the largest share of total forest stock (45%).
- In Wales:
  - The small sink (-2% of Welsh emissions) decreased in 2016 to 0.8 $MtCO_2e$. Between 2009 and 2016 the size of the sink has decreased by an annual average of 0.04 $MtCO_2e$.
  - Following an 89% decrease from 2013/14 to 2015/16, the tree planting rate in Wales increased by 300% in 2016/17 to around 400 ha of new woodland.
- In Northern Ireland:
  - The sector was a net emitter in 2016, emitting 0.3 $MtCO_2e$, with an annual average increase of 0.02 $MtCO_2e$ between 2009 and 2016. The sector accounts for 1.4% of total emissions in Northern Ireland.
  - Tree planting rates returned to 2014/15 levels in 2016/17, increasing by approximately 100% to 200 ha.

Figure 9.10. Emissions from land use, land-use change and forestry in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

8. Waste

Waste is fully devolved to the Scottish and Welsh Governments and Northern Ireland Executive. Estimates of emissions from the waste sector were affected by inventory changes (Box 9.1), so the figures in this report are not directly comparable to those in previous reports.

Waste emissions account for only a small proportion of total emissions of Scotland, Wales and Northern Ireland (4%, 3% and 4% respectively). In 2016, total emissions from waste decreased in Scotland (-5%) and Northern Ireland (-3%) and increased by 0.8% in Wales (Figure 9.11), compared to an increase of 5% in the UK as a whole.

In Scotland:

- The recycling rate of waste from all sources has increased from 56.4% to 61.0%.
- The share of total waste from all sources sent to landfill decreased by 12.4% in 2016 to 32.5% of total waste.

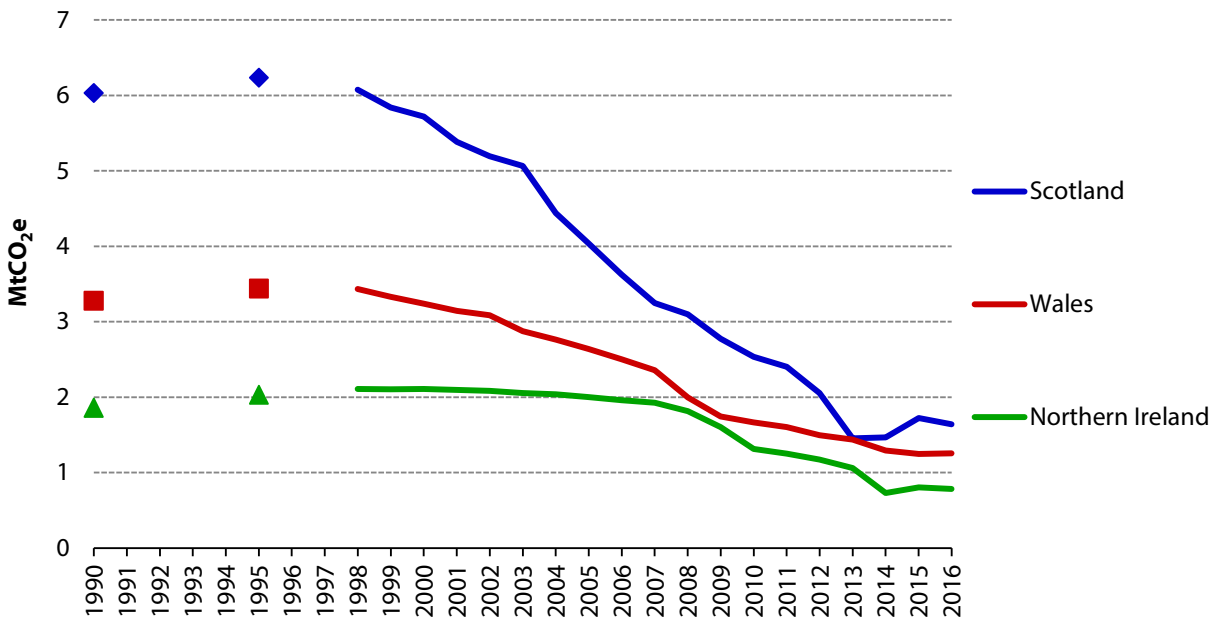
In Wales:

- Wales is leading in the UK regarding recycling rates. The percentage of waste reused, recycled, or composted increased from 60.2% in 2014/15 to 63.8% in 2015/16.
- Between 2012/13 and 2016/17 the proportion of annual waste sent to landfill has reduced by 77%, reducing the share of waste sent to landfill to 9.5% in 2015/16. This reduction has been enabled by a 22% increase in recycling rates and a 430% increase in waste incineration with energy recovery.

In Northern Ireland:

- Northern Ireland has a recycling rate for municipal waste of 44.0% in 2016/17, rising from 41.8% in 2015/16.
- Household waste recycling rate in 2016/17 was marginally higher than the total for all municipal waste, at 44.4%.
- The landfill rate for household waste recorded a new low of 36.7% in 2016/17, a drop of 3.0 percentage points on the 2015/16 rate.

Figure 9.11. Waste emissions in Scotland, Wales and Northern Ireland (1990-2016)



Source: NAEI (2018).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Conclusions

Overall progress in reducing emissions is mixed across the devolved administrations, with progress outside the Scottish power sector being limited and transport emissions on an upward trend:

- In **Scotland,** emissions fell by around 11% in 2016. Power sector emissions fell sharply in 2016 due to the closure of Longannet. Waste emissions have fallen steadily since 2009, but there has been considerably less progress in reducing emissions in other sectors. There is a downward trend in residential buildings emissions, although as 2015 and 2016 were colder than 2014 this has not immediately translated into lower emissions. Transport emissions in Scotland have risen in the past three years, while very little progress is apparent in agriculture and non-residential buildings.
- In **Wales**, emissions increased by around 5% due to a large increase in power sector emissions. In contrast to the UK as a whole, Welsh power sector emissions rose in 2016. This increase was partially offset by a fall in emissions from industry, whilst other sectors were broadly flat, although transport emissions have risen for three consecutive years. Welsh emissions have risen gradually since 2009, at an average of 1.4% per year.
- In **Northern Ireland**, emissions increased by 1.3% despite reductions in industrial sector emissions. Emissions increased in the power sector, and were broadly flat in all other sectors. Progress in reducing emissions is required across the board.

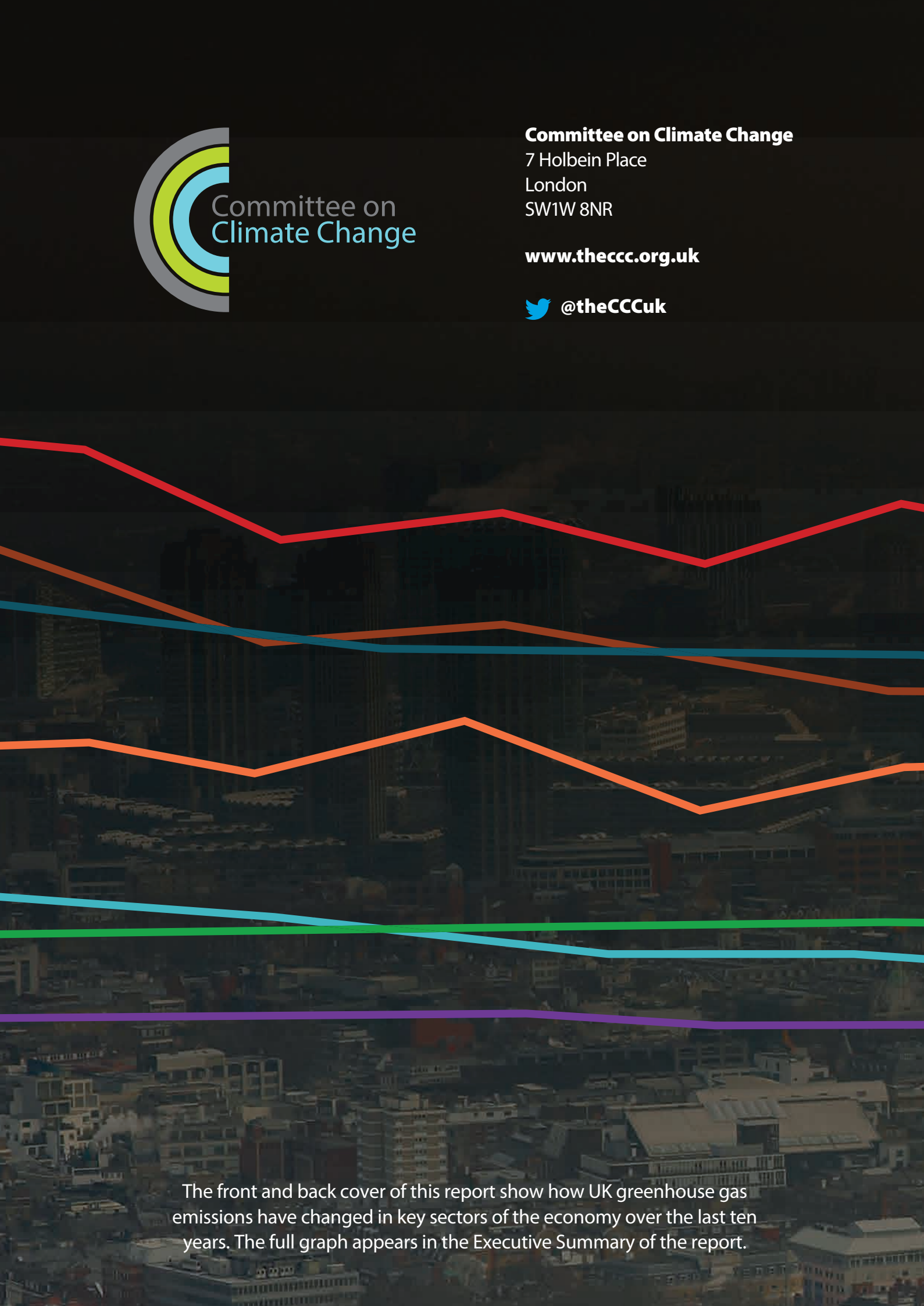
The devolved policy levers place an onus on the devolved administrations to address weaknesses in the current policy framework. Where policy areas are reserved, it will be important to work with the UK Government to ensure that the overall framework is strong enough to drive the necessary emissions reductions.

Climate change policies in Scotland and Wales could change significantly in the upcoming months, as plans are put in place to meet emissions targets.

The Scottish Government published its Climate Change Plan in February 2018 detailing how it plans to meet its existing targets to 2032. It has also published the Climate Change (Emissions Reduction Targets) (Scotland) Bill, which includes a 2050 target for a 90% reduction on 1990 emissions. The Committee provided advice on the Bill in March 2017 and December 2017, and will assess the policies and proposals in the final version of the Climate Change Plan as part of our Scottish Progress report in September.

The Committee provided advice to the Welsh Government on the design and level of the emissions targets and carbon budgets under the Environment Act (Wales) in April 2017 and December 2017. These targets will be placed in legislation later this year, after which Welsh Ministers are required to publish a report setting out their proposals and policies for meeting them.

The Department for Agriculture, Environment and Rural Affairs in Northern Ireland has requested the advice of the Committee on future actions that may help meet a range of emissions reduction targets by 2030. Further details will be confirmed later this year.



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The front and back cover of this report show how UK greenhouse gas emissions have changed in key sectors of the economy over the last ten years. The full graph appears in the Executive Summary of the report.