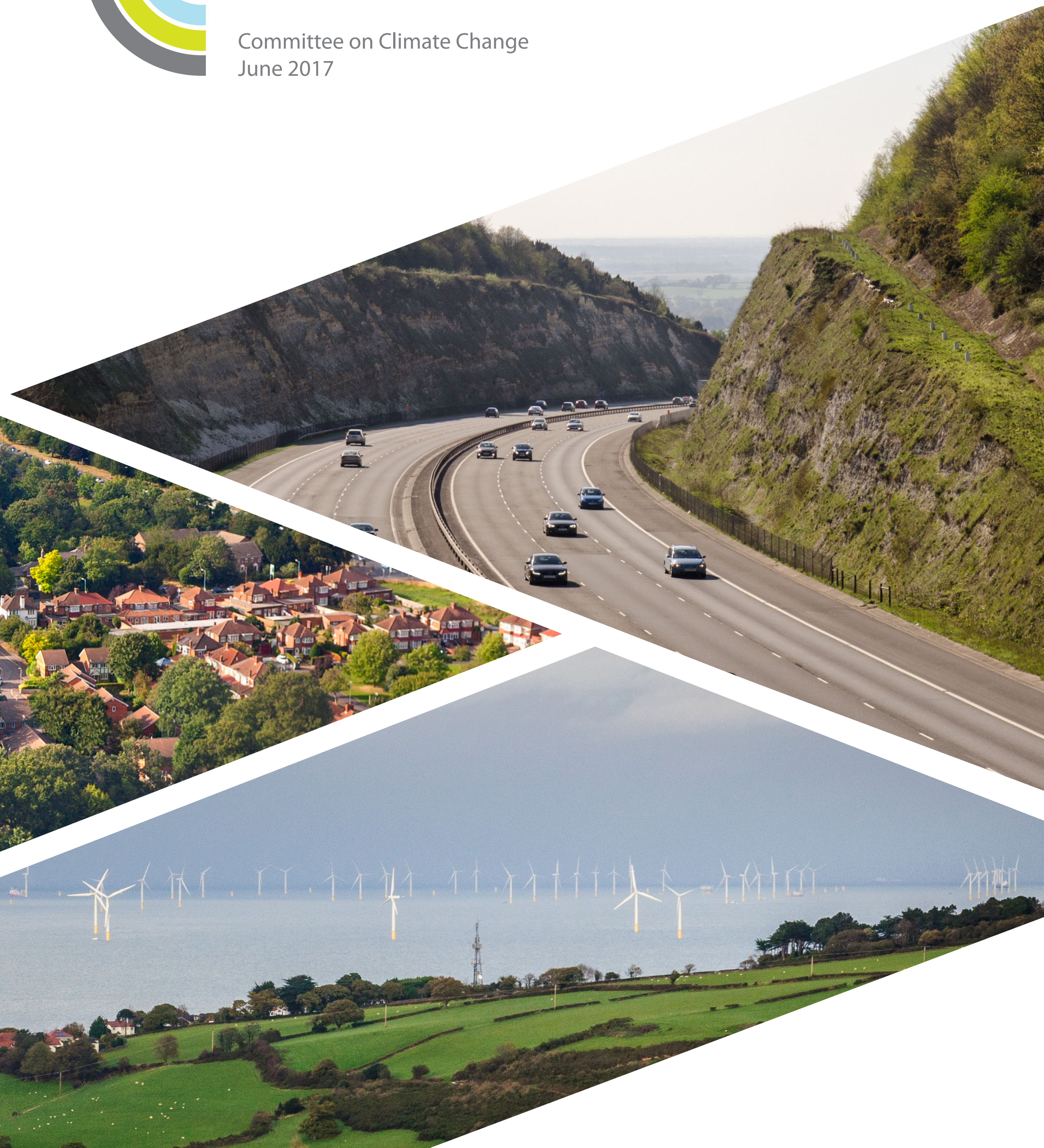
Meeting Carbon Budgets: Closing the policy gap

2017 Report to Parliament

Committee on Climate Change
June 2017



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Book 2 of 3

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

Contents

The Committee

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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 Investment Management and Financial Advice Association.

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Executive Summary

The UK urgently needs new policies to cut greenhouse gas emissions. Parliament has made commitments and the Government has a legal duty to propose policies to meet them. Despite this, no significant new policy plans have been published in the 11 months since the fifth carbon budget was set. Climate change will not wait while other priorities are addressed: plans must be published without delay, setting out how the Government intends to deliver the budget, which requires a 57% reduction in greenhouse gas emissions from 1990 to 2030.

Recent reductions in emissions should not detract from the urgent need for new policies to bring confidence to investors and to enable future targets to be met. Although UK emissions fell 6% in 2016 and are down 19% since 2012, progress has been dominated by the power sector. Carbon dioxide emissions from transport and buildings rose in 2015 and 2016, while progress in driving emissions reductions in industry and for non-CO_2 greenhouse gases has been minimal.

Despite promising advances in low-carbon technologies like electric cars and renewable power generation, emissions will not continue to fall without new and strengthened policies, and the fourth and fifth carbon budgets will be missed.

This report assesses recent progress and identifies the areas where new policies are needed. Our full set of recommendations is set out in Table 2. Our key messages are as follows:

- **UK emissions have fallen while the economy has grown, but progress will not continue without new policies.** It would be wrong to assume that the UK has permanently shifted to a path of falling emissions. Three-quarters of the decline in emissions from 2012 to 2016 has come from the reduction in the use of coal for power generation, which is now at low levels. Eliminating the remaining coal-fired generation would deliver less than two years' worth of the required progress to 2030. In stark contrast, emissions from transport (which make up 26% of total emissions) were higher in 2016 than in any year since 2009.
- **The Government must publish plans to meet the fourth and fifth carbon budgets without further delay.** Delays in extending policies into the 2020s are failing to meet the needs of low-carbon investors or the requirements of the Climate Change Act. To avoid derailing past good progress those plans must be published now.
- **New policies are needed across the economy.** By 2030, current plans would at best deliver around half of the required reduction in emissions, 100-170 $MtCO_2e$ per year short of what is required by the carbon budgets. An effective set of proposals to close this policy gap must: extend the approach to signing contracts for low-carbon power; extend and strengthen policies to switch to low-carbon vehicles; undertake a major overhaul of policy so as to cut emissions from buildings; and deliver a programme for carbon capture and storage.
- **The broader context underlines the importance and value of UK carbon budgets.**
  - Leaving the EU will change *how* carbon budgets are met. But it does not change either the need to cut emissions or the level of the carbon budgets, which are set in UK law.
  - Costs continue to fall for key low-carbon technologies such as wind power and electric vehicles whilst performance is improving fast.
  - Although the US Federal Government has signalled its intention to leave the Paris Agreement, many US States, cities, businesses and other major emitters like the EU, China and India have recommitted to the agreement, which has now entered into force.
  - The transition to a low-carbon economy should be a key part of the UK's industrial strategy and offers significant co-benefits particularly for air quality and health.

The rest of this summary sets out our assessment of these four areas.

Progress in reducing emissions

Total UK emissions of greenhouse gases fell by 6% in 2016 to 466 million tonnes of CO_2-equivalent ($MtCO_2e$). That continues a trend of large annual falls in emissions (averaging 5% per year) since 2012. Emissions are now 42% below 1990 levels, while the economy has grown by over 60% (Figure 1).

Since the Climate Change Act was passed in 2008, energy bills for the typical household have also fallen in real terms, as the benefits of improving energy efficiency have more than offset the increased cost of using renewable power generation, rising international gas prices and the increased number of electrical appliances in the home.[1]

It would be wrong to assume that, given strong recent progress, economic growth has been permanently decoupled from growth in emissions. Progress will need to extend beyond the power and waste sectors if carbon budgets are to be met while the economy continues to grow:

- 75% of the emissions reductions since 2012 have resulted from reduced burning of coal in the power sector (Figure 2). This is now at low levels, with limited potential for further reductions. Even if all coal generation stopped, which is the Government's announced intention by 2025, emissions would only fall by around 16 $MtCO_2e$, the equivalent of less than two years' worth of further progress required to 2030.
- In other sectors, recent progress has been far more limited or emissions have been rising:
  - **Transport** emissions have risen three years in a row to their highest level since 2009. This reflects rising demand for travel and a slowing of progress in improving the efficiency of new vehicles. In contrast, our scenarios for meeting the fifth carbon budget require transport emissions to reduce by an average of 4% per year to 2030.
  - **Buildings** emissions have risen in the last two years, with the trend only partly attributable to lower winter temperatures than in 2014. Most boilers have now been replaced with efficient condensing models (around 70% in 2016) and rates of installing insulation have been very low since 2012. Uptake of heat pumps and district heating remain minimal and new buildings with high-carbon heating systems are still being built.
  - **Industry** emissions fell in 2016, but over half of the reduction reflected reduced iron and steel production rather than improvements to energy productivity or shifts to low-carbon fuels. Plant closures have not been a result of climate policies since these had at most a marginal effect on relative plant economics (see Chapter 4). Effective policy is now needed to support UK industry to move towards low-carbon production methods.
  - **Non-CO_2** emissions data are not yet available for 2016, but in 2015 agriculture and F-gas emissions remained broadly flat and at their highest levels since 2007 and 2010 respectively. That is despite significant low-cost opportunities to cut emissions in both areas. Waste emissions have fallen strongly since 1996, but may now be flattening out.

The rapid falls in emissions since 2012 demonstrate that Government policy can successfully influence behaviour to cut emissions - the UK's carbon price floor and support for investment in renewable power have driven the reductions in coal use, while the landfill tax and policies to reduce waste and encourage recycling have helped cut waste emissions. Effective policy to reduce emissions must now be extended across the economy to ensure that progress continues.

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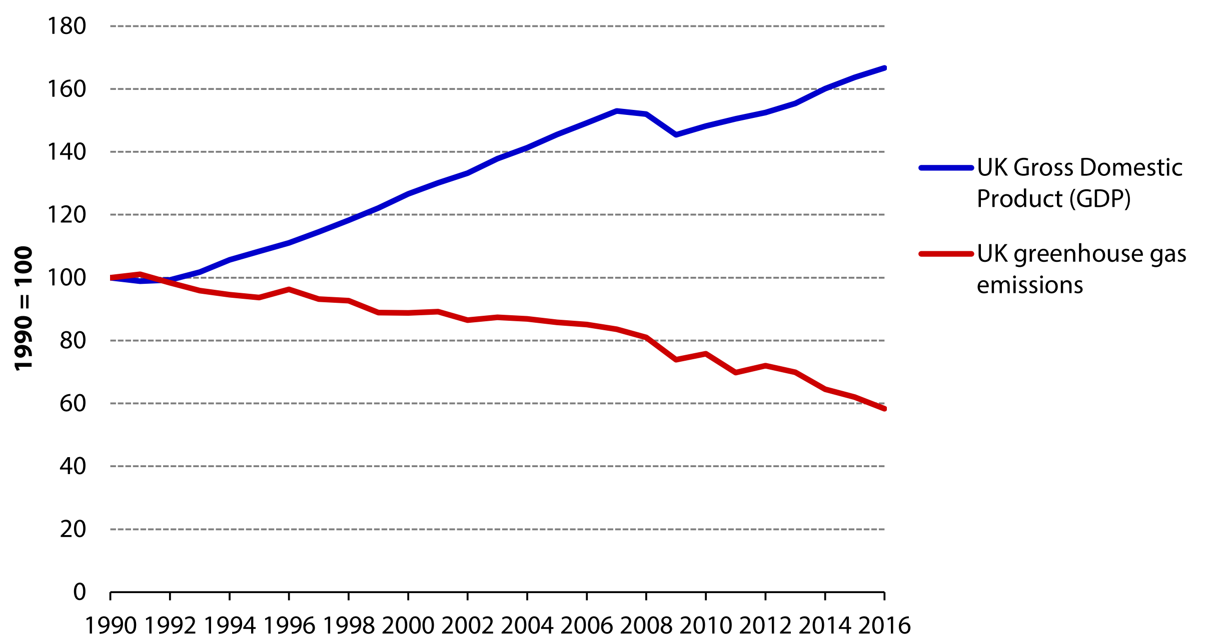
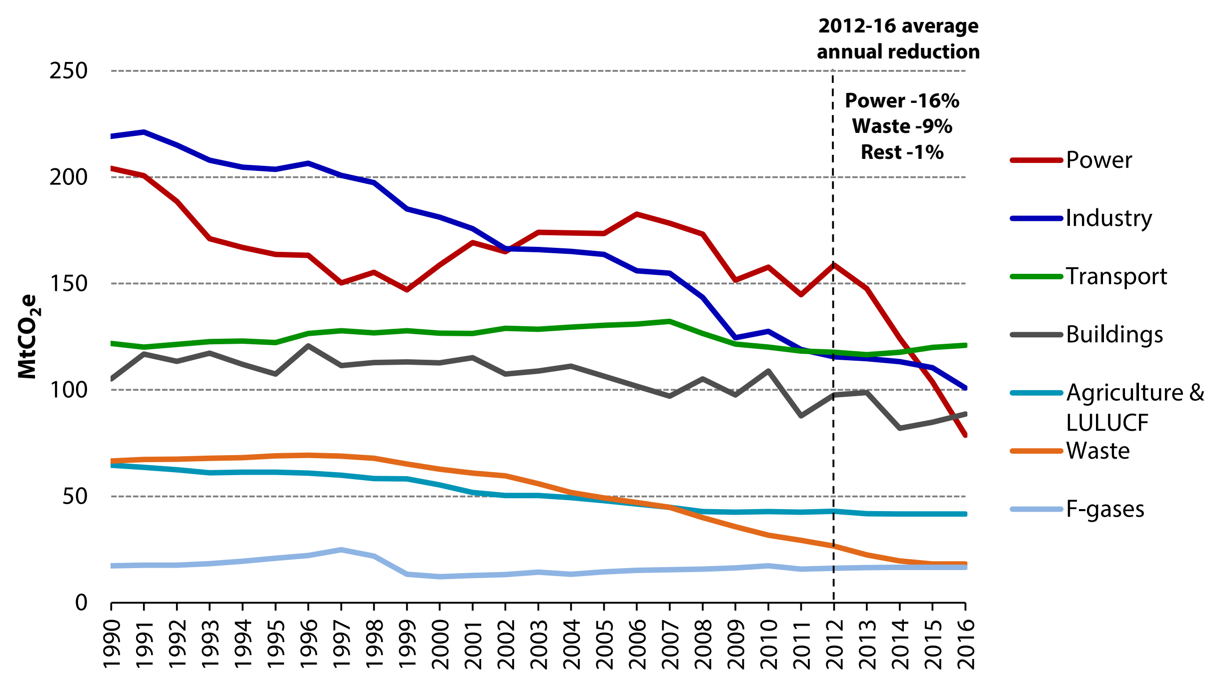
[1] See CCC (2017), *Energy prices and bills – impacts of meeting carbon budgets*. The average energy bill for a dual-fuel household with gas heating was £1,280 in 2008 and £1,160 in 2016 (both in 2016 prices). Household gas use fell 23% in this period while electricity use fell 17%.

Figure 1. Since 1990 UK emissions have fallen 42% while the economy has grown over 60%



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; ONS; CCC calculations.
Notes: Series indexed to start at 100. In 2016 UK GDP was £1.9 trillion and GHG emissions were 466 $MtCO_2e$.

Figure 2. There has been little progress recently apart from in the power and waste sectors



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015.*
Notes: 2016 emissions are provisional estimates and assume no change in non-CO_2 emissions from 2015.

Principles for the Government's plans for meeting the carbon budgets

In July 2016, after the vote to leave the EU, the Government legislated the fifth carbon budget. That budget sets a cap on UK emissions of greenhouse gases over 2028-2032. The budget requires that emissions are cut by at least 57% from 1990 to 2030 (26% from 2016 to 2030). The budget is based on the Committee's best estimate of the lowest-cost path to the UK's long-term target to reduce emissions by at least 80% by 2050 relative to 1990.

When setting the fifth carbon budget, the Government acknowledged that new and stronger policies would be needed to meet it and the existing fourth carbon budget (covering 2023-2027, and for which previous plans have not been translated into firm policies). The Government had committed to publish new plans to meet the budgets by the end of 2016. This would have been consistent with previous legislative timelines in 2008 and 2010, when plans to meet the third and fourth carbon budgets were published within six months of each budget being agreed by Parliament.

There have been delays from the vote to leave the EU, the change in Prime Minister and the general election. Continued delay would conflict with the requirement in the Climate Change Act to publish plans 'as soon as is reasonably practicable' after the budget is set.[2] Avoiding delay is crucial to unlocking investment throughout the supply chain, given the significant lead-times from policy development to a response from investors and consumers.

Under the Climate Change Act, the Government's new plans must enable the carbon budgets and the 2050 target to be met. Proposals should be flexible and credible, integrated with other policy priorities and should include clear timelines to move from proposals to actions:

- **The plans must enable the carbon budgets to be met and prepare for the 2050 target.**
  - The numbers must add up – taken together the Government's policies and proposals must be expected to deliver the emissions reductions required by the carbon budgets. The aim should be to meet the budgets without the use of international carbon units (i.e. credits) outside the EU Emissions Trading System.[3]
  - The Act also specifies that plans must prepare for meeting the 2050 target to cut emissions by at least 80% relative to 1990. As well as reducing emissions to 2032, proposals should lay the ground for further reductions in the 2030s and 2040s. That implies, for example, that it will be important to develop carbon capture and storage and to prepare for a widespread shift away from natural gas for heating.
- **Policy proposals should be flexible, robust, and joined-up with other priorities.**
  - Proposals should be flexible with respect to various uncertainties.
    - That includes uncertainties over how policies currently applied at the EU level will operate after the UK leaves the EU. The Committee's previous analysis suggests that EU-level policies currently cover around half of the UK's potential emissions

[2] Climate Change Act (2016), clause 14.

[3] If unexpected circumstances mean the budget cannot be met cost-effectively without recourse to purchase of credits, the Committee would revisit this advice, including an assessment of the strength and validity of the credit market at that time. Credits could also be used to go beyond the proposed budget to support international action to reduce emissions. For those sectors covered by the EU ETS, the Government's plans should set out not just the expected cap in the trading scheme, but also how policy will reduce actual emissions and ensure that investments stay on track to 2050.

reductions to 2030.[4] New UK policies will be needed to reduce emissions where policies previously agreed through the EU no longer apply or are weakened.

  - Proposals should also leave open the possibility of reducing emissions more quickly than required by the budgets, given that the Paris Agreement has more ambitious aims to limit global temperature increase than the aims on which the UK's carbon budgets are based.
  - Policy should be flexible to uncertainties relating to changing technology and behaviour, including potential changes to travel behaviour and energy use as autonomous vehicles and smart technologies become more widespread.

- Proposals should address areas with no current policy and where there are risks that existing policy will under-deliver. For example, efficiency standards for new vehicles must be extended beyond 2020 and to HGVs, but should also be strengthened to reflect real-world driving performance more closely.
- Proposals should be joined-up with other policy priorities, including the industrial strategy, the review of energy costs, efforts to improve air quality and actions to prepare for the impacts of a changing climate.

• **There should be a clear process to turn proposals into action.**

  - Where plans are only presented at the proposal stage there should be clear timelines for translating these into firm and funded policy and actions. For example, for residential heating an overhaul of the current policy approach is needed, and some aspects will require initial consultation, followed by implementation before current policies expire around 2020.
  - The Government should set out how it intends to monitor progress and adjust plans to remain on track. For example, the Government could link reviews to the annual Progress Reports provided by the Committee and/or to the annual emissions projections[5] that BEIS already produces.

Table 1 sets out an example package of outcomes that would be consistent with the requirements of the Climate Change Act. These reflect the scenarios produced for the Committee's advice on the fifth carbon budget and our best estimate of the lowest-cost path to the 2050 target. The Government may choose to aim for a different balance of effort, but any areas with less effort would need to be balanced by increased effort elsewhere.

[4] See CCC (2016) *Meeting Carbon Budgets - Implications of Brexit for UK climate policy*.
[5] The latest projections are BEIS (2017) *Updated energy and emissions projections: 2016*.

Table 1. Possible package of measures to deliver the changes required

36% reduction in UK emissions required from 2016 to 2030				
Power (79 $MtCO_2e$ in 2016) 62% reduction 2016-2030	**Buildings** (89 $MtCO_2e$) -20%	**Industry** (100 $MtCO_2e$) -20%	**Transport** (121 $MtCO_2e$) -44%	**Agriculture, LULUCF, Waste, F-gases** (77 $MtCO_2e$) -38%
• CfD contracts for further 80-100 TWh low-carbon generation (beyond delivery of Hinkley and planned auctions) • CCS strategy to allow deployment at scale by the 2030s • Additional storage, interconnection, flexible generation, and demand-side response to deliver smart flexible power	• Insulation of all practicable lofts by 2022 and cavity walls by 2030, and 2 million solid walls by 2030 • Stronger new build standards for energy efficiency and low-carbon heat • 2.5 million heat pumps in homes by 2030 • Around 40 TWh of low-carbon heat networks by 2030 • Around 20 TWh of biomethane to the gas grid by 2030	• CCS strategy to allow deployment at scale by the 2030s • Effective approach to drive uptake of low-carbon heat • Stronger framework for industrial energy efficiency	• 60% of new car and van sales ultra-low emission (e.g. electric) by 2030 • 32% improvement in efficiency of conventional cars by 2030 • Sustainable biofuels to supply 11% of road fuel by energy in 2030 • 5% reduction in travel demand below baseline levels by 2030	• Moving beyond a voluntary approach for on-farm emissions reductions • Afforestation rate to deliver 15,000 hectares per year • Near-zero biodegradable waste sent to landfill by 2025 • F-gases cut by at least 68%

Source: Scenarios for CCC (2015) *The Fifth Carbon Budget*.
Notes: The fifth carbon budget requires a 26% reduction in the UK's net carbon account from 2016 to 2030. However, this allows for trading in the EU ETS, where the UK is expected to be a net seller of allowances. On the basis of actual emissions and the latest projections the Committee scenarios involve a 36% reduction (equivalent to a 63% reduction from 1990 to 2030). This would keep the UK on the lowest-cost path to the 2050 target and to meet the fifth carbon budget taking account of possible trading of allowances within the EU ETS.

Policy priorities for the Government's plans

An effective policy package to meet the fourth and fifth carbon budgets must target emissions reductions across the economy, tackling financial and non-financial barriers to action and addressing innovation and infrastructure challenges.

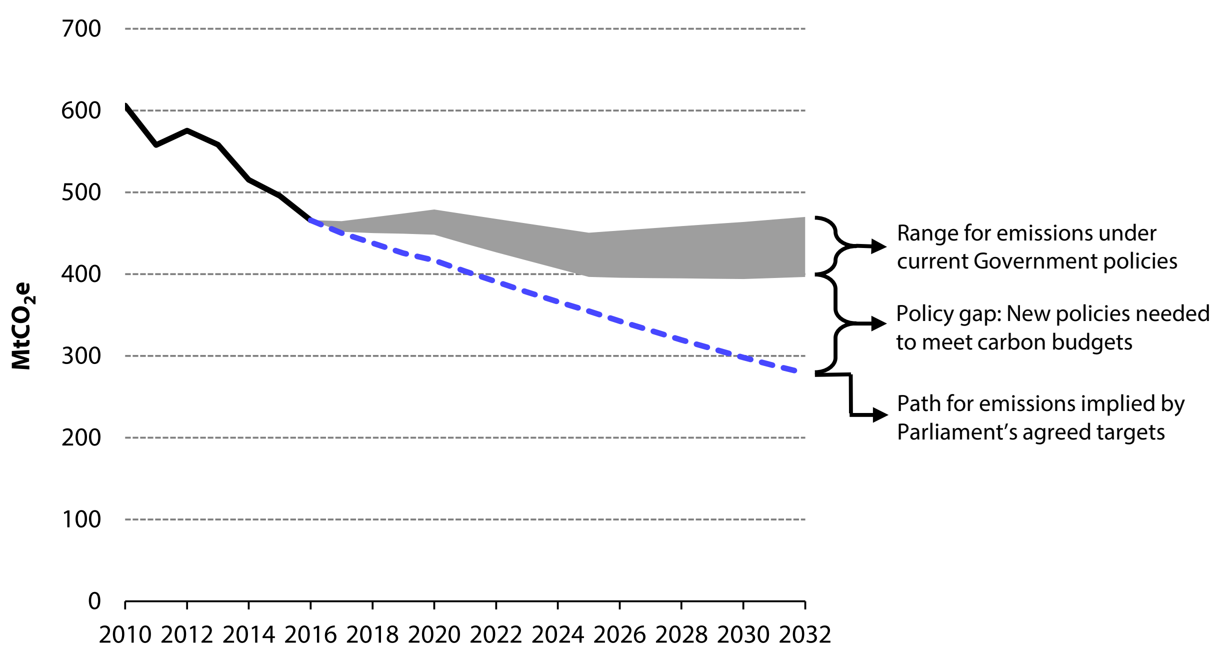
Current policies would leave a gap of at least around 100 $MtCO_2e$ in 2030 compared to what is required by the fifth carbon budget. Risks to those policies delivering in full (e.g. because of the failure of new vehicle emissions targets to take account of the discrepancy between testing and real-world driving conditions) mean the gap could be as large as 170 $MtCO_2e$ (Figure 3).

Table 2, at the end of this summary, sets out the full set of areas where the Committee has identified a need for stronger policy, new policies and new strategic approaches. Particular priorities are in low-carbon power generation, the shifts to low-carbon vehicles and to low-carbon heating and development of carbon capture and storage (CCS):

- **Low-carbon power.** The Government should plan to award contracts for a further 80-100 TWh of low-carbon generation in the 2020s, beyond the planned auctions for offshore wind and the contract for a new nuclear power station at Hinkley Point C.
- **Transport.** Stretching standards based on real-world testing are needed for new cars and vans beyond 2020. These should require a significant take-up of electric (or other ultra-low emission) vehicles, supported by additional Government policies (e.g. support for a national charging network and preferential tax treatment).
- **Heat.** A clear, combined strategy for energy efficiency and low-carbon heat is needed. It must significantly increase the delivery of energy efficiency measures, heat networks and heat pumps in cost-effective locations for both households and businesses. It should also test the possibility for low-carbon hydrogen to meet heat demand.
- **CCS.** A new strategic approach is required to CCS deployment in the UK, including a separate approach to development of transport and storage infrastructure. Contracts should be awarded by 2020 to allow CCS to operate at scale by the 2030s.

The Committee will publish our assessment of the Government's proposals after they have been announced.

Figure 3. Current policies fall far short of what is needed to meet the fourth and fifth carbon budgets



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; BEIS (2017) *Updated energy and emission projections 2016*; CCC analysis.
Notes: The grey area here corresponds to the yellow area in Figure 1.6 in Chapter 1.

Broader circumstances relevant to climate policy

The UK's carbon budgets have been set at levels that reflect the need for steady progress in reducing greenhouse gas emissions, taking into account a range of criteria including costs, competitiveness, and climate science.

Changes in international circumstances have underlined the importance of the UK carbon budgets:

- **The future impacts of leaving the EU.** Leaving the EU would change *how* carbon budgets are delivered: where policies previously agreed at EU level no longer apply or are weakened, new UK policies will need to replace them. But it does not change the need to cut emissions, the level of the carbon budgets (which are set in UK law) or the duty on the Government to act.
- **The Paris Agreement.** The Paris Agreement is the first fully global deal to cut emissions and tackle climate change and has now come into force. The announced withdrawal by the United States has been followed by renewed commitment from a number of other countries (including the UK, China, India and the EU) as well as many States, cities and businesses within the US. The Committee published advice in light of the Paris Agreement in October 2016, where we concluded that the most important contribution the UK Government can make now to the Paris Agreement is publishing a robust plan to meet the UK carbon budgets and delivering policies in line with the plan.[6]
- **Global temperature increase.** 2016 was the hottest year on record with global temperatures around 1.1°C higher than in the late 1800s. Each of the last three decades has been successively the hottest decade on record.

Furthermore, progress in low-carbon technologies and policies across the world is strengthening the case for the transition to a low-carbon economy:

- Wind and solar power are now the cheapest forms of electricity in many markets, with the potential to deliver low-carbon power without subsidy in the UK if they are allowed to compete for long-term contracts.
- Many countries have set ambitious goals for take-up of electric cars (e.g. India, China, Norway, the Netherlands, various US states), and new models with longer ranges are being introduced across car classes and manufacturers in the UK this year and next.
- 142 countries have submitted pledges to reduce emissions under the Paris process. 125 have also put in place their own domestic climate laws, including the UK Climate Change Act. By the end of 2017, 22% of global greenhouse gas emissions are due to be covered by carbon pricing schemes, as China commences national emissions trading.

Overall carbon budgets are still expected to involve some financial costs since many low-carbon technologies are currently more expensive than high-carbon alternatives. However, these costs are small relative to the costs of dangerous climate change and were accepted by Parliament when the fifth carbon budget was set. For the UK to contribute to tackling dangerous climate change, the budgets are aligned to our best estimate of the lowest-cost path to do so.

The transition to a low-carbon economy is already underway and presents opportunities for UK businesses, both new and existing firms. Grasping those opportunities and ensuring a smooth transition must be integral to the Government's new industrial strategy:

[6] CCC (2016) *UK climate action following the Paris Agreement*.

- The UK low-carbon economy is already estimated to employ hundreds of thousands of people and contribute around 2-3% of GDP, which is a comparable size to energy-intensive manufacturing. It has been growing faster than the rest of the economy.
- Following the Paris Agreement, global demand for low-carbon goods and services is set to expand many times over to 2030 and then again to 2050. UK businesses must adapt to meet this need in place of the declining demand for high-carbon goods and services.
- The UK is particularly well-placed to take advantage of growing global markets for: low-emission vehicles; low-carbon finance, insurance and consulting; low-carbon electricity; smart grids and energy efficient products.

Reducing emissions also brings important co-benefits, particularly for health, resulting from improved air quality, better insulated housing, reduced noise and more active transport (e.g. walking and cycling).

Efforts at the UK level need to be reinforced and supported by efforts at devolved level. Scotland and Wales are both in the process of legislating new emissions targets, the design of which we advised on in March:

- Scotland (9% of UK emissions) has produced a draft Climate Change Plan for meeting its existing targets, as well as a draft Energy Strategy. We will comment on these in our Scottish progress report in the Autumn.
- Wales (9% of UK emissions) will set the levels of their first two carbon budgets in 2018, following advice from the Committee in Autumn this year. Welsh Ministers will then publish a report setting out their proposals and policies for meeting them.
- Northern Ireland (4% of UK emissions) does not have its own climate legislation. However, it will have to contribute to emissions reductions if the UK targets are to be met.

The rest of this report provides an economy-wide view of progress, followed by assessments of progress and policy priorities across the emitting sectors of the economy. This report, Volume 2, is published alongside Volume 3, which covers progress in preparing the UK for the impacts of a changing climate and Volume 1, which provides a synthesis across Volumes 2 and 3.

Table 2. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

Policy requirement	Stronger implementation required	New policy required	New strategy required
<u>Power</u> (17% of 2016 emissions): Emissions intensity to fall by around 65% (to below 100 gCO_2/kWh) between 2016 and 2030, with options developed to allow near-zero emissions by 2050			
Extension of existing approaches to contract an additional 80-100 TWh low-carbon generation in the 2020s beyond existing plans (i.e. 130-150 TWh in total)		✗	
A new strategic approach to carbon capture and storage deployment in the UK should include power plants as anchor loads for strategic clusters		✗	✗
Implementation of plans for increasing flexibility (e.g. storage, interconnection, demand response, flexible generation)	✗		
Continued application of a carbon price after leaving the EU	✗		
Contingency plans for delay or cancellation of planned projects, for example of new nuclear power plants		✗	
<u>Buildings</u> (19% of 2016 emissions): Emissions to fall by around 20% between 2016 and 2030, with options developed to allow near-zero emissions by 2050			
***New-build:* Standards to ensure new-build properties are highly energy efficient and can use low-carbon heating systems from the start**		✗	
***Existing buildings:* A stable framework and direction of travel for improving the energy and carbon efficiency of existing buildings** joining up energy efficiency and low-carbon heat, with: an attractive, well-timed offer to households and SMEs; simple, highly visible information and certification, including enhanced business reporting, alongside installer training; backed by standards for emissions performance of buildings that tighten over time	✗	✗	✗
Reformed support for low-carbon heat through the 2020s, that deals with current barriers, provides a process for decisions on heat infrastructure, and is attractive enough to drive deployment of heat pumps, heat networks and biomethane in line with CCC scenarios	✗	✗	✗
Active preparations for strategic decisions in the early 2020s on the role for hydrogen for heat and the future of the gas grid, including pilots, demonstrations, and research on the challenges of a wider-scale hydrogen switchover			✗
<u>Industry</u> (22% of 2016 emissions): Emissions to fall by around 20% between 2016 and 2030			
An overall approach to long-term industrial decarbonisation, developing existing 'Roadmaps' into specific actions and milestones and extending coverage to other industries		✗	✗
A strategic, funded approach to industrial carbon capture and storage, based around clusters alongside power installations and shared infrastructure, with a new funding mechanism for industry		✗	✗
An effective approach to drive sustained uptake of low-carbon heat in industrial processes and buildings		✗	
The EU ETS and EU efficiency standards and policy to be preserved or replicated and strengthened in future	✗	✗	
A stronger policy framework for industrial energy efficiency, including an effective reporting mechanism	✗		
Tightly regulate and closely monitor any onshore petroleum wells (i.e. shale gas) during development, production and decommissioning to ensure rapid action to address leaks	✗	✗	

Policy requirement	Stronger implementation required	New policy required	New strategy required
Transport (26% of 2016 emissions): Emissions to fall by around 44% between 2015 and 2030 with options developed to allow near-zero emissions by 2050			
Stretching standards for new car and van CO_2 beyond 2020, that require increased electric vehicle sales, are independently enforced and use real-world testing procedures		✘	
Policies to deliver a high uptake of electric vehicles, of around 60% of new car and van sales by 2030, including: time-limited financial support, preferential tax rates and effective roll-out of charging infrastructure	✘		
Implementation of policy to deliver 8% of sustainable biofuels by energy by 2020 and maintain the biofuels volume after 2020	✘		
Policies to support emissions reduction from HGVs, including new vehicle efficiency standards requiring electric options for smaller trucks, more efficient logistics, increased uptake of eco-driving measures, and a shift to lower-carbon modes (e.g. rail)		✘	
National and local policies to reduce demand, to deliver car-km reductions of at least 5% below the baseline trajectory	✘	✘	
A plan to limit UK aviation emissions to the level assumed when the fifth carbon budget was set: around 2005 levels by 2050, implying around a 60% potential increase in demand, supported by strong international policies		✘	✘
Agriculture, land-use and forestry (8% of 2015 emissions): Emissions to fall by around 19% between 2015 and 2030, and afforestation rates to deliver 15,000 hectares per year			
The new 'Smart' inventory for agriculture emissions to be introduced in 2018, to enable better monitoring and tracking of progress	✘		
A stronger policy framework for reducing emissions from agriculture and land use in all UK nations to 2022, as current progress is off track	✘	✘	
New farming policies to 2030 that move beyond the current voluntary approach and replace CAP with a framework that links support to emissions reduction and removals		✘	✘
Addressing financial and non-financial barriers to increase afforestation and on-farm tree planting	✘	✘	
Waste (4% of 2015 emissions): Emissions to fall by around 53% between 2015 and 2030			
Strengthened approaches through the waste chain, from creation to disposal, including reducing waste arising, separate collections (e.g. of food waste), stopping biodegradable waste going to landfill, and maintaining or increasing methane capture at landfill sites	Wales Scotland	England N Ireland	
F-gases (3% of 2015 emissions): Emissions to fall by at least 68% between 2015 and 2030			
A UK approach to reduce F-gas emissions by at least 68%, in line with the EU regulatory minimum: Government to investigate and pursue any further cost-effective opportunities		✘	
Cross-cutting priorities			
A new strategic approach to carbon capture and storage deployment in the UK, including preparations for possible use in the production of low-carbon hydrogen		✘	✘
An updated strategy for increasing the supply of sustainable bioenergy feedstock and using it effectively			✘
A strategy for developing options for removing greenhouse gases from the air			✘
Notes: All policies, whether new or existing, will need to be strongly implemented. Latest non-CO_2 data is for 2015.			

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 in its plan for reducing emissions to meet the fourth and fifth carbon budgets.

Overall emissions fell by 6% in 2016 and are now 42% lower than in 1990, around halfway towards the 2050 target.

Our key messages for the economy as a whole are:

- **UK emissions fell by 6% in 2016 but progress was unbalanced.** The reduction was almost entirely from electricity generation, where emissions fell 24% as coal generation fell rapidly.
- **There has been very limited progress in developing the policy framework to drive emissions reduction. Policy strengthening will be required to meet the fourth and fifth carbon budgets.**
  - The Climate Change Act puts a duty on the Secretary of State to bring forward 'proposals and policies' to meet carbon budgets. The Government has not yet published its plans.
  - In this report we identify a gap of around100 $MtCO_2e$ - around half of the total required emissions reduction - between current Government plans and the path required to meet the fifth carbon budget in 2030. In addition, we assess that over three-quarters of the emissions reduction targeted by existing plans and policies (around 70 $MtCO_2e$) are at risk unless existing plans are implemented more strongly.
  - New policies are required to take forward low-carbon electricity generation, carbon capture and storage, new car and van CO_2 standards, and low-carbon heating. Existing policies need to be strengthened to ensure they do not under-deliver, including in transport (e.g. financial support for electric vehicles and roll-out of recharging infrastructure) and buildings (e.g. to increase installation rates of insulation and improve uptake of low-carbon heating options).
  - The Government's plan should be flexible to uncertainties - including from Brexit - so that carbon budgets will be met even if circumstances are different to central expectations.
- **Government plans to meet carbon budgets must include options to prepare for deeper emission reductions beyond 2030, to meet the 2050 target.** Achieving this target, of at least an 80% reduction in emissions below 1990 levels, in the most cost-effective way requires immediate and substantial progress in a number of key areas. These include carbon capture and storage, low-carbon heating and transport, greenhouse gas removal and the appropriate use of sustainable bioenergy.

In terms of cross-cutting priorities, we will assess the Government's plan for meeting the fourth and fifth carbon budgets against the following checklist (Table 1.1).

Key messages and recommendations

Table 1.1. Cross-cutting priorities for the Government's plan to meet the fourth and fifth carbon budgets

Economy-wide emissions to fall by 36% between 2016 and 2030, and develop options to allow for deeper emission reductions by 2050. In addition to actions set out in Chapters 2-9, this will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
A new strategic approach to carbon capture and storage (CCS) deployment in the UK, including preparations for possible use in the production of low-carbon hydrogen. CCS could enable large-scale emissions reduction from electricity generation and industry, plus the production of hydrogen. The new approach should include separation of support for CO_2 infrastructure, a new funding mechanism for industrial CCS and some sharing of risks across parties, and with Government, especially where they reflect future policy uncertainty. Contracts should be awarded by 2020 to allow operations at scale in the 2030s.		×	×
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.			×
A strategy for developing options for removing greenhouse gases from the air, alongside innovation in hard-to-treat sectors. Currently there are no clear routes to complete decarbonisation in sectors such as aviation, agriculture and parts of industry. Greenhouse gas removal options (e.g. afforestation, carbon-storing materials, bioenergy with carbon capture or direct air capture and storage) are needed alongside widespread emissions reductions to meet the 2050 target and beyond.			×

Introduction

In this chapter we review progress 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, if not, what new actions and policies are required. We also assess international progress in reducing emissions.

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

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

1. Economy-wide progress reducing emissions

UK greenhouse gas (GHG) emissions fell 6% in 2016 to 466 $MtCO_2e$ and are now 42% below 1990 levels. At the same time, the economy has grown by over 60% (Figure 1.1). Allowing for differences in temperature between 2015 and 2016 emissions still fell 6% overall.

Since the Climate Change Act was passed in 2008, energy bills for the average household have fallen in real terms as energy efficiency improvements have more than offset the rising cost of natural gas and the premium paid for low-carbon electricity (Figure 1.2).

We estimate that the net carbon account, which allows for international trading of carbon permits and is the basis on which achievement of carbon budgets is judged, was at a similar level to actual emissions in 2016 at 469 $MtCO_2e$. That is also 42% below 1990 and below the level required to meet the second and third carbon budgets (i.e. the emissions limits for 2013-2017 and 2018-2022, Figure 1.3).

Continuing the trend since 2012, the largest reduction in emissions in the last year was in the power sector, where emissions fell 24% as coal generation fell rapidly (Figures 1.4 and 1.5). Industry emissions fell 9% but emissions rose in both transport (1%) and buildings (4%).

Further substantial reductions in emissions are still required to meet the fourth and fifth carbon budgets, which 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.
- These cannot be delivered through reductions in the power sector alone. For example, if all remaining coal generation were replaced by gas generation, overall emissions would only fall by another two percentage points - around 16 $MtCO_2e$ - to 44% below 1990 levels.
- Similarly, the waste sector has been a significant contributor to recent falls, with emissions down 8 $MtCO_2e$ (31%) since 2012 and 48 $MtCO_2e$ (73%) since 1990. However, reductions are now flattening out, with only around a further 10 $MtCO_2e$ potential reduction to 2030.
- The budgets require a 3% reduction in emissions per year from all other sectors, compared to 1% on average since 2012.

The recent good overall progress must not lead to complacency. Although economy-wide emissions have fallen rapidly whilst the economy has grown, this cannot be replicated in future without extending progress to other sectors where emissions are currently increasing rather than decreasing.

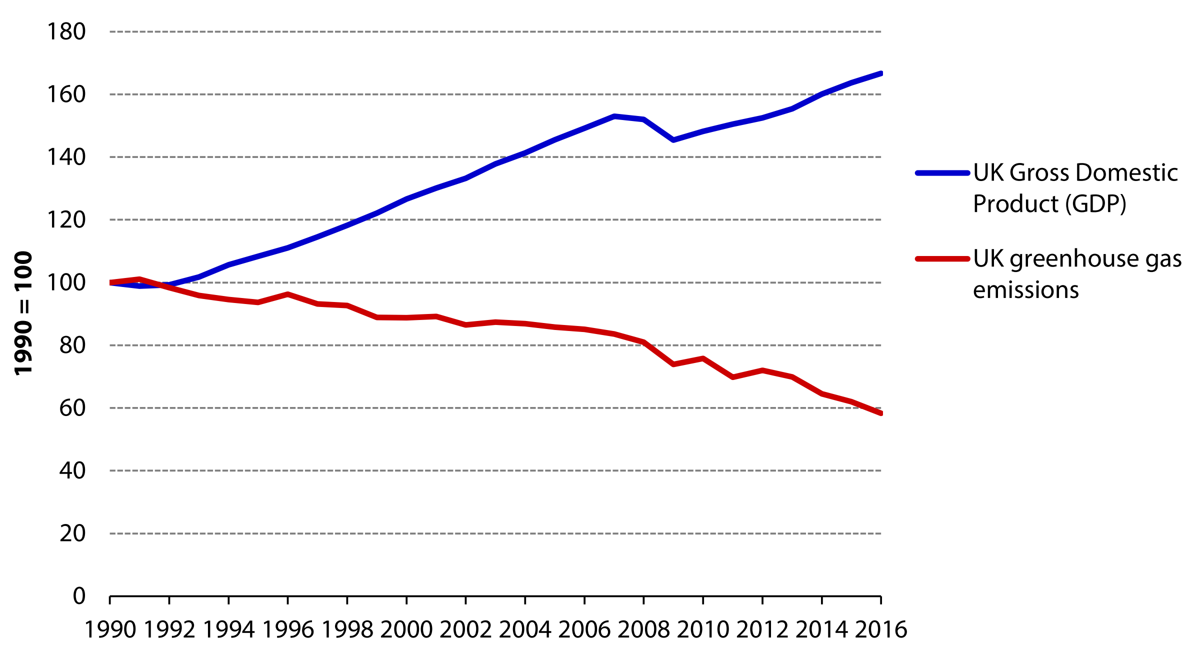
Effective measures to reduce emissions should also be accompanied by measures to adapt to the impacts and risks from climate change. The link between action to reduce emissions and action to prepare for future impacts of climate change is discussed in the accompanying summary report *Reducing emissions and preparing for climate change,* and details of measures to adapt to the risks are discussed in the report *Progress in preparing for climate change*.[7]

The headline emissions statistics are based on provisional data for 2016. Both these data and the 'final' statistics for 1990-2015 are subject to revision annually as the emissions inventory is updated. We have previously considered the implications for carbon budgets of these and other measurement uncertainties[8] and conclude:

- The UK's existing carbon budgets have been set at the right level and provide a reliable guide to the required reduction in emissions despite the uncertainty in emissions estimates.
- The methodology for constructing the GHG inventory is rigorous but the process for identifying improvements could be strengthened.
- A small number of sectors contribute most to uncertainty. Research efforts should be directed at improving these estimates as the sectors with the largest uncertainty are also the ones that will decarbonise last.

We will continue to keep these issues and uncertainties under review.

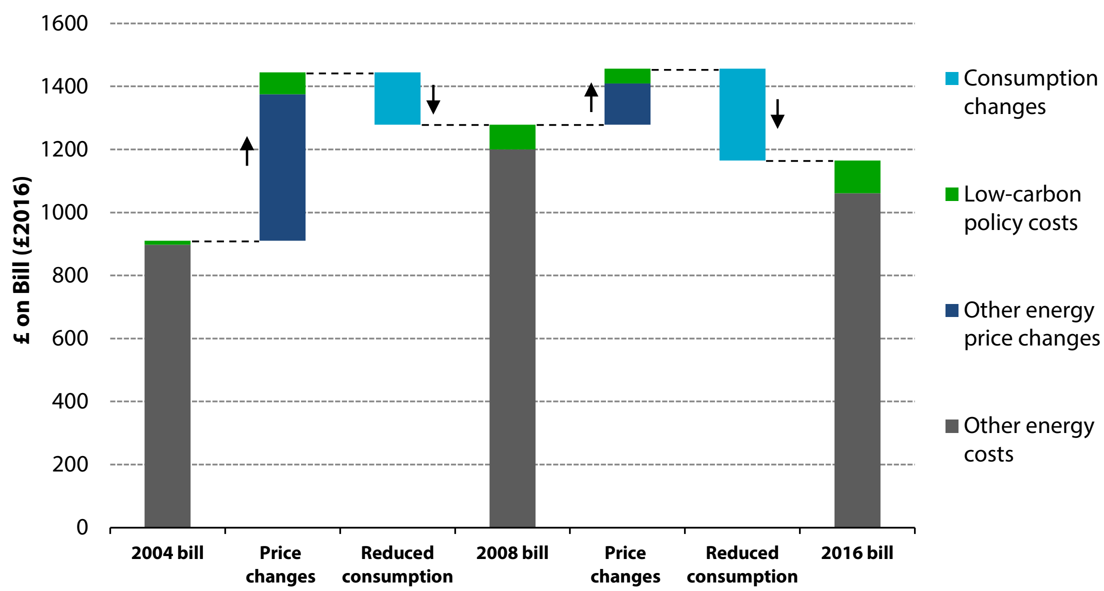
Figure 1.1. UK greenhouse gas (GHG) emissions compared to GDP (1990-2016)



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; ONS; CCC calculations
Notes: Series indexed to start at 100. In 2016 UK GDP was £1.9 trillion and GHG emissions were 466 $MtCO_2e$.

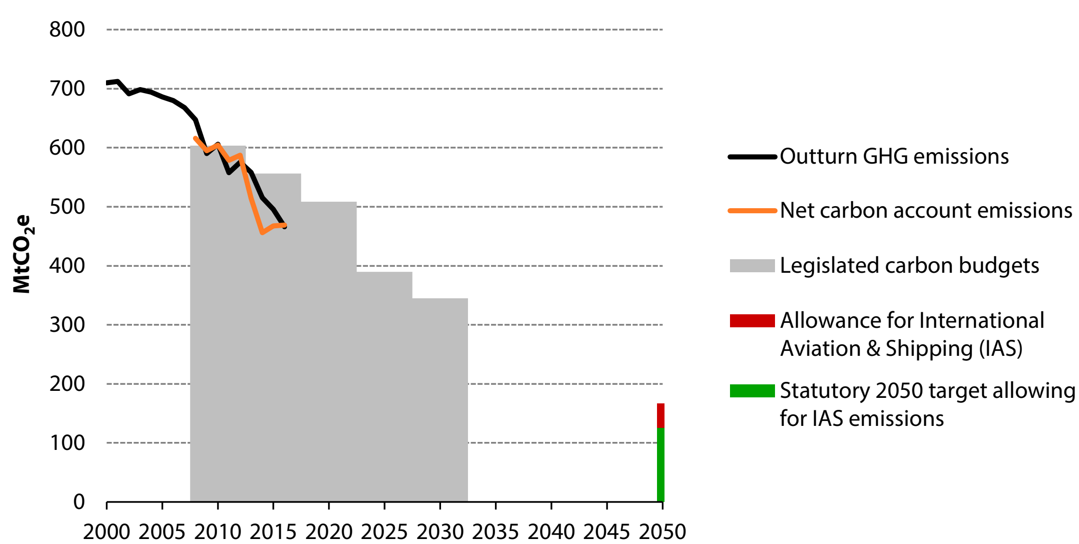
[7] Available on our website at www.theccc.org.uk/publications.
[8] CCC (2017) *Quantifying Greenhouse Gas Emissions.*

Figure 1.2. Changes in annual energy bills from 2004 to 2008 and from then to 2016



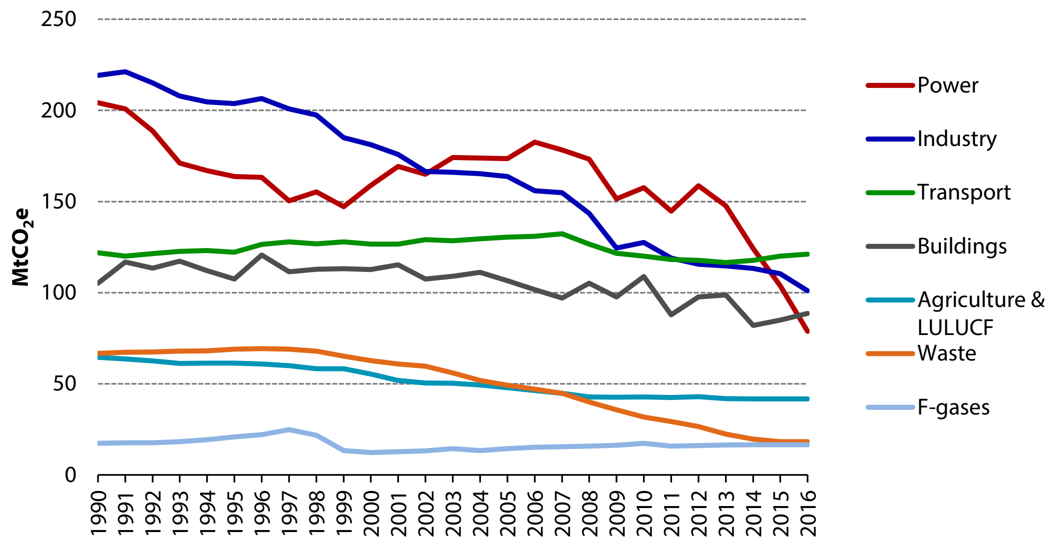
Source: CCC (2017) *Energy Prices and Bills - impacts of meeting carbon budgets.*
Notes: Estimates are for the average dual - fuel household with gas heating. 2016 estimates are based on consumption of 3,550 kWh for electricity and 13,500 kWh for gas. 2004 is the first year for which comparable data is available to allow comparison over time.

Figure 1.3. UK GHG emissions compared to legislated carbon budgets and the 2050 target (2000-2050)



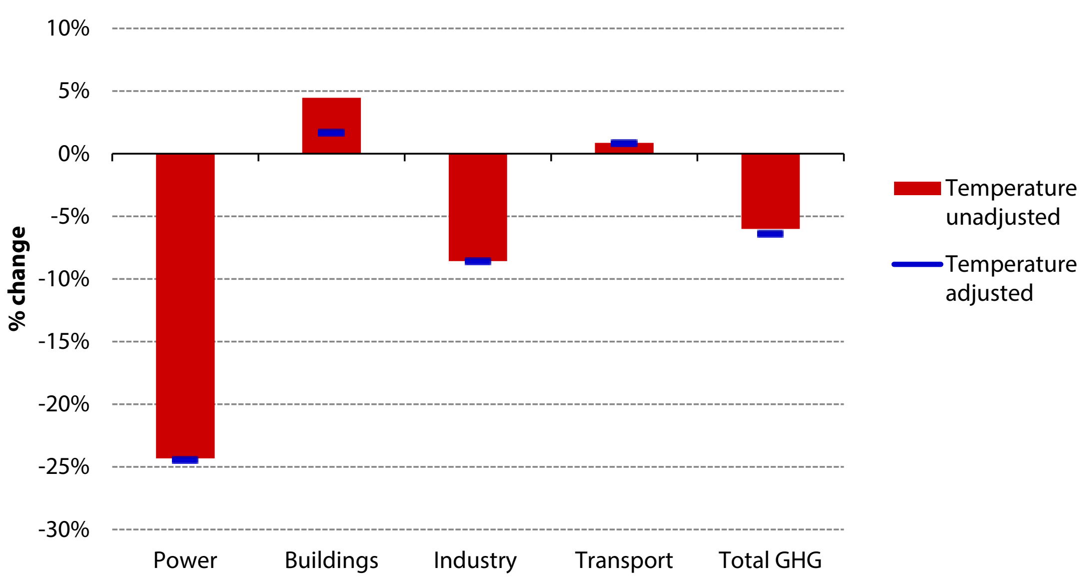
Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; CCC calculations.
Notes: GHG emissions are shown on a total (gross) basis, while carbon budgets represent the emissions under the net carbon account; IAS stands for International Aviation and Shipping.

Figure 1.4. UK GHG emissions by sector (1990-2016)



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; CCC calculations.

Figure 1.5. Change in UK domestic GHG emissions between 2015 and 2016



Source: BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; CCC calculations.
Notes: Provisional emissions for CO_2 are based on energy use statistics, as published in BEIS Energy Trends. Estimates of non-CO_2 gases are based on an assumption that emissions in 2016 will be the same as in 2015 and thus we do not report on 2015-16 change in the case of agriculture, land use, waste and F-gases. Emissions for industry and transport are not temperature-adjusted.

2. Meeting the fourth and fifth carbon budgets

The fourth and fifth carbon budgets (covering the period 2023-2027 and 2028-2032) were set to be on the cost-effective path to meeting the UK's 2050 target of at least an 80% reduction in GHG emissions compared to 1990. The fifth carbon budget allows for international trading of carbon allowances and requires a 57% reduction by 2030 in the net carbon account.

Our advice on the fifth carbon budget set out the progress required across the economy to meet the budgets. That includes: an increase in the share of low-carbon electricity generation from 45% currently to 75% in 2030, development of carbon capture and storage (CCS), 60% of new car sales in 2030 being ultra-low emission vehicles, and at least 25% of heating delivered from low-carbon sources (Table 1.2). Ignoring international trading of carbon allowances, the latest projections suggest this would deliver a 63% reduction in actual emissions by 2030 (Box 1.1).

In this section we set out our assessment that current policy plans would fall a long way short of delivering the progress required by the budget and our assessment of the policies needed to close this gap.

(a) The size of the policy gap and the requirement for the Government to close it

In order to assess whether future carbon budgets are likely to be achieved - and any policy gap that remains - we review Government plans to reduce emissions. We then compare these to our estimates of the cost-effective path required to meet the budgets - the set of actions that we identified in our advice as a suitable way to meet the budgets. We assess whether policies are expected to deliver emissions savings, where they may fail to deliver, and identify areas where there is no policy in place (Box 1.2).

Our assessment in this report reflects the lack of a new plan from Government setting out how the fifth carbon budget will be met. Such a plan is required under the Climate Change Act.

There has been little policy progress in the past year. Changes announced in the Budget and Autumn Statement were limited and include contracts for low-carbon electricity generation in the 2020s, additional funding for electric vehicles and investment in new road capacity, and a commitment to target a total carbon price. We assess these changes in the relevant chapters of this report.

We conclude that there is currently a policy gap between current Government policies and the cost-effective path to meet carbon budgets of at least around 100 $MtCO_2e$ in 2030 - half of the total reduction required (Figure 1.6). Additionally over three-quarters of current policies are at risk of under-delivering. New policies will be required to fill the gap and policy strengthening will be required to address the risks of under-delivery.

Box 1.1. The net carbon account

Under the Climate Change Act carbon budgets are set, and performance against them measured, on the basis of the ‘net carbon account’. The net carbon account can be calculated by adding the UK’s share of the EU Emissions Trading System (EU ETS) cap and actual emissions from sources not covered by the EU ETS.

The net carbon account will be different from actual UK emissions as the sources of emissions covered by the EU ETS (i.e. electricity generation and energy-intensive industry) will not typically equal the UK's share of the EU ETS emissions cap.

Box 1.1. The net carbon account

When monitoring progress towards meeting carbon budgets we primarily monitor actual emissions against our best estimate for the cost-effective path to the 2050 target, on which the carbon budgets have been based. This cost-effective path reflects the actions needed in each sector (e.g. uptake of electric vehicles, renewable electricity generation, insulation) in order to reduce emissions and to be on track to meet the 2050 target at least cost.

The fifth carbon budget requires a 57% reduction in the net carbon account from 1990 to 2030. Expectations for the cost-effective path for actual emissions now reflect a 63% reduction over that period. This compares to an expected 61% reduction when we advised on the budget in 2015. This change is due to a lowering of the government's baseline projection for emissions in the absence of policy action.

However, baseline projections are highly uncertain and could shift back. We therefore base our monitoring and recommendations in this report on the same set of actions that we identified for the cost-effective path in our 2015 advice.

It is possible that these actions could lead to emissions that are slightly lower in 2030 than required by the legislated budget. However, they are achievable and remain desirable as part of the lowest cost path to the 2050 target. In addition, our recommendation to government on the implications of the Paris Agreement was to aim to fully deliver all measures. To the extent that this reduces emissions further than the budget, this would help support the aim in the Paris Agreement of pursuing efforts to limit global temperature rise to 1.5°C.

Box 1.2. 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', whereas if they fail any one of the criteria we classify them as having 'delivery risks'.

The Climate Change Act requires that the Government develops and publishes a plan to meet the carbon budgets.[9] It must set out policies and proposals with sufficient ambition to close the policy gap to the fourth and fifth carbon budgets. This plan should demonstrate how the proposals will be flexible to the various uncertainties between now and 2030, so that it is clear that the carbon budgets will be met even if circumstances are different to central expectations.

[9] Climate Change Act (2008), clauses 13 and 14.

This includes changes in circumstances as the UK leaves the EU. Our assessment in 2016[10] was that over half of the emissions reduction required to meet the fifth carbon budget derives from policies agreed by the UK at the EU level. Carbon budgets must continue to be met after the UK has left the EU. New UK policies will therefore be needed to reduce emissions where policies previously agreed through the EU no longer apply or are weakened.

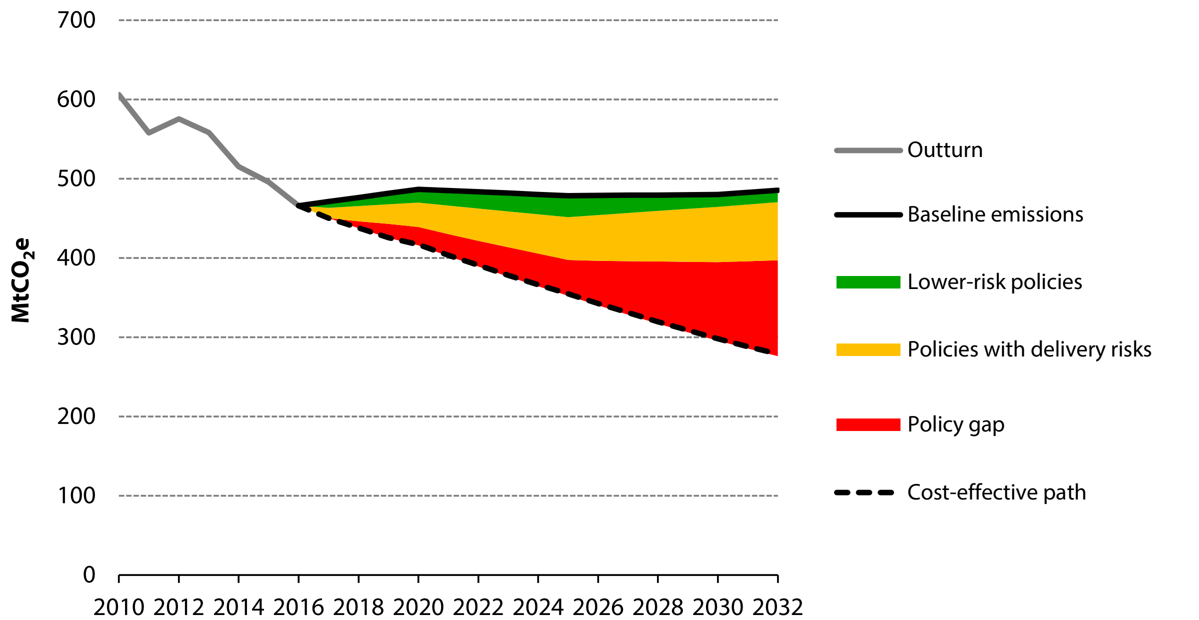
Table 1.2. Criteria to evaluate level of risk in Government policies

36% reduction in UK emissions required from 2016 to 2030				
Power (79 $MtCO_2e$ in 2016) -62% reduction 2016-2030	**Buildings** (89 $MtCO_2e$) -20%	**Industry** (100 $MtCO_2e$) -20%	**Transport** (121 $MtCO_2e$) -44%	**Agriculture, LULUCF, Waste, F-gases** (77 $MtCO_2e$) -38%
• CfD contracts for further 80-100 TWh low-carbon generation (beyond delivery of Hinkley and planned auctions) • CCS strategy to allow deployment at scale in the 2030s • Additional storage, interconnection, flexible generation, and demand-side response to deliver smart flexible power	• Insulation of all practicable lofts by 2022 and cavity walls by 2030, and 2 million solid walls by 2030 • Stronger new build standards for energy efficiency and low-carbon heat • 2.5 million heat pumps in homes by 2030 • Around 40 TWh of low-carbon heat networks by 2030 • Around 20 TWh of biomethane to the gas-grid by 2030	• CCS strategy to allow deployment at scale in the 2030s • Effective approach to drive uptake of low-carbon heat • Stronger framework for industrial energy efficiency	• 60% of new car and van sales ultra-low emission (e.g. electric) in 2030 • 32% improvement in efficiency of conventional cars by 2030 • Biofuels to supply 11% of road fuel by energy in 2030 • 5% reduction in travel demand below baseline levels by 2030	• Moving beyond a voluntary approach for on-farm emissions reductions • Afforestation rate to increase to 15,000 hectares per year • Near-zero biodegradable waste sent to landfill by 2025 • F-gases cut by at least 68%

Source: Scenarios for CCC (2015) *The Fifth Carbon Budget*.
Notes: The fifth carbon budget requires a 26% reduction in the UK's net carbon account from 2016 to 2030. However, this allows for trading in the EU ETS, where the UK is expected to be a net seller of allowances. On the basis of actual emissions the Committee scenarios involve a 36% reduction (equivalent to a 63% reduction from 1990 to 2030), which is the level required to keep the UK on the lowest cost path to the 2050 target and to meet the fifth carbon budget taking account of possible trading of allowances within the EU ETS. Reduction in emissions from buildings is equivalent to a 20% reduction in CO_2 and a 17% reduction if not including biomethane abatement (consistent with reporting in our 2015 *Fifth Carbon Budget* and 2016 *Next Steps for UK Heat Policy* reports).

[10] CCC (2016) *Meeting Carbon Budgets - Implications of Brexit for UK climate policy.*

Figure 1.6. The policy gap (2010-2032)



Source: BEIS (2017) *Updated Energy and Emission Projections 201;*, BEIS (2017) *Provisional GHG statistics for 2016*; BEIS (2017) *Final GHG statistics for 1990-2015*; CCC analysis.
Notes: See Box 1.2 for definition of categories. 'Baseline emissions' is the likely path of emissions in the absence of policy effort.

(b) New policies required to close the policy gap

Chapters 2-8 set out the full set of areas that need to be tackled in the Government's plans on a sector-by-sector basis. Action is required across the economy:

- **Low-carbon electricity generation.** The Government should contract an additional 80-100 TWh of low-carbon electricity generation for the 2020s, beyond the auctions that have already been funded and the new nuclear project planned at Hinkley Point C. They should also put in place plans for further flexibility options (e.g. storage, interconnection, demand response, and flexible generation).
- **Carbon capture and storage (CCS).** A new strategic approach is required to CCS deployment in the UK, including a separate approach to development of transport and storage infrastructure. Contracts should be awarded by 2020 to allow CCS to operate at scale in the 2030s.
- **New car and van CO_2 standards.** Stretching targets based on real-world testing are required for new car and van CO_2 standards beyond 2020 that take account of the need for high uptake of electric vehicles. These standards are currently set at EU level and the UK should either remain part of this legislation if it is sufficiently ambitious, or replicate this legislation at a UK level.
- **Heating.** A clear, combined strategy for energy efficiency and low-carbon heat is needed. It must significantly increase the delivery of energy efficiency measures, heat networks,

biomethane and heat pumps in cost-effective locations for both households and businesses. It should also test the possibility for low-carbon hydrogen to meet heat demand.

- **Industry and agriculture.** Industry and agriculture both require new overall approaches to long-term decarbonisation. In industry these need to turn the existing 'Roadmaps' into specific actions and milestones. In agriculture new policies are required to deliver emissions reduction beyond the current voluntary approach.

The Government must demonstrate that, as a whole, its plans would be sufficient to close the policy gap across a range of scenarios. We would expect the Government plans to include clear timelines for the development and implementation of any policies that remain at the proposal stage. They should also set out the intended approach to monitoring progress and adjusting policies as required to ensure progress remains on track. We will publish our assessment of the Government's proposals subsequent to their publication.

The Government should also make links between their plan to reduce emissions and the industrial strategy where relevant. This should include the wider benefits (e.g. for air quality, environmental protection, and employment) that would result from a successful low-carbon transition and industrial strategy.

(c) Ensuring current policies deliver

As well as following through on proposals for new policies to drive emissions reduction, the Government must ensure that existing policies deliver fully. Currently progress in this regard - summarised in Table 1.3 - is mixed. Good progress has been made in some areas (e.g. power) but underlying progress is already falling behind in many others (e.g. transport, buildings, industry, agriculture).

Across the economy our assessment is that over three-quarters of current policy plans are at risk of under-delivery in future (Figure 1.6). Current risks and priorities for strengthening these policies include:

- **Power.** Current progress is likely to be maintained until 2020. Existing plans and commitments are expected to add a further 50 TWh of generation in the 2020s but there are risks around these plans, particularly given that auctions have not yet completed and that the contract for the new nuclear power plant allows a delivery date any time from 2025 to 2033. The Government should develop contingency plans for if major projects should fail to deliver or be delayed.
- **Transport.** Current Government policies to tackle barriers to adoption of electric vehicles, including financial support and roll-out of recharging infrastructure run out from 2018. They should be extended. The Renewable Transport Fuel Obligation should be increased to deliver 8% of road fuels by energy by 2020, from the current level of 4.75% which is not sufficient to deliver the emissions reduction required to meet carbon budgets.
- **Buildings and industry.** Policy strengthening is required across all areas, including to improve the energy efficiency of existing buildings (e.g. to increase installation rates of insulation) and to improve uptake of low-carbon heat (e.g. heat pumps, heat networks, and biomethane).
- **Agriculture and F-gases.** In agriculture the voluntary approach to emissions reduction should be strengthened to ensure the stated ambition is met. In F-gases the existing approach agreed at the EU-level must be clarified and participation should either continue in

the EU scheme, or it should be replicated in the UK to deliver emissions reduction in-line with the full cost-effective opportunity available.

- **Waste.** Further action is needed throughout the waste chain to reduce emissions, including waste prevention, separate collections (e.g. of food waste), reducing the amount of biodegradable waste sent to landfill (e.g. to zero by 2025), and to increase methane capture at landfill.

Table 1.3. Underlying progress in 2016

Sector		**2016 indicator**	**2016 outturn**
Power	Total renewable generation	69.2 TWh	75.4 TWh
Transport	New car CO_2 (test cycle)	118 g/km	120 g/km
	Electric cars and vans (share of fleet)	1.4%	1.2%
Buildings	Low-carbon heat*	4% of heat demand	4% of heat demand
	Loft insulation	545,000 in year	64,000 in year
	Cavity wall insulation	200,000 in year	92,000 in year
	Solid wall insulation	90,000 in year	31,000 in year
Land Use and Forestry	Afforestation**	15,000 hectares	6,000 hectares
Waste	Biodegradable waste sent to landfill	57% below 2007	69% below 2007

Notes: *Low-carbon heat figures are for 2015. **Afforestation outturn is for the year ending in March 2016.

3. Preparing for the 2050 target

The Climate Change Act requires that the Government's plans for meeting carbon budgets are prepared with a view to meeting the 2050 target to reduce emissions by at least 80% from 1990 to 2050. Effective plans must reduce emissions over the period of the carbon budgets and develop options to enable the further reductions of around 4% per year required from 2030 to 2050. This will require a widespread shift to zero-carbon fuels.

Some key options are already relatively mature and have an important role throughout the period to 2050. For example, energy efficiency and low-carbon power generation will be crucial sources of emissions reductions to 2030 and enablers of deeper change beyond that.

However, there are several areas that will need to develop significantly between now and 2030 if they are to make a major contribution to meeting the 2050 target:

- **Electric vehicles and low-carbon heating** (e.g. heat pumps and heat networks) are currently niche options that must grow market share over the next decade to enable roll-out at scale over the 2030s and 2040s. The Government's plans to 2030 should set out clearly how the UK will significantly increase uptake in these areas and prepare for a potential complete shift across the vehicle and building stocks by 2050. Chapters 3 (Buildings) and 5 (Transport) set out the areas where public policy will need to support growth of these markets.
- **Carbon capture and storage (CCS)** is vital for meeting the 2050 target and could contribute to earlier carbon budgets. Our 2030 scenarios for the fifth carbon budget include applications for power generation and at industrial installations. CCS is also an enabler of low-carbon hydrogen production and removal of greenhouse gases from the atmosphere. A strategy for CCS deployment remains an urgent priority (Box 1.3). Without progress between now and 2030, the fifth carbon budget will be harder to meet and CCS will not be able to contribute fully to achieving the 2050 target.
- **Hydrogen from low-carbon sources** could have an important role in the decarbonisation of residential and commercial heating, industry, transport and increasing the flexibility of electricity generation. This would require Government leadership and co-ordination. Without action now, it will not be possible to assess the feasibility and cost-effectiveness prior to deciding on the path for large-scale decarbonisation of heating and large vehicles. The Committee will publish further analysis in 2018 on the opportunities and challenges of using hydrogen as part of the transition to a low-carbon economy.
- **Sustainable bioenergy** is likely to play a crucial part in meeting the carbon budgets and 2050 target as a consequence of the current lack of options for replacing hydrocarbons in sectors such as aviation and parts of industry. The Committee published a detailed review of the role of sustainable bioenergy in 2011 and intends to update this in 2018, to cover sustainability issues and the most appropriate use within a low-carbon strategy. The Government released their bioenergy strategy in April 2012 on the most cost-effective use of bioenergy for meeting decarbonisation targets. This included a stated intention to review the consistency of current policies with this strategy, in at least five year intervals. This is now overdue.
- **Development of greenhouse gas removal and innovation in hard-to-treat sectors** is important not just for meeting the 2050 target but also the aim of the Paris Agreement to balance sources and sinks of greenhouse gases. Hard-to-treat sectors include aviation, agriculture and parts of industry, while greenhouse gas removal covers a range of options such as afforestation, carbon-storing materials, bioenergy with carbon capture and direct air capture and storage. We detailed the need for a UK strategy to cover these areas in our report on the implications of the Paris Agreement[11] and have defined new indicators to track progress going forward (Box 1.4).

Analyses of the 2050 target suggest that the lowest cost ways of meeting it are likely to involve significant contributions from these options.[12] The Government's plans to 2030 must progress these areas.

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[11] CCC (2016) *UK climate action following the Paris Agreement.*

[12] UKERC (2013) *The UK Energy System in 2050: Comparing Low-Carbon, Resilient Scenarios;* ETI (2015) *Letter to the Energy and Climate Change Select Committee on CCS.*

Box 1.3 The need for Carbon Capture and Storage (CCS) to meet the 2050 target

In July 2016 the Committee wrote to the Secretary of State for Energy and Climate Change to reiterate our previous advice that a failure to deploy CCS could double the cost of meeting the 2050 target.[13] This reflects the fact that CCS offers opportunities to reduce emissions where alternatives are limited.

- CCS is the only option to enable continued production in some industrial sectors such as steel, cement and chemicals with deeply reduced carbon emissions.
- CCS can provide a source of flexible "mid-merit" power generation when applied to gas-fired power generation. Low-carbon flexible power is likely to be required alongside intermittent renewables (i.e. wind and solar) and inflexible nuclear.
- CCS is currently expected to be the lowest cost production method for low-carbon hydrogen, which is an important option to reduce emissions, particularly from heating, some parts of industry and potentially transport, especially heavy goods vehicles.
- In combination with the use of bioenergy, CCS has the potential to remove carbon dioxide from the atmosphere and permanently store it.

There is currently no Government strategy for deployment of CCS, following the cancellation of the CCS Commercialisation competition in November 2015. A new strategy should be published without delay, presenting viable options for CCS to operate at scale in the 2030s.

- Capture contracts should be awarded by 2020. These should cover a mixture of industry applications (where costs may be lowest), power (where risks of default are lower than for industry) and potentially hydrogen production or use with bioenergy.
- The level of deployment must be sufficient to realise economies of scale and to engage the financial community. Previous analysis[14] suggests that, by 2035, there should be 4–7 GW installed for power generation and 3–5 $MtCO_2$ per year captured from industrial installations.

In 2016 the Parliamentary Advisory Group on CCS was asked by the Secretary of State for Business, Energy and Industrial Strategy to assess the potential contribution of CCS to cost-effective UK decarbonisation. This group includes cross-party and cross-industry expertise on delivery, financing and regulation of energy infrastructure.

The Committee agree with the findings of this Group that an effective strategy can be lower cost than the previous approach, by suitably allocating risks between parties, and that this should move forward quickly over the next five years. Key proposals from the Advisory Group include:

- A CCS Delivery Company to deliver full-chain CCS for power, including transportation and storage infrastructure.
- A system of economic regulation for CCS in the UK, including a capacity contract to incentivise CCS for power.
- An incentivisation scheme to remunerate industry for capture and storage of their CO_2.
- An independent, cross-industry group to assess the relative costs and technical feasibility of heat decarbonisation via electrification or hydrogen.
- A certification scheme for the safe, long-term storage of CO_2.
- A scheme to oblige suppliers of fossil fuels to prove storage of an equivalent amount of CO_2.

Source: Oxburgh (2016) *Lowest cost decarbonisation for the UK: the critical role of CCS. Report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage (CCS).*

[13] CCC (2016) *Letter to Rt Hon Amber Rudd: A strategic approach to Carbon Capture and Storage.*
[14] Pöyry (2016) *A Strategic Approach for Developing CCS in the UK.*

Box 1.4 New indicators for tracking UK development of greenhouse gas removal options

Greenhouse gas removal (GGR) technologies are those that remove greenhouse gases from the air, rather than reduce emissions at source. We already include three such options in our scenarios for the cost-effective path to the 2050 target: afforestation, wood in construction and bioenergy with CCS. Nevertheless, there is a diverse range of other options at varying stages of technological development (such as direct air capture and storage, enhanced weathering and ocean liming).

Current estimates suggest that there is not enough GGR potential to substitute for the widespread deployment of zero-emission technologies envisaged in our scenarios. Rather, these technologies are a complementary and necessary addition to achieve net zero emissions.

We commissioned Ecofys to identify barriers to deployment of GGR options, develop a high-level path to overcome those barriers and recommend indicators that could be used to track UK progress. The project identified a range of barriers specific to each GGR option, but also important general barriers across all GGRs. These include:

- Low (but rising) awareness and policy priority.
- Key knowledge gaps requiring research and innovation.
- Lack of a business case due to the value of removal being absent from relevant policies.

The current wide uncertainties around the feasibility and wider impacts of nearly all GGR options at scale mean that the best future mix is unclear. Near-term actions by Government should therefore ensure that the range of GGR options is available to participate fully in the UK's climate strategy. Longer-term, they should be deployed according to their cost and wider impacts, compliance with other regulations and ability to sequester greenhouse gases reliably.

To monitor progress in achieving this we plan to track the following indicators:

- A UK strategy should be in place to develop GGR options, starting during the third carbon budget period (2018-2022).
- Increased funding for research, development and demonstration should be available for GGR options during the third and fourth carbon budget periods (covering priority areas such as total potential, monitoring and verification, safety and wider impacts, and capture methods).
- A new Government bioenergy strategy should be published and implemented in the third carbon budget period, to determine sustainable biomass criteria, stimulate domestic supply and reflect the carbon values of different end uses.
- A market mechanism is needed to value removal on a comparable basis to emissions reduction (e.g. in the EU ETS or any UK replacement). It should be introduced in the fourth carbon budget period.
- A Government review is required, during the third carbon budget period, of ways to encourage low-GHG and GHG-removing materials in construction (e.g. through building regulations). We note that currently 22% of new houses are timber-framed in England, compared to 76% in Scotland.

In addition, when monitoring the replacement by 2020 for the Common Agricultural Policy (CAP), we will expect the new rules to link support more closely to both the reduction and removal of emissions in the agriculture, forestry and other land use sectors (see Chapter 6).

Source: Ecofys (2017) *CCC indicators to track progress in developing Greenhouse Gas Removal options*; Structural Timber Association (2016) *Annual survey of UK structural timber markets.*

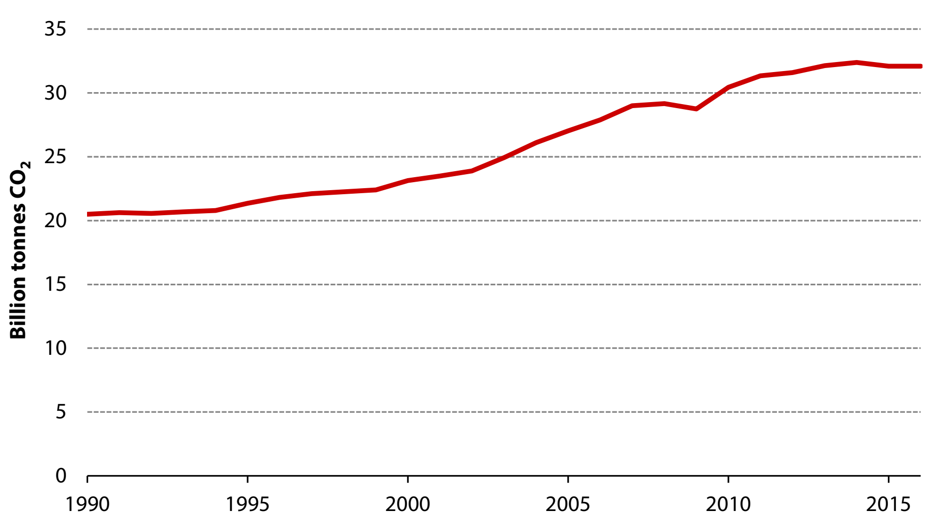
4. International progress in tackling climate change

(a) Global emissions trends

Global CO_2 emissions from fossil fuel combustion have remained flat over the last two years (Figure 1.7) even as the global economy has grown:[15]

- The International Energy Agency (IEA) reports global emissions from fossil fuel combustion in 2016 were 32.1 billion tonnes of CO_2 ($GtCO_2$), at around the same level as in 2015 and 2014.
- Several factors have been identified as playing a role in emissions not growing. While the global economy continued to grow, the pace of improvements in both energy efficiency and the carbon intensity of energy generation picked up:
  - **Continued economic growth.** Global GDP grew just over 3% per year during 2014-2016,[16] a similar rate to the average since 1990. Within this, the rate of GDP growth slowed in China while accelerating in the EU and other parts of the world.
  - **Increased energy efficiency.** Global energy use per unit of GDP has followed a decreasing trend since 2012. This has been through a combination of shifts in economic structure (particularly in China) and improvements to energy efficiency.
  - **Reduced carbon intensity.** Deployment of renewables has continued to increase, with 2016 the third successive year they met over half the growth in electricity demand. Total coal demand also fell in 2016 due to factors including the advance of renewables, the US boom in shale gas production and Chinese policies for improving air quality.

Figure 1.7. Global emissions of greenhouse gases (1990-2016)



Source: International Energy Agency (2016) *CO_2 emissions from fuel combustion*;
IEA finds CO_2 emissions flat for third straight year even as global economy grew in 2016,
https://www.iea.org/newsroom/news/2017/march/iea-finds-co2-emissions-flat-for-third-straight-year-even-as-global-economy-grew.html

[15] Peters et al. (2017) Key indicators to track current progress and future ambition of the Paris Agreement, *Nature Climate Change*; IEA, https://www.iea.org/newsroom/news/2017/march/iea-finds-co2-emissions-flat-for-third-straight-year-even-as-global-economy-grew.html

[16] IMF (2017) *World Economic Outlook April 2017.*

(b) International climate policy

The Paris Agreement is now in effect, meaning there is a global framework in place aimed at reducing emissions around the world. However, the new administration of the United States has announced it will leave the Agreement, and current pledges are not enough to meet the 2°C and 1.5°C limits for global temperature increase.

The Paris Agreement entered into force in November 2016. Countries from around the world have pledged to take action to reduce their emissions:

- After being ratified by over 55 parties to the UN climate process, covering over 55% of emissions, the Paris Agreement entered into force in November 2016.
- Under the Paris process all parties are required to submit pledges of action to reduce emissions. To date 142 parties (including China, India, the EU and the previous US administration) have done so.[17]
- The first meeting of the Parties to the Paris Agreement was held in Marrakech in December 2016. This group will need to agree aspects of delivering the Agreement, such as convening the dialogue in 2018 to take stock of the pledges, improving consistency and transparency of pledges, and setting the rules for a new market of emissions credits.

Current pledges are not enough in total to meet the goals of the Agreement:

- The overarching aim of the Paris Agreement is to hold the increase in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C.
- To stay below 2°C, CO_2 emissions will need to fall below zero (i.e. into net removals) by the 2050s-70s along with deep reductions of all other greenhouse gases. To stay close to 1.5°C, CO_2 emissions would need to reach net zero by the 2040s. If net removals cannot be achieved, global CO_2 emissions will need to reach zero sooner.[18]
- Projections of global emissions continue to show further increases out to 2030, although less than forecast before the Paris Agreement. Compared to these projections, paths to meet the Paris goals show emissions in 2030 lower by at least around 17 $GtCO_2e$ (30%).[19]

In the United States, the new administration has announced it will leave the Agreement, although several other countries, firms and sub-national governments have underlined their commitment in response:

- The new US administration has made clear it plans to de-prioritise climate action at a federal level. As well as relaxing regulations that restrict carbon emissions, it announced in May that it would leave the Paris Agreement.
- Leaders in other countries, including China, India, the EU, Canada, Mexico and Australia, have however reaffirmed their plans to continue with the Agreement since the US announcement. Reaffirmation has also come from within the US, notably the US Climate Alliance of states (covering about a fifth of all US emissions and two-fifths of US GDP), the US Climate Mayors (covering over 200 cities) and several US firms.

Progress in developing national-level policies around the world means that the global transition towards a low-carbon economy is well under way:

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[17] http://unfccc.int/paris_agreement/items/9485.php
[18] CCC (2016) *UK climate action following the Paris Agreement*.
[19] UNFCCC (2016) *Updated synthesis report on the aggregate effect of INDCs*.

- 142 countries have submitted pledges to reduce emissions under the Paris process. 125 have also put in place their own domestic climate laws, including the UK Climate Change Act.[20]
- Nearly 15% of global greenhouse gas emissions are now covered by carbon pricing schemes, up from 4% in 2008. This is due to increase further to around 22% by the end of 2017 as China commences its national emissions trading scheme.[21]

Overall, developments in national policies mean global emissions in 2030 could be lower than expected from the pledges, but not yet by enough to bridge the gap to the Paris goals: [22]

- Analysis suggests intended changes to federal policy will increase US emissions in 2030 by about 0.4 $GtCO_2e$ compared to previous policy.
- In contrast, emissions projections for China and India are coming down due to a combination of lower demand expectations, new policies and switching away from coal towards wind and solar power. In total these are projected to bring down expected emissions in 2030 by 2-3 $GtCO_2e$ compared to projections just one or two years ago.

The decline in UK emissions means that, on a per-person basis, the UK has almost converged to the global average (Figure 1.8):

- Global emissions per person were 7.4 tCO_2e in 1990, and are set to fall to just below 7 tCO_2e in 2030 if current national pledges of action are met. In contrast, UK emissions, measured as territorial emissions plus a UK share of international aviation and shipping, have fallen from 14.4 tCO_2e per person in 1990 to 7.7 tCO_2e per year.
- The UK 2050 target was derived from the principle that it was hard to see a global deal limiting warming to 2°C in which UK emissions per person would be above the global average in the long term. Given the decline in UK emissions and sustained global emissions, it appears this point may be reached by 2020.
- The average level of emissions per person in 2050 consistent with a 2°C pathway is around 2 tCO_2e or less. This underlines the need to achieve continued reductions in UK emissions and a step change in global reductions.

Although the UK is a richer nation with relatively high levels of consumption, this is not entirely reflected in the UK's emissions since the UK tends to import manufactured goods and export services. When measured on a consumption basis (i.e. including emissions embedded in imports and excluding exports) UK emissions are much higher and well above the global average. For instance, in 2013 (the most recent available data) they were over 16 tCO_2e per person.[23] A combination of UK and global action, as envisaged in the Paris Agreement, is required to cut these emissions.

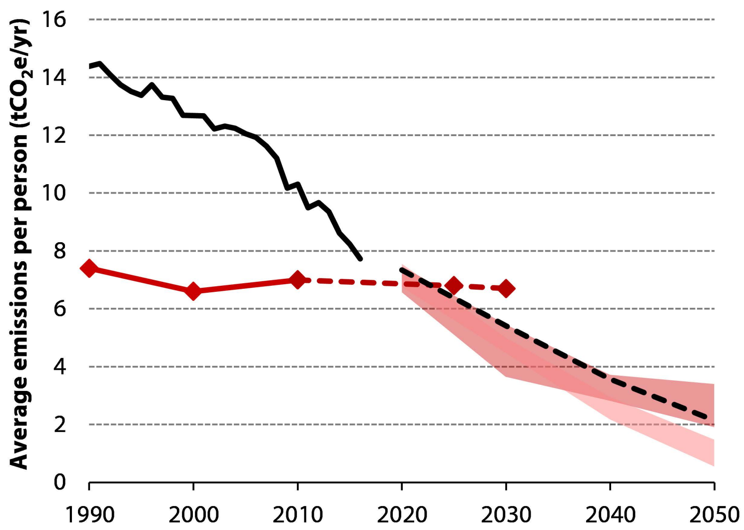
[20] Nachmany et al. (2017) *Global trends in climate change legislation and litigation*.

[21] World Bank, Ecofys (2017) *Carbon pricing watch 2017*.

[22] Climate Action Tracker (2017) *Action by China and India slows emissions growth, President Trump's policies likely to cause US emissions to flatten*.

[23] Defra (2017) *UK's carbon footprint.*

Figure 1.8. Comparison of trends in UK and global average emissions per person



Source: UNFCCC *2016 INDC review*, UNEP (2015) *The Emissions Gap Report 2015; May update*; ONS (2016) *United Kingdom population mid-year estimate*; ONS (2014) *National Population Projections*; DECC (2017) *Provisional GHG Statistics for 2016*; CCC calculations.

Notes: All paths to 1.5°C and 2°C assume further reductions to net zero emissions or below by 2100. The range for 1.5°C pathways consists of fewer model runs than for 2°C, which is why some of the range for 2°C includes lower emissions before 2040. Individual models consistently show swifter reductions to meet 1.5°C than to meet 2°C.

Chapter 2: Power

Key messages and recommendations

In this chapter we report on carbon dioxide (CO_2) emissions from electricity generation and progress in reducing emissions and preparing for future reductions. We also set out our recommendations and priorities for the Government's plans for meeting the fourth and fifth carbon budgets.

Our key messages for the power sector are:

- **There was strong progress in reducing power sector emissions in 2016, continuing the trend since 2012.** Emissions fell 24% in 2016 and are now 55% below 2008 levels, and 62% below 1990. The share of generation from low-carbon sources has increased to 45% (up from 20% in 2008), while coal's share has fallen to 10% (down from a recent peak of 42% in 2012). Emissions intensity is now 286 gCO_2/kWh, having been over 500 gCO_2/kWh as recently as 2012.
- **Progress is set to continue, albeit more slowly, to 2021.** Continued roll-out of renewables, driven by Government policies, should increase the low-carbon share of generation to around 55% in 2020. The emissions intensity of the power sector would then reach 200-250 gCO_2/kWh depending on how quickly the remaining coal exits the system.
- **Significant risks remain beyond 2020:**
  - The final investment decision taken for Hinkley Point C, and Government plans for Contract-for-Difference auctions would support around a further 50 TWh of low-carbon generation in the 2020s. However, around 130-150 TWh is needed in total to replace retiring plants and reach a system emissions intensity of below 100 gCO_2/kWh in 2030, which is part of the lowest cost path to meet the UK's carbon commitments.
  - 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 and for which deployment in the power sector is likely to be a key enabler of wider roll-out.
  - The electricity system must become significantly more flexible by 2030. That reflects the challenges of managing a more variable supply as renewable generation increases and as conventional thermal plant retires. It also reflects the opportunity offered by new technologies: smart appliances and energy-management systems in homes and businesses and the falling cost of batteries and other storage. Increasing flexibility will require policy and regulatory action to ensure barriers to entry for flexibility providers are removed.
- **Key priorities** for the Government's policies and proposals to meet the fifth carbon budget therefore include:
  - A new strategic approach to CCS. This will require a programme of CCS deployment across power and industry, alongside a separate approach to CO_2 capture and to the transport and storage infrastructure.
  - Continuing auctions to allocate long-term contracts for subsidy-free low-carbon generation, which together with CCS and any negotiated contracts should deliver a further 80-100 TWh of low-carbon generation in the 2020s beyond the auctions that are already planned and the nuclear project at Hinkley Point C.
  - Policy and regulatory changes to ensure that flexibility options are rewarded in the energy markets in a way that reflects the value they bring to the system.

We will assess the Government's plan for meeting the fourth and fifth carbon budgets against the following checklist (Table 2.1).

Key messages and recommendations

Table 2.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

Power sector emissions intensity to fall by around 65% between 2016 and 2030 (from 286 gCO_2/kWh to around 200-250 gCO_2/kWh in 2020 and below 100 gCO_2/kWh by 2030), and create options to allow near-zero emissions by 2050. This will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
Extension of existing approaches to contract an additional 80-100 TWh low-carbon generation in the 2020s beyond existing plans (i.e. 130-150 TWh in total)		×	
A new strategic approach to carbon capture and storage deployment in the UK should include power plants as anchor loads for strategic clusters		×	×
Implementation of plans for increasing flexibility (e.g. storage, interconnection, demand response, flexible generation)	×		
Continued application of a carbon price after leaving the EU	×		
Contingency plans for delay or cancellation of planned projects, for example of new nuclear power plants		×	

Introduction

In this chapter we review progress in decarbonising the UK power sector in 2016. We outline priorities for taking forward the policy framework to ensure that we build on this progress and meet future carbon budgets. We also report on new work that the Committee has undertaken in the last year to look at the flexibility requirements of a low-carbon power sector and to identify regulatory and other changes required to deliver those at least cost.

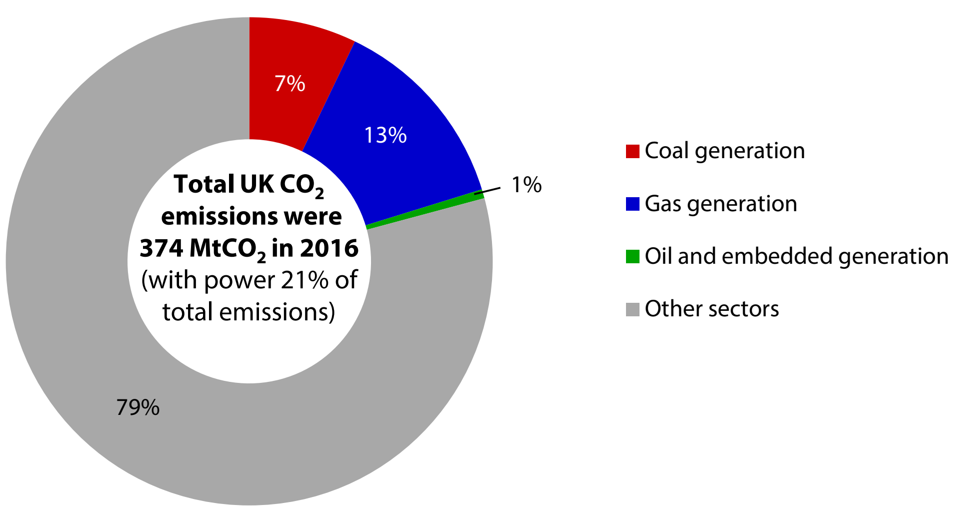
We summarise the analysis that underpins our key messages and recommendations in the following four sections:

1. The power sector
2. Recent progress in reducing emissions in the power sector compared to required progress
3. Policy progress towards the fourth and fifth carbon budgets
4. Delivering system flexibility

1. The power sector

Power sector CO_2 emissions (21% of total UK CO_2 emissions, Figure 2.1) reduced by 25 $MtCO_2$ (24%) between 2015 and 2016 to 78 $MtCO_2$[24], having fallen around 16% per year in the two previous years. Emissions in the power sector are now down 55% from their 2008 levels and down 62% from 1990 (Figure 2.2).

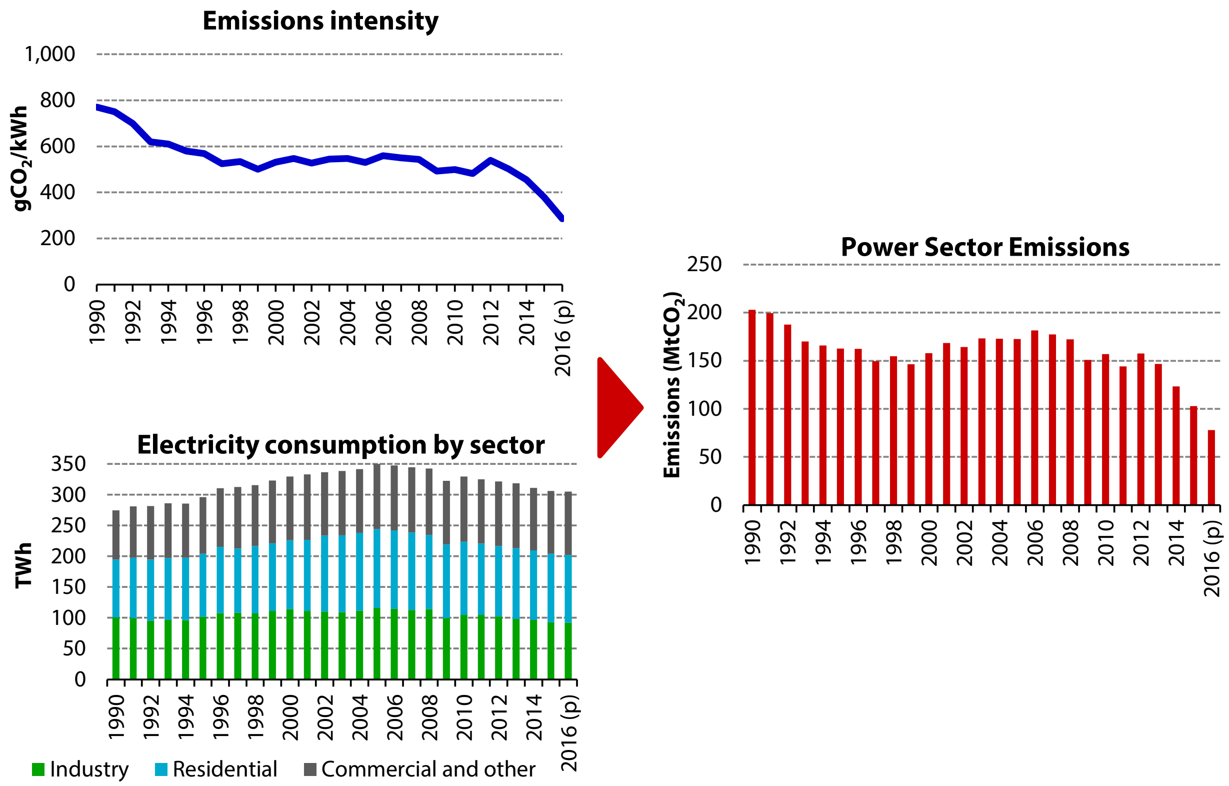
Figure 2.1. Power sector CO_2 emissions as a share of UK total, 2016



Source: CCC analysis based on: BEIS (2017) *UK Greenhouse Gas Emissions 1990-2016 (provisional)* and BEIS (2017) *Energy Trends*.
Notes: Estimates of emissions from coal and gas generation are based on generation from Major Power Producers in BEIS (2017) *Energy Trends: Table 5.1*.

[24] In addition to CO_2, the power sector emitted 0.6 $MtCO_2e$ of N_2O and 0.2 $MtCO_2e$ of CH_4 in 2015 (the most recent year for which estimates are available).

Figure 2.2. Emissions intensity, electricity demand and CO_2 emissions from the power sector (1990-2016)



Source: BEIS (2017) *Energy Trends*; BEIS (2017) *UK Greenhouse Gas Emissions 1990-2016 (provisional)*; CCC calculations.
Notes: Emissions intensity is UK based useable generation, i.e. excluding losses. Electricity consumption includes imported power. 2016 data are provisional.

Emissions trends and drivers

Recent reductions in emissions have been due to a decrease in the emissions intensity of the power sector, to 286 gCO_2/kWh in 2016. This reflected a shift from coal to gas generation in 2016, while over the last few years it reflects an increasing amount of renewable electricity alongside energy efficiency improvements and growing imports:

- In 2016, emissions fell as generation shifted from coal to gas driven by UK carbon prices and fossil fuel prices that favoured gas generation.
  - The UK applies a tax on CO_2 emissions from power generation on top of the price paid through the EU Emissions Trading System (ETS). While the carbon price in the ETS was broadly stable at around €5/tCO_2, the UK's Carbon Price Support increased from £9/tCO_2 to £18/tCO_2 in April 2015. This favoured a shift away from coal as its carbon emissions are roughly double those of gas, per unit of generation.
  - Fuel prices also favoured gas over coal in the last year: average gas prices fell 19% between 2015 and 2016, whilst coal prices increased 16%.
  - As a result, average load factors for coal plants declined to 17% in 2016 (29 TWh, 10% of UK generation), from 42% (72 TWh) in 2015 and 52% (95 TWh) in 2014. This, alongside

European environmental standards and the UK Government's commitment to close all UK coal plant by 2025, reduced prospects for UK coal power and led to the closure of 4.2 GW of coal capacity[25] in 2016.

  - The reduction in coal generation in 2016 was compensated for by an increase in gas generation, which saw plant load factors increase from 25% in 2015 (87 TWh) to 43% in 2016 (129 TWh, 43% of generation).
  - Electricity demand and generation from renewables and nuclear remained roughly constant from 2015 to 2016. Renewable output fell slightly despite an increase in installed capacity due to an average 11% reduction in wind speeds compared to 2015.[26] Overall output from renewable generation has increased 250% since 2008 (from 21 TWh in 2008 to 75 TWh in 2016).

- Since 2008, gas generation is also down and the share of demand met by fossil fuels has fallen as renewable generation has expanded, demand has reduced and imports have increased.
  - The share of electricity generated from fossil fuels has decreased from 80% to 53% between 2008 and 2016 as renewable generation has expanded from 6% to 25% of total generation. Electricity generated from existing nuclear power plants has remained fairly constant across this period, at around 60 TWh per annum (22% of generation).
  - Total electricity consumption has decreased around 12% since 2008; total residential electricity use decreased by 9% over the same period, whereas electricity consumption per household decreased by 17%. In 2016, households accounted for 36% of electricity consumption, with the remainder being used in the public and commercial sectors (34%) and industrial processes (30%) (Figure 2.2).
  - Imported electricity to the UK has increased from an annual average of 7 TWh during 2008-2012 to 18 TWh (6% of generation) over 2013-2016. Had this electricity instead been provided by UK gas generation then the emissions intensity of the UK power sector in 2016 would have been 292 gCO_2/kWh (Box 2.1).

The deep emissions reductions in the UK were not replicated elsewhere in Europe, where carbon prices were not topped up as much beyond the low EU ETS price. The total reduction in EU ETS emissions from all other countries in 2016 was about the same as in the UK alone.

UK power sector emissions reductions of recent years (i.e. 80 $MtCO_2$, 55%, since 2012) cannot be sustained into future years solely through coal to gas switching. Complete closure of the UK's remaining coal fleet and replacement by gas generation would only cut emissions by around 16 $MtCO_2$ while a reduction of around 46 $MtCO_2$ to 2030 is needed.

[25] Coal power stations at Longannet, Ferrybridge and Rugeley all closed.

[26] 2015 wind speeds were 5% above the 10-year mean, 2016 was 7% below. Sun hours were also 3% less than 2015, leading to a 1.5% reduction in solar load factors.

Box 2.1. The treatment of imported electricity in UK carbon budgets

Emissions from imported electricity occur outside the UK and therefore do not count towards the limit on emissions set in the carbon budgets. They are accounted for in exporting countries, and are covered by the EU ETS.

We estimate actual emissions intensity of the power sector based on UK emissions and UK generation. Both these input figures would be higher if imports were lower: if UK gas generation replaced the 18 TWh of imports in 2016, then UK emissions would have been 7 $MtCO_2$ higher, and emissions intensity would have been 292 gCO_2/kWh instead of 286 gCO_2/kWh.

In the longer term, the UK should not rely on imported electricity to cut UK emissions unless it is clear that imports are from low-carbon sources and the UK can rely on their continued supply:

- The UK currently imports electricity as over the course of the year it has had higher wholesale electricity prices more often than connected markets. However, future relative prices in the UK and connected markets are hard to predict. Increasing penetration of low marginal cost low-carbon generation could depress wholesale prices in the UK, while the potential for connected markets to impose their own top-ups to the EU ETS carbon price could increase prices elsewhere. If changing market dynamics mean that the UK does not import electricity in future, then UK sources of low-carbon generation will be needed to maintain security of supply and meet carbon budgets.
- It may be possible to connect to other markets and import surplus low-carbon generation, such as Concentrated Solar Power (CSP) from North Africa or geothermal power from Iceland. These options are not yet well developed and involve a number of challenges, but the UK has expressed an interest in exploring them and in principle they could provide a reliable cost-effective source of low-carbon power.

When we build scenarios for development of the UK power sector consistent with UK carbon commitments we assume that by 2030 the UK is neither a net importer nor a net exporter of electricity. If the UK is able to reliably import low-carbon power then less UK-based low-carbon capacity would be required.

When we monitor underlying progress by estimating achievable emissions intensity (section 2) we calculate what would be achievable with zero net imports.

Even with net imports of zero, interconnection can be valuable in increasing system flexibility (section 4). Security of supply and operating efficiency can be improved through sharing of back-up capacity and provision of ancillary services. Intermittent and renewable generation can be better accommodated and better take advantage of geographical diversity of renewable output and demand profiles.

Progress indicators

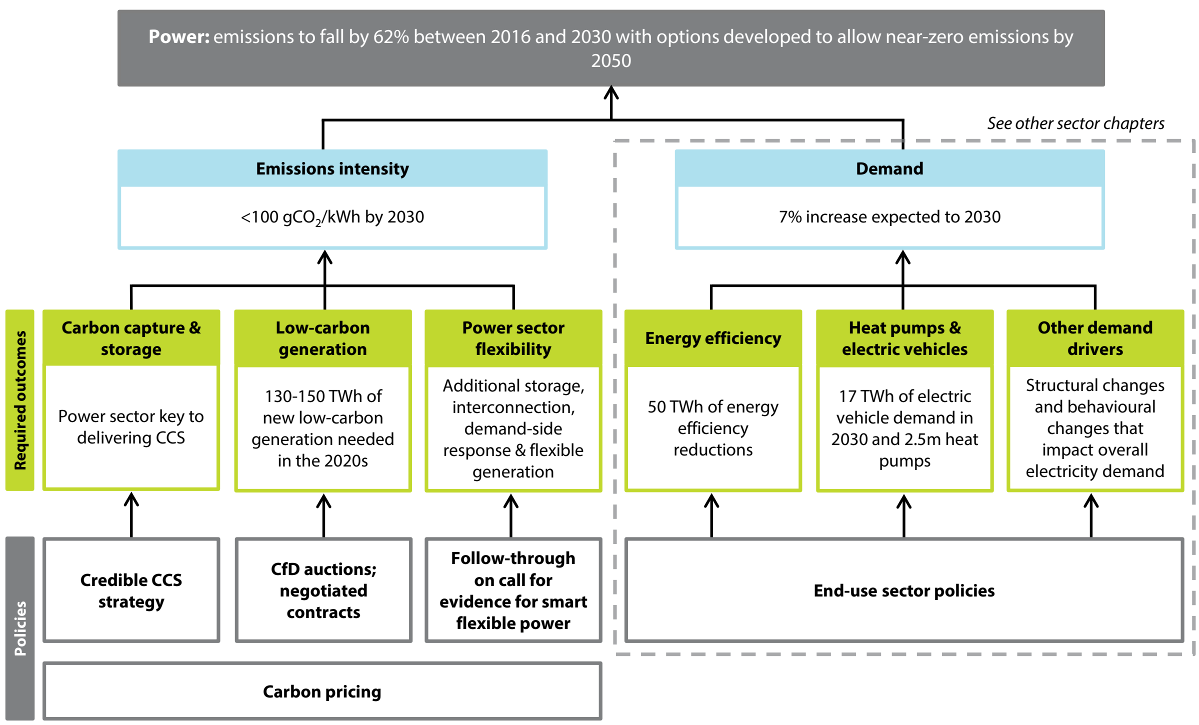
We monitor progress based on a set of indicators that reflect underlying progress in the sector and a possible set of actions that would deliver on the legislated carbon budgets and prepare for the 2050 target. Our progress indicators for the power sector (Figure 2.3) cover the expansion of low-carbon generation and the successful integration of low-carbon sources into the electricity system. To reduce emissions further from the power sector requires a continued expansion of low-carbon generation, which should increase from 45% of generation in 2016 to around 75% in 2030 (Figure 2.4):

- **Low-carbon generation.** On top of the 130 TWh of low-carbon generation we expect to be online in 2020 (and remain online in 2030) an additional 130-150 TWh of low-carbon generation should be added in the 2020s. Given expected retirements, particularly of existing nuclear capacity, that would bring total low-carbon generation to around 260-280 TWh. Allowing for an increase in demand as electric vehicles and heat pumps are deployed in-line with our scenarios (see Transport and Buildings chapters), this would leave around 100 TWh of generation required from gas-fired plants, implying an emissions intensity in 2030 of around 100 gCO_2/kWh.

- **Carbon capture and storage (CCS).** Alongside renewables and nuclear we would expect some of the new low-carbon generation to come from plants fitted with carbon capture and storage. CCS technology is important to meeting the UK's 2050 emissions target at least cost and the power sector is an important element in a credible strategy for developing a UK CCS infrastructure[27].
- **Flexibility.** The UK's electricity system will also have to become more flexible in order to accommodate more variable and inflexible generation and changing demand patterns that will arise as new technology is installed in homes and businesses. We consider the shift to a more flexible electricity system in section 4 and set out a new set of indicators for monitoring progress in these areas.
- **Policy.** As well as tracking low-carbon generation we track the investments that will lead to increased generation and the policies that will support those investments.

The next section sets out progress towards these indicators in 2016. Section 3 sets out what is required from policy to keep progress on track. Section 4 presents new indicators on flexibility following new analysis by the Committee this year.

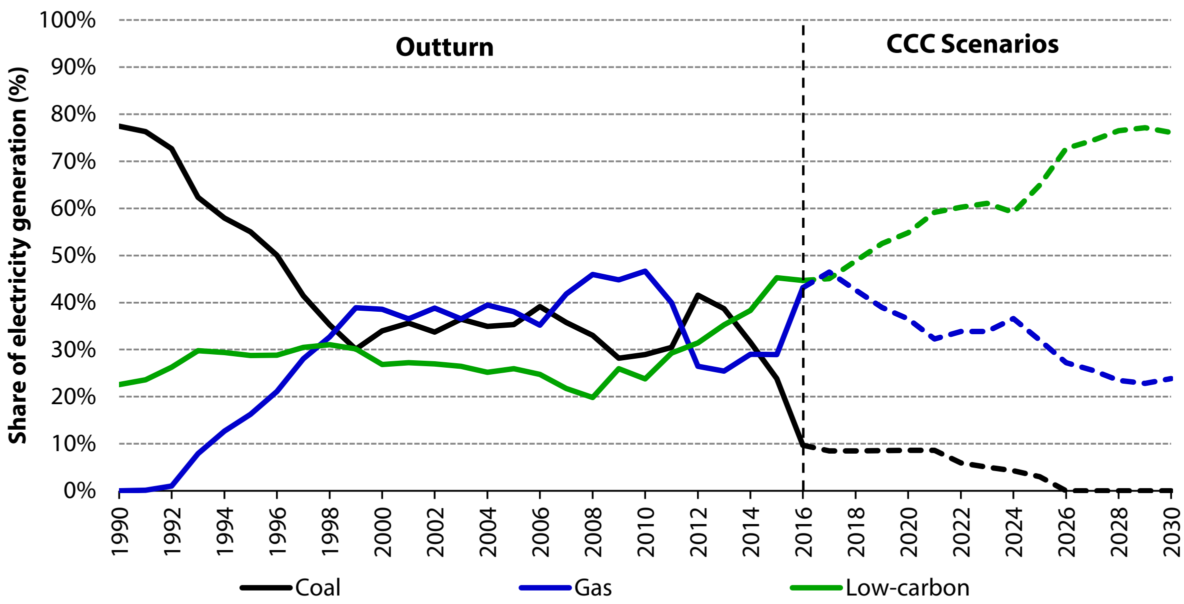
Figure 2.3. CCC indicators for monitoring progress in the power sector to 2030



Note: CfD = Contract for Difference; CCS = Carbon Capture and Storage.

[27] Pöyry (2016) *A Strategic Approach for Developing CCS in the UK.*

Figure 2.4. Share of generation by source (1990-2030)



Source: CCC analysis based on BEIS (2017) *Energy Trends*; CCC *Fifth Carbon Budget* scenarios, BEIS (2017) *Energy and Emissions Projections*.
Note: The rate of increase in share of low-carbon generation in the CCC's scenarios is comparable to the rate of increase in low-carbon generation since 2008. Variability in projected generation in the CCC's scenarios reflects uncertainty over retirement dates of existing coal and nuclear generation in BEIS's *Energy and Emissions Projections* scenarios.

2. Recent progress in reducing emissions in the power sector compared to required progress

Progress towards CCC indicators

Planned projects continued to be rolled out in 2016 and the potential pipeline of new projects increased:

- 1.4 GW of onshore wind and 2.4 GW of solar commissioned in 2016 (Table 2.2). No offshore wind plant completed construction in 2016 - this in part reflects the 'lumpiness' of these large investments, with 5.6 GW of projects still expected to deploy by 2021.
- In early 2016, EdF announced plant life extensions to 3.6 GW of the UK's 9 GW nuclear fleet that it operates. This low-carbon generation will now continue into the 2020s. However, 8 GW of the existing capacity is still set to come offline by the end of the fifth carbon budget period.
- New low-carbon projects continued to move through the project development pipeline in 2016:
  - 3.3 GW of projects commenced construction (including 1.7 GW of offshore wind and 1 GW of onshore wind). Of the 2.9 GW of onshore wind projects currently awaiting

construction, 2.2 GW are in Scotland, with 0.3 GW in both Wales and Northern Ireland, and 0.1 GW in England.

  – 3.6 GW of renewables received planning approval, including 1.8 GW of offshore wind, 0.8 GW of onshore wind and 0.7 GW of solar PV. This leaves a pipeline of 18.7 GW of renewables capacity across the UK.
  – 1.2 GW submitted planning applications (0.8 GW was new onshore wind, representing a slowdown on 2014 and 2015, when 1.7 GW and 2.5 GW of projects entered the planning system respectively).

This continued good progress has led us to increase our assessment from our 2016 *Progress Report to Parliament* for renewable generation expected by 2020. We now expect this to reach around 37% of overall expected generation, or 130 TWh (Table 2.2):

- Existing capacity would be expected to generate around 87 TWh in a typical year (it generated 75 TWh in 2016 despite unfavourable wind conditions).
- Contracts have been signed for an expected 30 TWh of low-carbon generation to come online by 2021.
- We expect around 12 TWh of further generation to come online by 2020 under Feed-in-Tariffs (FiTs) and the Renewables Obligation (RO) despite closures of those schemes.
  – Following cuts of around 65% to small-scale FiT rates in January 2016, annual deployment of solar PV under the scheme has dropped by around 90% per annum, meaning that just 0.1 GW of capacity was deployed under FiTs in 2016, compared to 0.8 GW in the previous year. We expect an increase in FiT generation of around 1 TWh to 2020.
  – The RO closed to solar PV and onshore wind in April 2016, though around 2.5 GW of onshore wind projects have 'grace periods' which allow them to commission by April 2018 (1.7 GW of which is in Scotland, alongside 0.4 GW in Wales, 0.3 GW in Northern Ireland and less than 0.1 GW in England). Similarly we expect 1.3 GW of offshore wind to commission under the RO. Together these would generate around 11 TWh in a typical year.
- In our 2016 Progress Report we expected 115 TWh of renewable generation to come online by 2020 under FiTs, the RO and CfDs. Given additional projects coming forward under the RO, we now expect 130 TWh of renewable generation to be online in 2020/21.

Broader upgrades to the UK electricity system will help to accommodate this increase in low-carbon generation.

- A major upgrade to the UK transmission system is expected in 2017, when the 2.2 GW Western HVDC link between Scotland and England is completed. This will enable more low-carbon capacity to be deployed in Scotland and is expected to reduce payments to Scottish generators for curtailing their generation at times of system stress.
- Approximately 6m smart meters were installed by March 2017 as part of a Government mandated programme, aiming to install a smart electricity and gas meter in every home (and 2m small businesses) by the end of 2020. This is behind the original expected deployment trajectory.[28]

[28] BEIS (2016) *Smart Meter roll-out cost-benefit analysis*.

Of the 24 GW of coal and nuclear capacity on the system at the end of 2016, 23 GW is set to retire by the end of the fifth carbon budget period. This capacity generated around 95 TWh in 2016, and, if running at maximum load factors, would be capable of producing around 180 TWh of generation per year. Older gas capacity may also retire, depending on market conditions, leaving a generation gap which should be replaced by low-carbon power.

After 2020, investment prospects remain unclear, albeit with some progress in the last year:

- The Government has announced its intention to hold up to three 'Pot 2' auctions by 2020[29][30] for offshore wind and other less mature renewable technologies. Depending on the clearing prices for the auctions, these could support around 25 TWh of new low-carbon generation to be deployed from 2021 to 2026.
- EdF have signed the contract offered by the UK Government and taken a final investment decision to proceed with the Hinkley Point C nuclear power plant. The plant is aiming to commission in 2025 and is expected to generate around 25 TWh per year.
- There was mixed progress in developing other new large-scale nuclear projects in the UK, and the Government is yet to confirm the winner of its Small Modular Reactor (SMR) competition.
  – Although the AP 1000 reactor planned for NuGen's Moorside project passed the regulator's Generic Design Assessment (GDA) process in early 2017, the future of the project is currently uncertain following the bankruptcy of Westinghouse. Horizon's Wylfa project continues to make progress, with completion of its GDA expected in December 2017. China General Nuclear gained ownership of the Bradwell nuclear site and submitted its GDA application in January 2017.
  – In March 2016 the Government launched a Small Modular Reactor competition, with the intention of providing £250m of funding over the next five years to the best value SMR design for the UK, alongside an SMR roadmap for the UK. To date, no further details have emerged.
- The independent Hendry Review recommended that the Government proceed with the Swansea Bay tidal lagoon as a 'pathfinder' project, but no contract has yet been offered. If built Swansea would generate around 0.5 TWh per year, while a programme that also included Cardiff Bay and Newport could be delivered in the 2020s and generate 8 TWh a year (around 3% of current UK generation)[31].

There has been no progress in bringing forward policy for mature renewables (e.g. onshore wind and solar) or for CCS. That is despite record low prices being set for renewables in European auctions and despite further advice emphasising the importance of CCS from the Committee[32] and from the Parliamentary Advisory Group.

Section 3 considers what is needed to improve prospects for investment in the 2020s.

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[29] Under the Energy Act (2013) the Government introduced long-term contracts for low-carbon power generation, known as 'Contracts for difference' (CfDs), which allow low-carbon generators to recoup their investment costs through fixed prices for electricity generation. These contracts can be won via competitive auctions split between three auction pots: Pot 1: onshore wind, large-scale solar PV; Pot 2: offshore wind, tidal stream, wave, "Advanced Conversion Technologies", and Biomass Combined Heat and Power (CHP); Pot 3: Biomass conversion. The Government recently consulted on including Scottish Island onshore wind in Pot 2.

[30] Up to three auctions were announced in the previous Parliament, which would have run to 2020.

[31] Pöyry (2014) *Levelised costs of power from tidal lagoons*.

[32] CCC (2016) *Letter to Rt Hon Amber Rudd: A strategic approach to Carbon Capture and Storage*.

Table 2.2. Deployment of renewables in 2016

Technology (% of UK Generation in 2016)	Installed Capacity in 2016 (GW)	Of which, capacity added in 2016 (GW)	Further capacity in pipeline to 2020[1] (GW)	Expected capacity and generation in 2020	CCC indicator generation in 2020	Indicative current cost estimates (£/MWh)[2,3]
Onshore wind (7%)	10.6	1.4	2.5	13.1 GW, 35 TWh	30 TWh	£49-79
Offshore wind (5%)	5.1	-	5.6	10.7 GW, 41 TWh	36 TWh	£101-129
Biomass (9%)	5.6	0.3	0.8	6.4 GW, 35 TWh	24 TWh	£85-88
Solar PV (2%)	11.6	2.4	0.3	12.0 GW, 12 TWh	-	£62-84
Hydro (2%)	1.8	0.1	<1	1.8 GW, 5 TWh	-	£61-107
Wave (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	*£200-430*
Tidal stream (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	*£170-365*
Tidal lagoons (0%)	0	0	0	0	-	£115

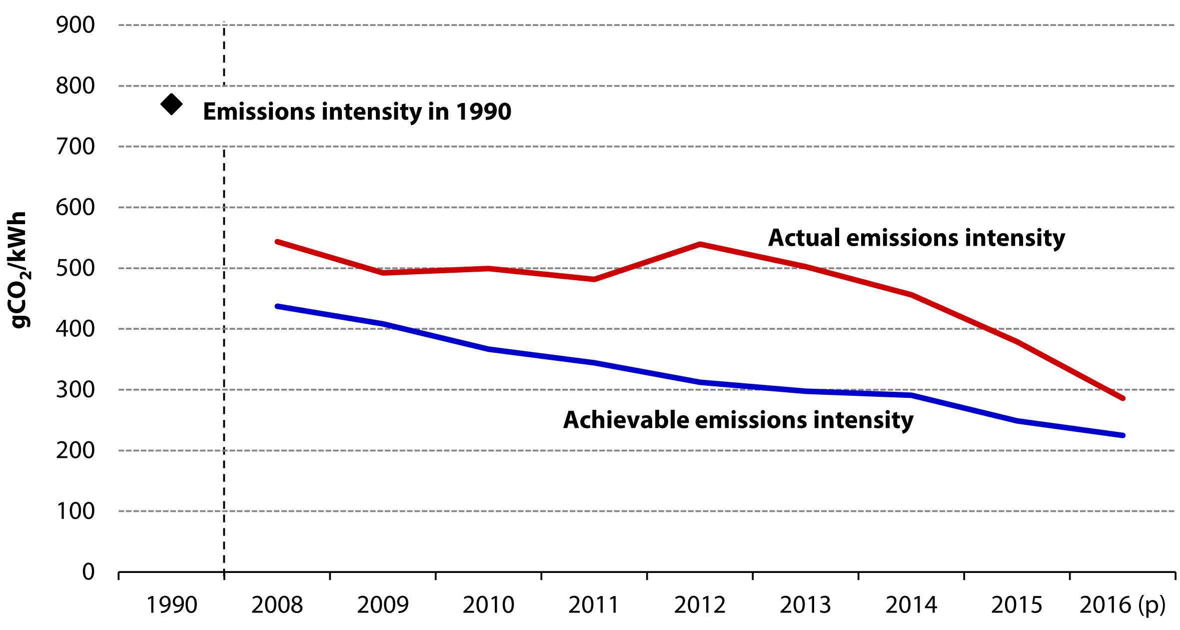
Source: BEIS (March 2017) *Energy Trends*, Low Carbon Contracts Company (2017) *CfD Register*, BEIS (2017) *Renewable Energy Planning Database*, BEIS (2016) *Electricity Generation Costs*, CCC analysis.
Notes: 1. Awarded a CfD, or expected to deploy under the Renewables Obligation. Note this includes the Neart Na Goithe offshore wind farm (0.45 GW), which has appealed against a cancelled CfD.
2. £2014. Levelised cost estimates for projects commencing generation in 2018 (2025 for wave and tidal), from BEIS (2016) *Electricity Generation Costs*. In addition to these costs, intermittent renewables (e.g. wind, solar) may impose additional costs of up to £10/MWh by 2030; see CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
3. For reference, BEIS estimates levelised costs for current new build CCGT to be £60-62/MWh, for gas plant facing a market carbon price. We estimate gas plant costs would be up to £17/MWh higher if facing a 'target-consistent' carbon price. For more information see: CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
4. 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).
5. Biomass includes biomass from: biomass conversions, dedicated biomass, energy from waste, landfill gas and anaerobic digestion. Levelised costs are for biomass conversions.

Achievable emissions intensity

In order to identify underlying progress we also track the Achievable Emissions Intensity of the power system (Figure 2.5): the emissions intensity of the grid if it were operated to minimise emissions by dispatching least-emitting plant first (i.e. renewables and nuclear, followed by gas and finally coal). Achievable intensity improved by 10% to 224 gCO_2/kWh in 2016 due to increased deployment of onshore wind and solar capacity. This represents a slowdown compared to 2015 where the achievable intensity improved by 15%, reflecting that no offshore wind was commissioned in 2016.

There is sufficient low-carbon capacity to meet over half of electricity demand in a typical year, and sufficient gas capacity to meet the remainder. Additional capacity may be required in a backup role, to ensure system security. We expect the gap between actual and achievable emissions intensity to continue to narrow, as coal comes off the system.

Figure 2.5. Achievable emissions intensity of the power sector (1990, 2008-2016)



Source: CCC calculations based on BEIS (2017) *Energy Trends*; BEIS (2017) *UK Greenhouse Gas Emissions 1990-2016 (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 has no effect on achievable emissions intensity. In 2015 we updated the AEI methodology to include lifecycle emissions of 200 gCO_2/kWh for biomass. 2016 data are provisional.

3. Policy progress towards the fourth and fifth carbon budgets

Effective policy in the power sector should allow for steady deployment of low-carbon technologies, where these are low cost over their lifetimes compared to gas generation facing a rising carbon price, or where they are required to drive down the costs of important options for the longer-term, such as offshore wind and carbon capture and storage. That implies moving steadily towards a power system with emissions of below 100 gCO_2/kWh by 2030.

In this section we evaluate the set of current and planned policies, assessing the risk that these policies might fail to deliver the necessary reductions in emissions. We then assess the "policy gap", where the set of current and planned policies are not sufficient to meet the cost-effective path through the recommended fifth carbon budget (to 2032).

Current policy

Last year we identified significant risks to sustained progress, particularly beyond 2020 and made several recommendations to address these. Several of these have made no progress, notably CCS and developing an approach to contract for the cheapest low-carbon generation. Early steps have been taken on improving system flexibility and contingency plans, while offshore wind auctions for the 2020s have begun following allocation of funding in the 2016 fiscal Budget. We would expect all of these issues to move forward in the forthcoming plan for meeting the fifth carbon budget.

Existing policies could deliver around 50 TWh of the 130-150 TWh of additional low-carbon generation that we identify as being appropriate to deploy in the 2020s:

- The Hinkley Point C nuclear power project was originally offered a contract by the Government in 2013. A review of the contract concluded in September 2016, reaffirming the Government's commitment to the project. EdF, the company developing the project, aims to commission the project by 2025. It is expected to provide around 25 TWh of low-carbon power once fully operational. Should the project suffer serious delays, and not commission by 2033, its contract would be terminated.
- In Budget 2016 the Government allocated funding of £730m per annum for 'Pot 2' technologies (i.e. offshore wind and other less mature technologies), commissioning between 2021 and 2026. 'Up to three' auctions are planned by 2020 to allocate this funding. We expect the first of these auctions - which is currently underway - to contract 4-6 TWh of generation, if contracted at the auction's reserve prices. Given potential for lower prices than the reserve prices and for further contracts in subsequent rounds we expect around 25 TWh could be contracted in total. As these projects are expected to mark an important milestone in offshore wind cost reductions, and provide a strong contribution to power sector decarbonisation in the 2020s, it is important that the Government stick to the planned timetable and funding allocation for these auctions.

Despite a Parliamentary report on the necessary next steps to develop CCS in the UK and a Government-backed review of tidal lagoons, limited proposals exist to secure the additional 80-100 TWh of low-carbon generation required, such as allowing for a route-to-market for mature low-carbon generation options:

- A report from the Parliamentary Advisory Group on CCS (chaired by Lord Oxburgh) in September 2016 reiterated the Committee's conclusions on the next steps for CCS deployment in the UK. CCS deployment in the power sector could make a significant contribution in terms of low-carbon power generation, whilst supporting development of a cost-effective transport and storage infrastructure to be used for CCS deployment in other sectors (Chapter 1).

- The Hendry review of tidal lagoons concluded in January 2017, backing Government support for a pathfinder tidal lagoon project at Swansea Bay in Wales, to test the potential long-term contribution of this technology to the UK's energy mix. The Government has not yet responded to the review.
- Although the Government confirmed it was working on a 'market-stabilising' contract for difference in February 2016, no further progress was made towards allocating contracts for mature low-carbon generation options such as onshore wind and solar PV from 2020, or offshore wind from 2026. That is despite a growing body of evidence to suggest that, with a suitable contract, these technologies could provide the lowest cost power of any options (including gas-fired generation).
- There is potential for repowering of existing wind and solar sites that are expected to come to the end of their lives under the RO in the second half of the 2020s. These sites may have the potential to produce more energy if repowered with larger turbines, but the treatment of repowering in future power markets is unclear.

As well as expanding low-carbon capacity, the flexibility of the system will need to improve. BEIS and Ofgem jointly launched a call for evidence on improving the flexibility of the power system in November 2016.[33] That publication recognised many of the current barriers to efficiently improving system flexibility, but these have not yet been sufficiently addressed. We consider these issues further in section 4.

The vote to leave the European Union has potentially important impacts for the power sector. Most notably there are questions over the future of emissions trading, and the regulatory arrangements for nuclear power (both existing and new build), given that much of the regulatory oversight is from Euratom at the EU level. There is also uncertainty about the UK's membership of the Single Energy Market and therefore the role of interconnection.

Our assessments of existing policies against the options included in our scenarios for meeting the carbon budgets are set out in Table 2.3. The resulting policy gap, in terms of emissions and generation is set out in Figures 2.6 and 2.7.

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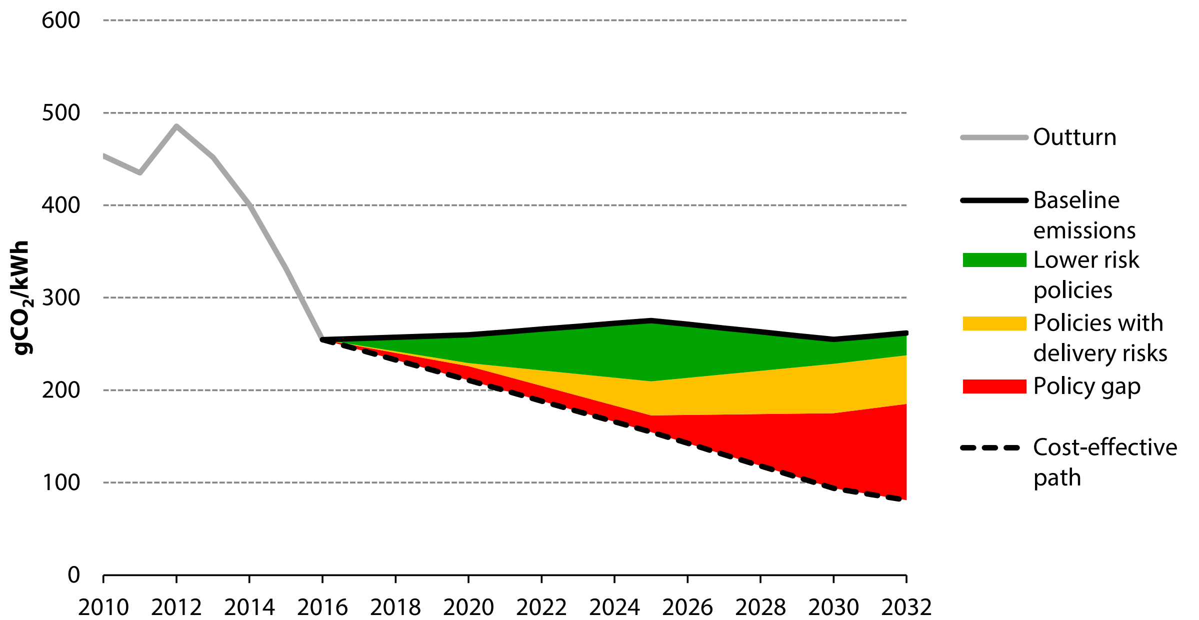
[33] BEIS (2016) *Call for evidence a smart, flexible energy system*.

Table 2.3. Assessment of policies to drive abatement in the power sector

Abatement option	2016 policy		2017 policy assessment and updates	
Pre-2020 renewables (Renewables Obligation, FiTs, FIDER and the first CfD allocation round)	Green	Delivery of over 100 TWh of generation per year by 2020.	Green	Although schemes are being closed early, projects have come through as planned or quicker, and higher load factors from new technology should see around 130 TWh of generation online by 2020/21.
Carbon Capture and Storage	Red	No policy, following cancellation of commercialisation programme in 2015.	Red	Parliamentary advice published, but no policy or proposals from Government. Some small-scale CCS projects continue to develop, but a CCS strategy is urgently needed.
Fuel switching away from coal	Green	Announcement on coal closures.	Green	The power sector continues to see fuel switching away from coal, as existing plant close and load factors reduce.
Nuclear – first 2 reactors at Hinkley	Amber	Negotiations to reach FID.	Amber	The Government recommitted to the contract offered to Hinkley Point C, and EdF confirmed a final investment decision on the project, though risks remain around delivering an infrastructure project of this magnitude.
Support for offshore wind until cost-competitive in the mid-2020s	Amber	Pot 2 auctions and £730m funding announced.	Amber	First auction round underway. Further auctions for offshore wind should proceed, in line with existing commitments. Risks remain until contracts are signed and progress is made in delivering the projects.
A subsidy-free route to market for the cheapest low-carbon generation after 2020 (e.g. onshore wind, large-scale solar PV)	Red	No policy.	Red	Government previously indicated that it is working on a market-stabilisation CfD, but no plans have been announced for auctions.
Power system flexibility	Amber	Joint (BEIS and Ofgem) review and call for evidence on flexibility in the electricity market.	Amber	BEIS and Ofgem conducted a joint review and call for evidence on flexibility in the electricity market. National Grid is undertaking several actions to enhance system flexibility.
Contingency plans for delay or cancellation of planned projects, for example new nuclear power plants	Red	Hendry Review of Tidal Lagoons ongoing. Government launch of SMR competition.	Red	Hendry Review of tidal lagoons published, but no Government response. No winners have been announced for the Government's SMR competition for nuclear power.

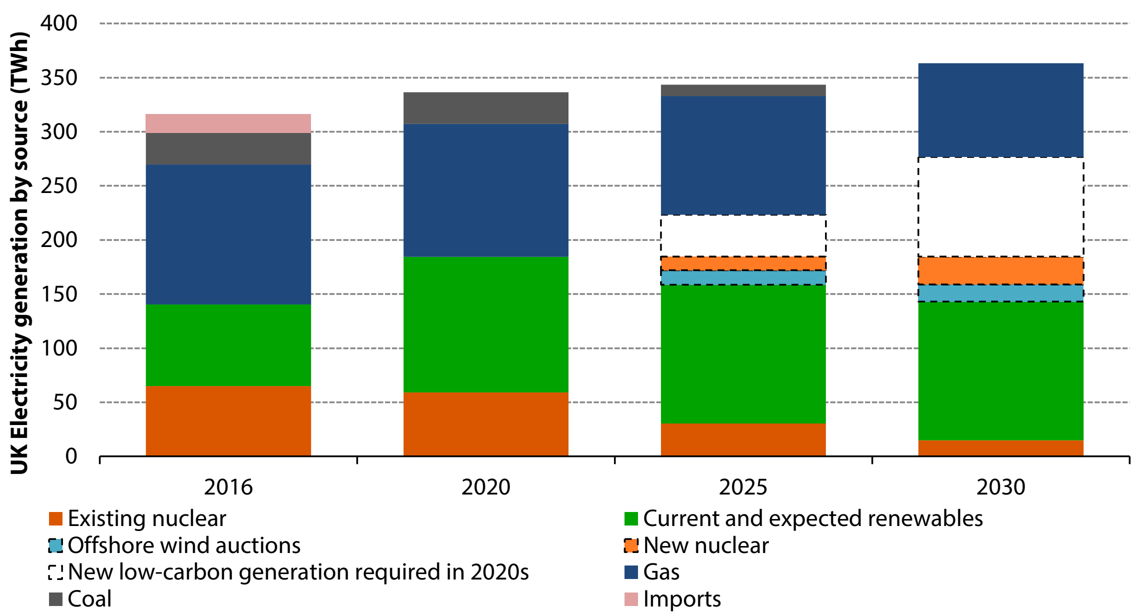
Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Policy with delivery risk - stronger implementation required. Green: Lower-risk policy - expected to deliver.

Figure 2.6. The Policy Gap in the power sector (2010-2032)



Source: CCC analysis based on BEIS (2017) *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 2016. Emissions in the baseline increase beyond 2030 due to nuclear plant retiring from the electricity system.

Figure 2.7. UK electricity generation by source (2016-2030)



Source: BEIS (2017) *Energy Trends*, Low Carbon Contracts Company (2017) *CfD Register*, BEIS (2017) *Renewable Energy Planning Database*, CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget.*

Required progress towards the fourth and fifth carbon budgets

In order to meet the requirements of the Climate Change Act and to close this policy gap, the shortcomings in existing policy set out above must be addressed in the Government's proposals:

- **A new strategic approach to CCS** (chapter 1). This would require a programme of CCS deployment across power and industry, alongside a separate approach to CO_2 capture and to the transport and storage infrastructure.
- **The Government must extend its approach to contracting low-carbon generation, to the 80-100 TWh of additional generation in the 2020s required.** An approach to contracting mature low-carbon generation, together with CCS and any negotiated contracts, should deliver a further 80-100 TWh of low-carbon generation in the 2020s beyond the planned 'Pot 2' auctions and the nuclear project at Hinkley Point C.
  - A programme of regular CfD contracting is required as a pragmatic and cost-effective approach to delivering the low-carbon generation required to replace retiring generation and keep the UK on track to a system emissions intensity of below 100 gCO_2/kWh in 2030, which is part of the lowest cost path to meet the UK's carbon commitments. A commitment to regular contracting, subject to cost, can provide investors with the confidence that there will be a market for low-carbon generation in the 2020s, whilst keeping costs to bill payers to a minimum (Box 2.2).
  - Latest estimates from BEIS and others[34] suggest onshore wind and solar PV are already cheaper than fossil-fired generation. We expect offshore wind to be cost-competitive with fossil fuel generators facing a rising carbon price, later in the 2020s. These projects could be brought forward by auctions with low reserve prices that imply no net subsidy over their lifetimes, including when allowing for the system costs imposed by intermittent generation. Even though no subsidy is required, the CfD mechanism remains important given its effect in reducing the cost of capital for projects.
  - While auctions have proven effective in driving down costs, they could be supplemented by negotiated contracts for projects not well suited to auctions (e.g. because there are few potential bidders and they require different terms to wind projects), if they can be agreed at attractive strike prices. This is the current approach for new nuclear projects, tidal lagoons and CCS plants.
  - Carbon pricing is likely to continue having an important role alongside long-term contracts. In the Spring Budget 2017, the Government stated its intention to target a 'total carbon price' for fossil fuel generators operating in the UK power sector from 2021/22. That could help provide clarity over future plans while the UK's future membership of the EU Emissions Trading System remains uncertain following the vote to leave the European Union.
- **Contingency plans for delay or cancellation of planned projects, for example of new nuclear power plants.** The Government's plan to meet the fourth and fifth carbon budgets needs to demonstrate multiple plausible routes to keep the power sector on track to 2030 (i.e. towards a 100 gCO_2/kWh intensity of generation), and towards a fully decarbonised electricity system by 2050. If existing projects were delayed or cancelled this would require alternative low-carbon technologies to increase their contribution. Options include tidal

[34] BEIS (November 2016) *Electricity Generation Costs*. Baringa (2017) *An analysis of the potential outcome of a further 'Pot 1' CfD auction in GB*.

lagoons or barrages, further offshore wind, other renewables (to the extent these are locally acceptable, sustainable and can be accommodated on the system), CCS, small modular nuclear reactors and low-carbon generation sourced from connected markets.

- **Policy and regulatory changes to ensure that flexibility options are rewarded in the energy markets in a way that reflects the value they bring to the system.** The Government and Ofgem must follow through on the intentions set out in the Call for Evidence and address the challenges set out in section 4 below.

Taken together, the new plans should put the UK electricity sector on track to an emissions intensity below 100 gCO_2/kWh in 2030 across multiple scenarios, should see CCS deployed at scale during the 2020s and should ensure that flexibility options are able to capture their full value to the electricity system.

In our March 2017 report on *Energy Prices and Bills* we estimated that meeting the fifth carbon budget will add around a further £85-120 to the annual household energy bill (£95 in our central estimate). Added to the current impact on bills (or around £105), this implies that low-carbon policies will add £190-225 in total to the average annual bill in 2030 (£200 in our central estimate). As well as the costs of sourcing 75% of UK generation from low-carbon sources by 2030, this includes the system costs of integrating that generation, the costs of supporting residential energy efficiency improvements and the higher per unit costs of maintaining the gas grid as households cut demand and shift to low-carbon heating.

Households could more than offset this bill impact through energy efficiency improvements between 2016 and 2030, which would save around £150 on average if prices remain at current levels. The majority (85%) of this saving is available from replacing appliances, lights and boilers at the end of their lives with the latest equivalent models. To date, energy efficiency savings have more than offset increases to household bills from the costs of supporting renewables. A typical household bill in 2016 was lower in real terms than it was in 2008 when the Climate Change Act was passed, despite rising wholesale gas prices over this period.

Meeting the fifth carbon budget offers multiple opportunities for UK businesses. The Government's recent consultation on the industrial strategy noted the scale of industrial opportunities for offshore wind and nuclear power, and the importance of realising further cost reductions in offshore wind technology. Furthermore, it recognised the importance of improving the flexibility of the UK's electricity system (section 4) through innovation funding to support energy storage and Demand Side Response (DSR) technologies, and by improving the efficiency of electricity networks in a low-carbon energy system.

The industrial strategy also announced a review of energy costs, set in the context of the need to meet the targets in the Climate Change Act. There are various elements of energy pricing that could be reviewed whilst still delivering an additional 80-100 TWh of low-carbon generation in the 2020s. That includes consideration of wholesale and network costs for businesses. These appear to result in higher industrial electricity prices in the UK than elsewhere in Europe, but the reasons - which are not a result of climate policies - are not clear.

We will publish our assessment of the Government's proposals for meeting the fifth carbon budget subsequent to their publication.

Box 2.2. Beyond the Levy Control Framework (LCF)

The Levy Control Framework (LCF) sets a cap on the amount of support paid to low-carbon generators. In the past this has also served as a signal of how many contracts will be available in total for new low-carbon generators. However, the Committee have previously identified that the LCF is not a good measure of subsidy as it is partly calculated as a top up against the wholesale electricity price, which is lower than the cost of alternative generating options. It would also be a poor signal of contract availability in the 2020s, when the support for existing projects (and therefore the remaining support for new projects) would vary considerably as the wholesale price varies.

The Spring Budget 2017 announced that the LCF would not continue beyond 2020/21. It is due to be replaced by a new set of controls later this year. Details have not been confirmed, but some new controls and spending have been agreed:

- The total annual support available for the planned 'Pot 2' auctions for 2021-2026 (which include offshore wind) has been capped at £730 million (2012 prices). Depending on how low the winning bids are, this could procure around 25 TWh of generation.
- The contract for the new nuclear power station at Hinkley Point C has a strike price of £92.50 in 2012 prices. For its expected output of 25 TWh and compared to a projected wholesale price of £53/MWh that implies annual support payments of around £1 billion in 2030.

These commitments give certainty to investors that allow development to continue, whilst having an impact for consumers that can be identified. A similar approach, focused on controls for new contracts could continue these benefits:

- In setting out its plans for the fourth and fifth carbon budgets, the Government should set out its intention to contract a further 80-100 TWh of low-carbon generation in the 2020s.
- Some of this generation should come from CCS, for which the Government must set out its new approach to delivery and to funding. Our analysis suggests 27 TWh per year of CCS generation could be secured with support of around £1.4 billion above the wholesale price in 2030.
- For mature technologies that require long-term contracts, but not subsidies (e.g. onshore wind, solar, possibly offshore wind from around 2025), the Government could set out the TWh it intends to contract for each year (or delivery window of several years) and the maximum ('subsidy-free') price at which contracts will be awarded.
- The Government may also choose to negotiate specific contracts for known amounts of power at agreed prices or to run further auctions with fixed budgets for less-mature options.
- The Government should continue to work with the industry to ensure the policy environment is supportive of cost reduction (e.g. in finalising the auction rules).
- The amount of planned contracting could be updated over time as circumstances evolve (e.g. demand, plant retirements and extensions, cost of alternatives). The total expected impact on consumers could be calculated in advance. To the extent that gas or carbon prices end up lower than expected, support costs would be higher, but consumer's bills would be lower. If gas or carbon prices are higher, then support costs would be lower.

We expect the generation required in our power scenarios in the 2020s to require around £4bn per annum by 2030 above the wholesale price, in addition to what has already been contracted. This is not a measure of subsidy, since the assumed wholesale price (£53/MWh) is lower than the expected new build cost of gas generation (£73/MWh). Under the scenarios from our advice on the fifth carbon budget and latest cost assumptions, the new generation in the 2020s could be secured at an average cost per unit of generation that is 21% below the cost of contracts to date.

Source: CCC analysis based on CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
Notes: All values in £2012. Wholesale electricity price projections from BEIS (2017) *Energy and Emission Projects: Annex M*.

4. Delivering system flexibility

(a) Context

A functioning electricity system must balance generation and consumption to provide a high quality of service, and remain stable by maintaining the system frequency within narrow limits. This will increasingly require **flexibility**, where generators and consumers increase or decrease output or consumption, for example in response to changes in output from the increasing share of renewable generation. Flexibility is also required as the location of generation changes, as conventional thermal power plants retire and as energy consumption patterns change as new energy-management technologies are placed in businesses and homes. The electricity System Operator (National Grid) currently arranges a number of services to secure these changes in output or consumption (Box 2.3).

Box 2.3. Flexibility services in the electricity system

A number of services exist to ensure the electricity system is managed securely and effectively:

- Wholesale energy (arranged up to one hour ahead).
- Balancing (arranged half an hour ahead).
- Reserve (arranged 10-20 minutes ahead). Addresses unexpected reduction in generation or increase in consumption, to maintain system reliability.
- Frequency response (arranged 1-30 seconds ahead). Addresses sudden loss of generation (e.g. failure of large generator or interconnector) or increase in consumption, in order to keep system frequency within statutory limits.
- System inertia (provided instantaneously and automatically). Provided by stored kinetic energy of the rotating mass of a thermal generator's turbines. A high degree of system inertia reduces the speed of fluctuations in frequency, reducing the level of frequency response required.
- Shifting transmission of energy to uncongested periods, therefore reducing the need to reinforce transmission and distribution networks

Each of these services has its own market arrangements, with the exception of inertia, which is not currently remunerated.

Notes: National Grid procures a number of services that do not directly relate to the definition of flexibility proposed above (e.g. Intertrips, Black Start, Reactive Power Services). These services are outside the scope of this analysis.

Until recently, these flexibility services have mostly been provided by fossil generation, supported by pumped-storage hydroelectricity, with large industrial electricity users providing a degree of demand response in the wholesale energy and balancing markets. As renewable generation increases and fossil generation decreases, these services will increasingly need to be met by non-fossil generation.

In 2015 we commissioned Imperial College to investigate the system integration costs of low-carbon generation. A key finding of this work was that flexibility must improve significantly if additions of variable renewables are to effectively reduce system carbon intensity (Box 2.4). Improved flexibility would mean that the overall costs of running the electricity system would be reduced and the incremental system costs of adding wind and solar generation would be limited to £10/MWh.

Key options for flexibility include fossil-fired generation that is designed to be highly flexible, storage, demand-side response, and interconnection. There are also opportunities to provide more flexibility services from existing generators and to adjust existing system operation.

Box 2.4. Impact of low-carbon generation on system carbon intensity, and importance of flexibility

Recent modelling from Imperial College helped to identify and quantify the extent to which the low-carbon generation in our scenarios will change system flexibility requirements. Increased generation from variable renewable generation can impose costs and constraints on the existing electricity system, if not properly managed. This is because:

- Some renewable generation will be curtailed at times of low demand and high output (e.g. on sunny, windy summer days). Reducing **curtailment** would avoid the need for further low-carbon investment.
- Renewable generation will often be insufficient to meet demand, requiring **back-up** capacity.
- Intermittent renewable generation, like wind power, will increase the volatility of net demand (the amount of demand that remains unmet after intermittent generation is subtracted), requiring **steeper ramping up and down** of other generation. Imperial College estimated around a doubling in system ramping requirements in our 2030 scenarios.
- Additional **reserve capacity** (up to 40% increase in our scenarios) must be held to accommodate the possibility that renewables will generate less than forecast, alongside a more frequent need for these higher reserve levels to be used (double the amount of hours).
- System **inertia** will decrease as fossil generation decreases, requiring a higher degree of **frequency response**. Frequency response requirements will be greatest at times of high renewables output and low demand. Additional frequency response is also required if the system is unable to meet a steeper ramping requirement. Imperial's modelling suggests a future system requires a larger capacity of frequency response plant in 2030, operating in twice the amount of hours as today's system.
- Conventional fossil generators have a level of **minimum stable generation** (i.e. are not able to start up instantly and must therefore run part-loaded in order to be available when required). Furthermore, such generators are not **fuel-efficient** at minimum stable generation. Conventional generators also have a **maximum ramp rate**, such that they cannot generate large volumes of electricity over short spaces of time.
- If the system is unable to absorb all of its renewable generation, and requires fossil plant to run part-loaded in order to provide the necessary back-up, ramping, reserve and frequency response, the system CO_2 intensity will remain high (e.g. up to 200 gCO_2/kWh) even with a major expansion of low-carbon capacity.

In order to minimise the carbon intensity of a system with high levels of renewables, some combination of the following options is necessary:

- Deploy **flexible fossil generators** with lower levels of minimum stable generation and faster ramping, and that are more efficient under these conditions. Technologies to achieve this are available at moderate cost, but there is currently insufficient incentive to deploy them.
- Use **storage, demand-side response and interconnection** to absorb surplus renewable generation, and provide reserve and frequency response services, limiting the role of fossil

Box 2.4. Impact of low-carbon generation on system carbon intensity, and importance of flexibility

generators in providing back-up generation, reserve and frequency response.

- Reduce the need for reserve through **improved forecasting** of wind and solar generation.
- Reduce the need for frequency response by deploying **smaller generators**, reducing rate of change of frequency **(RoCoF) constraints**, allowing **nuclear generators to provide inertia** and wind generators to provide **"synthetic inertia"**, and deploying **higher-inertia fossil generators**.
- Allow **renewables to provide frequency response** when curtailed.

Imperial estimated that the overall annual costs of running the electricity system would be reduced by £3-5 billion if flexibility resources were able to make a full contribution in 2030. Even without a shift to intermittent renewables, flexibility would reduce the overall costs of running the system.

Source: Pöyry and Imperial College (2017) *Roadmap for flexibility services to 2030*.

(b) Flexibility roadmap

Barriers to increasing flexibility and options for tackling them

Given the importance of improving flexibility to reducing CO_2 emissions and cutting cost we commissioned Pöyry and Imperial College to develop a roadmap for what is needed to enable low-carbon flexibility resources to come onto the system at sufficient scale to 2030. Pöyry and Imperial College identified a range of barriers, which are likely to result in under-investment in flexibility solutions, and a set of actions to resolve these barriers.

The barriers and required actions can be grouped into four main areas: ensuring that markets reflect full system value, managing complexity, supporting innovation and ensuring effective consumer participation:

- **Ensuring that markets reflect full system value.** The current set of markets do not incentivise sufficient deployment of flexibility technologies as technology providers are not able to capture the value of all the services they are capable of providing, or face unnecessary risks in doing so.
  - **Providers cannot receive remuneration for all sources of value** (e.g. providers of Enhanced Frequency Response are not able to participate in the capacity market). Combining value streams is important, as for example for a battery storage operator frequency response represents just 30% of the total value it is able to provide to the system, the capacity market represents another 20%, balancing services 20%, and energy arbitrage and avoiding network reinforcement the rest.
  - **There is considerable uncertainty over future requirements** for flexibility services, particularly over longer (e.g. ten-year) time horizons. That partly reflects uncertainty over how policy will drive deployment of intermittent capacity or different sources of flexibility.
  - **There is a lack of appropriate temporal price signals**. For example, 'gate closure' (the last point at which generators can sell their energy in the wholesale market) is one hour ahead of real-time. Other European countries are moving to periods that are closer to real time (e.g. 15-30 minutes). Separately, Frequency Response contracts are procured several weeks in advance, so may not align to real-time system needs.

- **Procurement of flexibility services is complex and lacks transparency**, differing in terms of technical requirements, validation processes, contract types and procurement platform, increasing complexity and reducing transparency.
- **The current allocation of network charges is not cost-reflective**. For example, storage operators are treated as both a consumer and a generator, which results in them paying twice for transmission and distribution charges.
- **The current allocation of non-network charges is also not cost-reflective.** For example, the largest plant on the system drives the need for frequency response, but the cost of providing this is socialised. Separately, renewables offer limited capacity value, but are not charged for the provision of back up capacity that they then require.

- **Managing complexity.** There will be an increase in the complexity of the electricity system, across multiple network operators and an increasing heterogeneity of infrastructures. This will make it more important that operators are incentivised to minimise costs across the whole system, not just in their networks.
- **Supporting innovation.** Incentives to develop and reward innovative flexibility solutions are currently inadequate. Current network standards do not allow investment in flexibility resources and further innovation required to develop pre-commercial technologies to maturity.
- **Ensuring effective consumer participation.** There are a range of barriers to unlocking demand-side response, including improving consumer awareness and engagement, and both real and perceived issues around data privacy and cyber security. Appliance manufacturers may choose not to implement demand-response ('smart') capability across product ranges.

Our recommendations below are intended to deal with these barriers to create a technology-neutral investment environment, which must enable efficient investment decisions, manage greater complexity, support innovation and ensure effective consumer participation.

The full list of barriers and actions, including the associated time frame, responsibility and priority, is set out in Pöyry and Imperial College (2017) *Roadmap for Flexibility Services to 2030*, published on the Committee's website.

Scenarios for increasing flexibility

Modelling by Pöyry and Imperial College identified a range of scenarios for growth of different flexibility providers to 2030 (Table 2.4). The wide ranges reflect that the best balance between different forms of flexibility will depend on factors that are hard to predict in advance, such as how technologies will develop, how consumers will respond and what the mix of low-carbon generating technologies will be.

Given the uncertainty, we will monitor progress against the ranges in Table 2.4, rather than against specific point estimates. Lower deployment of one option could be compensated by higher uptake of another technology, thus meeting the system's overall flexibility requirements. However, a consistent low deployment of one or more technologies across several years would be a flag for further investigation.

As key enablers of demand-side response, we will also continue to monitor the take-up of smart meters (for which the Government has published a target trajectory) and we will monitor take up of smart appliances and growth in the market for aggregation (firms that 'aggregate' demand response across multiple consumers and provide flexibility services based on the aggregated potential). These will be part of our broader monitoring, but we have not set target trajectories given limited evidence to base them on.

Table 2.4. Potential levels of flexibility providing capacity (GW), in addition to today's levels

New flexible technology requirements (GW)	By 2020		By 2025		By 2030		Existing
	Low	High	Low	High	Low	High	2016
New flexible generation	1.0	5.0	2.0	10.0	3.0	15.0	0.0
Storage	0.8	5.0	3.2	20.0	5.6	35.0	2.7
Demand-side response	2.1	10.5	2.8	13.8	3.4	17.1	0.5
Interconnection	3.4	3.4	4.5	7.2	5.5	11.0	4.0

Source: Pöyry and Imperial College (2017) *Roadmap for flexibility services to 2030*.
Notes: The table shows additional flexibility technology requirements compared to today's levels. New flexible generation is defined as a CCGT 'H' class generator (or a generator with similar or more flexible characteristics).

Recommendations

The barriers must be addressed in order to enable fully low-carbon flexibility resources. We therefore make the following recommendations:

- **Markets should be designed to reflect the full system value of flexibility options.** The market design must effectively price and reward energy, capacity and flexibility. For example, this requires removal of double-charging for storage, completing the shift to half-hourly settlement and allowing flexibility providers to receive multiple revenue streams across different services.
- **Market rules should seek to reduce complexity, but system operators will need to manage greater complexity (across multiple sources/boundaries).** Increasing flexibility implies a shift in system control from the transmission to the distribution level and a capability of the system to deal with more interactions between distribution and transmission networks, and to promote and utilise more active demand management.
- **Support should be available for innovation in technology, services and operating models.** It will be important that, as the institutional and market framework evolves, the drive for innovation across the value chain is not dampened. Where innovation offers significant system benefit that cannot be captured by the innovators, it may require public support.
- **Intervention may be needed to encourage greater consumer participation.** In addition to establishing the technical infrastructure for demand-side response, legal and regulatory frameworks around consumer protection and data protection will be necessary to achieve widespread consumer acceptance. Standards may be required to ensure widespread uptake of smart appliances.

To monitor implementation of these recommendations, we will monitor progress against a number of high priority actions that Pöyry and Imperial identified (Table 2.5).

Table 2.5. High priority actions for developing electricity system flexibility

Action	Responsibility	Timing
Publish projections of future requirements Publish annual projections (in each year) of longer-term future procurement requirements across all flexibility services including indication of the level of uncertainty involved and where possible location specific requirements, to provide greater visibility over future demand of flexibility services.	SO and DSOs	2020 onwards
Review procurement processes for flexibility services Review characteristics of current procurement processes (i.e. gate closure periods, threshold capacity level to participate, contract terms / obligations, and the procurement route - e.g. open market, auctioning or competitive tendering) that enable more efficient procurement of services without unduly restricting the provision of multiple services by flexibility providers.	Ofgem, SO, TOs, DSOs	By 2020
Review network charges Assess the materiality of distortions to investment decisions in the current network charging methodology (e.g. lack of locational charging, double-charging for stored electricity), and reform charging methodology where appropriate.	SO, DSOs, Ofgem	By 2020
Review non-network charges Assess the materiality of distortions to investment decisions in the absence of non-network related system integration charging (i.e. back up capacity and ancillary services) and implement charging where appropriate.	SO, DSOs, Ofgem	By 2020
Ensure all network operators face incentives to maximise total system benefits Publish a strategy for developing the longer-term roles and responsibilities of system operators (including transitional arrangements) that incentivises system operators to access all flexibility resource by making investments and operational decisions that maximise total system benefits.	Ofgem, industry	2018
Reform network standards and price control framework to make full use of flexibility resources Periodical review of existing system planning and operational standards for networks and generation, assessing whether they provide level-playing field to all technologies including active network management and non-build solutions (e.g. storage and DSR), and revise these standards as appropriate.	Industry codes governance and Ofgem	Initial review by 2019

Source: Pöyry and Imperial College (2017) *Roadmap for flexibility services to 2030*.
Notes: High priority recommendations taken from Pöyry and Imperial College (2017).

Progress is already being made in addressing the barriers and actions identified:

- In late 2016 BEIS and Ofgem conducted a joint call for evidence on the actions required to transition to a smart, flexible electricity system.
- Ofgem is making progress with half-hourly metering, and embedded benefits reform.
- The Energy Networks Association has created a working group to identify the appropriate long-term roles for transmission and distribution system operators.
- National Grid, through its Power Responsive programme, is working on improving information on system requirements, reducing complexity in its contracting system and reforming its energy services markets. The recent publication of National Grid's *System Needs and Product Strategy* consultation marks an important step in addressing these issues.

Progress will need to continue from all parties, to manage the transition to a smart, flexible electricity system and to ensure that the future electricity system delivers power at the lowest possible cost.

Chapter 3: Buildings

Key messages and recommendations

Direct emissions in buildings rose for the second year running in 2016, to 89 $MtCO_2e$. Adjusting for annual variations in winter temperatures, emissions rose by around 2%.

Progress made in reducing emissions from homes over the first carbon budget period (2008-2012) has stalled. Progress in reducing emissions across public and commercial buildings has hardly begun.

Although around 4% of heat now comes from low-carbon sources, around 80% of this is bioenergy (largely biomass, which could be used more effectively for emission reduction elsewhere in the longer term). The deployment of heat pumps and low-carbon heat networks is below what is required for meeting future carbon budgets. Progress in reducing demand through insulation has stalled with modest installations occurring through the Energy Company Obligation (ECO), overall rates down over 90% from 2012, and a significant policy gap in incentivising uptake from able-to-pay households.

Our key messages are:

- **Policy gap.** Compared to our assessment of the cost-effective path to meeting the fifth carbon budget, there is a policy gap to decarbonising buildings of 19 $MtCO_2$ in 2030 (a fifth of the total policy gap across the economy, and nearly twice the expected reduction from existing buildings policies). 9 $MtCO_2$ of the savings from existing policies are at risk due to policy design and implementation issues, which mean that they may not deliver. This must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets, as set out in our 2016 report, *Next Steps for UK Heat Policy*.
- **New-build.** New homes should be built to be highly energy efficient and designed for low-carbon heating systems. That will avoid costly retrofit in future and ensure household energy bills are no higher than needed. There is no robust evidence this would appreciably reduce or delay new housing supply to meet Government targets for new housing.
- **Energy efficiency improvement to existing buildings.** Energy efficiency should be improved across the existing building stock. This can reduce emissions and energy bills, improve competitiveness and asset values for business, improve health and wellbeing, help to tackle fuel poverty and make buildings more suitable for low-carbon heating in future.
- **Low-carbon heat.** Deployment of low-carbon heat cannot wait until the 2030s. Low-regret opportunities exist for heat pumps to be installed in homes that are off the gas grid, to install low-carbon heat networks in heat-dense areas (e.g. cities) and to increase volumes of biomethane injection into the gas grid. These opportunities can be started within funding that has been agreed to 2020, although this could be better targeted. Further support beyond 2020 will need to be agreed by 2019.
- **Strategic decisions for the longer term.** Beyond these low-regret measures, key strategic decisions will be needed on low-carbon heat for properties on the gas grid, especially those outside heat-dense areas.
  - The main options for reducing emissions from heating in these buildings are electrification using heat pumps and repurposing of gas networks to hydrogen. It is important that active preparations are made so that the Government is well placed to make decisions in the early 2020s, including undertaking hydrogen pilots of sufficient scale and diversity.
  - As large-scale hydrogen deployment would require use of carbon capture and storage (CCS), a strategy for CCS deployment remains an urgent priority.

We will assess the Government's plans for meeting the gap in the fourth and fifth carbon budgets against the following checklist (Table 3.1).

Key messages and recommendations

Table 3.1. Buildings recommendations for the Government's plan to meet the fourth and fifth carbon budgets

Buildings emissions to fall by around 20% between 2016 and 2030,[35] and create options to allow near-zero emissions by 2050. This will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
New-build. Standards to ensure new-build properties are highly energy efficient and designed to accommodate low-carbon heating from the start, meaning that it is possible to optimise the overall system efficiency and comfort at a building level.		×	
Existing buildings. A stable framework and direction of travel for improving energy and carbon efficiency, joining up energy efficiency and low-carbon heat, backed up by **standards for the emissions performance of buildings** that tighten over time and including an **attractive well-timed offer to households and SMEs** aligned to 'trigger points'. • Clear schedule of future standards to allow businesses and consumers to prepare efficiently and for dynamic markets to emerge. Standards should focus on ends (e.g. reducing carbon emissions) rather than the means (e.g. specific technologies) and actual rather than modelled performance (e.g. by using data from smart meters). • Where existing standards are in place or planned under EC law (product standards), these will need to either remain in place or be replaced with equivalent standards following UK exit from the EU. • Some households and small businesses will require improved access to low-cost finance and clear incentives - especially at trigger points such as the sale or rental of buildings. • Improving the efficiency of existing heating systems (e.g. by moving to lower flow temperatures) in homes connected to the gas grid through the 2020s is needed to cut bills and emissions and prepare the stock for widespread roll-out of either heat pumps or hydrogen after 2030.	×	×	×
Simple, highly visible information and certification including enhanced business reporting alongside installer training to ensure that low-carbon options are understood by consumers and that installers are effective and trusted. • Improved information (which could be enabled by smart meters), through business performance reporting and building performance labelling that	×	×	×

[35] This is equivalent to a 16% reduction in CO_2 if not including biomethane abatement (consistent with reporting in the CCC, 2015, *Fifth Carbon Budget* and CCC (2016) *Next Steps for UK Heat Policy*).

Key messages and recommendations			
generates value in low-carbon investment. • A nationwide training programme is needed to develop high professional standards and skills for implementation of low-carbon choices in the building and heat supply trades. • Leadership must be shown through public procurement and low-carbon investment.			
Reformed support for low-carbon heat through the 2020s that deals with current barriers and is attractive enough to drive deployment levels of low-regrets measures (heat pumps, heat networks and biomethane) in line with requirements for meeting carbon budgets. This should also include: • A process for making decisions on heat infrastructure through the 2020s, including the roles for different actors and a coherent governance structure. • A mechanism for supporting the continued expansion of low-carbon heat networks through the 2020s, including attracting new types of investor and establishing a proportionate regulatory framework.	✗	✗	✗
Active preparations for strategic decisions in the early 2020s on the role of hydrogen for heat and the future of the gas grid. • Pilots and demonstrations rolled out alongside a programme of research to better understand the challenges of a wider-scale hydrogen switchover. • A new strategy is required that will develop a CCS infrastructure and industry in the UK capable of expanding to large-scale hydrogen production by the 2030s.			✗

Introduction

In this chapter we review progress in decarbonising UK buildings in 2016. We draw on the findings from our 2016 report, *Next Steps for UK Heat Policy*, in addressing the current weaknesses in the policy framework for meeting future carbon budgets.

We summarise the analysis that underpins our key messages and recommendations in the following three sections:

1. Buildings emissions trends and drivers
2. Recent progress in reducing emissions in buildings compared to required progress
3. Policy progress towards the fourth and fifth carbon budgets.

1. Buildings emissions trends and drivers

Direct emissions from buildings were 89 $MtCO_2e$ in 2016, accounting for 19% of UK GHG emissions (Figure 3.1):

- Direct CO_2 building emissions were 88 Mt in 2016, split between homes (76%), commercial buildings (15%) and public buildings (10%).
- Buildings are responsible for 66% of UK electricity consumption, equivalent to a further 52 Mt CO_2e of indirect emissions. These emissions are falling, both due to falls in demand and decarbonisation of electricity supply (Chapter 2).
- There are small quantities of non-CO_2 emissions (methane and nitrous oxide). Estimates for 2016 are not available, so we assume that they remain at 2015 levels in line with Government assumptions.

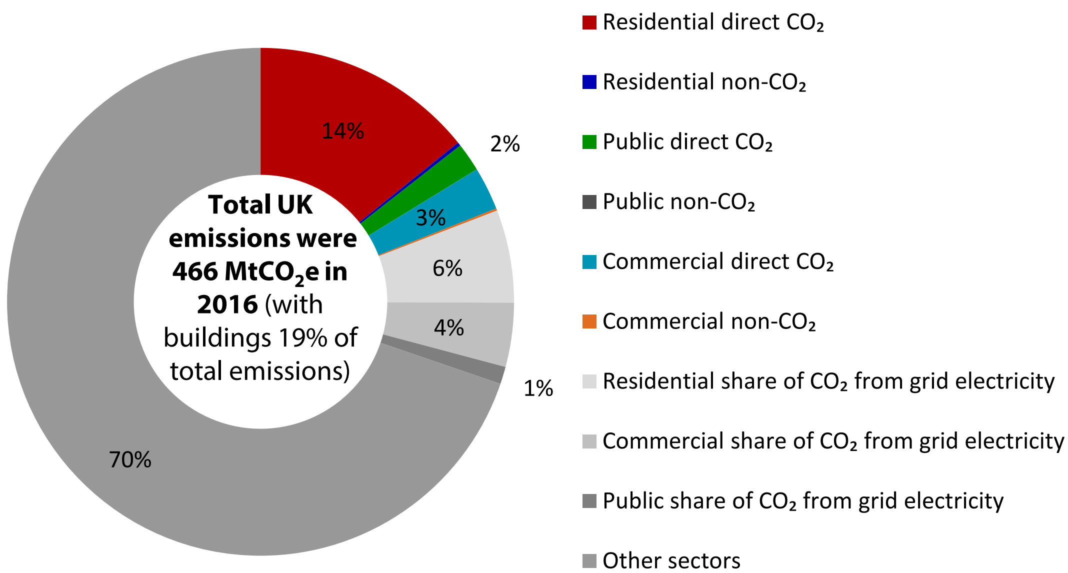
Throughout the rest of this chapter, we focus on CO_2 emissions, for which we have provisional 2016 estimates.

Direct CO_2 emissions increased for the second year running in 2016 (Figure 3.2). Adjusting for annual variations in winter temperatures, emissions rose by around 2% (Table 3.2).[36]

The progress made in reducing emissions from homes over the first carbon budget period (2008-2012) has stalled. Progress in reducing emissions across public and commercial buildings has hardly begun.

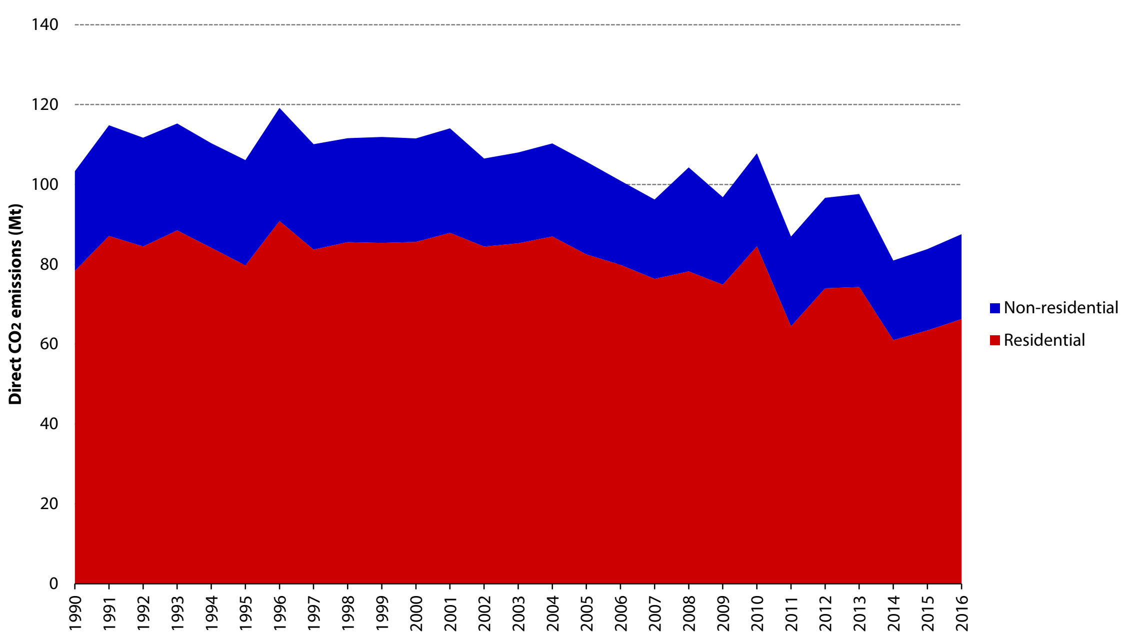
[36] Compared to a 4% rise in direct CO_2 emissions in the unadjusted emissions data.

Figure 3.1. Buildings greenhouse gas emissions as share of UK total (2016)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*, BEIS (2017) *Provisional UK greenhouse gas emissions national statistics 2016*, BEIS (2017) *Energy Trends, March 2017.*
Notes: 2016 emissions are provisional. Residential, public and commercial non-CO_2 emissions are not zero, although to the nearest percentage point they round to 0% of total UK emissions.

Figure 3.2. Direct CO_2 emissions from buildings (1990-2016)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*, BEIS (2017) *Provisional UK greenhouse gas emissions national statistics 2016.*
Notes: 2016 emissions are provisional. Emissions data are not temperature-adjusted.

Table 3.2. Summary of buildings emissions trends

	2016 direct emissions (Mt CO_2)		Change (temperature-adjusted)	
	Actual	**Temperature-adjusted**	**% change 2015-2016**	**Annual average % change 2009-2015**
Residential	66	69	+1%	-2%
Non-residential	21	22	+4%	-1%
of which commercial	13	13	+3%	0%
of which public	8	9	+5%	-2%
All buildings	88	91	+2%	-1%

Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*, BEIS (2017) *Provisional UK greenhouse gas emissions national statistics 2016.*
Notes: 2016 emissions are provisional. Figures may not sum due to rounding.

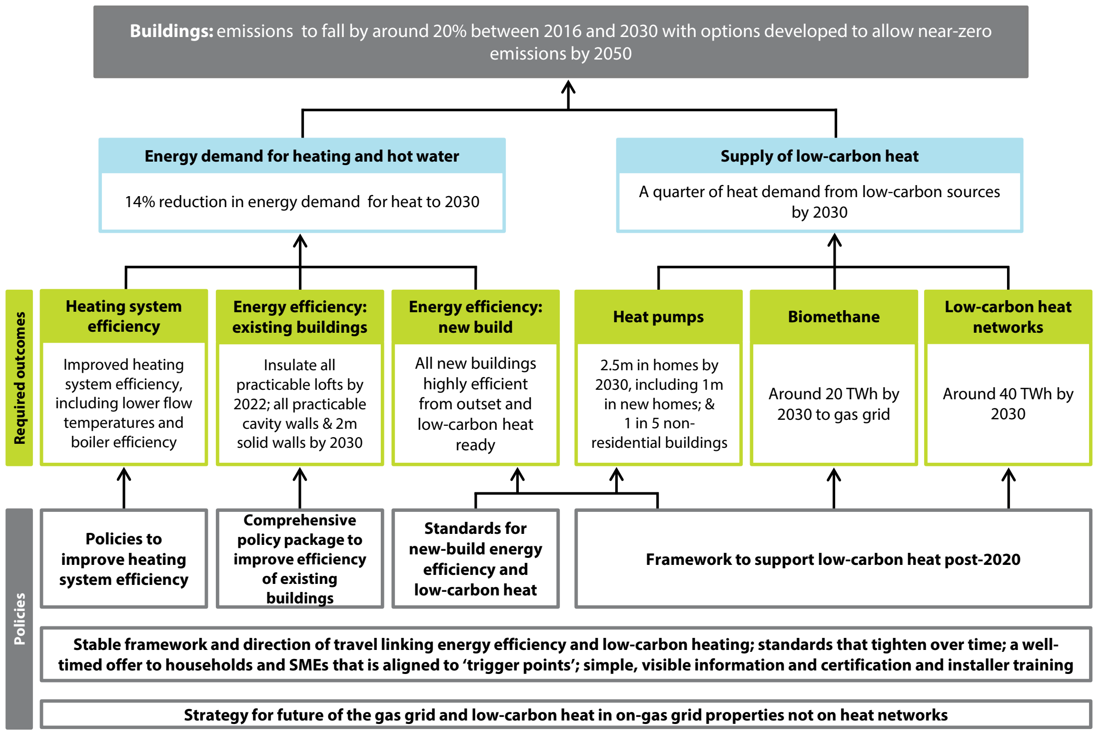
The least-cost pathway to the legislated carbon budget requires a CO_2 emissions reduction of around 20% in buildings from 2016 to 2030,[37] equivalent to a fall of 32% from 1990 levels. Decarbonising the building stock will require both ***decarbonising the supply*** by substituting fossil fuels with low-carbon electricity, fuels and heat sources ('low-carbon heat'), along with ***reducing and managing demand*** through energy efficiency measures, storage and demand-side response.

Our indicator framework for buildings is designed to capture changes on both fronts, with top-level indicators tracking total demand for energy used for heat and the supply of low-carbon heat. These top-level indicators are complemented by a set of supporting indicators which track the rollout of low-carbon measures and policy indicators that highlight necessary policy development (Figure 3.3).

To 2030, emission reductions can be achieved by supporting the roll-out of low-regrets supply-side measures such as heat pumps primarily in buildings not connected to the gas grid, low-carbon heat networks and biomethane injected into the gas network. This is required together with low-cost energy efficiency measures across all buildings (unlocking energy savings of around 15%), and tighter standards in new-build to avoid further costly retrofit between now and 2050.

[37] This equates to a 20% reduction in CO_2e to 2030. Excluding biomethane abatement, consistent with reporting in the CCC (2015) *Fifth Carbon Budget* and CCC (2016) *Next Steps for UK Heat Policy*, it is equal to a 16% reduction in buildings CO_2.

Figure 3.3. CCC indicators for buildings



2. Recent progress in reducing emissions in buildings compared to required progress

The necessary progress is not being made in shifting to low-carbon heating or improving energy efficiency:

- Low-carbon heat deployment to date, whilst on track against our current indicator in aggregate, is dominated by bioenergy deployment (around 80% of which most is solid biomass), whilst the deployment of heat pumps and low-carbon heat networks lags behind what is required to meet future carbon budgets. The dominance of biomass in low-carbon heat uptake to date is an issue because of questions around whether this is the long-term best use of finite bioenergy resource, and due to the existence of other options for decarbonising space heating in buildings.[38]
- Progress in reducing demand through insulation has largely ground to a halt with modest installations occurring through the Energy Company Obligation (ECO) and a significant policy gap in incentivising uptake by able-to-pay households (Table 3.3).
- We do not have a set of detailed indicators on public and commercial energy efficiency due to a lack of consistent data sources, but energy intensity (kWh/m^2 of floor space) remained flat in 2015, the latest year for which data are available.

The following section considers progress in each of these areas in turn.[39]

[38] CCC (2016) *Next Steps for UK Heat Policy*.

[39] Some measures arguably cover both elements: heat pumps, for example, can make use of low-carbon electricity and use a fraction of the energy of traditional combustion heating. We consider them primarily as a key form of low-carbon heating.

Table 3.3. Table of key outcomes (indicators) for 2030 and latest outturn against progress required.

Key outcome	2016 indicator	2016 outturn
Headline indicators		
Reduce direct CO_2 from buildings by 32% by 2030, from 1990 levels*	-15%	-12%**
24% reduction in direct CO_2 from homes by 2030, from 1990 levels*	-12%	-12%**
58% reduction in direct CO_2 from non-residential buildings by 2030, from 1990 levels*	-24%	-13%**
Low-carbon heat uptake		
At least a quarter of buildings heat from low-carbon sources by 2030	4% in 2015 (lag in data publication)	4% in 2015
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	2015 sales of 20,000 units Estimated stock of around150,000
Around 40 TWh of heat supplied through low-carbon heat networks by 2030, and 10 TWh by 2020	4 TWh	No data - estimate < 1 TWh
Around 20 TWh of biomethane injection by 2030	3 TWh	1.5 TWh
Energy efficiency uptake		
All practicable lofts insulated by 2022	545,000 per year	64,000 installed in 2016
All practicable cavity walls insulated by 2030	200,000 per year	92,000 installed in 2016
2 million solid walls insulated by 2030	90,000 per year	31,000 installed in 2016

Notes: * Including abatement from biomethane. ** Temperature-adjusted emissions, to show underlying trend.

Low-carbon heat

Our approach for tracking the decarbonisation of heat supply is to track the contribution of low-carbon sources to heat demand in buildings and industry (Chapter 4) at an aggregate level. This is currently at around 4% in buildings, although around 80% bioenergy - dominated by biomass consumed in homes (62%).[40]

We also consider progress in the areas which we have highlighted as low-regrets on a supply-side basis, either because they are valuable across all decarbonisation pathways (biomethane, low-carbon heat networks) and/or because current deployment is required to keep in play the option of more extensive future deployment (heat pumps and low-carbon heat networks). Progress is improving for biomethane but remain insufficient on heat pumps:

- Current levels of deployment of biomethane are below our indicator, although output doubled in 2016, significantly narrowing the gap (Table 3.3).
- Annual heat pump sales were around 20,000 in 2015, broadly in line with annual levels of delivery since 2008, and below the 30,000 required annually to meet the 2020 critical path. Installations of heat pumps in public and commercial buildings remain at very low levels (a few thousand a year).
- No consistent data are available on low-carbon heat networks deployment, as we highlighted in last year's report. Government should address this as a priority action.

We consider options for improving policy to address this slow progress in section 3.

Demand reduction and management in homes

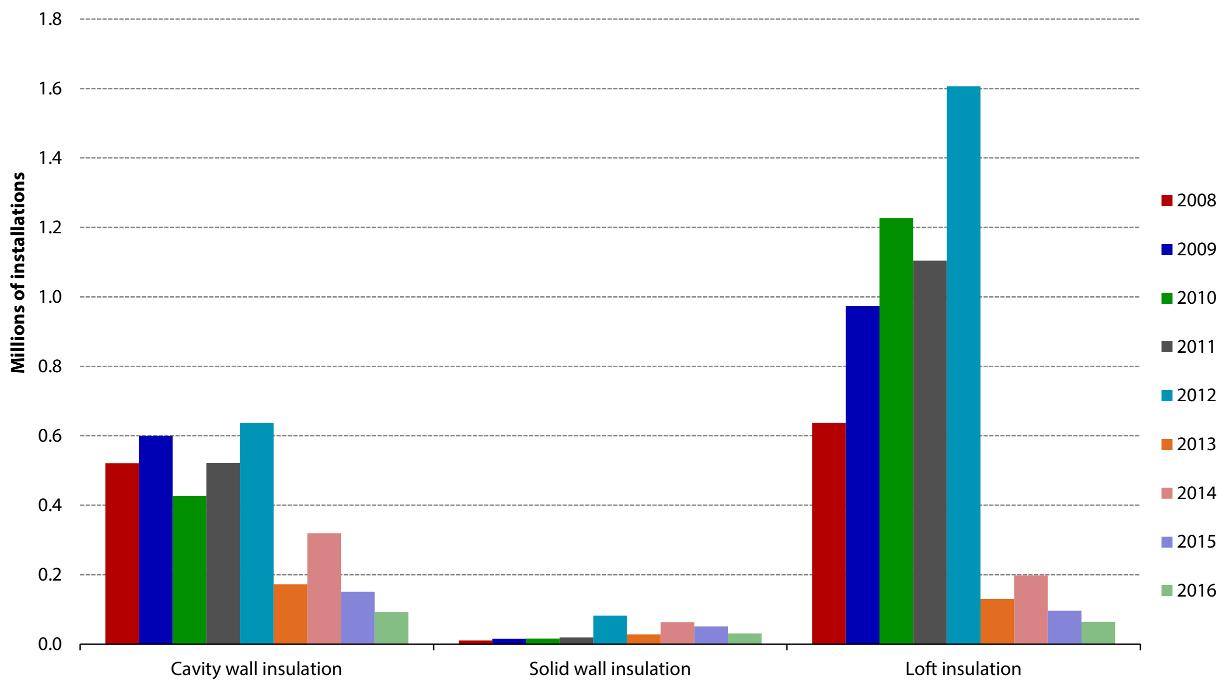
Progress in delivering insulation slowed during 2016 from levels already far lower than achieved up to 2012 (Figure 3.4).

The natural replacement of older boilers continued to deliver some reductions in emissions: 1.5 million old boilers were replaced with more efficient A-rated boilers in 2016. The average design efficiency of boilers sold in 2016 was 90.5%.

Total household electricity demand in 2016 fell by 1%, continuing a longer-term trend. Falling demand has been driven by a general improvement in the energy efficiency of appliances. However, the penetration of the most energy efficient appliances still remains low (fewer than 1% of lightbulbs are LEDs and under 2% of cold appliances meet the highest A++ rating) leaving plenty of further potential to reduce demand.

[40] We do not include biomass consumed on open fires since this does not constitute meaningful progress towards decarbonising the supply of heat.

Figure 3.4. Annual insulation installation rates (2008-2016)



Source: BEIS (2017) *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 of building type and lack of consistent datasets covering all buildings. Overall measures of energy intensity show no evidence of underlying progress in 2015. There is some evidence of reductions in energy consumption in (larger) organisations covered by the CRC Energy Efficiency Scheme:

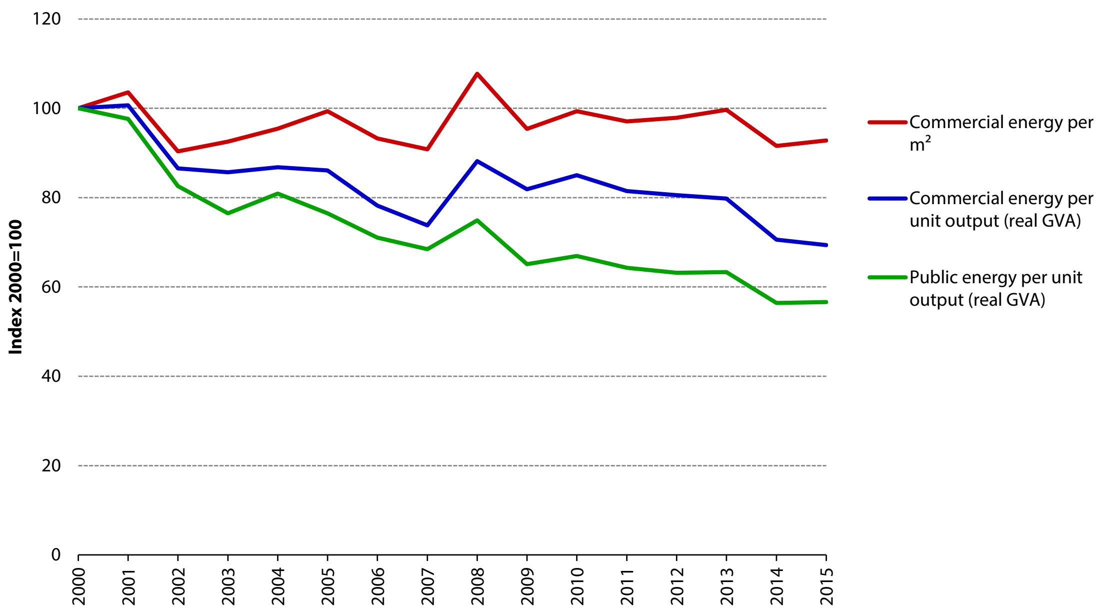
- Energy intensity remained unchanged in 2015, the latest year for which there are available data (Box 3.1).
- There were greater reductions in electricity and gas consumed by organisations covered by the CRC Energy Efficiency Scheme than in non-residential buildings overall (Box 3.2).
- The wider ESOS energy audits scheme is struggling to achieve levels of basic compliance (Box 3.2).

There remains significant potential for improved energy efficiency in public and commercial buildings.

Box 3.1. Lack of progress in energy intensity of public and commercial buildings

Energy intensity measured as energy consumption per unit of output was little changed in 2015. This follows on from a gradual decline from 2010, with a marked decrease in 2014. However, change in energy consumption per unit of floor-space is likely to be a better indicator. While information for the public sector is not available, Figure B3.1 shows only a marginal improvement since 2000 for commercial buildings on this basis, with energy intensity slightly worse in 2015 than in 2014. While data on public sector floor-space are not available, we anticipate that public sector floor-space has decreased over this period, meaning it too would have a lesser improvement in energy intensity if measured on a floor-space basis rather than by output.

Figure B3.1. Energy intensity of public and commercial buildings



Source: BEIS (2016) *Energy Consumption in the UK*, VOA (2016) *Business Floorspace*.
Notes: Energy consumption is final consumption across all fuel types. 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.

Box 3.2. Progress in buildings covered by the CRC Energy Efficiency Scheme and Energy Savings Opportunity Scheme

The CRC Energy Efficiency Scheme covers 60% of electricity consumption and 39% of gas consumption in non-residential buildings, as well as large industrial and agricultural firms outside the EU ETS. Phase 2 of the scheme started in 2014/15, making significant changes in scope, so trends over longer periods are not readily comparable. There have been greater reductions in electricity and gas consumption for organisations in the CRC Energy Efficiency Scheme than the wider public and commercial sectors in 2015/16:

- Electricity consumption was 5% lower in private buildings in the CRC in 2015/16 than the previous year compared to a 1% decrease in the sector overall. Gas consumption in 2015/16 was 1% lower in

Box 3.2. Progress in buildings covered by the CRC Energy Efficiency Scheme and Energy Savings Opportunity Scheme

private buildings in the CRC than the previous year compared to no change in the sector overall.

- Electricity consumption in 2015/16 was 4% lower in public buildings in the CRC than the previous year compared to a 2% increase in the sector overall. Gas consumption was 3% lower in public buildings in the CRC than the previous year, compared to 2% lower in the sector overall.

The Energy Savings Opportunity Scheme (ESOS) is a mandatory energy assessment scheme for organisations in the UK that meet the qualification criteria. Organisations must have assessments every 4 years, which audit the energy used by their buildings, industrial processes and transport to identify cost-effective energy saving measures. The deadline for the first compliance period was December 2015. There have been relatively low compliance rates. By the end of January 2017 around 6,800 organisations had submitted a notification of compliance, which is around 860 more than had complied by the extended deadline of January 2016. 30 more have submitted an intent to comply. While data are not released on those who have not self-declared, there are expected to be significant numbers of other organisations not complying, given BEIS's estimate of around 10,000 organisations being covered by the scheme.[41]

Source: CRC data: Environment Agency, unpublished, ESOS data: Environment Agency, available at: https://data.gov.uk/dataset/energy-savings-opportunity-scheme
Notes: Consumption data here have not been temperature adjusted.

3. Policy progress towards the fourth and fifth carbon budgets

In October 2016 we published a report on *Next Steps for UK Heat Policy*, which set out our assessment of the set of policy options to drive decarbonisation of the building stock to 2030. It underscores the need to prepare for Government-led decisions on the future of the gas grid, together with strengthened policy now to increase the implementation of energy efficiency measures and low-carbon heat over the next decade.

Current policy provides some incentives for low-carbon measures, including the pilot round of heat networks capital funding, hydrogen research and ongoing revisions to the Energy Company Obligation (ECO) announced in the year since our 2016 progress report:

- **Heat networks.** The Government's Heat Networks Investment Project (HNIP) has announced the results of the first pilot round of the pot of £320m to 2020 to support low-carbon heat networks. This was limited to public sector applicants. The schemes funded are mainly gas CHP rather than more innovative low-carbon networks.
- **Hydrogen trials.** Government has announced £25m funding for a three-year hydrogen trial looking at developing standards and testing appliances, running from 2017.
- **Energy efficiency.** The main change has been to redesign ECO. It is planned to run from April 2017 for five years at an estimated cost of £640m per year (compared to £870m per year in the scheme 2015-2017).
  - The ECO scheme has entered a transition period from April 2017 to September 2018, moving towards a new scheme focused on fuel poverty from 2018-2022. Changes in the transition period include a greater focus on providing Affordable Warmth for fuel-poor

[41] BEIS (2017) *Updated energy and emissions projections: 2016, Annex D: Policy savings in the projections.*

households, less emphasis on cost-effective insulation and the removal of a community based sub-obligation.

– The ECO redesign has also moved towards 'deemed scores' - intended to reduce administrative costs - and a limit upon the extent boiler replacements can count towards targets. While reduced emphasis on boilers is helpful in improving efficiency longer-term, we expect the reduced size and focus away from low-cost insulation to generate lesser emission savings than under the previous scheme.

In other areas such as low-carbon finance and company reporting, it is less clear how policy will impact future decarbonisation and there remains a risk to the effectiveness of regulations on the minimum energy efficiency of private rented dwellings (Box 3.3).

Box 3.3. Recent developments with low-carbon finance and the future of the CRC Energy Efficiency Scheme

In January 2017 Greenstone Finance and Aurium Capital Markets acquired the business and assets of the Green Deal Finance Company, which the government had ceased funding in July 2015. Installations using the Green Deal, which ceased during the latter part of 2016, may start to return. However, it is not clear that the take-up will be any better than for the original scheme, under which rates of insulation were well below the necessary level.

The return of the Green Deal also adds complexity to policy reform in other areas, for example the domestic Private Rented Sector (PRS) regulations which were set up to be reliant on the Green Deal, but which the government were reviewing given the impracticality of this going forward. Urgent action is needed to amend the regulations, as from October 2017 landlords can register for exemptions (lasting five years) if they would face upfront costs in undertaking the necessary improvements.

The government announced in April 2017 its sale of the Green Investment Bank to Macquarie bank. This has received a mixed reaction in terms of confidence that it will continue to provide support to the low-carbon transition.

The government plans to close the CRC Energy Efficiency Scheme after the 2018/19 compliance year and rebalance the Climate Change Levy. Plans for a new reporting framework to fill gaps left by the ending of the CRC Energy Efficiency Scheme - first promised March 2016 - are still awaited.

Source: Green Deal Finance Company (January 2017) *Press release;* available at: www.gdfc.co.uk/press-releases; Nick Hurd MP (April 2017) *Written statement to Parliament: Sale of Green Investment Bank; HM Treasury (March 2016) Reforming the business energy efficiency tax landscape: response to the consultation.*

There are several important areas that current policy does not cover and where there are significant risks of under-delivery (Table 3.4). These must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets, as set out in our 2016 report, *Next Steps for UK Heat Policy*:

- New homes can and should be built to be highly energy efficient and designed for low-carbon heating systems. That will avoid costly retrofit in future and ensure household energy bills are no higher than needed.
- Energy efficiency should be improved across the existing building stock. This can reduce emissions and energy bills, improve competitiveness and asset values for business, improve health and wellbeing, help tackle fuel poverty and make buildings more suitable for low-

carbon heating in future. The planned future review of business energy costs must include the significant energy efficiency potential in commercial buildings.

- Deployment of low-carbon heat cannot wait until the 2030s. Low-regret opportunities exist for heat pumps to be installed in homes that are off the gas grid, to install low-carbon heat networks in heat-dense areas (e.g. cities) and to increase volumes of biomethane injection into the gas grid.
  - Heat pumps have faced challenges to date, but remain the leading low-carbon option for buildings not connected to the gas grid. Together with installation in new-build properties, heat pump installation in buildings off the gas grid can help to create the scale needed for supply chains to develop, including developing skills and experience, potentially in advance of accelerated roll-out after 2030. Installation of around 200,000 heat pumps between 2015 and 2020 under our scenarios is consistent with the announced funding to 2020 available under the Renewable Heat Incentive, provided that funding is focused on heat pumps and deployed efficiently, learning lessons from past experience in the UK and elsewhere. Further funding will be needed for deployment in the 2020s.
  - Low-carbon heat networks require a certain density of heat demand in order to be economic, which means that they are suited to urban areas, new-build developments and some rural areas. Low-carbon heat sources can include waste heat, large-scale (e.g. water-source) heat pumps, geothermal heat and potentially hydrogen. Current capital funding to 2020 is sufficient to meet the ambition required to 2020, provided it is deployed effectively. A mechanism is needed for supporting the continued expansion of low-carbon heat networks through the 2020s, including attracting new types of investor and establishing a proportionate regulatory framework.
  - Injecting biomethane into the gas grid is a means of decarbonising supply without requiring changes from consumers, and provides a route for capture and use of methane emissions from biodegradable wastes. However, its potential is limited to around 5% of gas consumption.
- Beyond these low-regret measures, key strategic decisions will be needed 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. It is important that active preparations are made so that the Government is well placed to make decisions in the early 2020s, including undertaking hydrogen pilots of sufficient scale and diversity. As large-scale hydrogen deployment would require use of carbon capture and storage (CCS), a strategy for CCS deployment remains an urgent priority.

The previous Government recognised the need to improve the evidence base and provide policy direction. It recognised that whilst there is "no consensus on the best mix of these technologies … we need a clearer shared understanding … Our ambition is to be able to agree in the next few years, together, on the right long-term direction for heat policy".[42] A programme of research on strategic heat options was established to support this aim, delivering through 2017, covering infrastructure impacts, costs and future market models.

However, until these areas are addressed there will remain a policy gap to the fourth and fifth carbon budgets (Figure 3.5).

[42] Speech (2016) by Baroness Neville-Rolfe (then BEIS Minister).

In our 2016 report, *Next Steps for UK Heat Policy*, we identify a number of policy principles for an effective approach to increase the implementation of low-carbon actions, based on evidence from three 'What Works' policy reviews and an expert advisory group. This evidence supports the need for a stable framework and direction of travel taking a joined-up approach on energy efficiency and low-carbon heat, which is backed up by standards tightened over time and simple, highly visible information and certification:

- A stable framework and direction of travel, backed up by standards for the emissions performance of buildings that would tighten over time.
  - The schedule of future standards should be clear to allow businesses and consumers to prepare efficiently and for dynamic markets to emerge. As far as practical, standards should be focused on ends (e.g. reducing carbon emissions) rather than the means (e.g. specific technologies) and based on actual rather than modelled performance (e.g. by using data from smart meters).
  - Where existing standards are in place or planned under European law (product standards), these will need to either remain in place or be replaced with equivalent regulation following UK exit from the EU.
- A joined-up approach to energy efficiency and low-carbon heat that works across the building stock, targets specific segments and focuses on real-world performance where possible.
  - Emissions reductions can be achieved by improving energy efficiency and by shifting to low-carbon fuels. Many of the barriers to action (e.g. disruption from changes, the need to find a trusted installer, financing constraints) are shared across both types of measure. In addition, improved energy efficiency can reduce the cost and improve the suitability of buildings for low-carbon heat options.
  - Policy should target distinct groups of householders and businesses. For example: some householders and small businesses will require improved access to low-cost finance; existing subsidies for heat pumps are less attractive for smaller homes given economies of scale; more generally, small and medium-sized enterprises (SMEs) are poorly addressed by existing policies.
  - Improving the efficiency of existing heating systems (e.g. by moving to lower flow temperatures) in homes connected to the gas grid through the 2020s can cut bills and emissions, and helps to prepare the stock for widespread roll-out of either heat pumps or hydrogen after 2030.[43]
- A well-timed offer to households and SMEs on energy efficiency and low-carbon heating systems that is aligned to 'trigger points,' such as house moves, when refurbishment is least disruptive. This should include improved access to low-cost finance and clear, consistent incentives.
- Simple, highly-visible information and certification alongside installer training to ensure that low-carbon options are understood by consumers and that installers are effective and trusted.

[43] Condensing boilers need to be set with return temperatures no higher than 55 degrees Celsius in order to work efficiently.

- Awareness of low-carbon heating and energy efficiency options is currently 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'. A key policy focus must be improved information (which could be enabled by smart meters), through business performance reporting and building performance labelling that generates value in low-carbon investment.
- A nationwide training programme is needed to develop high professional standards and skills for implementation of low-carbon choices in the building and heat supply trades. There is a need to build an improved understanding across the construction sector, installers and Government about what is required for high-quality heat pump and heat network retrofit across a range of different types of buildings, the interactions with measures to improve fabric efficiency of buildings, and how to standardise and drive down retrofit costs.
- There is also an opportunity for leadership through public procurement and low-carbon investment, given that the public sector constitutes a third of non-residential heating needs and almost a fifth of heating energy in non-residential leased buildings.

In the 2016 report, we published a set of example policy packages which show how measures can be combined to form coherent policy packages for residential and non-residential buildings, together with supporting heat infrastructure.

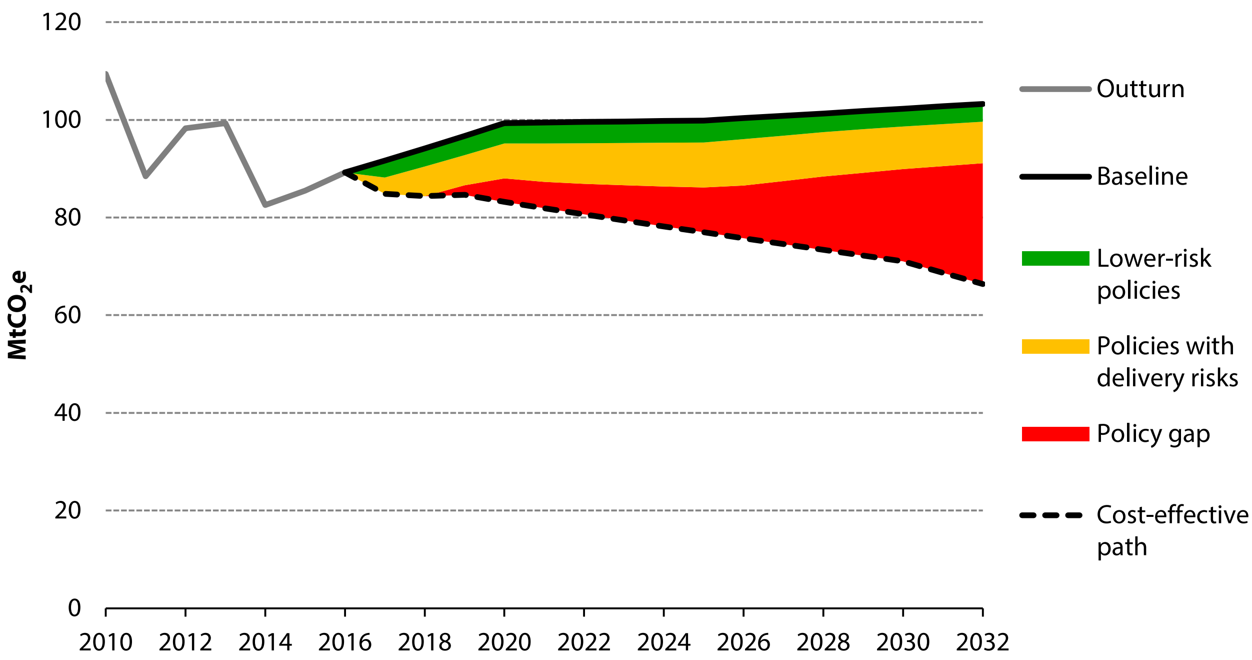
We expect the plans for meeting the fifth carbon budget to address all the areas set out above and set clear timelines for the development and implementation of policies that remain at the proposal stage. We will publish our assessment of the proposals subsequent to their publication.

Table 3.4. Assessment of policies to drive abatement options in buildings

Abatement options	2016 policy		2017 policy assessment and updates	
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	No change.
Building-scale low-carbon heat options in existing buildings from 2021	Red	No policy.	Red	Further research underway on infrastructure and options.
Heat networks to 2021	Amber	£320m capital funding.	Amber	Outcome of first round of funding announced.
Hydrogen	Amber		Amber	Need for strategy.
Standards for new-build to drive low-carbon heat and energy efficiency	Red	No policy.	Red	No policy.
Residential energy efficiency, able-to-pay	Red		Red	Green Deal Finance Company sold. PRS regulations need urgent amendment. Lack of incentives for owner-occupiers.
Residential energy efficiency, low income	Amber		Amber	ECO transition April 2017-Sep 2018 – reduced size and focused on fuel poverty. ECO specification unclear beyond Sep 2018.
Non-residential energy efficiency	Amber		Amber	Sell off of GIB, CRC Scheme closing in 2019 with rebalancing of CCL, and poor compliance under ESOS. PRS regulations in place along with Salix finance in for public sector. Gap in policy for SMEs.

Notes: Red: Policy gap - new policy required. Amber: Policy with delivery risk - stronger 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 3.5. 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 the Policy Gap Chart (e.g. heat networks to 2021, hydrogen).

Figure 3.5. Policy Gap Chart (2010-2032)



Source: BEIS (2017) *Updated energy and emission projections 2016*; CCC analysis.
Notes: Residential baseline emissions align to BEIS projections rather than the CCC baseline projection developed for the fifth carbon budget analysis (which factor in savings from boiler efficiency). This is to illustrate the gap with current Government projections. The cost-effective path for buildings has been updated to reflect a new residential baseline emissions projection, which is 2 Mt higher for 2030 than previously.

Chapter 4: Industry

Key messages and recommendations

Based on provisional data, industry emissions fell by 9% in 2016 to 100 $MtCO_2e$ while industrial output grew around 1%. This follows average annual emissions reductions of 2% over the period 2009-2015 and a halving of emissions since 1990. Almost half of the reduction in industrial emissions in 2016 reflects the closure of the Redcar steelworks, which was mainly due to the depressed price of steel from global overcapacity and an appreciation in the pound.

Our key messages for the industry sector are:

- **There has been limited progress developing the policy framework to drive industrial emissions reduction.** In our 2015 and 2016 Progress Reports, we recommended development of plans with clear actions and milestones to realise abatement identified by the '2050 Roadmaps' – a set of decarbonisation pathways to 2050 for eight of the most energy-intensive industrial sectors. We also highlighted that there is an urgent need for an approach to the demonstration and commercialisation of industrial carbon capture and storage (CCS). There has been no progress on these issues in the past year.
- **Policy strengthening will be required to achieve the necessary emissions reductions to 2030.** Industrial emissions are expected to be higher than the levels set out in our fifth carbon budget scenarios, under current Government plans. There are many areas of potential emissions reduction where policies are either missing (10 $MtCO_2e$ in 2030) or have significant delivery risk (3 $MtCO_2e$ in 2030).

We will assess the Government's plan for meeting the fourth and fifth carbon budgets against the following checklist (Table 4.1).

Table 4.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

Industrial emissions to fall by around 20% between 2016 and 2030. This will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
An overall approach to long-term industrial decarbonisation, developing existing 'Roadmaps' into specific actions and milestones and extending coverage to other industrial sectors. The opportunities identified in the action plans should be taken into account in the Industrial Strategy white paper and any sector deals.		×	×
A strategic funded approach to industrial carbon capture and storage based around clusters alongside power installations and shared infrastructure, with a new funding mechanism for industry.		×	×
An effective approach to drive sustained uptake of low-carbon heat in industrial processes and buildings.		×	

Key messages and recommendations			
The EU ETS and EU product efficiency standards and policy to be preserved after leaving the EU, or equivalent mechanisms put in place that achieve at least as much emissions reduction.	✗	✗	
A stronger policy framework for industrial energy efficiency, including an effective reporting mechanism.	✗		
Tight regulation and close monitoring of any onshore petroleum (i.e. shale gas) wells during development, production and decommissioning to ensure rapid action to address leaks: • Work with the Environment Agency to ensure that an appropriate range of technologies and techniques to limit methane emissions are required. • Put in place a monitoring regime that catches potentially significant methane leaks in order to limit the impact of 'super-emitters'. • Prohibit production in areas where it would entail significant CO_2 emissions resulting from the change in land use. • Ensure that the regulatory regime requires proper decommissioning of wells at the end of their lives.	✗	✗	

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 three sections:

1. Industry emission trends and drivers

2. Progress in reducing industrial emissions

3. Policy progress towards the fourth and fifth carbon budgets

1. Industry emission trends and drivers

Background

Direct[44] emissions from industry[45] in 2016 (100 $MtCO_2e$) 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 (Figure 4.2):

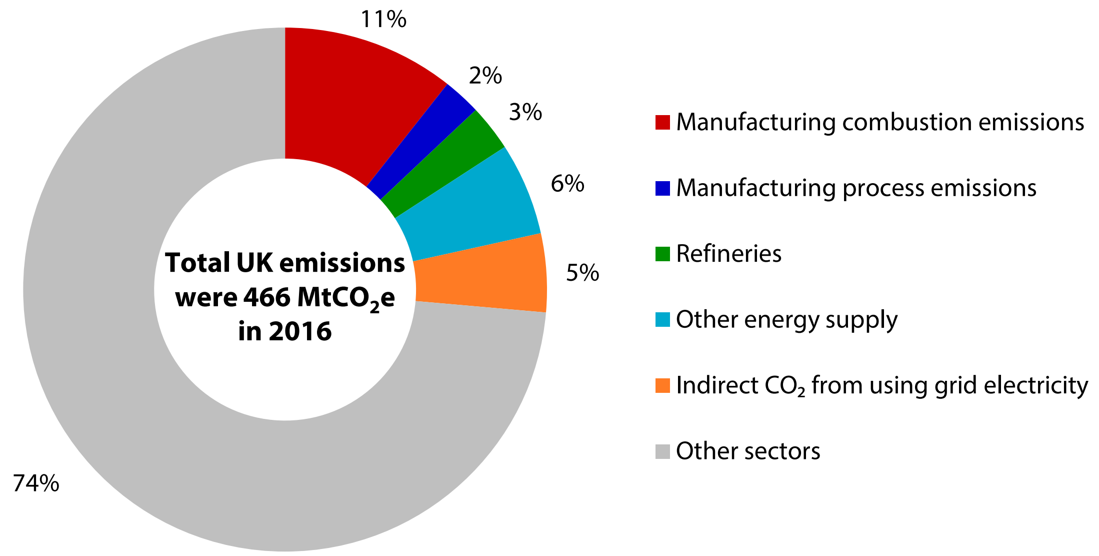
- **Manufacturing, construction, water and waste management** made up 60% of industrial GHG emissions.[46]
  - Combustion emissions, from burning fuel for the production of low- and high-grade heat, drying/separation, space heating and electricity generation for own use accounted for 80% of manufacturing emissions. Almost a third of combustion emissions were unclassified (i.e. not attributed to a sector or segmented by use).
  - Process emissions from chemical reactions within industry (e.g. calcination of limestone in the production of cement) accounted for the remaining 20%.
- **Refining of petroleum products and other energy supply** made up 40% of industrial emissions. Other energy supply emissions (extraction and production of oil, gas and solid fuels) 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 around 5% of UK GHG emissions (see Chapter 2).

Industrial production and emissions are not evenly spread across the UK. For example, industry accounted for 34% of total Welsh emissions in 2015, with nearly half of these coming from the Port Talbot steelworks.

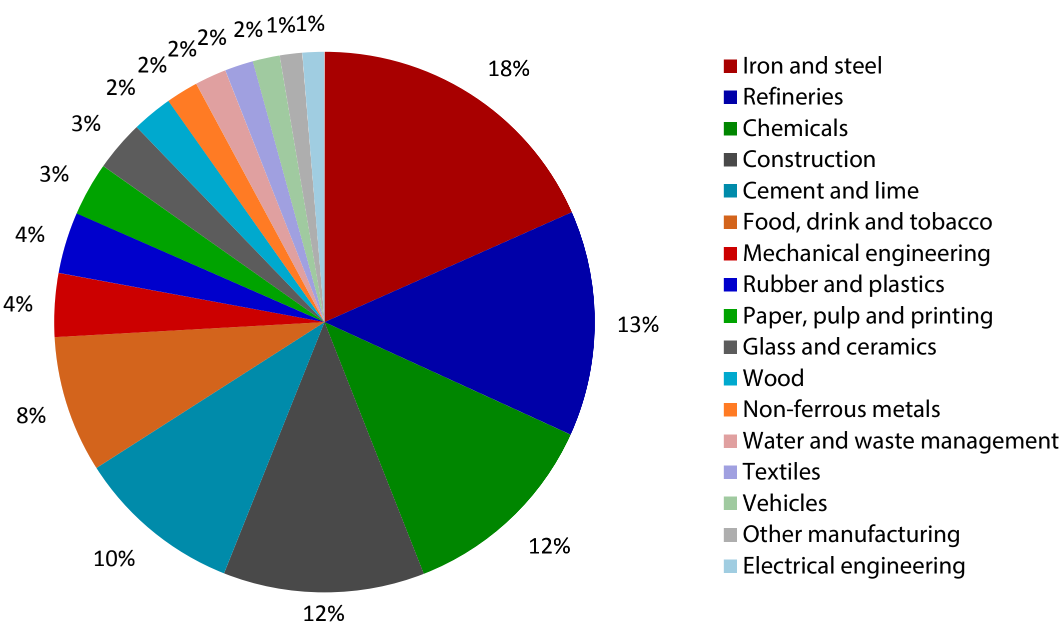
[44] Direct emissions exclude emissions from generation of electricity supplied through the grid, which are covered in Chapter 2.
[45] Industrial activity includes manufacturing, construction, water and waste management, refining of petroleum products and a range of activities linked to energy supply (extraction and production of oil, gas and solid fuels).
[46] From this point forward references to manufacturing will also include the construction and waste and water management sectors.

Figure 4.1. Direct GHG emissions from industry and indirect CO_2 from grid electricity use as a share of total UK emissions (2016)



Source: BEIS (2017) *Provisional UK GHG national statistics*, BEIS (2017) *Energy Trends*, CCC analysis.
Notes: 2016 emission estimates are provisional. Percentage figures may not sum to 100% due to rounding.

Figure 4.2. Direct Manufacturing and refining GHG emissions by sector (2014)



Source: ONS (2016) *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 with an 18-month lag.

Emission trends

Provisional data suggest that direct industrial GHG emissions fell by 9% in 2016 (Table 4.2) while industrial output grew around 1%. This follows average annual emissions reductions of around 2% over the period 2009-2015 and a halving of emissions since 1990 (Figure 4.3):

- Direct CO_2 emissions from industry fell by 9.3% in 2016, following an annual average 1.6% decrease over the period 2009-2015:
  - Manufacturing CO_2 emissions fell 13% in 2016, following a 4% fall in 2015. Around two-thirds of the falls in 2015 and 2016 can be explained by a reduction in iron and steel production, which was largely due to the closure of Redcar steelworks in Teesside as a result of oversupply in the global steel market.
  - From 2009 to 2014, manufacturing CO_2 emissions fell by an annual average of around 0.4%, 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, to a lesser extent, switches to lower-carbon fuels (Box 4.1).
  - Refineries and other energy supply CO_2 emissions fell 1% in 2016, following an annual average 2.5% decrease over the period 2009-2015. Half of the 2016 fall can be explained by a decrease in refinery output. The 2009-2015 trend can be attributed to a fall in fuel production and closures of refineries.
- Non-CO_2 emissions data are produced with a one-year lag.[47] The latest data show 2015 emissions fell by 6% on 2014 levels, with half of the fall resulting from a fall in the amount of methane vented from deep coal-mines. Over the period 2009-2015, these emissions decreased 6% annually on average. These reductions have been due to a fall in fuel production and the introduction of technologies to abate N_2O emissions in industrial processes.
- Grid electricity consumption in manufacturing rose by 0.4% in 2016, following an average annual 1% decrease over the period 2009-2015.

The closure of the Redcar steelworks in late 2015 was responsible for almost half of the fall in industry emissions in 2016. Some reports cited the impact of low-carbon policies on electricity prices as the cause of the closure. However, analysis of available evidence 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 polices.[48]

The Committee also looked at the impact of low-carbon policies on business more broadly in early 2017 and concluded that they have not had a major impact on the competitiveness of UK manufacturing to date (Box 4.2).[49]

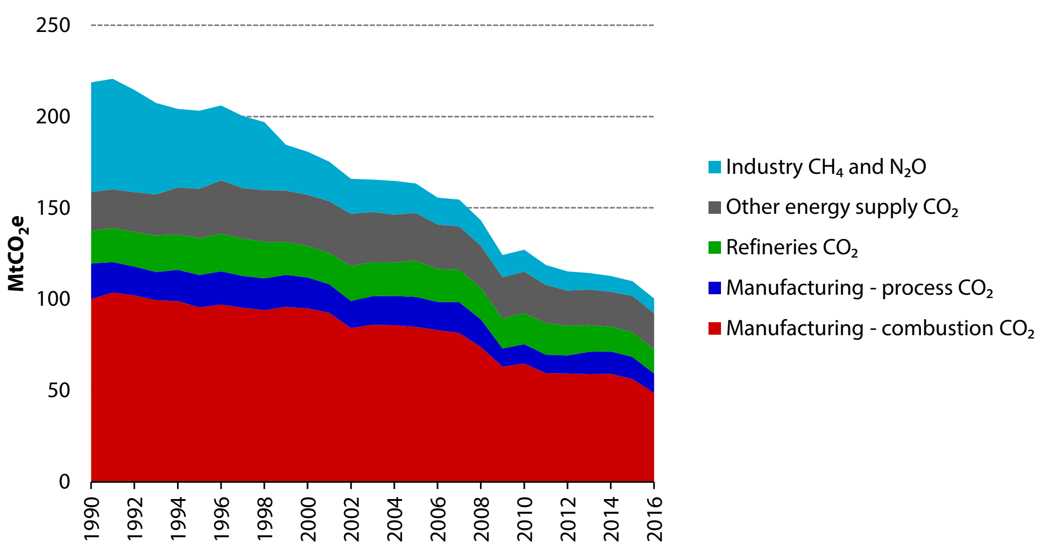
[47] As in previous years, the official statistics assume that non-CO_2 emissions for the most recent year are the same as those for preceding year (i.e. the most recent year for which data are available).
[48] CCC *Technical note: low-carbon policy costs and the competitiveness of UK steel production*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

Table 4.2. Changes in industrial GHG emissions (2009-2016)

	2009-2015 average annual % change	2015-2016 % change
Manufacturing: combustion CO_2 emissions	-2%	-13%
Manufacturing: process CO_2 emissions	+3%	-13%
Manufacturing: total direct (non-electricity) CO_2 emissions	-1%	-13%
Refineries and other energy supply direct CO_2 emissions	-2.5%	-1%
Total industrial direct CO_2 emissions	-1.6%	-9%
Total industrial direct non-CO_2 emissions	-6%	n/a
Total direct GHG emissions	-2%	-9%
Grid electricity consumption	-1%	+0.4%

Source: BEIS (2017) *Provisional UK GHG national statistics*, BEIS (2017) *Digest of UK Energy statistics (DUKES)*, BEIS (2017) *Energy Trends*, CCC analysis.
Notes: The 2016 provisional estimate for non-CO_2 emissions assumes no change from final 2015 emissions.

Figure 4.3. GHG emissions from industry (1990 -2016)



Source: BEIS (2017) *Provisional UK GHG national statistics*, BEIS (2017) *Final UK GHG national statistics*, National Atmospheric Emissions Inventory, CCC analysis.
Notes: 2016 emission estimates are provisional. The 2016 provisional estimate for non-CO_2 emissions assumes no change from final 2015 emissions.

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

A decomposition model for the UK manufacturing and refining sectors 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 lower direct emissions** (e.g. coal to gas, or fossil fuel to electricity).
- **Energy intensity** (e.g. due to energy efficiency, changes in product mix within sectors, or plant utilisation).

This analysis shows that between 1992 and 2007 improvements in energy intensity and switching to lower-carbon fuel 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 lower direct emission fuels 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 2009-2014 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 45% of the change), improvements in energy intensity (45%) and changes in fuel mix (10%).

Energy intensity in this analysis is only a proxy for technical energy efficiency, 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 2014.

Box 4.2. Business energy prices and competitiveness

In March 2017, the Committee published its latest independent analysis of how the UK's carbon budgets and related policies affect energy bills for businesses and the implications for competitiveness. The report found that:

- **Current bills.** Low-carbon policies have increased energy prices for businesses, but have only a limited impact on the total costs of production for the majority of businesses:
  - **Sector averages.** In 2016, energy costs made up an average of 0.9% of operating costs for companies in the commercial sector, 2.0% for manufacturing and 3.8% for the fifth of manufacturing defined as energy-intensive. The costs associated with low-carbon policies made up 0.2%, 0.4% and 0.7% of operating costs in the respective sectors, before accounting for any benefits resulting from energy efficiency policies.
  - **Energy-intensive industry.** Energy use varies significantly across businesses, as do energy prices and the impact of climate policies. Company-level data are not available to make a full assessment of overall impacts. However, whilst for the most energy-intensive producers energy costs are a much larger proportion of total costs, these companies are considered for compensations and exemptions from policy costs.
  - **International comparison.** UK industrial gas prices are low by European standards but electricity prices are high. Differences in low-carbon policies cannot explain the difference in electricity prices, which stem primarily from higher wholesale and network costs. It is not clear why these costs are higher in the UK than in many comparable economies. This should be considered further in the review of business energy costs announced in the Government's consultation on the industrial strategy.
- **Competitiveness.** Low-carbon policies have not had a major impact on the competitiveness of UK manufacturing to date. There are at least three reasons to think that competitiveness effects of UK carbon budgets have been low:
  - **Output trends.** With the exception of the financial crisis, the UK's manufacturing output has shown fairly steady slow growth since 1990, despite strengthening low-carbon policies since the early 2000s.
  - **Emissions drivers.** Outside the financial crisis, falls in UK industrial emissions largely reflect shifts to lower-carbon fuels, improved energy intensity and structural changes towards less carbon-intensive manufacturing.
  - **Impact of low-carbon policy on prices.** Following some delays in introduction, industrial sectors deemed by the Government 'at most risk of carbon leakage' now receive compensation and exemptions from the costs of low-carbon policies. These can reduce low-carbon policy costs on electricity by up to 80%. For these companies low-carbon policy adds less than 10% to the electricity price, which in the case of steel for example, adds less than 2% to operating costs. To ensure that low-carbon policy impacts on competitiveness remain small, the Government should ensure compensations and exemptions for companies at risk of carbon leakage are predictable and reliable.

Source: CCC (2017) *Energy Prices and Bills*.

2. Progress in reducing industrial emissions

In this section we outline what progress we expect in reducing emissions to 2030, how we will track progress in future and the current progress against existing indicators.

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 100 MtCO_2e in 2016:

- **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 have 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 have 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 have identified around 1 MtCO_2e of cost-effective abatement potential by 2030.
- **Industrial carbon capture and storage and utilisation (CCS/U).** Carbon Capture and Storage (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. It will require a new strategy for carbon capture and storage or utilisation to be developed immediately. That is considered further in Chapter 1.

There is likely to be further abatement potential from resource efficiency in constructing buildings and infrastructure, reducing demand for carbon-intensive products.

Tracking progress

Figure 4.4 summarises how low-carbon policies and actions feed through to progress reducing emissions in the industry sector.

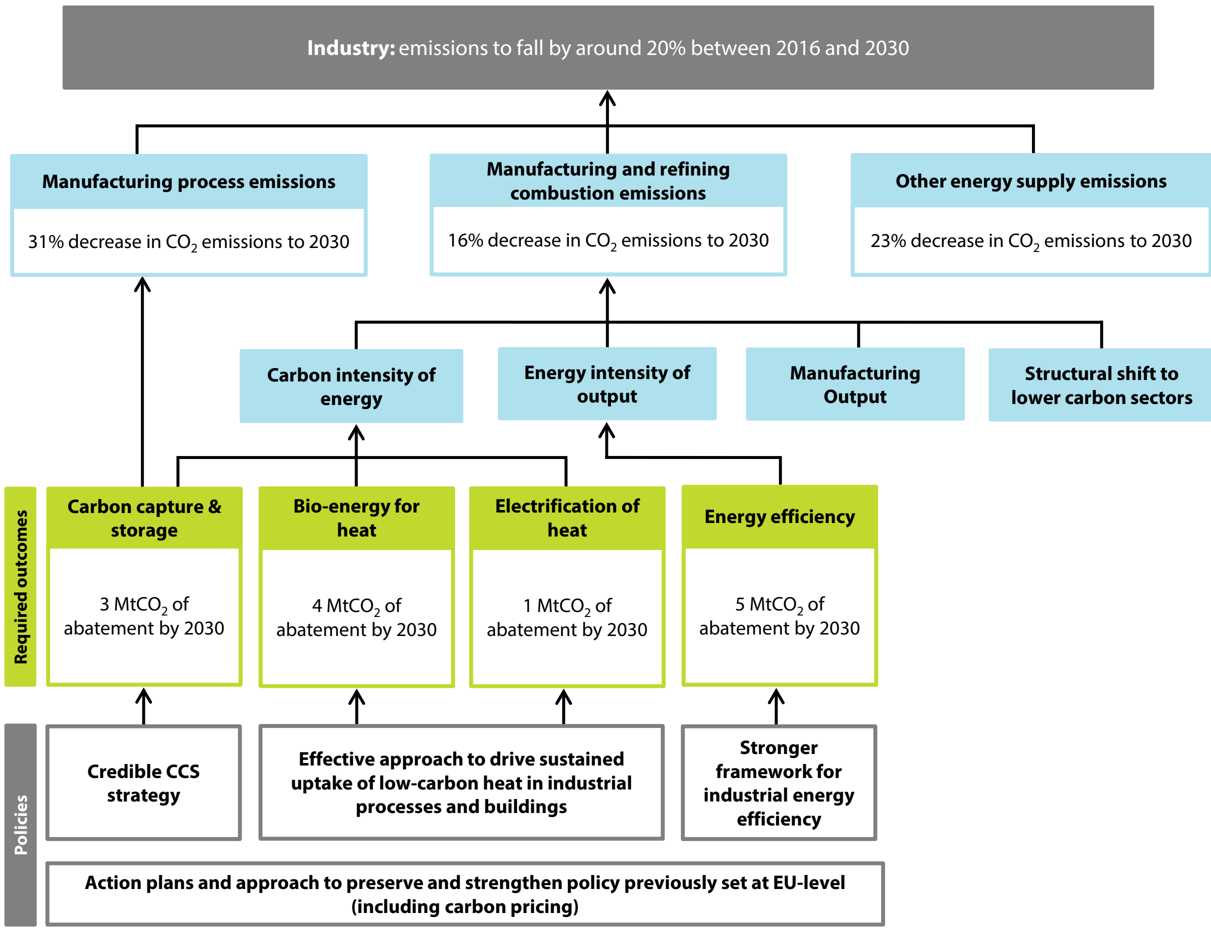
- Progress requires improvements in energy intensity (TWh/GVA) and in the carbon intensity of energy (g/kWh). [50]
- Suitable policies are needed to drive improvements in energy intensity and carbon intensity through the approaches highlighted above: energy efficiency improvements, CCS, bioenergy and electrification.

[50] 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.

- CCS also offers the opportunity to reduce process emissions from the manufacturing and refining sectors.

We currently track progress against indicators that cover some of these factors and also track other changes, such as output and structural changes to provide context.

Figure 4.4. CCC indicator framework 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.

Current progress

There has been mixed progress against our key existing indicators (Table 4.3). Energy intensity and carbon intensity have both fallen since 2007, but this mainly reflects structural changes rather than genuine progress, and key policies are overdue:

- From 2007 to 2016, overall direct CO_2 emissions from industry, the emissions intensity of industrial output, and the energy intensity of industrial output have all matched or outperformed our existing indicators.
- However, this may not reflect full implementation of cost-effective abatement measures, because a significant part of the reductions have been the result of changes in industrial output rather than abatement. A decomposition analysis (Box 4.1) shows that much of the

emissions reductions were the result of structural changes in industry (towards lower-carbon sub-sectors) or falls in industrial output (over the period 2007-2009).

- There has been no progress against three of our key milestone indicators regarding the development of an approach for deploying industrial CCS, the publication of an industry strategy for meeting carbon budgets and the publication of an evaluation of the effectiveness of compensation packages.

We intend to develop a fuller set of indicators for industry in line with Figure 4.4 and will report against those after the Government publishes its plan to meet the fourth and fifth carbon budgets.

Table 4.3. The Committee's industry energy and emissions indicators and outcomes

	2016 Indicator	**2016 Outturn**
Direct CO_2 emissions (% change from 2007)	-34%	-34%
Manufacturing and refining (direct) CO_2 emissions intensity of output (% change from 2007)	-30%	-34%
Manufacturing and refining (direct) energy intensity of output (% change from 2007)	-18%	-24%
BEIS to set out approach to deploying initial industrial CCS projects compatible with widespread deployment from the second half of the 2020s	End 2016	No progress
Publish industry strategy setting out milestones, incentives and mechanisms for meeting carbon budgets	End 2017	No progress
Publish an evaluation of the effectiveness of compensation packages	End 2016	No progress

Source: CCC analysis.
Notes: Intensity estimates based on energy and emissions from all manufacturing and refining sectors.

3. Policy progress towards the fourth and fifth carbon budgets

To meet the fourth and fifth carbon budgets and 2050 target, policy for industry should deliver cost-effective abatement, as outlined in Section 2. To achieve this it must also overcome a number of challenges (Box 4.3). 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.

Box 4.3. Challenges to reducing industry emissions

Achieving our indicated level of abatement will be challenging. It will be important to plan for investment in low-carbon measures given long project lead times, and the need to synchronise investment 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.

Assessment of existing policy

The Government has a number of policies for reducing emissions, aimed at encouraging energy efficiency improvements, uptake of low-carbon heat and use of bioenergy in industry. However, there are significant risks that these policies will under-deliver and there are also gaps in policy that need to be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets (Table 4.4):

- Existing policies risk under-delivery against the Government's current expectations. According to BEIS's *Updated Energy and Emissions Projections* policies for industry will encourage 2.6 $MtCO_2e$ of abatement in 2030. However, 2.1 $MtCO_2e$ of these estimated reductions are associated with policies that have significant delivery risk. To strengthen these policies, the Government needs to monitor closely uptake of low-cost measures and adapt the policy framework to overcome non-financial barriers.
- We have identified two key areas where the policy framework does not support sufficient emissions reductions or there is no policy: low-carbon heat after 2021 and industrial CCS (Table 4.4). These gaps need to be filled in order for decarbonisation in industry to be on track and to fill the10 $MtCO_2e$ gap between our cost-effective path in 2030 and BEIS's estimate of industry direct emissions under current policies.

The Government's industrial roadmaps project (Box 4.4) was an important first step towards unlocking cost-effective abatement potential, but these now need to be translated into delivery plans strong enough to support the level of investment required.

Box 4.4. Industry Roadmaps and Action Plans

Parsons Brinckerhoff and DNV GL were appointed by DECC and BIS to produce a set of 'Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050' for eight energy-intensive sectors with a cross-sector report identifying conclusions that apply across multiple sectors and technology groups.[51] The roadmaps, published in March 2015, are based on a collaborative process featuring contributions from industry sector trade associations, their members, officials from DECC and BIS, and other experts.[52] The sector-specific approach to the roadmaps reflects the nature of the challenges and opportunities for each sector, including the barriers and enabling actions to abatement. The Government is working with industry to set out plans for how the UK will move abatement efforts forward, following the work of the Roadmaps.

[51] Cement, ceramics, chemicals, food and drink, glass, iron and steel, oil refining, and paper and pulp. These sectors represent around 70% of manufacturing and refining CO_2 emissions.
[52] BIS and DECC (2015) *Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050*.

Table 4.4. Assessment of policies to drive abatement in the industrial sector

Abatement		2016 policy		2017 policy assessment and updates	
Energy efficiency		Amber	There were a range of policies to support industrial energy efficiency including: CRC, CCL, CCA, EU Products Policy, ESOS, ECAs, Building regulations part L and Private rented sector regulations. The EU ETS also provides an incentive for energy efficiency (as well as other abatement).	Amber	Some policies are at risk of failing to deliver the savings that BEIS project. Emissions savings from the EU ETS and EU product policies are at risk due to the UK leaving the EU. Savings from building standards are uncertain because of compliance and performance uncertainty. The industrial strategy green paper announced a review of how best to support greater energy and resource efficiency. The 25-year environment plan will set out a long-term vision for resource efficiency. The EU winter package also proposes further product standards, which are expected before the UK leaves the EU.
Low-carbon heat and use of bioenergy	To 2021	Amber	RHI funding was extended to 2020/21 and the Government consulted on reforms.	Amber	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. The UK leaving the EU could affect the Renewable Energy Directive, which has prompted the Government to support renewable heating. The RHI reforms that were consulted on in 2016 are due to go to Parliament.
	After 2021	Red	No policy.	Red	No policy.
Industrial CCS		Red	£300,000 funding to the Teesside Collective to support work on the potential for industrial CCS in Teesside.	Red	Funding awarded (from UK and EU funds) to a feasibility study in to a small scale industrial CCS project in North East Scotland.

Source: CCC analysis.
Notes: Red: Policy gap - new policy required. Amber: Policy with delivery risk - stronger 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 4.6. This reflects that it is an aggregate assessment for areas that may have a number of existing policies, such as energy efficiency.

Policy recommendations

To address the shortcomings in existing policy we have identified a number of areas where stronger policy is required:

- **A stronger policy framework for industrial energy efficiency.**
  - **A new reporting framework.** Following the decision in March 2016 to abolish the CRC energy efficiency scheme, the Government announced that it would consult on a replacement reporting framework. However, the consultation has not yet been published. The Government should publish this consultation and the new reporting framework should maintain incentives, fill information gaps and raise the profile of energy efficiency (e.g. through board sign-off).
  - **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).
  - **Combined Heat and Power (CHP).** A range of incentives exist to encourage take-up of CHP in industry. At present, these primarily encourage investment in gas-fired CHP. As grid electricity decarbonises in the 2020s, savings from gas CHP will erode. Therefore, policy should encourage low-carbon CHP.
- **An effective approach to drive sustained uptake of low-carbon heat in industrial processes and buildings.** An acceleration in low-carbon heat uptake will be required over the next few years, which will be difficult to meet without addressing all the barriers to uptake. This will require a policy framework to ensure investment in large-scale industrial low-carbon heat projects.
- **A strategic funded approach to industrial carbon capture and storage.** Industrial CCS is a key set of technologies to meet future carbon budgets and the 2050 target. The Government should develop a strategic funded approach to industrial CCS, based around clusters alongside power installations and shared infrastructure, with a new funding mechanism for industry (Chapter 1).
- **Some 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.
  - **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 proposed in the EU Winter Package to avoid inefficient products with higher running costs and emissions being dumped on the UK market.
  - **EU ETS.** The 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 develop new approaches to ensure industry has incentives to become more energy

efficient and to invest in low-carbon technologies. Any new approaches outside of the EU ETS should not disadvantage UK competitiveness.

- **An overall approach to long-term industrial decarbonisation.** The Government should continue to work with industry to develop and publish a set of plans to move abatement efforts forward along the paths developed in the Roadmaps, setting out specific actions and clear milestones. The Government should also extend the coverage of the Roadmaps and action plans to other industrial sectors. The opportunities identified in the action plans should be taken into account in the Government's plan to meet the fourth and fifth carbon budgets, the Industrial Strategy white paper and any future sector deals.
- **Tight regulation and close monitoring of any onshore petroleum wells (i.e. shale gas) during development, production and decommissioning to ensure rapid action to address leaks. The government should:**
  - Work with the Environment Agency to ensure that companies are required to implement an appropriate range of technologies and techniques to limit methane emissions.
  - Put in place a monitoring regime that catches potentially significant methane leaks in order to limit the impact of 'super-emitters'.
  - Prohibit production in areas where it would entail significant CO_2 emissions resulting from the change in land use.
  - Ensure that the regulatory regime requires proper decommissioning of wells at the end of their lives.

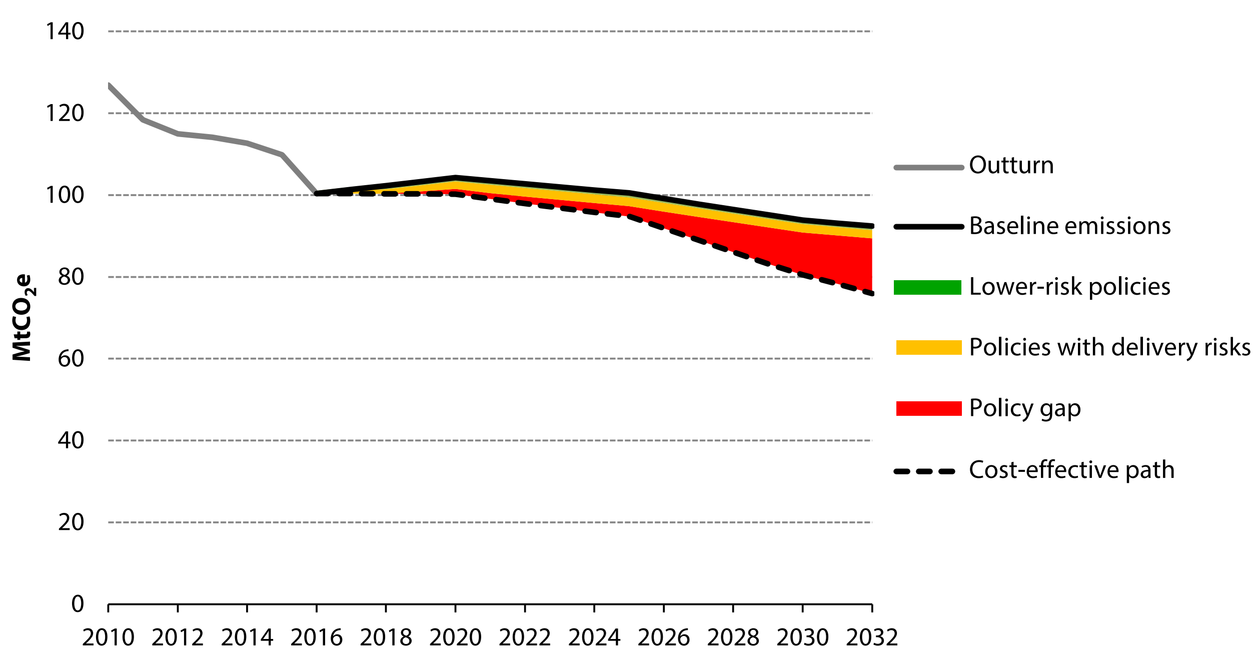
Until these areas are addressed there will remain a policy gap (Figure 4.5) between the current path and the cost-effective path towards the 2050 target, and therefore the requirements of the Climate Change Act (sections 13 and 14) will remain unmet.

The transition to a low-carbon economy is already underway and presents opportunities for UK businesses, both new and existing firms. Grasping those opportunities and ensuring a smooth transition must be integral to the Government's new industrial strategy:

- The UK low-carbon economy is already estimated to employ hundreds of thousands of people and contribute around 2-3% of GDP, which is a comparable size to energy-intensive manufacturing. It has been growing faster than the rest of the economy.
- Following the Paris Agreement, global demand for low-carbon goods and services is set to expand many times over to 2030 and then again to 2050. UK businesses must adapt to meet this need in place of the declining demand for high-carbon goods and services.
- The UK is particularly well-placed to take advantage of growing global markets for: low-emission vehicles; low-carbon finance, insurance and consulting; low-carbon electricity; smart grids and energy efficient products.

As well as producing low-carbon goods and services, industries that will flourish in the future must ultimately use low-carbon means of production. An effective approach to support that will contribute to the carbon budgets and the industrial strategy.

Figure 4.5. The policy gap in the industrial sector (2010-2032)



Source: BEIS (2017) *Updated energy and emissions projections: 2016*; CCC analysis.
Notes: Cost-effective path includes an additional 1MtCO$_2$e abatement in 2030 from biomethane injected into the natural gas grid.

Chapter 5: Transport

Key messages and recommendations

Transport is the largest emitting sector of the UK economy at 121 $MtCO_2e$, with 26% of UK greenhouse gas (GHG) emissions in 2016. Emissions in domestic transport rose for the third consecutive year in 2016. Demand for travel continues to grow, fleet efficiency reductions have slowed and biofuel usage has reduced. The global market for electric vehicles (EVs) is increasingly positive, and UK support should continue while the market develops, delivering significant additional benefits in improving air quality. Significant opportunities remain to reduce emissions in this sector, but require stronger policies and signals over the longer term to provide incentives for efficiency improvements in conventional vehicles, switching to ultra-low emissions vehicles and changing travel behaviour.

Our key messages for the transport sector are:

- **Transport sector emissions increased by 1% in 2016.** Increased demand for travel of 2% in both 2015 and 2016 has outpaced efficiency improvements and uptake of sustainable biofuels for cars, vans and HGVs. Emissions from vans and HGVs increased by 4% and 5% respectively in 2015, the latest year for which a detailed breakdown of emissions is available.
- **Test-cycle new car and van CO_2 improvements fall short of required reductions.** New car CO_2 emitted per km (intensity) measured by standard test-cycles fell 1.0% in 2016, the lowest decrease since regulations were introduced. A decrease of 5.7% per year in the remaining four years would be required to meet the EU wide 2020 target. Concerns remain about the gap between test-cycle measurements and actual driving emissions.
- **Actual fleet CO_2 intensity improvements stalled in 2015 and 2016,** due to a reduction in the proportion of biofuels, slow fleet efficiency improvements and a growing gap between real-world and test-cycle emissions intensity.
- **Sales of electric cars and vans increased to 1.2% of new vehicles in the UK in 2016** to around 38,000 vehicles, in line with our assessment of the cost-effective path. The global EV outlook is increasingly positive, with an increasing number of longer range EVs becoming available and costs falling. The market will continue to require support, although it is possible that this could be phased out sooner than previously expected. Further development of electric vehicle technologies presents significant business opportunities for the UK.
- **Uptake of biofuels fell in 2015 from 2.9% to 2.3% by energy and remained at 2.3% in 2016.** The government has not yet set a trajectory for biofuel uptake to 2020, whilst they consult on how to extend the policy.

Existing and planned policies leave a further 42 $MtCO_2$ reduction required in 2030 to meet our assessment of the cost effective path to meeting the fifth carbon budget. To close that gap, the Government's plans for the fourth and fifth carbon budgets must include proposals for setting stretching vehicle standards through the 2020s. These should reflect real-world driving emissions, necessitate increased take-up of electric vehicles and be effective for the UK market outside the European Union.

We will assess the Government's plan for meeting the gap in the fourth and fifth carbon budgets against the following checklist (Table 5.1):

Key messages and recommendations

Table 5.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets.

Domestic transport emissions should fall by around 44% between 2016 and 2030 and create options to allow near-zero emissions by 2050. This will require:	Stronger Implementation required	New policy required	New strategy required
Stretching standards for new car and van CO_2 beyond 2020 that take account of the need for high penetration of EVs (e.g. ~60 gCO_2 /km for cars and ~80 gCO_2/km for vans on a real-world basis by 2030) and are independently enforced with real-world testing procedures. The UK could remain a part of the EU legislation if it is sufficient to meet these targets, or replicate this legislation at a UK level.		✘	
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.	✘		
Align fiscal instruments (e.g. Vehicle Excise Duty) with new car and van emissions targets to strengthen incentives to purchase more efficient and lower emission vehicles.	✘		
Implement policy to deliver 8% of sustainable biofuels by energy to 2020 and maintain the biofuels volume to 2030.	✘		
Policies to support emissions reduction from HGVs. This should include new vehicle efficiency standards requiring electric options for smaller trucks, more efficient logistics, increased uptake of eco-driving measures and a shift to lower carbon modes (e.g. rail).		✘	
National and local policies to reduce demand, to deliver car-km reductions of at least 5% below the baseline trajectory (e.g. policies incentivising walking, cycling and usage of public transport).	✘	✘	
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.		✘	✘

Source: CCC analysis.

Introduction

In this chapter we present the latest data on trends in transport sector emissions and review progress towards meeting carbon budgets. We assess current policies and measures in addition to outlining policy priorities needed to deliver the cost-effective level of abatement to 2030. We report on the broader opportunities that following this path present in other areas such as improving air quality and contributing to the UK's industrial strategy.

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

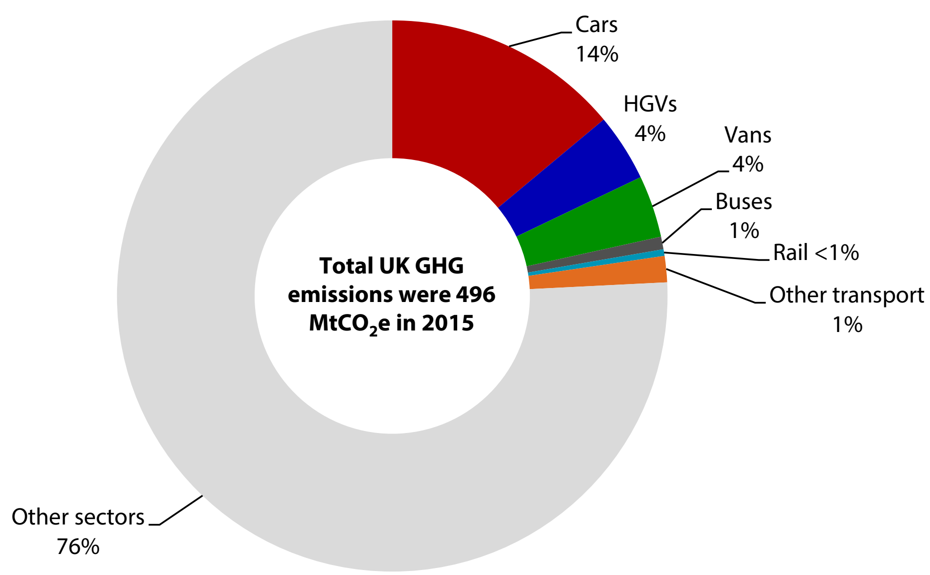
1. Trends in transport emissions
2. Progress in decarbonising surface transport
3. Progress in reducing aviation and shipping emissions
4. Policy progress towards the fourth and fifth carbon budgets

1. Trends in transport emissions

Domestic transport emissions

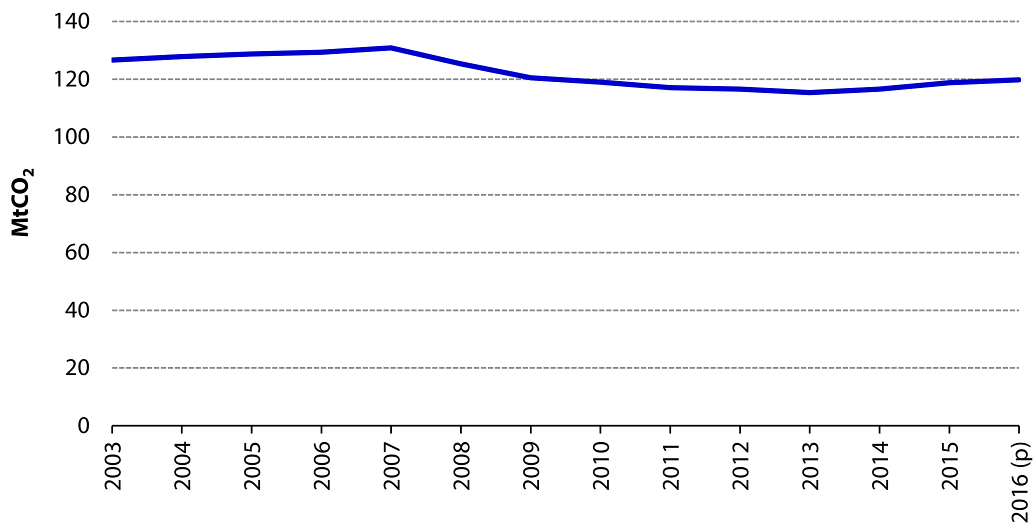
Domestic transport greenhouse gas (GHG) emissions are provisionally estimated to be 121 $MtCO_2e$ in 2016, and continue to be the largest emitting sector, accounting for 26% of total GHG emissions. A detailed breakdown of transport emissions is only available to 2015. Cars, vans and HGVs are the three most significant sources of emissions, accounting for 89% of domestic transport GHG emissions. (Figure 5.1). Carbon dioxide emissions increased 0.9% from 2015 to 2016, the third successive year that emissions have risen (Figure 5.2).

Figure 5.1. Transport sector GHG emissions as a share of UK total, 2015



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*
Notes: Other transport includes domestic aviation and shipping, mopeds and motorcycles, liquified petroleum gas fuelled vehicles and other road vehicle engines.

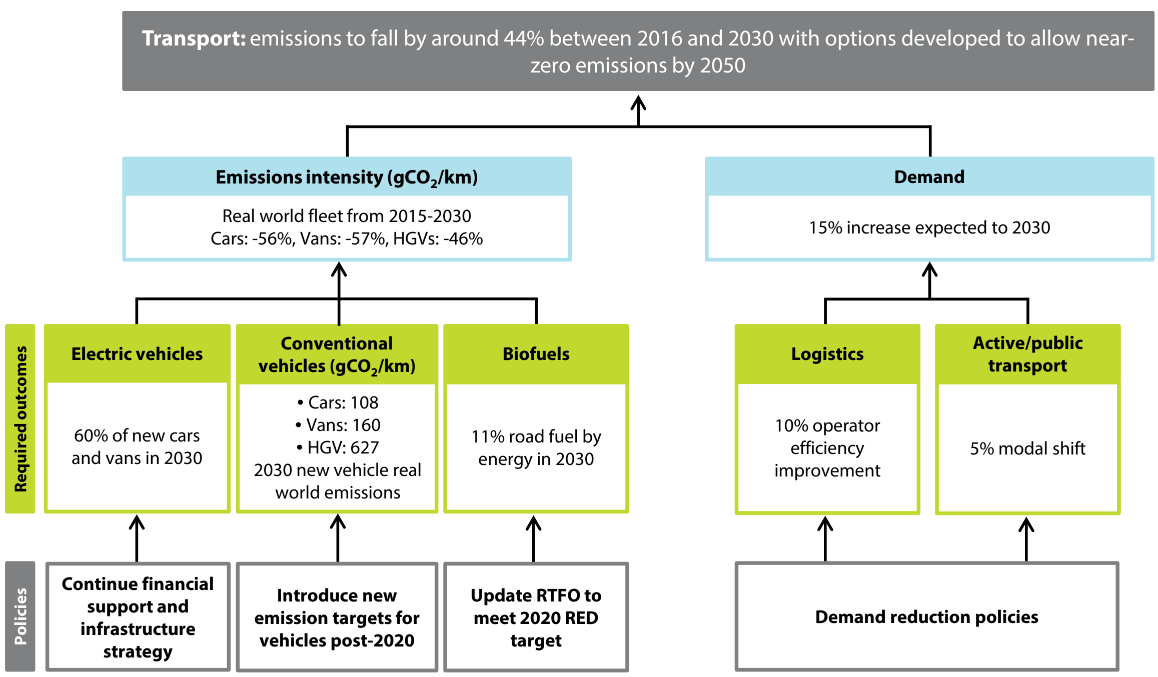
Figure 5.2. Domestic transport CO_2 emissions (2003-2016)



Source: BEIS (2017) *Provisional UK greenhouse gas emissions national statistics 2016.*

This trend needs to be reversed, as a matter of urgency, to deliver a reduction in emissions of 44% from 2016 to 2030. This will require a major increase in the uptake of electric vehicles, improved efficiency of conventional vehicles, increased biofuels use and measures to moderate road travel demand across all modes (Figure 5.3).

Figure 5.3. CCC indicators for the transport sector



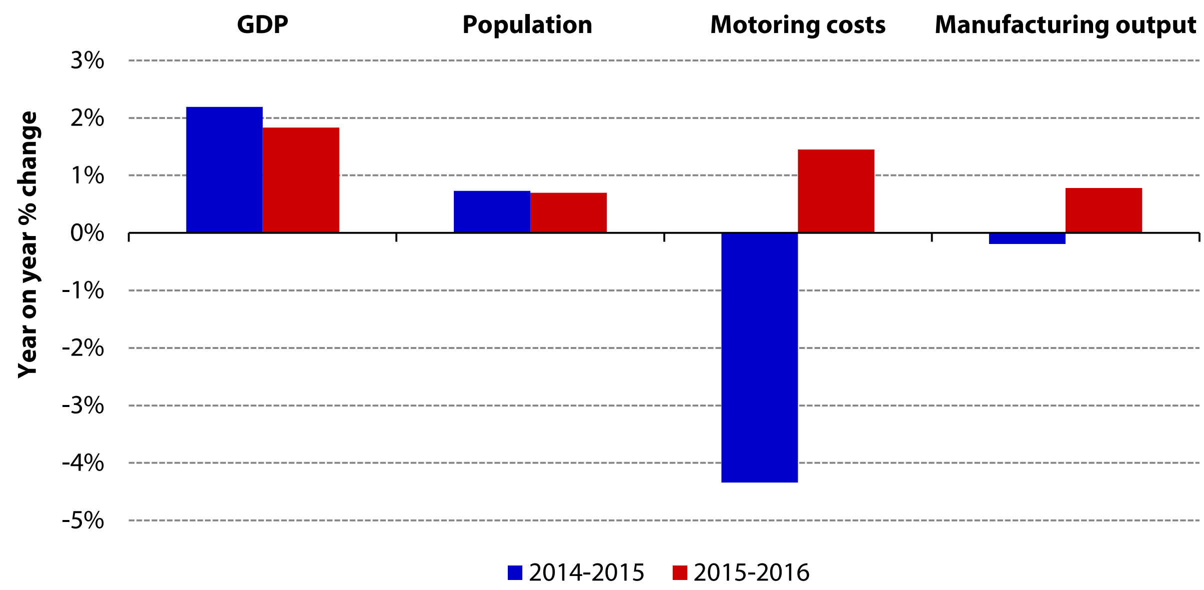
Source: CCC analysis.

Economic context

Changes in road transport have historically been driven by factors such as population, income growth and motoring costs (e.g. car purchase, fuel and insurance costs). While other social and economic factors such as the rise in internet shopping and availability and reliability of alternative transport choices are also important, these are less well understood.

In 2015, most social and economic drivers supported an increase in demand for travel apart from a slight fall in manufacturing output. The most significant change was a steep fall in motoring costs. The picture was similar in 2016, although there was a rise in motoring costs largely due to increased costs of car insurance (Figure 5.4). The Government's decision to freeze fuel duty since 2010/11 has contributed to a reduction in the fuel cost element of motoring costs.

Figure 5.4. Change in key drivers of transport demand



Source: CCC calculation based on data from the Office for National Statistics and DfT *Transport Statistics Great Britain.*

Surface transport emissions trends

In 2015, surface transport emissions, accounting for 95% of domestic transport, increased 1.9% to 114.0 $MtCO_2e$. Road transport emissions increased by 2.1% in 2015 against a 2.2% decrease in our indicator based on our fifth carbon budget assessment of the cost-effective path to the 2050 target. Emissions from cars, vans and HGVs all rose in 2015. The continued growth in road transport emissions highlights the urgent need for stronger policies to reduce emissions and moderate growth in demand for travel.

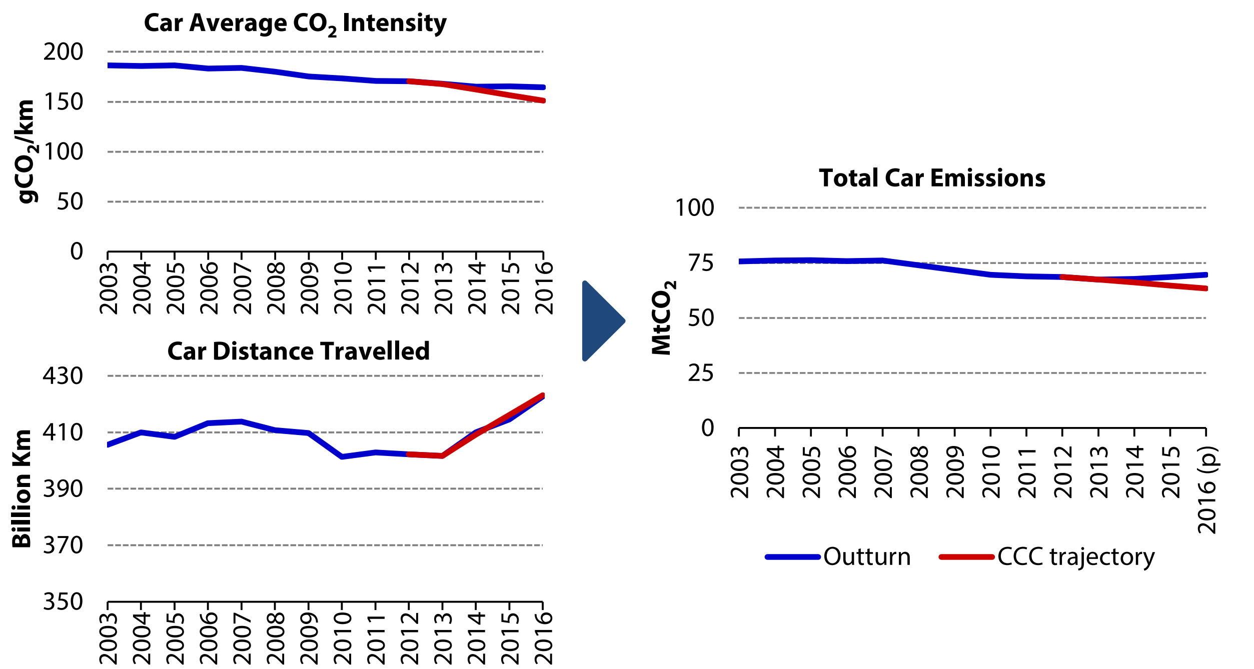
In the sections that follow, we compare emissions, demand and intensity in each mode in 2015 to our indicators, which reflect our estimates of the cost-effective trajectory to meet the fifth carbon budget.

Cars

Emissions from cars increased by 1.2% in 2015 to 69.1 $MtCO_2e$, whilst the cost-effective path requires a decrease of 2.0% (Figure 5.5):

- Fleet average real-world car CO_2 intensity (CO_2 emitted per km driven) increased by 0.1% in 2015, compared to a 3.4% decrease in our indicator. Average car efficiency improved, resulting in a 0.3% increase in fleet efficiency, which was offset by a reduction in biofuel usage, which decreased fleet efficiency by 0.5%.
- Car km increased by 1.1% in 2015, with a further increase of 2.0% in 2016. This increase in demand is comparable to expectations in our indicator.

Figure 5. 5. Car emissions, demand and intensity



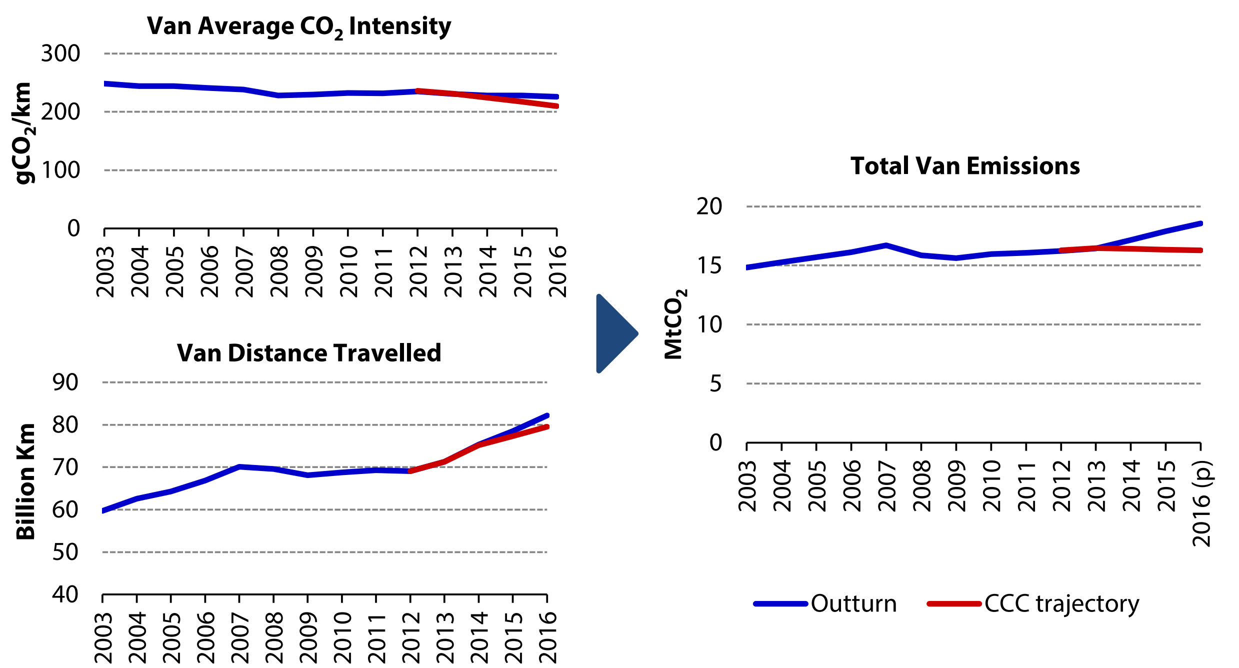
Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*; DfT (2017) *Road Traffic Statistics;* CCC analysis.

Vans

Van emissions increased by 4.2% in 2015 to 18.0 $MtCO_2e$, compared with a 0.4% decrease in our indicator (Figure 5.6):

- Demand is increasing rapidly, with an increase of 4.3% in van-km in 2015, against an increase of 2.9% in our indicator.
- Reductions in CO_2 intensity have slowed, with a decrease in fleet average van CO_2 intensity of 0.1%, compared with a 3.2% decrease in our indicator. The reduction in biofuels led to a 0.9% increase in fleet intensity, although improvements in average van efficiency contributed a 1.0% decrease in fleet intensity.

Figure 5.6. Van emissions, demand and intensity



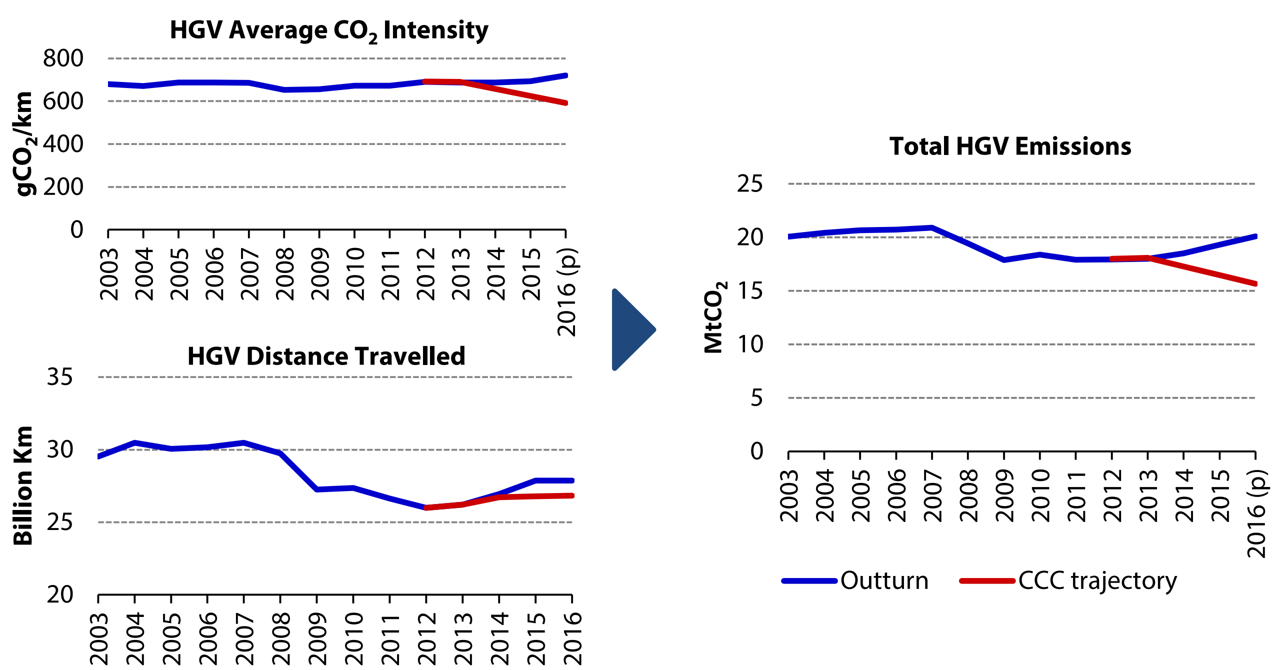
Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*; DfT (2017) *Road Traffic Statistics;* CCC analysis.

HGVs

HGV emissions increased by 4.5% in 2015 to 19.6 $MtCO_2e$, against a 4.6% decline in our indicator, reflecting an increase in HGV-kms and a worsening CO_2 intensity (Figure 5.7):

- HGV-kms increased by 3.5% in 2015, but remained flat in 2016. HGV-kms driven remain 3.9% above the CCC indicator in 2015.
- Average real-world fleet intensity (gCO_2/km) increased by 0.9% in 2015 as a slight improvement in fleet efficiency (contributing a 0.1% decrease in fleet intensity) was offset by a fall in biofuels (contributing a 1% increase in fleet intensity).

Figure 5. 7. HGV emissions, demand and intensity



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015*; DfT (2017) *Road Traffic Statistics;* CCC analysis.

Aviation and shipping emissions

Aviation

Total domestic and international aviation emissions increased by 1% in 2015, to 34.8 $MtCO_2e$ (Figure 5.8). Most of the rise came from international emissions, which represent the vast majority of aviation emissions and which are not formally included in carbon budgets. International emissions rose by 1.5%.

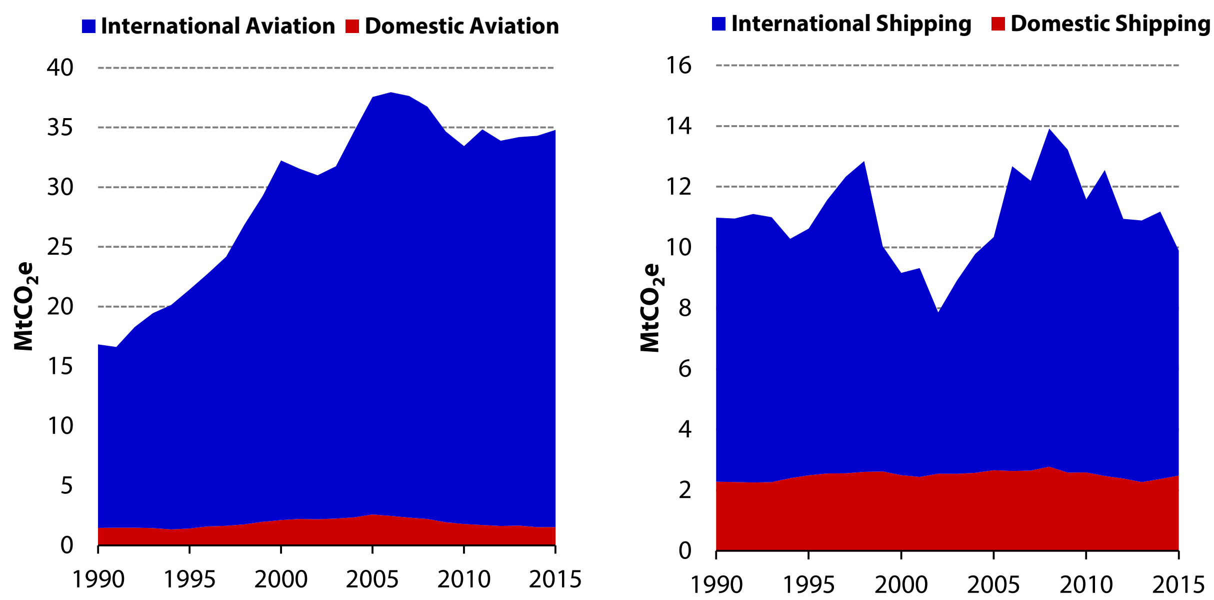
In 2015 passenger demand rose by 5.5% and the number of flights increased by 2.5%. That emissions only rose 1% suggests a range of efficiency improvements are likely to have limited the increase in emissions. These could include higher load factors (e.g. the number of passengers per flight increased by 3% in 2015 and is now 20% higher than in 2005), improved fuel efficiency of aircraft as new models enter the UK fleet, and/or changes in the route mix towards closer destinations.

Shipping

Total domestic and international shipping emissions fell 12% in 2015, to 9.9 $MtCO_2e$. This continues the reduction seen in recent years, and emissions are now 29% below 2008 levels. The reduction came entirely from international emissions, which fell 16%. Domestic emissions rose by 5%.

There is limited data available to explain the change in emissions, but imports of cargo fell 4% in 2015. However, the number of ship movements increased by 1% and the average size of ship decreased by 0.4%. Since both of these changes would tend to suggest an increase in emissions, other factors must have contributed to the fall in emissions. These could include falling ship speeds, improvements in fuel efficiency of ships, or changes in bunkering patterns (e.g. taking on more fuel at ports outside the UK, which would therefore not be counted towards UK emissions).

Figure 5.8. UK aviation (left) and shipping (right) emissions (1990-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*

2. Progress in decarbonising surface transport

Recent progress in reducing surface transport emissions

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 and measures to change travel behaviour.

Progress in reducing emissions from road vehicles is slow, with new test-cycle CO_2 intensity for cars and vans significantly higher than our indicator and the uptake of biofuels by energy lagging behind what is required (Table 5.2).

We will be developing an assessment of the number of public chargers and rapid public chargers required to support the levels of electric vehicle uptake in 2030 in line with our cost-effective path over the coming months. The research used in the development of these figures is described in Box 5.1.

Table 5.2. Table of key outcomes (indicators) to be on track for 2030 (and latest outturn)

Key outcome	2016 indicator	Outturn
Headline indicators		
Reduce road vehicle emissions by 46% by 2030, from 2010 levels	-9%	+3%
Vehicle kms driven to be 23% above 2010 levels by 2030	+6%	+7%
Supporting indicators		
New test-cycle car intensity of 48 gCO_2/km by 2030	118 gCO_2/km	120 gCO_2/km
New test-cycle van intensity of 63 gCO_2/km by 2030	169 gCO_2/km	174 gCO_2/km
60% of new cars and vans to be electric vehicles by 2030	1.4%	1.2%
Number of public charging points by 2030 (to be developed)	To be developed	12,800
Number of public rapid charging points by 2030 (to be developed)	To be developed	2,300
11% of fuels are sustainable biofuels (by energy) by 2030	5.2%	2.3%

Source: CCC analysis.

Box 5.1. Electric vehicle charging infrastructure research

The CCC has commissioned research to enable us to assess progress in the coverage and availability of the expanding electric vehicle public charging network. The work will assess how well the charging network satisfies demand for charging in 2016 and where further expansion is required in order to provide charging for the increased numbers of electric vehicles in our fifth carbon budget scenarios in 2020, 2025 and 2030. Our research classifies charging infrastructure into the following functions and locations, each meeting a different requirement:

- Private off-street home charging, which is determined by the proportion of electric vehicle owners that have access to off-street parking and are able to install a charger.
- Public on-street home charging for those who do not have a dedicated parking space where a charger can be installed and instead make use of an on-street charger near the home.
- Destination charging (e.g. shopping centres, car parks etc.) where the vehicle is charged while the

Box 5.1. Electric vehicle charging infrastructure research

owner is undertaking some other activity such as shopping or leisure activities.

- Workplace charging, where charging facilities are provided for employees.
- Park and ride charging.
- Specialist fleet charging for vehicles such as buses, taxis and council fleets, which is not likely to be available to the public.
- Rapid charger hubs used solely for the purpose of gaining a charge in urban areas to top up the car when unable to charge enough elsewhere.
- Inter-urban 'en route' rapid chargers where the electric vehicle user is undertaking a long journey and needs to recharge at an intermediate location.

Two analytical models to estimate different charging needs have been developed to assess the required number and location of charging stations. This analysis is confined to publically available charging points (the model does not estimate on the numbers of private home charging points, workplace charging points for employees or charging points for specialist fleets such as buses or taxis).

- Estimates of the number and type of charging points required for normal daily journeys within the local area are provided for 50 areas across Great Britain. These charging points could be on-street, at destinations, at park and ride sites or rapid charger hubs. Department for Transport data are used to estimate the number of car vehicle trips with destinations in each of the local areas.
- The number and location of chargers required to enable electric vehicles to drive long distance journeys is calculated by considering vehicle travel demand patterns across Great Britain. The model considers the diversion required to reach the charging location, the average waiting time to gain access to the charger, the charge time (which will be dependent on the charging rate and battery size) and the cost of the charge in order to optimise the required number of chargers and locations.

Improving conventional vehicle efficiency

Cars and vans

EU regulations apply to the average CO_2 intensity of a manufacturer's fleet of new cars and vans. Car regulations have been in place since 2009, with a target of 95 gCO_2/km for new cars sold in 2020/21. Van targets are 175 gCO_2/km for 2017 and 147 gCO_2/km for 2020.

This policy has led to improvements in test-cycle CO_2 intensity across all car segments since its introduction, although there is evidence of a growing gap between test-cycle emissions and those achieved in real-world driving conditions.

The rate of progress in reducing average new car CO_2 intensity has slowed, and there is a significant risk that the 2020/21 target will not be met (Figure 5.9):

- New cars sold in the UK in 2016 had an average test-cycle CO_2 intensity of 120.1 gCO_2/km, a decrease of 1.0% since 2015.[53] This is below the EU 2015 target of 130 gCO_2/km, but is the lowest annual reduction since the regulations were introduced.
- This slower rate of improvement is partly due to a move towards larger vehicles, particularly a shift from super-minis to dual-purpose vehicles in 2016. If the distribution in size bands had not changed from 2015, the CO_2 intensity reduction would have been 1.7%:

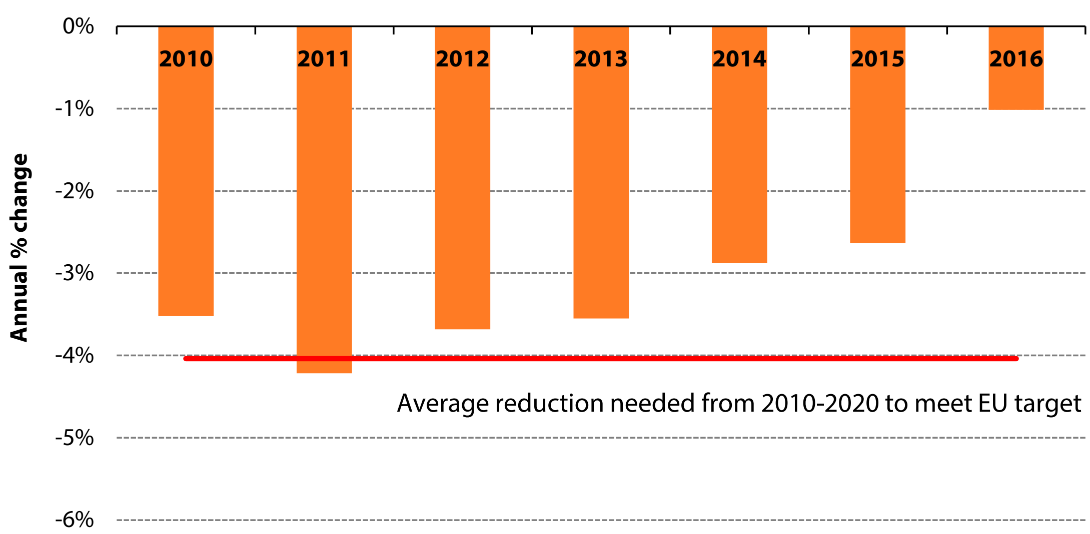
[53] SMMT (2017) *New Car CO_2 Report*.

– The average CO_2 intensity of new cars in all segments has reduced since the regulations were introduced, with decreases among medium sized cars slightly larger than others.
– The majority of new cars sold are in the 'supermini' and 'lower medium' segments, with 60% of the market, although there has been a marked shift towards dual-purpose vehicles with 50% growth in the past two years.

- The EU wide new car average CO_2 is 118 gCO_2/km and must fall by 5.3% per year in the remaining four years to meet the EU 2021/21 target of 95 gCO_2/km.[54] UK new car CO_2 progress is slower and so must fall by 5.7% 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. If steady progress had been made since the regulations were introduced, a 4% reduction year on year would have been required.

This shift towards higher emitting vehicles shows that it is important that fiscal incentives to purchase lower emission vehicles (such as Vehicle Excise Duty (VED)) are aligned with the new car regulations, so that both measures work together to reduce emissions.

Figure 5.9. New car CO_2 intensity - recent changes

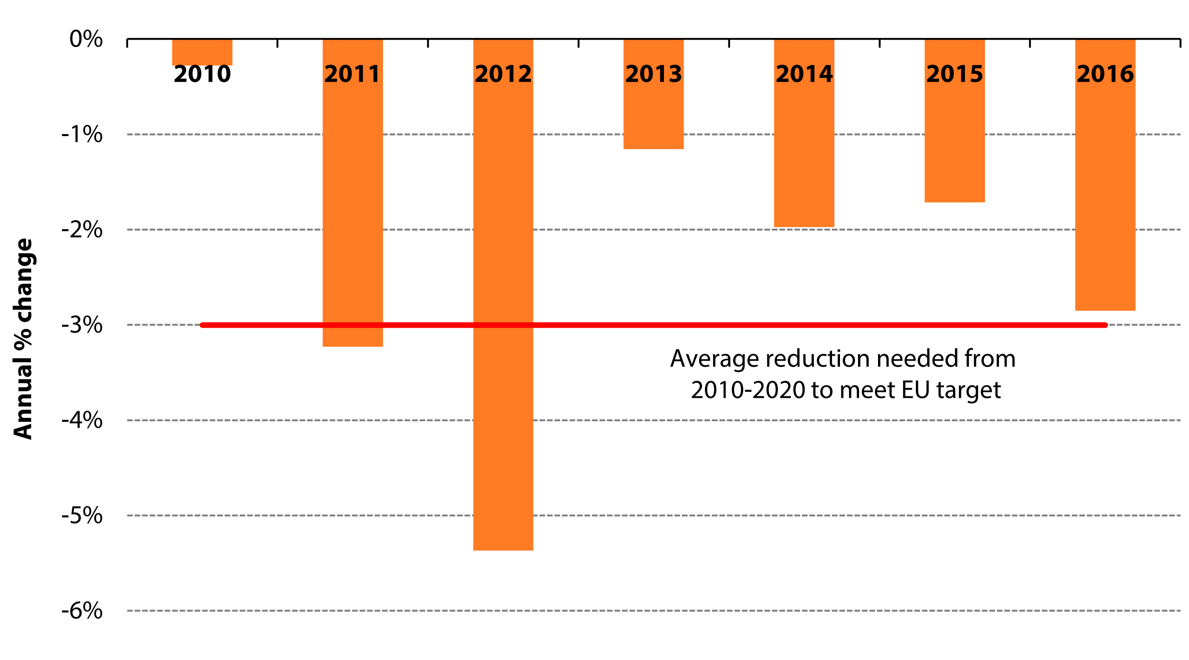


Source: SMMT (2017) *New car CO_2 Report 2017*; CCC analysis.

The average CO_2 intensity of new vans was 173.7 gCO_2/km in 2016, a decrease of 2.9% since 2015, a larger reduction than the previous year (Figure 5.10). Whilst the 2017 target has already been met, the rate of reduction needs to accelerate to 4.1% per year for the remaining four years in order for the UK to reduce intensity to 147 gCO_2/km (the EU wide target).[55]

[54] European Commission (2017) https://ec.europa.eu/clima/policies/transport/vehicles/cars_en
[55] The EU average is below the UK average, at 164 gCO_2/km(European Commission (2017). https://ec.europa.eu/clima/news/co2-emissions-new-vans-sold-europe-continued-decrease-2016_en), meaning that the EU wide target can be met at a slower rate of improvement of 2.7%.

Figure 5.10. New van CO_2 intensity - recent changes



Source: SMMT (2017) *New car CO_2 report 2017*; CCC analysis.

The gap between real-world and test-cycle emissions remains a concern, with evidence that real-world emissions from new cars in the EU could be around 40% higher than on the official test-cycle as measured by the New European Driving Cycle (NEDC).[56] The introduction of the new Worldwide Harmonised Light Vehicle Test Procedure (WLTP) later this year should reduce this gap but is not expected to close it entirely. Given the continuing risk this poses to delivering real-world emissions reduction, new car and van CO_2 targets should be tested with the more stringent Real Driving Emissions (RDE) standard as soon as feasible, with more independent testing across Europe.

HGVs

There is no available measure of new HGV gCO_2/km, as this is not currently regulated. However, the average real-world CO_2 intensity of the UK HGV fleet has remained relatively flat over the last decade, and has increased in the past two years, which could reflect a shift to heavier vehicles. The tonnes carried per km by HGVs have also increased by 1.8%, which could reflect logistical efficiency improvements and/or the shift to heavier vehicles.

Uptake of electric vehicles

Supply of electric vehicles

The number of electric car and van models available (including both plug-in hybrid electric vehicles and battery electric vehicles) has increased from 25 models in June 2015 to 38 in June 2016 and 46 in June 2017, with electric vehicles now available in every market segment. The

[56] ICCT (2016) *2020-2030 CO_2 standards for new cars and light-commercial vehicles in the European Union.*

number of battery electric vehicles available with over 200 miles of range (according to the NEDC test-cycle) has also increased to 3 models, with additional models expected to be released over the next year. Battery pack costs account for a significant proportion of the cost of both types of electric vehicles, and are falling faster than projected (Box 5.2). It is likely electric vehicles will become cost competitive with conventional vehicles earlier than previously estimated. Several large car manufacturers have now stated that they expect between 15-25% of sales in 2025 to be electric vehicles.[57]

Box 5.2. Electric vehicle battery costs

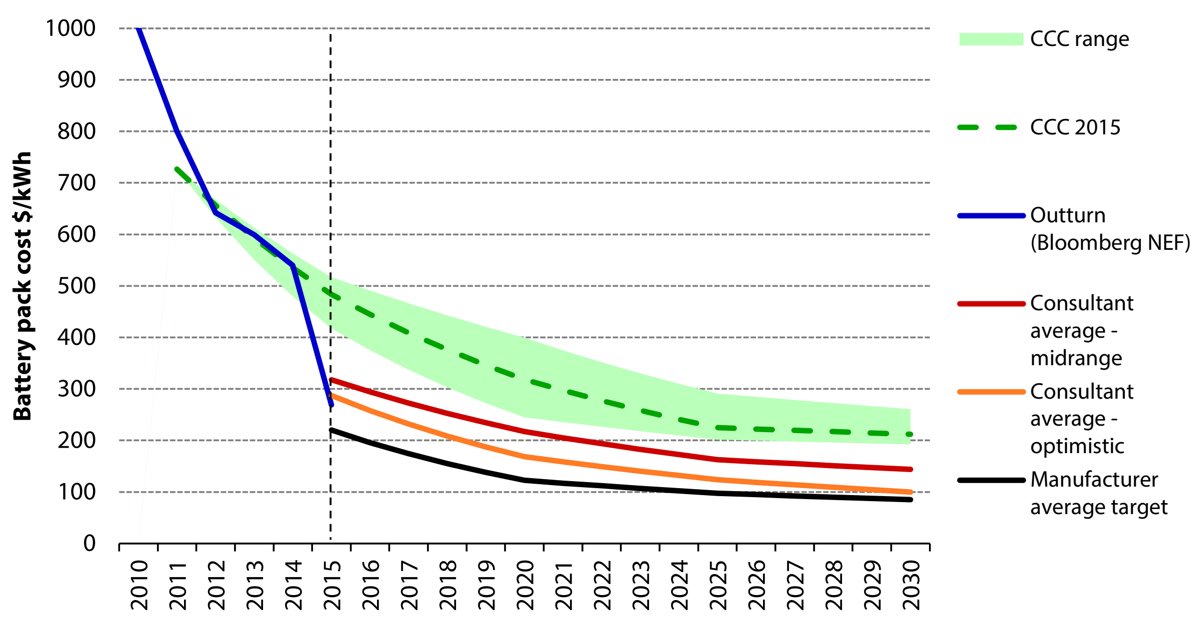
In recent years, battery pack prices have fallen significantly faster than anticipated (Figure B5.1).

Although information on the cost of batteries remains commercially sensitive, announcements by manufacturers such as Tesla, Ford and General Motors, as well as new estimates by consultancies, point to a decline in costs far greater than projected in the Committee's fifth carbon budget analysis.

Consultants estimate that battery pack production costs will fall below $100/kWh before 2030, while manufacturers are now targeting 2025. Estimates for the Committee in 2015 were around double this.

Batteries are a key component of the total cost of a battery electric vehicle, accounting for up to a third of total costs. With pack costs falling faster than projected, it is likely that EVs will become cost competitive with conventional vehicles earlier than previously estimated.

Figure B5.2. Battery cost estimates



Source: Consultant optimistic average: Aurora Energy 'Breakthrough', Bloomberg New Energy Finance 'Aggressive', Morgan Stanley, Goldman Sachs 'Tesla', National Academy of Sciences 'Optimistic', ICCT 'Optimistic', McKinsey & Co., Bain & Company; Consultant midrange: Aurora Energy 'Consensus', Bloomberg 'Conservative', Morgan Stanley, Goldman 'Industry', National Academy of Sciences 'Midrange', Ricardo, Accenture, ICCT 'Midrange', BNP Paribas, Bain & Company; Manufacturer average target: Tesla, Ford, GM, Audi, Renault-Nissan.

[57] Volkswagen (2016) *'TOGETHER - Strategy 2025'*; BMW (2017) *'Annual Accounts Press Conference for the Business Year 2016'*; Press Statement by Markus Schäfer, Mercedes-Benz Cars (2017)

Uptake of electric vehicles

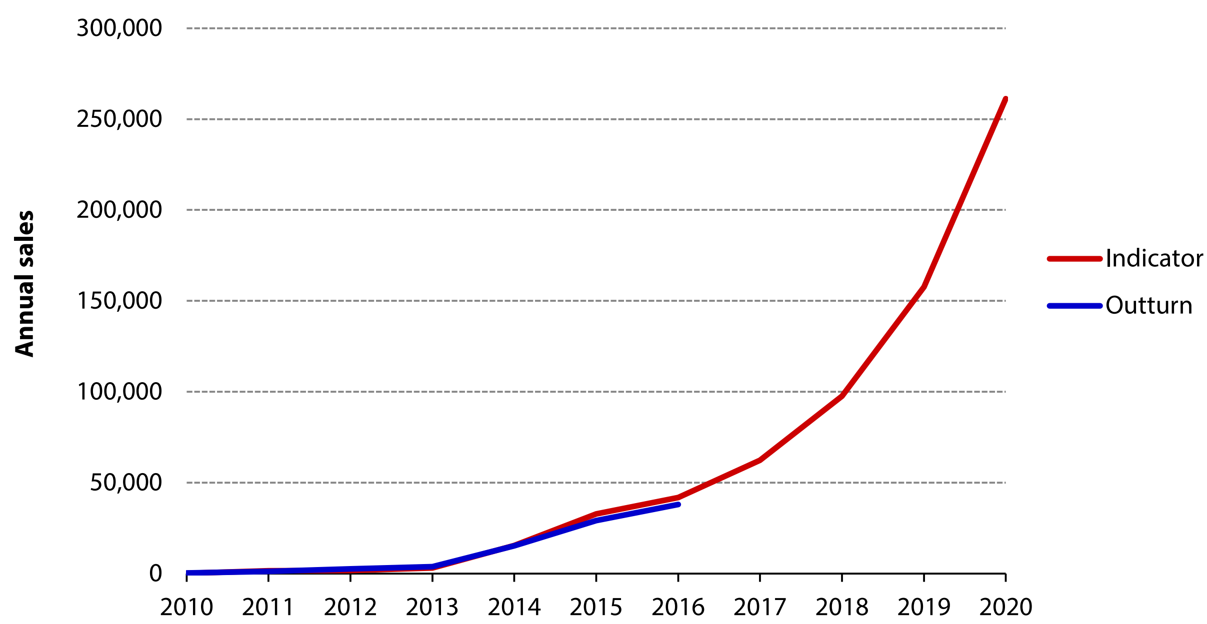
Sales of electric vehicles increased in 2016 and early 2017, and are currently in line with our indicator (Figure 5.11):

- 38,000 electric cars and vans were sold in 2016, representing 1.2% of car and van sales. Electric car sales increased by 30% compared to 2015, whereas electric van sales increased by 13%.
- Sales have continued to increase in the first quarter of 2017, with electric vehicles making up 1.4% of new car and van sales.

The Committee has emphasised the importance of a national charging network to enable an accelerated roll-out of electric vehicles. The number of publically available charging points for electric vehicles continued to grow in 2016 and early 2017:

- The total number of publically available charging connectors of all types has increased from 10,000 in June 2016 to 12,800 in June 2017.[58]
- The rapid charger network has also expanded to 2,300 connectors in 700 locations in May 2017, compared with 1,800 connectors in 2015.

Figure 5.11. Electric vehicle sales vs central scenario



Source: DfT (2017) *Vehicle Licensing Statistics*; CCC analysis.

The number of electric buses in operation grew to 123 buses in June 2016. In addition, seven councils successfully bid for funding from the Low Emission Bus Scheme for electric buses and associated charging infrastructure in July 2016.

[58] Zap-Map (2017).

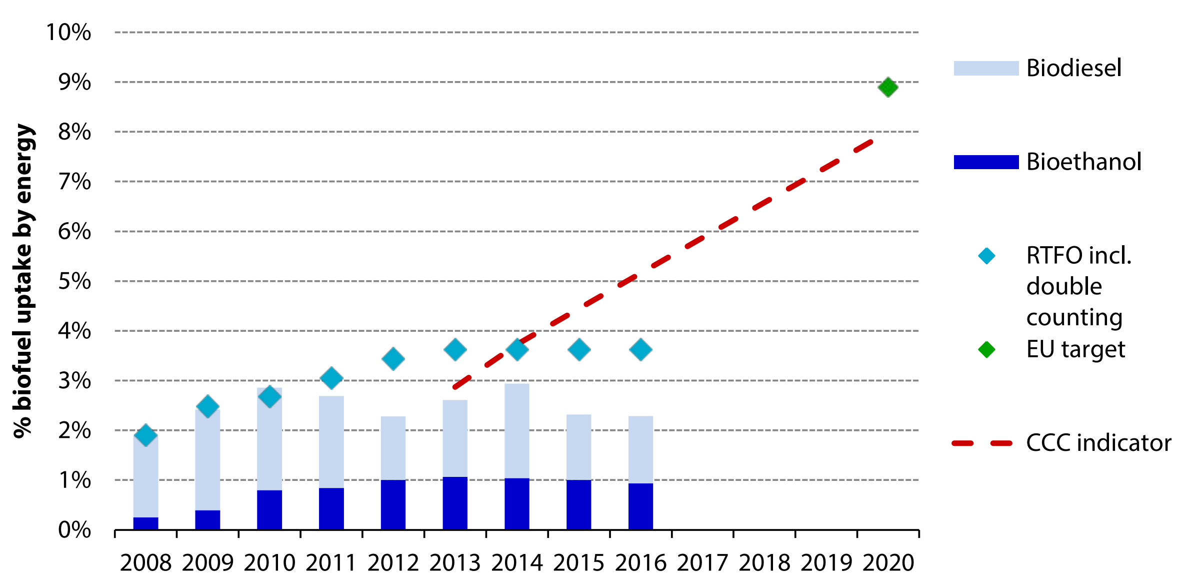
Biofuels

Biofuel uptake has reduced or remained flat in recent years (Figure 5.12). The sustainability of biofuels is increasing:

- Biofuels share of fuel sales decreased from 2.9% in 2014 to 2.3% by energy in 2015 and remained constant in 2016. This is lower than our indicator of 5.2% in 2016 based on the fifth carbon budget assessment of the cost-effective path.
- Average GHG savings from biofuels increased to 74% (in 2015/2016) from 70% (in 2014/2015) by volume, excluding emissions from indirect land-use change (ILUC).
- 60% of all biofuels by volume were from waste feedstocks in 2015/16, slightly higher than the previous year. 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.

The energy content of biofuels drives emissions intensity in the fleet, rather than volumes that are double-counted towards the RTFO. Low biofuel uptake on an energy basis has therefore contributed to the lack of progress in reducing CO_2 intensity in road transport in 2015 and 2016. Biofuel uptake is currently below levels required to reach 8% of fuel by 2020 by energy.

Figure 5.12. Biofuel uptake from 2008-2016 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

Changing the travel behaviour of individuals and businesses can help reduce emissions through avoiding trips, using lower carbon forms of transport (such as walking, cycling and public transport) or altering driving styles. However, it is difficult to track overall progress in reducing demand.

Active travel is walking or cycling as a means of getting to a destination, meaning that it could replace a car trip, as opposed to walking or cycling for pleasure or exercise. It is difficult to monitor changes in active travel at a national level as the measured statistics differ across the devolved administrations. England and Northern Ireland use the same methodology, whereas Scotland and Wales both differ.

The number of bus journeys has fallen in Great Britain over the past few years, declining by 5% in December 2016 since the recent peak in January 2014. It is difficult to measure the impact of this reduction on the demand for car travel.

There is evidence of slight improvements in logistical efficiency for freight, with empty running reduced by 0.7% and tonnes carried per km increased by 1.8% in 2015.

3. Progress in reducing aviation and shipping emissions

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. The International Civil Aviation Organisation (ICAO) agreed a global offsetting scheme in 2016 but the International Maritime Organisation (IMO) has made less progress:

- **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.
  - Available estimates suggest that the scheme will cover less than half of total international aviation kilometres flown in 2030, given that it only covers emissions above 2020 levels and given available exemptions (e.g. for some developing countries and countries that have a small proportion of total kilometres flown).
  - 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.
  - It is important that data to monitor compliance with the agreement are available when details of the scheme have been agreed.

- **Shipping.** In October 2016 the IMO adopted mandatory requirements for large ships to record and report data on their fuel consumption. This broadly aligns the IMO with the EU's approach, which is also to introduce a monitoring and reporting system for CO_2 emissions. The IMO also approved a roadmap for developing a strategy to reduce emissions from ships. The aim is for an initial strategy to be adopted in 2018, with adoption of a revised version in 2023 to take into account the new available data from reported fuel consumption, and further consideration of measures required.

In the context of future UK policy and infrastructure investment decisions, appropriate long-term assumptions for government planning are for aviation emissions to be around 2005 levels in 2050 (implying around a 60% increase in demand over the same period), and for shipping emissions to be around one-third lower than 2010 levels. Government should publish an effective policy framework for aviation emissions on this basis. If aviation emissions are anticipated to be higher than 2005 levels – as in the central case in the business case for an additional runway at Heathrow airport – then other sectors would have to plan for correspondingly higher emissions reductions. We would expect to see this reflected in the Government's plan for meeting the fourth and fifth carbon budgets.

These planning assumptions should be regarded as proxies for outcomes under long-term international agreements. The Government should therefore continue to push for rapid agreement of strong international policies - and implementation plans - consistent with long-term climate goals. These will be required to unlock the full range of abatement potential whilst limiting risks of competitive distortions.

4. Policy progress towards the fourth and fifth carbon budgets

Effective policy to meet future legislated carbon budgets must cover efficiency improvements for new cars, vans and HGVs, action to increase electric vehicle uptake, greater use of sustainable biofuels, action to increase walking, cycling and the use of public transport to limit demand for car travel and freight efficiency improvements through a shift to rail, eco-driving measures and improved logistics.

Ultra-low emission vehicles

Progress has been made by the Government in providing support for the higher costs of electric vehicles across a greater variety of vehicle types and in developing the infrastructure required:

- Upfront grants remain available to support the purchase of several different types of electric vehicles. Fully electric cars are eligible for a grant of £4,500, whilst plug-in hybrid cars can apply for a reduced grant of £2,500. The government has committed to maintain these rates until at least October 2017. These incentives are approximately in line with those offered by other countries (Table 5.3).
- The Plug-in Van Grant gives a discount of up to £8,000 for electric vans of up to 3.5 tonnes and was extended in October 2016 to cover larger electric vans above 3.5 tonnes. These vans are eligible for grants of up to £20,000. This grant will be reviewed in March 2018 or when 5000 vans have been ordered (whichever comes first). By December 2016, 3,000 vans eligible for the grant had been sold.
- A Plug-in motorcycle grant was introduced in October 2016, with zero emission motorcycles and scooters now eligible for a grant of £1,500.

- The Government committed around an additional £300 million of support for ultra-low emissions vehicles and renewable fuels in the 2016 Autumn Statement. This included:
  - £80 million for ULEV charging infrastructure used by the Office for Low Emission Vehicles (OLEV) to fund chargers at homes and workplaces. In addition, OLEV is working with councils to provide funding for on-street residential charging.
  - £150 million in support for low emission buses and taxis including the provision of supporting infrastructure. The Plug-in Taxi Grant will give taxi drivers up to £7,500 off the price of a new vehicle and dedicated charging points for taxis will be installed in 10 council areas.
  - £20 million for the development of alternative aviation and heavy goods vehicle fuels.

Table 5.3. International comparisons of electric vehicle subsidies.

Country	Maximum BEV subsidy available ($)	Extra information
Europe		
United Kingdom	5,700	$3,170 provided for PHEVs (priced under £60,000). Vehicle Excise Duty and Company Car Tax are waived for BEVs and reduced for PHEVs (not included in subsidy figures given).
France	7,050	Provides $1,120 for PHEVs. Scrapping a car older than ten years increases subsidy to $11,200. Regional exemptions from registration tax. Electric vehicles are exempt from Company Car Tax.
Germany	4,480	Provides $3,360 for PHEVs. Electric vehicles are exempt from road circulation tax.
Norway	≈26,000	Norway has the highest market share of electric vehicles worldwide but does not have a set subsidy per vehicle. Instead, conventional vehicles are taxed heavily on purchase, with exemptions for BEVs and reductions for PHEVs. Level of subsidy heavily dependent on cost of comparison vehicle used.
Rest of world		
China	7,050	$3,520 provided for PHEVs (with sufficient electric range). Subsidies only available to cars manufactured in China. Other local state subsidies. EVs have a higher chance of gaining a license plate to drive in cities where license plates are rationed.

India	2,140	Many states have reduced VAT rate for electric vehicles.
USA	7,500	Subsidy is offered as an income tax credit. Owners of PHEVs can also claim but size of credit depends on battery capacity. 200,000 vehicles per manufacturer are eligible, before credit phases out gradually. States also offer further incentives (e.g. $1,000-$3,000 in California).

Source: ACEA (2017) *Overview of incentives for buying electric vehicle;* ICCT (2016) *Hybrid and electric vehicles in India;* ICCT (2017) *Adjustment to subsidies for new energy vehicles in China;* ICCT (2016) *Evolution of incentives to sustain the transition to a global electric vehicle fleet.*
Notes: Conversion to US dollars ($) in June 2017.

Ultra-low emission vehicles were identified as an industry where the UK has a competitive advantage in the Industrial Strategy Green Paper.[59] In the 2017 Spring Budget, the Industrial Strategy Challenge Fund allocated £246 million over four years to help UK businesses seize the opportunities presented by the transition to a low-carbon economy, including the design, development and manufacture of batteries for electric vehicles. The UK Government have invested £80 million in a £325 million plant producing electric taxis and work vans near Coventry. From 2018, all new London taxis must have a minimum electric range of 30 miles. Sir Mark Walport (Government Chief Scientific Adviser) is reviewing whether the Government should set up a new research institution to work on battery technology, energy storage and grid technology.

HGV emissions

There is currently no legislation covering CO_2 emissions from HGVs. In May 2017, the EU agreed that truck manufacturers would be obliged to measure their fuel consumption with the VECTO tool, from 2019 onwards.[60] This is designed to increase transparency of fuel and CO_2 efficiency for new trucks, and should be used as the basis for setting new vehicle CO_2 standards in this sector in the future.

Cycling and walking

The Cycling and Walking Investment strategy has set objectives for increasing walking and cycling. Cycling and walking will be measured in stages, where a stage is a section of a trip. This means that cycling or walking to another form of transport will be included, even if they are not the main form of transport. The Government has set the following cycling and walking targets to 2025:

- Doubling cycling activity from 0.8 billion stages in 2013 to 1.6 billion stages in 2025.
- Increasing walking activity to 300 stages per person per year in 2025.

[59] BEIS (2017) *Building our Industrial Strategy: green paper.*
[60] European Commission JRC Technical Reports (2016) *Report on VECTO Technology Simulation Capabilities and Future Outlook.*

- Increasing the percentage of children aged 5 to 10 who usually walk to school from 49% in 2014 to 55% in 2025.

The Government should develop a set of indicators to track progress and assess the impacts on car travel of policies to promote cycling, walking and public transport.

Air quality

The new draft UK Air Quality plan gives responsibility for improving air quality to local authorities and does not specify additional Government plans for action at a national level, making it difficult to assess the impact of the plan on transport GHG emissions.[61] The plan states that diesel vehicles are the largest source of nitrous oxide emissions in the local areas of greatest concern. Diesel cars typically emit less CO_2 than equivalent petrol cars, with new diesel cars in 2016 emitting 3% less CO_2 per km than petrol cars. Actions to combat air quality could result in a consumer shift from diesel to petrol cars, although under the latest Euro 6 standards, the NO_x emissions of petrol and diesel cars are at their lowest ever levels and are approaching parity.[62] Our analysis for the fifth carbon budget suggested that even a large shift away from diesel cars would not have a significant impact on CO_2 emissions provided it is coupled with a longer term shift to electric vehicles. There are options for local authorities to consider that would reduce emissions from transport including:

- Local authorities should consider buying electric vehicles for their fleets and encouraging local transport operators to do the same.
- Adequate charging infrastructure should be installed to encourage the uptake of electric vehicles by private consumers.
- Public transport, cycling, walking, park and ride schemes and car sharing should all be encouraged.

Areas where additional action is required

There are several important areas that current Government policy does not cover and where there are significant risks of under-delivery. These must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets:

- CO_2 intensity standards to 2030 on a real-world basis for new cars (60 gCO_2/km), vans (80 gCO_2/km) and HGVs should be negotiated at an EU-level or introduced for the UK. These should be introduced as soon as possible to provide the motor industry with greater certainty. It is likely the design of new vehicles sold into the UK will continue to comply with future EU standards, but manufacturers could shift to marketing and selling larger, less efficient vehicles in the UK if their UK sales do not count towards the EU target and there is no equivalent UK legislation. This could include fewer electric vehicles, particularly if the supply of these is capacity constrained. Realistic testing procedures should be used to measure compliance with the standard.
- The take-up of electric vehicles needs to accelerate to reach around 9% of market share in 2020 and 60% by 2030 (a mixture of both battery electric vehicles and plug-in hybrid electric vehicles). Although it is now anticipated that electric vehicles will become cost-effective earlier than previously expected due to reductions in battery costs, financial incentives for

[61] Defra (2017) *Improving air quality: reducing nitrogen dioxide in our towns and cities.*
[62] SMMT (2017) *New Car CO_2 Report.*

electric vehicles should continue whilst they remain more expensive than conventional vehicles from a consumer perspective. As an alternative to grant funding, a reform to vehicle taxation with much steeper differentiation bewteen the lowest and higher emitting cars could provide much stronger incentives for both plug-in hybrids and battery electric vehicles. Any phase out of support for upfront costs should be staged and announced as early as possible, so as not to adversely affect the emerging market.

- Fiscal incentives (e.g. Vehicle Excise Duty) should be aligned with CO_2 intensity standards to ensure that they both work to incentivise the purchase of more efficient conventional vehicles and electric vehicles.
- A national publically available charging network must be developed, including both rapid chargers for long inter-urban trips and destination chargers (e.g. at retail locations, public car chargers and park and ride sites). Private investment is likely to continue to expand the network, but public investment may be required in locations that aren't currently commercially viable. A strategy for delivering on-street residential charging infrastructure is required for drivers without access to off-street parking, in order to enable them to choose an electric vehicle.
- The Renewable Transport Fuel Obligation should be increased to 8% of transport fuel demand by energy by 2020, with strong sustainability standards and should be extended to 2030. As this policy was introduced to contribute to the UK's target under the EU Renewable Energy Directive, outside the EU the UK should either adopt targets domestically or develop alternative approaches that deliver equivalent emissions reduction.
- Sustainable travel schemes promoting walking, cycling and public transport should be evaluated and extended if they provide cost effective emissions reductions. National and local policies should be used to reduce car km driven by 5% below the baseline scenario. These policies could include:
  - Investment in cycling, walking and public transport infrastructure
  - Travel planning services and information campaigns
  - Car clubs, which can make it easier for individuals to choose not to own a car
  - Better land-use planning to provide easy access to public transport infrastructure.
- The impact on emissions of funding for new roads and road improvements should be carefully assessed. The Government announced £1.1 billion of investment in local roads and public transport networks in Autumn Statement 2016 and should take action to ensure that this does not lead to increased demand above our recommended trajectory.
- Emissions from road freight should be reduced by training drivers to drive more efficiently, more efficient logistics, retrofitting existing vehicles with fuel saving technologies and shifting to less carbon intensive modes such as rail.

Current and planned policies are aiming to reduce domestic transport emissions from 121 $MtCO_2e$ in 2016 to 110 $MtCO_2e$ in 2030, but have delivery risks and there remains a gap between anticipated emissions and our cost-effective path (Figure 5.13):

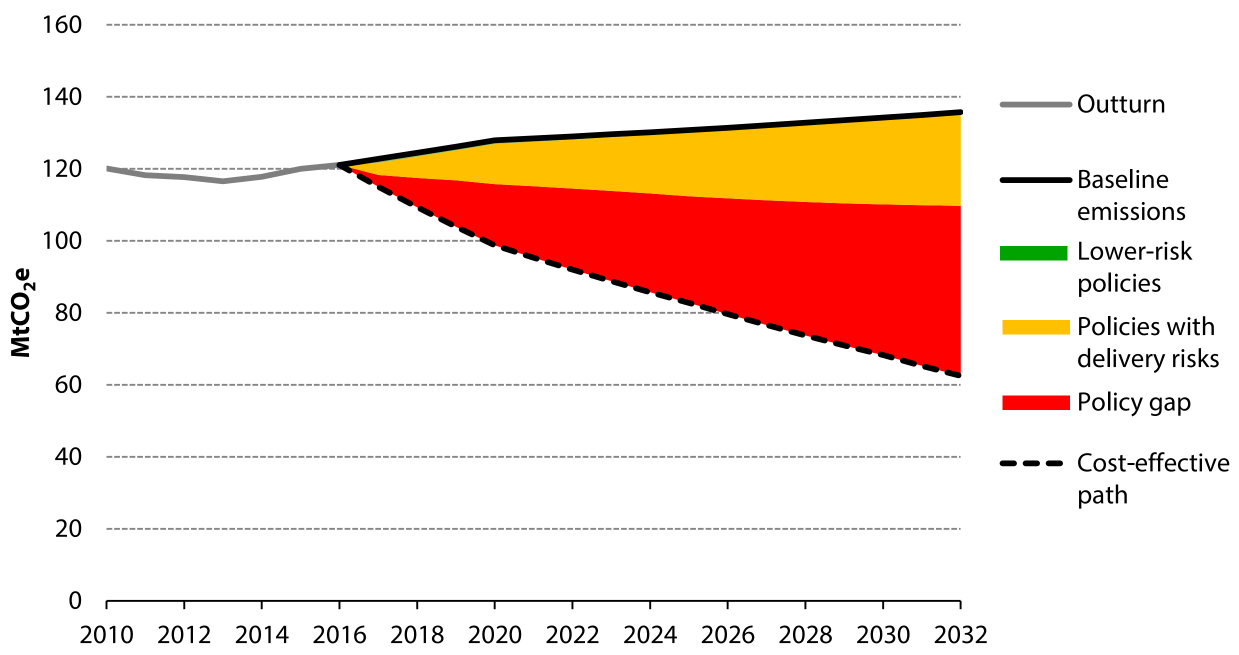
- We identify risks with successful delivery of many of these policies, including car, van and HGV fuel efficiency policies, planned policy to increase the usage of biofuels to 8% of transport fuel by energy by 2020 and rail electrification.

- Even with the delivery of full emissions reductions from announced policies, reductions would fall short of our cost-effective path by around 42 $MtCO_2e$ in 2030, delivering less than 40% of the required abatement.

Our assessment of policies to drive abatement options in the transport sector is shown in Table 5.4.

Until these areas are addressed there will remain a policy gap to the fourth and fifth carbon budgets and therefore the requirements of the Climate Change Act (sections 13 and 14) will remain unmet.

Figure 5.13. The policy gap (2010-2032)



Source: CCC analysis.

Table 5.4. Assessment of policies to drive abatement options in the transport sector

Abatement option		2016 policy		2017 policy assessment and updates	
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 real-world emissions savings will be delivered. VED change reduces incentives to buy lower emitting cars (announced Summer Budget 2015, introduced April 2017).
	After 2020	Red	No EU targets beyond 2020.	Red	EU consulting on targets but uncertain if UK will participate in EU wide target or develop UK specific legislation.
Electric vehicles	Financial Incentives	Amber	Grant funding committed to 2018.	Amber	No longer term plan. VED change reduces incentives to buy electric vehicles (announced Summer Budget 2015, introduced April 2017).
	Infra-structure	Amber	Rapid network on track but lack of strategy for on-street residential charging.	Amber	Rapid charging network growth, but little progress in developing infrastructure for households without off-street parking.
Biofuels increase to 8% by energy		Green	RTFO target at 4.75%. No policy to meet 2020 target.	Amber	Consultation on new RTFO target held in early 2017 but no policy decision on trajectory to meet 2020 target, with limited time remaining to ramp up biofuel supply.
Sustainable travel		Green	Central Government funding for pilot schemes.	Green	Walking and cycling investment strategy published in April 2017, containing targets for increase in uptake.
HGV and freight efficiency		Amber	Industry-led schemes to reduce emissions.	Amber	Freight Carbon review published in February 2017 but little concrete action identified.

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

Chapter 6: Agriculture and land use, land-use change and forestry

Key messages and recommendations

Agricultural greenhouse gas (GHG) emissions were 49 $MtCO_2e$ in 2015, unchanged from the previous year, and represent 10% of UK GHG emissions. The land use, land-use change and forestry sector continued to be a net carbon sink, sequestering 7 $MtCO_2e$ in 2015, but the pace of removals is declining due to the ageing profile of trees. Stronger policies are required to meet England and devolved administration ambition for these sectors to 2020 and beyond.

Our key messages are:

- **Agriculture emissions.** There has been little change in emissions over the past six years and no change in 2015 from the previous year. The share of emissions reached a high of 10% in 2015, reflecting the slow rate of progress in reducing the sector's emissions and the faster pace of decarbonisation in other sectors.
- **Emissions intensity.** Since 2009, there has been no real improvement in the emissions intensity associated with growing crops (CO_2e/crop output), and there was a deterioration in 2015. In contrast, livestock emissions intensity (CO_2e/livestock output) has improved:
  – N_2O intensity of crops increased by 2.7% in 2015 as crop output fell faster than N_2O emissions. The opposite was the case for N_2O livestock intensity which improved by 6%.
  – Methane intensity improved by 2% in 2015 as livestock output increased more than emissions.
- **Indicator framework.** Agriculture non-CO_2 emissions are above our indicators for the second successive year. Emissions are not on track to meet carbon budgets.
- **Land use and forestry emissions.** The amount of net carbon sequestered was broadly unchanged in 2015 at 7$MtCO_2e$. Future sequestration is at risk from the ageing profile of trees and the low level of new tree planting.
- **Progress in developing policies.** Significant gaps remain in establishing an effective policy framework to deliver required emissions reductions in both sectors:
  – Agriculture emissions. The UK agriculture sector is not on track to deliver the agreed level of ambition for a reduction of 3 $MtCO_2e$ in England (4.5 $MtCO_2e$ in the UK) by 2022. Defra has indicated it will not move beyond the voluntary approach to reducing emissions in this period, putting at risk this level of abatement and the cost-effective path to 2030 set out in the fifth carbon budget.
  – Smart Inventory: Uncertainty in current agricultural emissions estimates is high relative to other sectors, making it difficult to assess mitigation options effectively. Defra work in developing the Smart Inventory would significantly improve this, and should be implemented without further delay.
  – Afforestation: England and the devolved administrations have targets for woodland creation which, if achieved, are sufficient to meet our trajectory to 2030. However, progress to date remains short of the ambition and continued efforts are needed to address barriers.
- **Leaving the European Union.** Defra and the devolved administrations must consider what replaces the Common Agricultural Policy (CAP) once the UK leaves the EU. The current CAP should be replaced with a UK based policy framework that links support more closely to the reduction of emissions and increase in sequestration in agriculture, forestry and other land use sectors.

Key messages and recommendations

We will assess the Government's plan for meeting the gap in the fourth and fifth carbon budgets against the following checklist (Table 6.1):

Table 6.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

Agriculture emissions to fall by 17% between 2015 and 2030, and afforestation rates to deliver 15,000 hectares a year. This will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
A stronger policy framework for agriculture emissions reduction across all nations to 2022, as current progress is not on track.	✗	✗	
The new 'Smart' inventory for agriculture to be introduced in 2018, to enable better monitoring of progress in reducing emissions including assessment of mitigation options.	✗		
New policies and measures required to deliver emissions reductions in agriculture and afforestation to 2030 that moves beyond the current voluntary approach, and with CAP replaced, from 2020, by a policy that links support more closely to the reduction and removal of emissions in agriculture, forestry and other land use sectors.		✗	✗
Addressing financial and non-financial barriers to increase afforestation rates and on-farm tree planting schemes.	✗	✗	

Source: CCC analysis.

Introduction

In this chapter we assess current trends in agriculture and land use sector emissions and review progress towards meeting carbon budgets. We outline policy priorities needed to deliver the cost-effective level of abatement identified in these sectors to 2030, and the opportunities that these present in adapting to climate change.

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

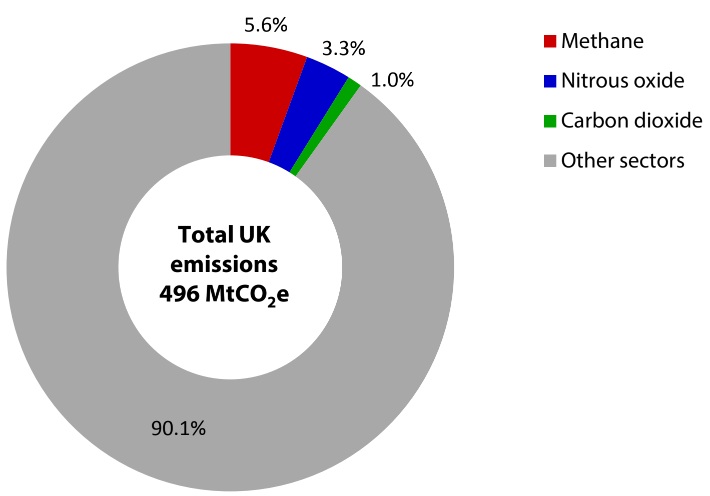
1. Agriculture emissions trends and drivers
2. Progress in reducing emissions in agriculture
3. Policy progress towards the fourth and fifth carbon budgets
4. The land use, land-use change and forestry (LULUCF) sector

1. Agriculture emissions trends and drivers

Emissions trends

Agricultural GHG emissions were 49 $MtCO_2e$ in 2015[63], unchanged from the previous year. The sector's share of UK GHG emissions reached a high of 10%, which reflects both the slow rate of progress in reducing the sector's emissions, and the faster pace of decarbonisation elsewhere in the economy. Most emissions (56%) are methane, 33% are nitrous oxide (N_2O) mainly from soils and 10% are carbon dioxide (CO_2) from mobile and stationary machinery (Figure 6.1). Although over the longer term emissions in this sector have been declining, since 2009, emissions across all main gases and sources have increased, and overall GHG emissions have risen by an annual average of 0.3% (Figure 6.2). This trend needs to be reversed to deliver the cost-effective reduction in emissions of 17% from 2015 to 2030.

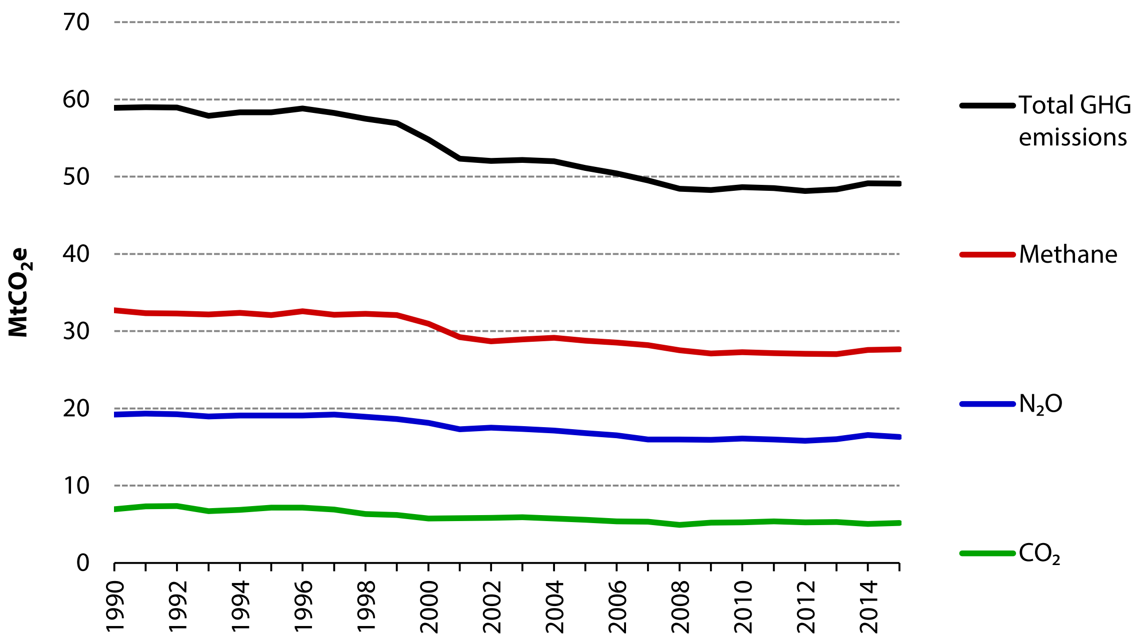
Figure 6.1. GHG emissions from agriculture as a share of UK emissions (2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*

[63] The dominance of non-CO_2 emissions in agriculture means we are only able to report on 2015 emissions because of the lag in reporting non-CO_2 data.

Figure 6.2. Agriculture emissions by GHG (1990-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*

A breakdown of emissions in 2015 by gas and source shows slight changes compared to the previous year and from 2009 (Figure 6.3). Absolute changes in this sector are not large and may not be statistically significant given the relatively high uncertainty in this sector (14%[64]):

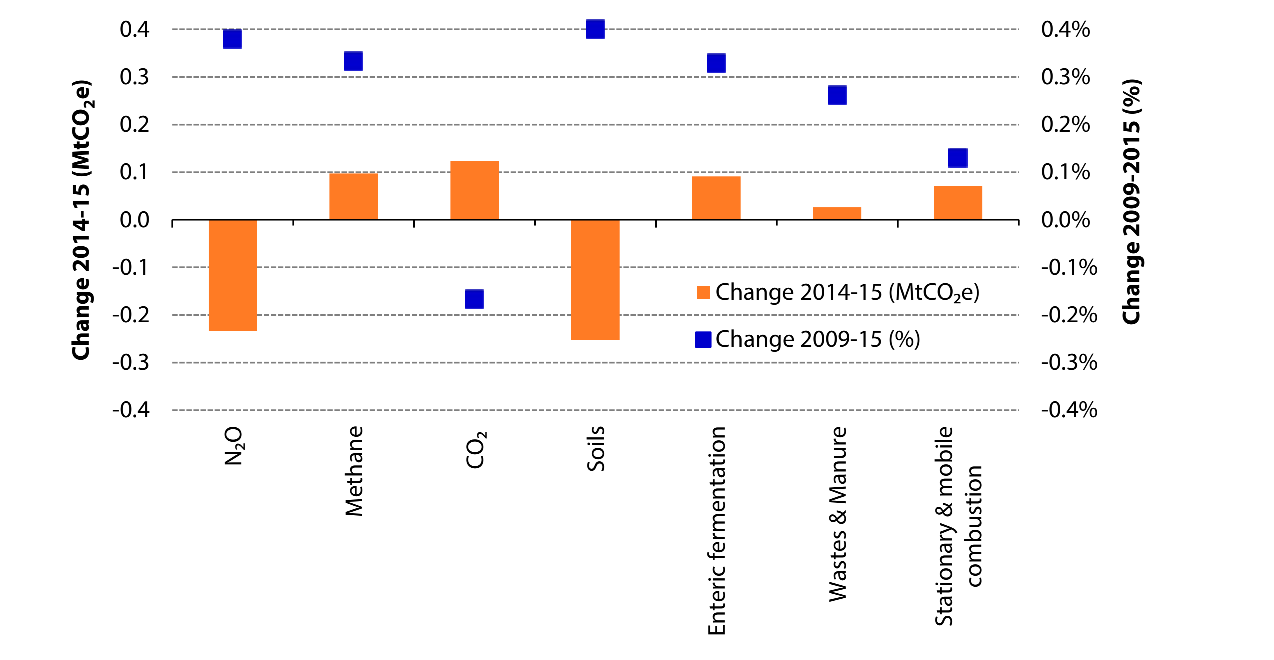
- The largest change was a fall in N_2O emissions of -0.2 $MtCO_2e$ in 2015. These emissions are mainly due to agricultural soils and emissions from this source also declined by a similar amount.
- Methane emissions increased by 0.1 $MtCO_2e$ due to rising emissions from enteric fermentation and waste and manure management.
- CO_2 from combustion and the application of lime and urea to soils rose by 0.1 $MtCO_2e$.

As annual changes can be affected by weather and other one-off factors, changes over a longer period are more indicative of trends in the sector. Since 2009, N_2O and methane emissions have increased by an annual average of 0.4% and 0.3% respectively, as have most sources related to these emissions - soils, enteric fermentation and manure management. Since 2009 CO_2 emissions have decreased by an annual average of -0.2%, largely due to reductions in lime and urea applied to land.

In the next section we discuss the drivers of changes of emissions.

[64] At the 95% confidence level.

Figure 6.3. Changes in GHG emissions from agriculture by gas and source in 2015 and 2009-2015



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*
Note: % change 2009-2015 is on an annual average basis.

Estimating emissions in the agriculture sector is subject to more uncertainty than most other sectors of the economy due to the complexity inherent in biological processes[65]. While ongoing improvements to the methodology under the GHG Research Platform have been made, Defra must ensure that the new Smart Inventory is rolled-out next year. The new inventory will reduce uncertainty and enable better monitoring of progress in meeting carbon budgets and farming practices that reduce emissions in this sector.

Emissions drivers

Nitrous oxide

The vast majority of N_2O emissions are from agricultural soils, two-thirds of which are from fertiliser application and crop residues. N_2O emissions decreased by 1.8% in 2015 due to a reduction in inorganic fertiliser use. This is against the longer term trend where N_2O emissions increased by an annual average of 0.4% since 2009:

- Emissions from inorganic fertiliser declined by 5.4% in 2015 as usage on grasslands decreased by 6%, while rates remained unchanged on arable land.
- Other sources of N_2O emissions such as incorporation of crop residues into soils and application of sewage sludge were largely unchanged.
- The longer term trends are not consistent with this pattern. Since 2009, crop-related N_2O emissions have risen by 0.8% on an average annual basis, while those on grasslands have declined by 0.2%. This is largely due to increases in inorganic fertiliser use on crops and decreases on grasslands.

[65] CCC (2017) *Quantifying Greenhouse Gas Emissions.*

The different pattern of fertiliser use on cropland and grasslands largely explains an improvement in N_2O emissions intensity on grasslands but not on cropland. This is explored in more detail in the next section.

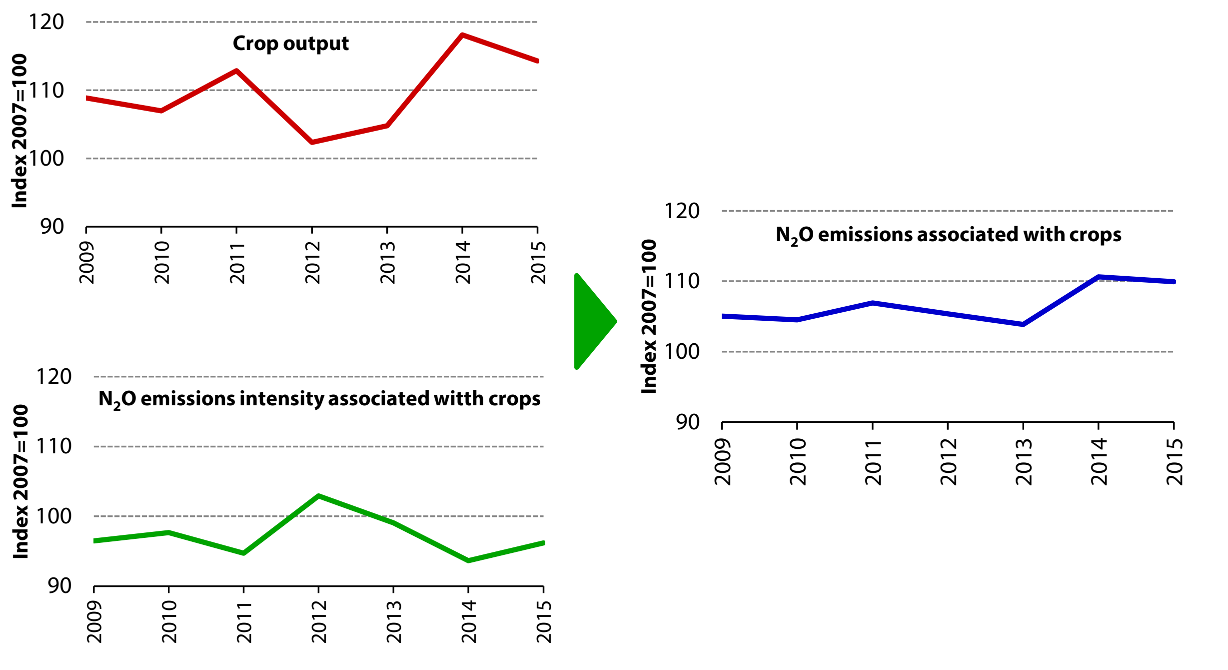
Crops

Emissions and emissions intensity of crops have shown no real improvement since 2009, as a 5% increase in crop output has been almost matched by an increase in fertiliser use. In 2015 N_2O emissions associated with growing crops fell but output reduced further, leading to an increase in the emissions intensity of crops (Figure 6.4):

- Following record yields in 2014, crop output fell back in 2015 by 3%. However, levels still remained high when compared to most of the period since 2009.
- N_2O emissions associated with growing crops decreased by around 0.5%. This can be attributed to a 1% decline in the total area of land planted with arable crops and an unchanged application rate of inorganic fertiliser which combined to reduce total nitrogen use.

With crop output declining at a faster rate than associated emissions, the N_2O emissions intensity of crop output increased by 2.7% in 2015.

Figure 6.4. Crop output, N_2O emissions associated with crops and emissions intensity of output (2009-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* Defra (2016) *Agriculture in the UK*, and CCC calculations.

An effective nutrient management plan can help minimise emissions from crop production as well as deliver other benefits such as reducing diffuse water pollution and improving biodiversity which are also important for adapting to climate change. According to survey data[66]:

- In 2015, the proportions of cereal and other crop holdings in England with a nutrient management plan were high at 88% and 83% respectively. While these are slightly higher than the previous year, these proportions have been in the 80-85% range since 2011.
- There was mixed reporting of the proportion of holdings taking action to reduce GHG emissions, with a rise among cereal farms and a decrease for other crop holdings in 2015.
- For those taking action to reduce emissions, there was also a clear association with farmers believing this was best business practice and improved profitability.

The data indicate that there is limited scope to further roll-out nutrient management plans and that other measures will be needed to reduce crop-related N_2O emissions.

Livestock

In contrast to the increase in crop-based emissions, N_2O emissions associated with livestock have fallen by 1% since 2009. This has been associated with an 11% increase in output and a similar improvement in intensity (Figure 6.5).

This improvement continued in 2015, with the N_2O emissions intensity of livestock products down by almost 6%:

- Livestock output increased for the third successive year, with levels up 2.5% in 2015. Output increased across all meat and non-meat products. For example, milk output reached a 30 year high in 2015, as the dairy herd increased by 2% and average milk yields by 1%, to 7,994 litres per dairy cow.
- N_2O emissions associated with livestock declined by 3.6% as the application rate of inorganic fertiliser on grassland fell by 7%. This more than offset the much smaller increase in emissions from grazing returns due to the increase in cattle numbers.

There remains scope to further reduce fertiliser related emissions in the livestock sector. For example:

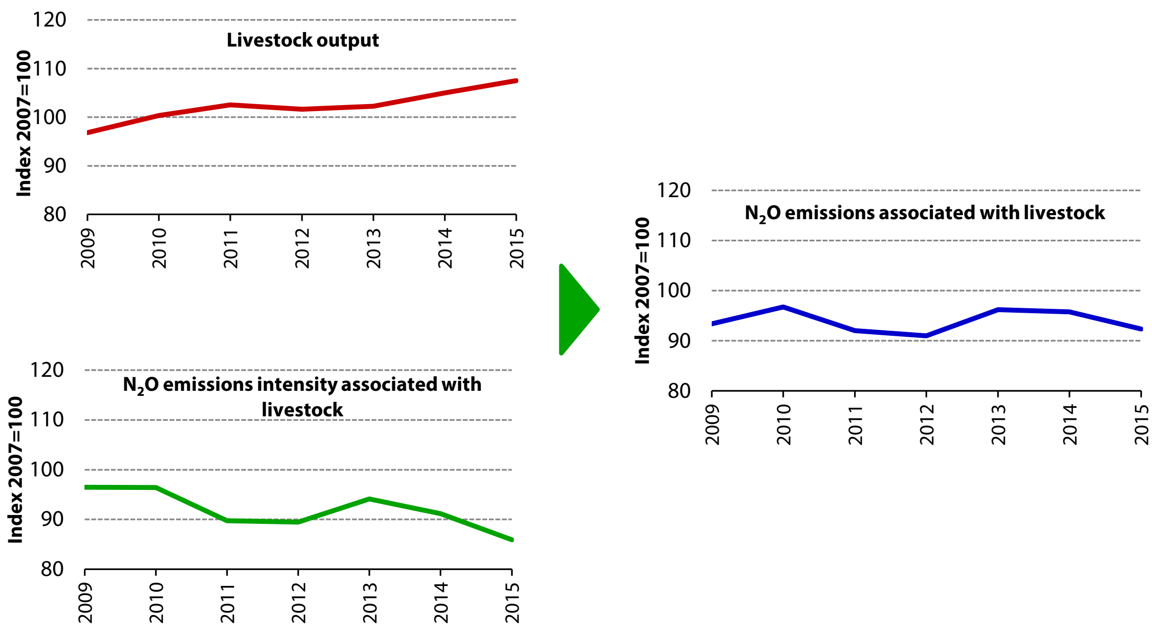
- Only 30% of grazing livestock farmers in England reported possessing a crop nutrient management plan from an accredited FACTS[67] advisor, compared to around 90% of arable farmers.
- Of those who responded to the 2015 Farm Practices Survey, those holding a nutrient management plan only covered 43% of the land area for grazing livestock in the lowlands.
- Planting clover mix on grasslands can help fix nitrogen in soils, but in 2015 the proportion of temporary grasslands holdings using a clover mix reduced from 78% to 74%.

The industry's Greenhouse Gas Action Plan (GHG Action Plan) should consider how barriers to uptake amongst livestock farmers can be addressed so that they can better manage their fertiliser requirements. For example, over 1,000 plus Feed Advisers (on the Feed Adviser

[66] Defra (2015) *Farm Practices Survey*.
[67] Fertiliser Advisers Certification and Training Scheme (FACTS).

Register) are engaging with livestock farmers - who aren't necessarily being reached by FACTS advisers - in order to boost their knowledge on improving grass and forage nutrient management efficiencies.

Figure 6.5. Livestock output, N_2O emissions associated with livestock and emissions intensity of output (2009-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* Defra (2016) *Agriculture in the UK*, and CCC calculations.

Methane

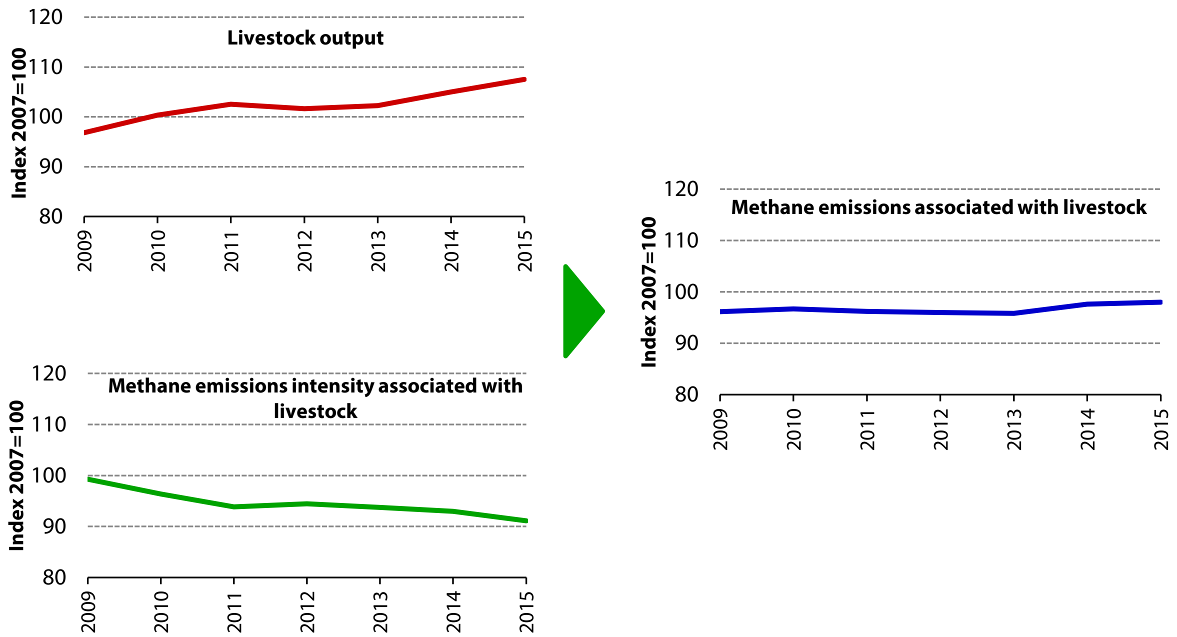
Enteric fermentation arising from the digestive process of ruminants (e.g. cattle and sheep), and the management of livestock waste and manures account for almost all of the methane emitted in agriculture. Cattle accounted for 79% of methane emissions and sheep 16% in 2015.

Since 2009, methane emissions have increased by 2% but output increased by 11% leading to a reduction in emissions intensity of 8%. Intensity continued to improve in 2015 as productivity improved (Figure 6.6):

- Livestock output rose by 2.5% in 2015, and was accompanied by productivity gains as measured by milk yields, and average dressed carcase weights (the latter up 1.6% for steers and heifers and 1% for clean sheep).
- Methane emissions increased by 0.4% due primarily to a 2% increase in the beef and dairy herd, which more than offset a 1% decline in sheep numbers.

These factors combined to improve methane intensity of livestock in 2015 by 2%, continuing the longer term de-coupling of output and emissions.

Figure 6.6. Livestock output, methane emissions associated with livestock and emissions intensity of output (2009-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* Defra (2016) *Agriculture in the UK,* and CCC calculations.

The improvement in methane intensity has been achieved despite other indicators associated with livestock performance showing little change since 2011. Of those that responded to the England Farm Practices Survey:

- 71% of farmers had a Health Plan in 2015, unchanged since 2011.
- 73% had a ration formulation programme or expert nutritional advice, slightly lower than 2011.
- The proportion of farms using high Profitable Lifetime Index (PLI) when breeding cows and Estimated Breeding Values (EBVs) to estimate genetic traits in meat production remained broadly unchanged since 2011.

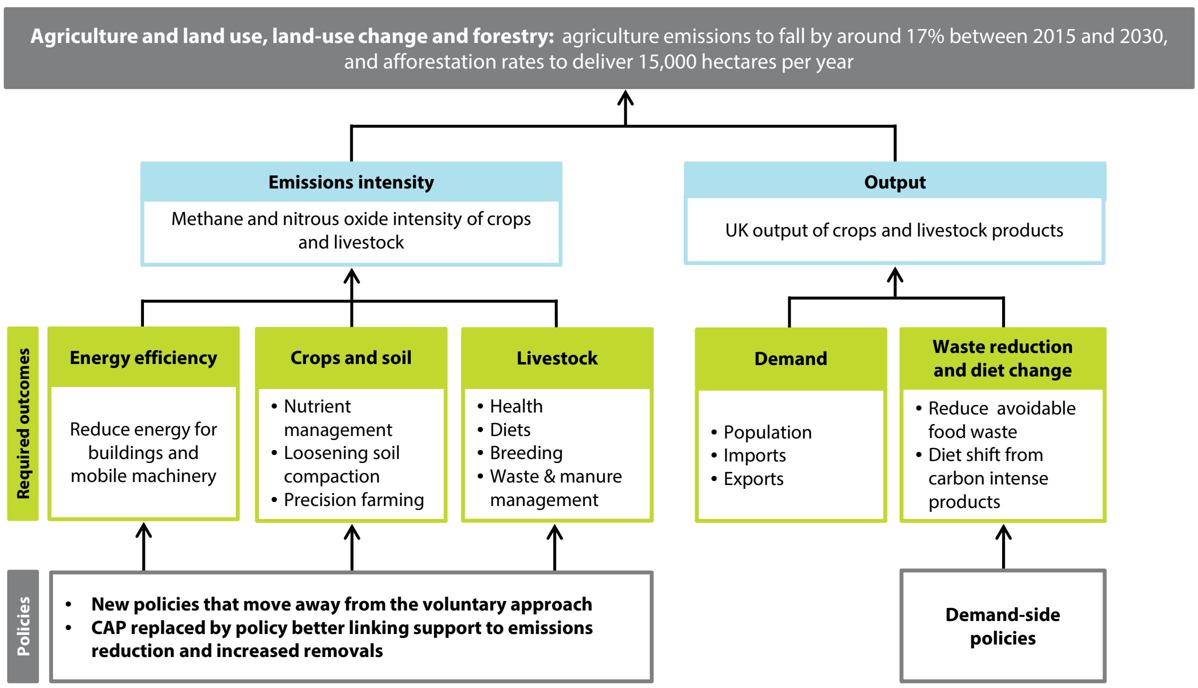
Despite this, the de-coupling of methane emissions from output suggests that emissions intensity of livestock has been reduced at the same time as increasing output and productivity as measured by higher average dressed carcase weights for meat and milk yields. However productivity gains do not always translate into overall emissions reduction if for example, livestock numbers increase.

Going forward deeper reductions in agricultural emissions will be required to meet future carbon budgets which imply an 18% reduction in GHG emissions compared to 2015, equivalent to a 1.3% annual reduction between 2015 and 2030. Our analysis for the fifth carbon budget identified a range of on-farm measures that could deliver this cost-effectively. The measures target both non-CO_2 and CO_2 emissions from soils, livestock, waste and manure management, and machinery, saving an estimated 7.3 $MtCO_2e$[68] by 2030.

Figure 6.7 provides an indication of the range of indicators we could use to track progress to 2030. The CCC indicators will be updated as part of next year's Progress Report in light of the launch of the new Smart Inventory, which will include different farming practices that influence emissions.

While our central scenario for the fifth carbon budget does not include abatement from demand-side measures by 2030, we note that diet change and reducing food waste will be needed to deliver deeper cuts in agricultural emissions beyond 2030. Therefore consideration of these options before 2030 will be required in order to prepare for their implementation.

Figure 6.7. CCC indicators for the agriculture sector



Source: CCC analysis.
Note: Values for the indicators will be developed next year once the new Smart Inventory data becomes available.

[68] This has been downscaled from our original assessment to take account of inventory improvements in measuring N_2O emissions introduced in 2016. This had the effect of reducing N_2O emissions in the sector, and therefore the abatement potential.

2. Progress in reducing emissions in agriculture

Defra has set an ambition for reducing non-CO_2 emissions in the agriculture sector in England by 3 $MtCO_2e$ by 2022 from 2007 levels, which scales up to 4.5 $MtCO_2e$ for the UK. In order to track progress against this ambition, we set indicators for total non-CO_2 emissions, and trajectories for reducing emissions by gas and source.

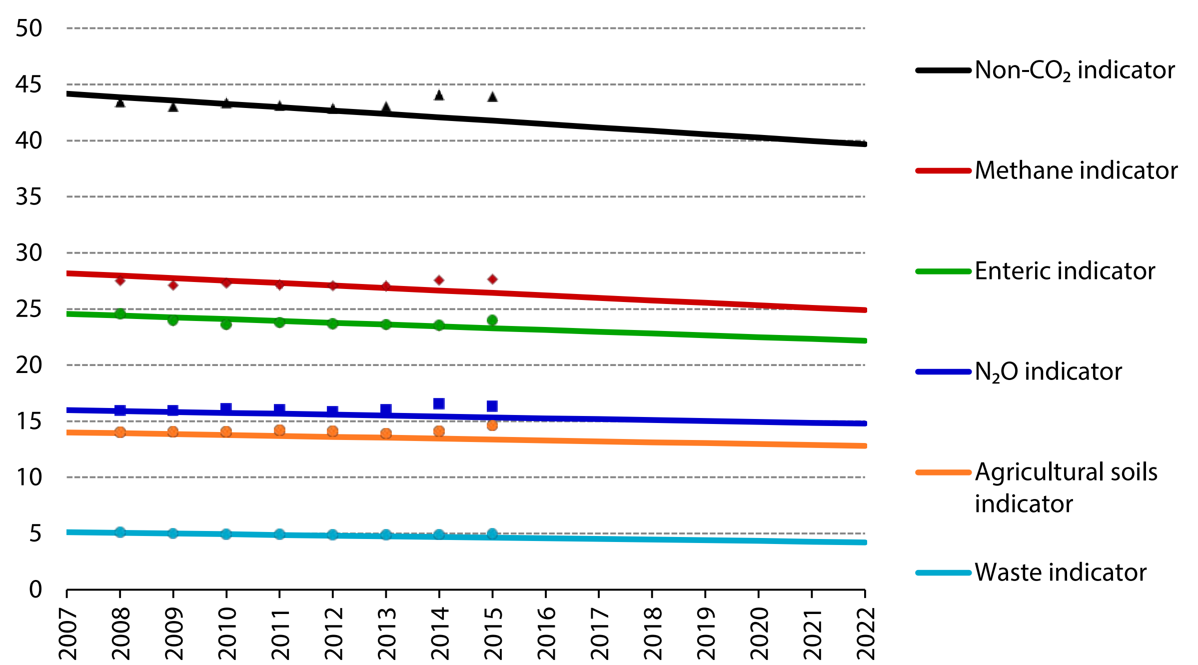
Agricultural emissions in 2015 were not on track against the trajectories (Figure 6.8):

- Emissions for all three sources: enteric fermentation, agricultural soils and wastes are off-track. Soils have the largest discrepancy, with emissions 9% higher than the trajectory in 2015.
- The indicators by gas show that both methane and N_2O emissions are well above the indicator (6% and 5% respectively in 2015) and not in line with meeting the longer-term cost-effective path in this sector.

Overall, our assessment for 2015 suggests that agricultural emissions are off track against our indicators. We do not judge this to be a temporary trend as emissions have been off-track for a few years. A continuation of this trend would have serious consequences for meeting carbon budgets and greater effort is now required to close the gap to ensure the 4.5 $MtCO_2e$ ambition is met. To achieve this will require annual emissions reduction of 1.5% to 2022.

The launch of the new Smart Inventory next year will enable better monitoring of progress, and will allow us to update and extend our indicators to align with our fifth carbon budget trajectory.

Figure 6.8. Progress against the CCC indicators for agriculture to the end of the third budget period



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015,* and CCC calculations.
Note: Marker points indicate outturn data.

Government review of the GHG Action Plan (2017)

Agricultural policy is a devolved matter. The Government's ambition for a 3 $MtCO_2$ reduction in non-CO_2 emissions in England between 2007 and 2022 is being delivered through a voluntary, industry-led approach as set out in the Greenhouse Gas Action Plan (GHG Action Plan).

Defra published a review[69] of the Plan's progress in reducing emissions earlier this year. The review represents the Government's long standing commitment to assess the current voluntary approach to reduce emissions, and represents a follow-up to its first review published in 2012.

The current review assessed the effectiveness of the Plan between 2012 and 2016. It concluded that while a good level of progress in reducing emissions had been made, the pace of reductions needs to ramp-up in order to meet the ambition of 3 $MtCO_2e$ of abatement by 2022:

- Using survey data and the industry's own progress report to assess the uptake of mitigation measures covered by the Plan, Defra estimates that 1 $MtCO_2e$ of annual abatement had been delivered by 2016. Soil nutrient management was found to have delivered just under half of this abatement.
- Looking ahead, further uptake of these measures plus the identification and deployment of new measures are needed to meet the ambition by 2022.

Defra has indicated it will not move beyond the voluntary approach to reducing emissions to 2022. Our assessment is that this approach is unlikely to deliver the level of abatement set out in the GHG Action Plan. Whilst at an economy-wide level the third carbon budget (to 2022) is likely to be met, under-delivery of abatement in agriculture will undermine future carbon budgets as this sector forms an increasing share of remaining emissions. Actions needed for the fourth and fifth carbon budgets are set out in section 3.

3. Policy progress towards the fourth and fifth carbon budgets

In its review of the GHG Action Plan, Defra acknowledged that a ramp-up in abatement in agriculture is required in the 2020s and beyond. Measures cited as possible options included the development of new agri-technologies, novel production systems and innovative food products.

However, in order to deliver these types of approaches, and the type of abatement measures we set out in our fifth carbon budget advice, effective policy must move beyond the current voluntary approach that is largely based on the provision of advice and information. As yet no policy announcement to reduce agricultural emissions post-2022 has been made, which means there are significant risks of under-delivery (Table 6.2). This must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets.

As part of this, Defra and the devolved administrations must consider what replaces the Common Agricultural Policy (CAP) once the UK leaves the EU[70]. Any replacement of CAP with a UK based policy framework should link farming support more closely to the reduction of emissions in agriculture.

Until this is addressed there will remain a policy gap to the fourth and fifth carbon budgets (Figure 6.9), and the 17% emissions reduction required to meet the cost-effective path between 2015 and 2030 will not be met.

[69] Defra (2017) *The Greenhouse Gas Action Plan for Agriculture, Review 2016*.
[70] The Government has guaranteed CAP payments until 2020, which is when the current CAP ends.

We would expect Government plans to address all the areas set out above and set clear timelines for the development and implementation of policies that remain at the proposal stage. We will publish our assessment of the Government's proposals subsequent to their publication.

Table 6.2. Assessment of policies to drive abatement options in agriculture

Abatement option	2016 policy		2017 policy assessment and updates	
GHG Action Plan – to 2022	Amber	Some measures being delivered but unable to fully assess.	Amber	In its review of the GHG Action Plan, Defra stated it would not introduce new 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.	Red	No policy.

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

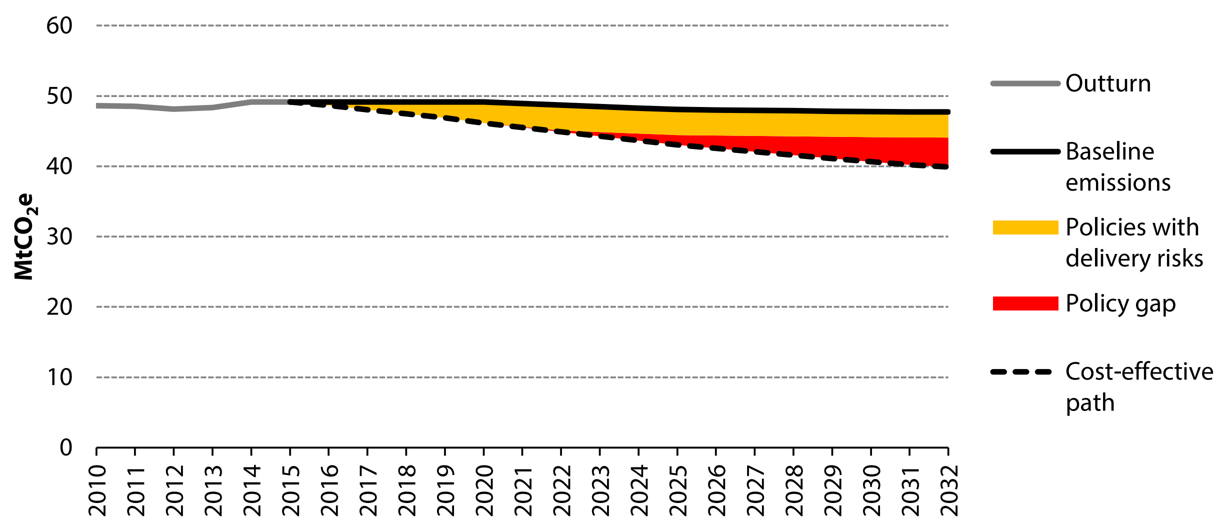
In this year's Scottish draft Climate Change Plan[71], which sets out proposals and policies to meet targets to 2032, the Scottish Government highlighted the lack of progress in reducing emissions in agriculture to date. The Plan includes the following proposals:

- By 2020, to work with farmers to increase awareness about soil pH testing and to complete carbon audits, both of which can deliver reduced emissions and increased profitability.
- By 2030, raise knowledge and awareness amongst farmers on the nutrient value of improved soil and implementing best practice in nutrient management and application.

The Committee will comment on the draft Plan in our progress report on Scottish climate change mitigation later this year.

[71] Scottish Government (2017), '*Draft Climate Change Plan: The draft third report on policies and proposals 2017-2032*'.

Figure 6.9. The Policy Gap in agriculture (2010-2032)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* BEIS (2017) *Updated Energy and Emissions Projections 2016*, and CCC calculations.
Notes: Estimated N_2O abatement has been scaled down to take account of the revised methodology for calculating N_2O in 2016 inventory and methane abatement downscaled to take account of the removal of the Dairy Growth Plan from the baseline projections.

4. The land use, land-use change and forestry (LULUCF) sector

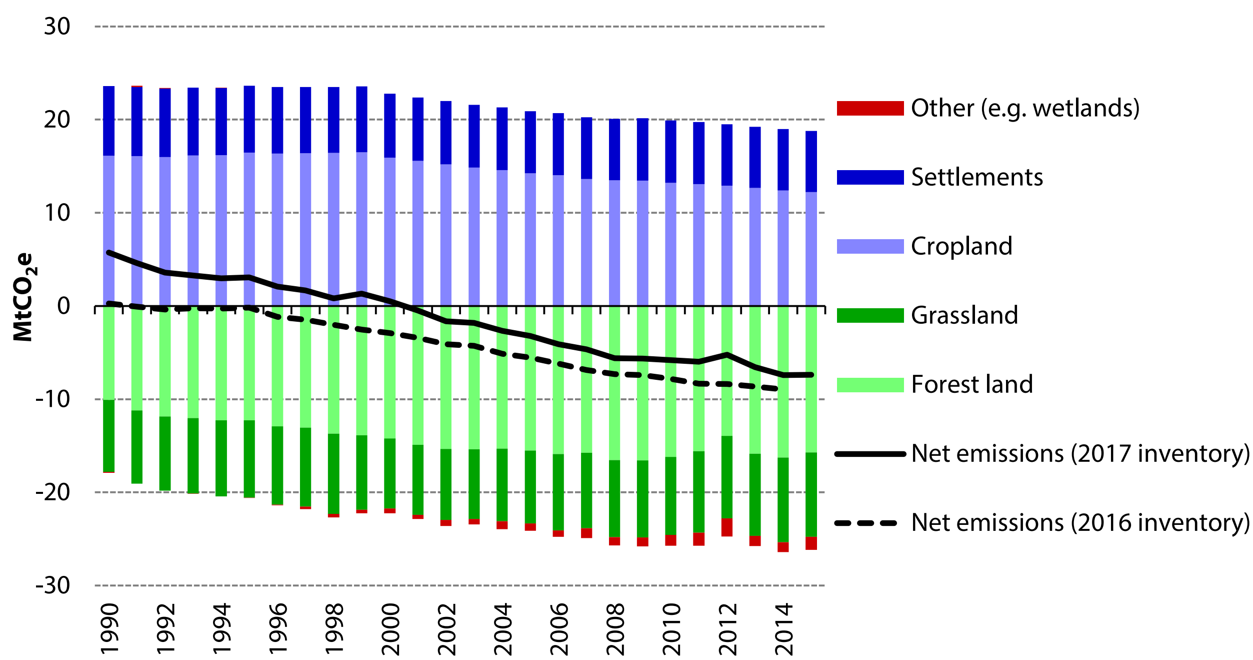
Emissions trends

The use and change in use of different land types in the UK both sequesters carbon and releases GHG emissions. The main land categories are cropland, forestry, grassland, wetlands and settlements. The sector is currently a net sink which sequestered 7 $MtCO_2e$ in 2015, largely unchanged from the previous year. There has been a weakening in CO_2 sequestration from forests in 2015 due to the age profile of trees, which has not been offset by new tree planting. This could affect future sequestration in the sector and reverse the longer-term trend from 1990 of an increased net sink (Figure 6.10).

The 2017 inventory has been significantly revised since last year, resulting in an upward shift in net emissions across all years:

- Net emissions are now higher in all years since 1990 (for example, 5.5 $MtCO_2e$ and 3.2 $MtCO_2e$ higher in 1990 and 2014 respectively when comparing the 2016 and 2017 national inventories).
- The sector became a net sink of emissions much later than previously estimated, in 2000 rather than 1991.

Figure 6.10. LULUCF emissions and removals (1990-2015)



Source: BEIS (2017), *Final UK greenhouse gas emissions national statistics 1990-2015,* DECC (2016), *2014 UK Greenhouse Gas Emissions, final figures.*

These changes are largely due to inventory improvements in the reporting of net emissions on forest land:

- A revision to estimates of the forest land area in Great Britain that is larger than 0.5 hectares, based on the National Forest Inventory (NFI) dataset.[72] This has replaced the National Inventory of Woodland and Trees used in previous inventories, which was found to have under-estimated both the forest area and the numbers of trees.
- Estimates of small woods of between 0.1 and 0.5 hectares in size are incorporated for the first time, following an assessment by the Forestry Commission.[73] These small woods cover an estimated 390,000 hectares in Great Britain and represent about 10% of total woodland area.

The net result of these two improvements is an increase in total estimated forested area and therefore carbon removals.

There was a further change in the inventory to include a new soil carbon module for forested land.[74] The impact of this is to take account of changes in carbon from soils and litter when new trees are planted. However, the methodology for estimating the carbon in litter is still being developed and it is likely that the level of sequestration of newly forested land is currently underestimated. This will be addressed in next year's inventory.

[72] https://www.forestry.gov.uk/inventory
[73] Forestry Commission (2017), *Tree cover outside woodland in Great Britain*.
[74] A new soil carbon module has been incorporated into the woodland accounting model, Carbine, developed by Forest Research.

While these and other minor changes have reduced the range of uncertainty in estimating LULUCF emissions from ± 7.4 $MtCO_2e$ in 2014 estimates to ±6.4 $MtCO_2e$ in this year's inventory, it still remains the most uncertain of all sectors in the national inventory (86% at a 95% confidence level). This is because of the sector's complex biological processes.

In a recent report[75] we highlighted the need to prioritise inventory improvements in the sectors with the highest uncertainty. Work by BEIS is underway to develop a more accurate and repeatable way to track land-use change in a spatially-explicit way. This should not only help to improve GHG emissions estimates in this sector, but is also needed for the analysis of land-use and how this relates to resilience impacts.

Progress in reducing net emissions and policy progress towards the fourth and fifth carbon budget

A range of options can increase carbon sequestration and reduce the release of emissions in this sector. For our fifth carbon budget abatement estimates, these options focus on the planting of more trees.

Forestry

New tree planting has fallen in recent decades, down by 85% in 2010 compared to levels in 1989. We have previously recommended that the rate of tree planting in the UK should be increased by an additional 15,000 hectares annually between 2015 and 2030 in order to deliver 1.8 $MtCO_2e$[76] of savings by 2030.

England and the DAs have all set out plans to increase woodland cover which, if achieved, would meet our recommendation. Progress to date however, has been short of the ambition, with UK tree planting levels reaching only 5,500 and 6,400 hectares in the years to end March 2016 and 2017 respectively. This represents a sharp decline on the 10,300 hectares achieved in 2015 and partly reflects the slow take-up of the new Rural Development Programme (RDP), which started in 2015.

This slow-down has been particularly acute in England. In the last two years, tree planting rates have slumped due to the low uptake of funding available under the RDP's Countryside Stewardship (CS) scheme, the main source of public funding and the lack of traction with the new Woodland Carbon Fund:

- **The Countryside Stewardship scheme.** Tree planting has fallen sharply under the first two years of the new RDP[77] from 1,782 hectares in 2014[78] (under the previous RDP) to just 546 hectares in 2015 and 525 hectares in 2016. This large decline is attributed to the more onerous process of applying for funding under the current CS scheme, which has resulted in interested parties dropping out of the application process. The recent enquiry by the Environment, Food and Rural Affairs (EFRA) Committee on the role of Defra in supporting the forest economy[79] concluded that the CS scheme was 'not fit for purpose', citing the 'complex and overly bureaucratic' grant application process as a key barrier to increasing woodland

[75] CCC (2017) *Quantifying Greenhouse Gas Emissions*.
[76] Level of abatement as estimated in the CCC's fifth carbon budget report. This abatement level has not been scaled to take account of our scaling of BEIS' 2016 emissions projections (see Figure 6.11).
[77] Under the RDP, woodland creation is funded by the English Woodland Grant Scheme and Countryside Stewardship.
[78] Financial year.
[79] EFRA (2017) *Forestry in England: Seeing the wood for the trees.*

cover. They called for a return to a one-stop shop for forestry grants in order to simplify the process.

- **The Woodland Carbon Fund.** The 2015 Spending Review promised £19 million for woodland creation until 2020. Launched in November 2016, take-up has been slow as reflected by the number of applications to date. Potential applicants may be deterred from applying as the Fund only provides capital funding for the cost and planting of trees, but not ongoing maintenance, unlike the CS scheme.

We recommend that Defra addresses these issues as soon as possible in order to ensure that its ambition to increase woodland cover to 12% by 2060 is not further obstructed.

Integrating trees and shrubs in agricultural production (Agroforestry)

In our advice on the fifth carbon budget, we use the term agroforestry to mean the integration of trees or shrubs into a sustainable production system on arable land and grasslands. Our scenarios focus on a relatively low level of uptake to achieve some low-cost abatement between now and the fifth carbon budget. The extent of this uptake will depend on the development of measures to address current financial and non-financial barriers. In future work, we will consider whether more cost-effective abatement opportunities exist for agroforestry in the UK.

Our fifth carbon budget estimates include 0.6 $MtCO_2e$ of abatement in 2030. Our estimates only include the carbon benefits of growing trees and do not take account of other potential benefits such as the reduction of N_2O emissions through reduced fertiliser use. The level of savings included in our assessment corresponds to around an additional 0.6% of UK agricultural land area on top of the 1% of land that is currently used for hedgerows and shelter belts. This serves as a useful proxy for broader agroforestry activities in the absence of any official estimates.

We have previously cited the lack of information for land owners and managers about integrating trees and shrubs onto agricultural land and the associated benefits as key barriers to uptake. Defra is conducting a review of agroforestry, which is considering the evidence base, the barriers to uptake and how it could operate within the RDP. It will be helpful for this to be published as soon as possible. While agroforestry benefits have been recognised at the EU level, and farmers in some member states such as Scotland and Wales are able to receive funding under Pillar II of the CAP to plant trees, and receive subsidy payments, farmers in England are not able to do so.

In its draft Climate Change Plan[80], the Scottish Government is looking to develop policy to increase trees and hedgerows planted on agricultural land. Suggested mechanisms to increase planting include payment for carbon sequestration and the setting of woodland targets on agricultural land. The Committee will consider the draft Plan in our progress report on Scottish climate change mitigation later this year.

In addition to planting more trees for carbon sequestration, there are benefits to adapting to climate change such as alleviating the risk of downstream flooding. The CCC's Adaptation Sub-Committee's (ASC) progress report[81], also notes that planting a more diverse set of trees species is important as an adaptation strategy to improve resilience from the threats of pests and diseases.

[80] Scottish Government (2017), '*Draft Climate Change Plan: The draft third report on policies and proposals 2017-2032'*.
[81] ASC (2017) *Progress in preparing for climate change: 2017 Report to Parliament*.

Peatland

Action is required to reduce carbon losses from degraded peat, albeit this is not included in our carbon budget estimates. We await the results of work by the Government to better quantify emissions estimates from both upland and lowland peat. This work will feed into next year's national GHG inventory, which will provide a full account of all sources of peatland emissions.

Having established the baseline level of emissions, the next step will be to assess the abatement potential from restoration that could eventually contribute towards future carbon budgets. Data on peatland emissions in the lowlands should help inform how sustainable management practices can reduce degradation on cultivated soils. A current project (SEFLOS[82]) being led by Bangor University will assess the scope for a range of practices such as seasonal management of the water table and the use of cover crops to reduce GHG emissions and soil loss in the Fens. The project is expected to complete next year.

In the meantime, a further £10 million of capital grants[83] will be made available for peatland restoration in England between 2018 and 2021. Although details are yet to be finalised, funding in the form of a grant scheme is expected to support practical restoration initiatives and reducing emissions will be a key criteria in the assessment of bids. This £10 million follows an earlier £4 million of capital grants that is already funding restoration run by Natural England.

In addition to the carbon benefits of restoring peatlands, there are positive links to efforts to adapt to climate change. These include enhancing water and soil quality as well as improving biodiversity. Recommendations set out in the ASC's 2017 Progress Report call on Defra to set out proposals to reverse the ongoing loss of lowland peat soils by 2019, and to target the restoration of all designated upland blanket bog habitats to good condition by 2030.

Policy progress towards the fourth and fifth carbon budgets

The cost-effective path set out in our fifth carbon budget included emissions savings of 2.4 $MtCO_2e$ by 2030 from additional tree planting, including some on agricultural land. However, policies to deliver this abatement are currently not delivering or are absent (Table 6.3). Therefore, policies to deliver these saving must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets. This should include replacement of CAP with a policy framework that links support more closely to the reduction and removal of emissions in forestry, peatland and other land use sectors by 2020. Until this happens, there are delivery and policy risks attached to the 2.4 $MtCO_2e$ of savings (Figure 6.11).

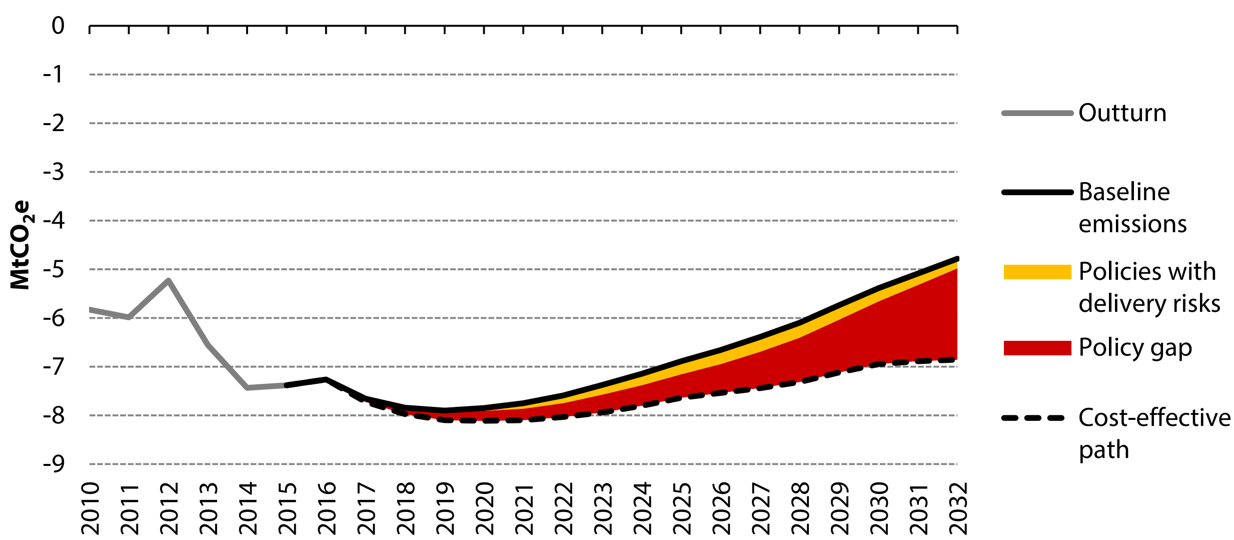
[82] SEFLOS (Securing long-term ecosystem function in lowland organic soils).
[83] The Spending Review 2015 announced £100 million of capital spend for projects supporting the natural environment.

Table 6.3. Assessment of policies to drive abatement options in forestry

Abatement option	2016 policy		2017 policy assessment and updates	
Afforestation	Amber	Public funding available, but not clear on private investment being brought forward.	Red	Overly burdensome application process for RDP funding is impacting tree planting levels in England.
Agro-forestry	Red	No policy.	Red	No change.

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

Figure 6.11. The Policy Gap in the LULUCF sector (2010-2032)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* BEIS (2017) *Updated Energy and Emissions Projections 2016*, and CCC calculations.
Notes: Methodology changes for calculating net outturn emissions were included in the 2017 national inventory but not in the 2016 baseline emissions projections. Therefore, we have scaled projections of emissions in 2016 to match 2015 outturn. Projections going forward change at the same percentage as given in the BEIS UEP 2016 projections.

Beyond 2050

Beyond the fifth carbon budget and the longer-term 2050 UK statutory target, the contribution required from the UK agriculture and LULUCF sectors will need to increase significantly if the ambition of the Paris Agreement for net zero global emissions in the second half of this century is to be reached. Land is unique in that it is the only sector at present to remove CO_2 from the atmosphere, and coupled with the possibility of combining it with technologies such as carbon, capture and storage (CCS) it could deliver further negative emissions.

It is against this background that we are exploring further how the use and management of land and livestock could deliver deeper emissions cuts and increased GHG removals in the UK agriculture and LULUCF sectors by 2100 as well as delivering benefits from adapting to climate change such as biodiversity and resilience to flooding. The Committee's Land Use Project has just completed a pilot phase in conjunction with the Environmental Change Institute (ECI) at Oxford University. The ECI work provided useful insights into how the warming climate alone could significantly change the use of land in the UK by 2050. Further work on the project will be published in due course.

Chapter 7: Waste

Key messages and recommendations

Emissions from waste totalled 18.4 $MtCO_2e$ in 2015, accounting for almost 4% of total UK greenhouse gases (GHG). They mainly comprise methane emissions from the decomposition of biodegradable waste in landfill sites in the absence of oxygen.

Waste emissions data lag other sectors by a year due to the longer time required to collate non-CO_2 emissions data. In this chapter, we present the latest emissions data by GHG and source for 2015, the drivers of change and policy progress required to deliver the abatement needed to meet the fifth carbon budget.

Our key messages are:

- **Emissions trends and drivers.** Waste emissions fell by 7% in 2015, a slower reduction than in the recent past as emissions fell by 11% on an annual average basis between 2009 and 2014. Since 1990 waste emissions have fallen by 73%. These reductions have mainly been due to reduced biological waste going to landfill, investment in methane capture technology and improved management at landfill sites.
- **There is need for accurate data for wastewater emissions and the identification of further abatement potential.** Currently the GHG inventory estimates emissions of 4 $MtCO_2e$ from wastewater treatment. This is based on high default values due to limited available data on wastewater emissions and could be an overestimate.
- **Indicator framework.** Our progress indicators for the sector cover reduced material going to landfill, and methane capture and flaring at landfill. All have been on track for 2015, which means that the overall 69% decline in landfill emissions since 2007 is above our indicator decrease of 67%,
- **Further policy strengthening will be required to meet the fourth and fifth carbon budgets.** Each nation must set specific actions and clear milestones to strengthen policy through the whole waste chain, through: minimising waste arising, separate collection and diversion of biodegradable waste from landfill. There may also be potential for further progress in avoiding the release of methane emissions at landfill sites**.**

We will assess the Government's plan for meeting the gap in the fourth and fifth carbon budgets against the following check list (Table 7.1):

Table 7.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

Waste emissions to fall by around 53% between 2015 and 2030. This will require:	**Stronger implementation required**	**New policy required**	**New Strategy required**
Strengthened approaches through the waste chain, from creation to disposal, including reducing waste arising, separate collections (e.g. of food waste), stopping biodegradable waste going to landfill, and maintained or increased methane capture at landfill sites**.**	Scotland Wales	England N Ireland	

Source: CCC analysis.

Introduction

In this chapter we assess emissions trends in the waste sector and review progress towards meeting carbon budgets.

We summarise the analysis that underpins our key messages and recommendations in the following three sections:

1. Waste emissions trends and drivers
2. Recent progress in reducing emissions in the waste sector compared to required progress
3. Policy progress towards the fourth and fifth carbon budgets

1. Waste emissions trends and drivers

Waste emissions are largely made up of non-CO_2 gases, which are reported a year later than CO_2. We therefore focus on 2015 emissions in this chapter. This section sets out the change in emissions from 2014 and in the recent past, and the main drivers of change.

Emissions trends

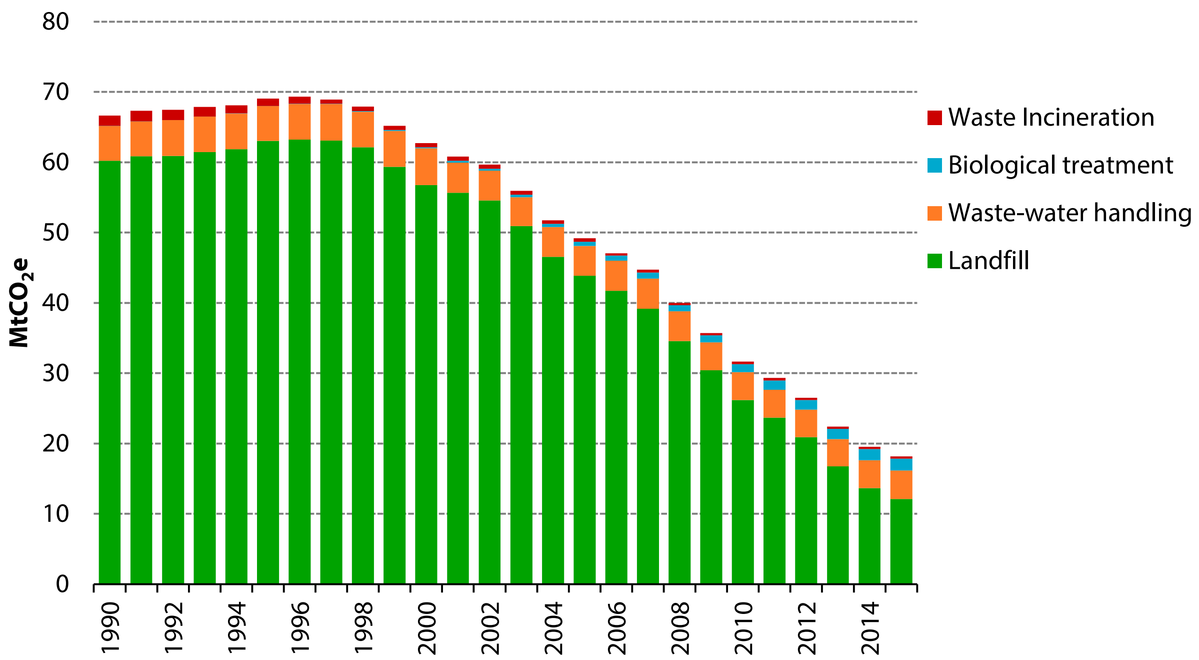
Waste emissions account for less than 4% of total UK greenhouse gas (GHG) emissions. Emissions declined by 7% to 18 $MtCO_2e$ in 2015, following an annual average decrease of 11% over the period 2009-2014. Over the longer term, emissions have declined by 73% since 1990 (Figure 7.1).

Waste emissions are predominantly methane (91%) 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:

- **Landfill emissions** (12 $MtCO_2e$) account for 67% of waste emissions and are entirely methane. Landfill emissions fell by 11% in 2015, which is slightly lower than the 12% annual average decrease over the period 2009-2014. Since 1990 they have fallen by 80% due to reductions in biodegradable waste going to landfill, investment in methane capture technology and improved management at landfill sites.
- **Wastewater treatment emissions** (4 $MtCO_2e$) account for 22% of waste emissions. 83% are methane and the remaining 17% nitrous oxide (N_2O). Wastewater treatment emissions increased for the second successive year, up 3% in 2015, which reverses the slight annual average decline over 2009-2014. Since 1990 they have fallen by 18%.
- **Biological treatment emissions** (1.7 $MtCO_2e$) are a mixture of methane and N_2O from industrial and domestic composting, anaerobic digestion of non-agricultural waste and mechanical biological waste treatment (MBT). These account for 9% of waste emissions and increased by 4% in 2015, as compared with an annual average increase of 10% over the period 2009-2014.
- **Incineration (without energy recovery) emissions** (0.3 $MtCO_2e$) account for 2% of waste emissions which are mainly CO_2. Incineration emissions fell by 2% in 2015, following an annual average 1% increase over the period 2009-2014.

Given their dominance in waste emissions, we focus on methane emissions from landfill.

Figure 7.1. GHG emissions from waste by source (1990-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*

Waste emission drivers – methane from landfill

Estimated methane emissions from landfill are 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 arising.** New data published by the Waste Reduction Action Programme (WRAP) this year[84] suggests that, despite efforts to reduce food waste under schemes such as the Courtauld Commitment[85], the level of avoidable household food and drink waste (i.e. that could have been consumed) in 2015 increased by 5% to 4.4 million tonnes, compared to 4.2 million tonnes in 2012. The upturn is attributed to changing economic conditions since the start of 2014 (e.g. decreasing food prices and rising wages in real terms), which weakened the incentive for people not to waste food.
- **Biodegradable waste sent to landfill.** Although the amount of food waste increased in 2015, the amount of landfilled biodegradable waste reduced by 11%, the same reduction as over the period 2009-2014. Biodegradable waste sent to landfill in 2015 has fallen by 84% since 1990.
- **Methane emissions avoided at landfill sites**. Methane emissions at landfill can be avoided by capture, flaring to CO_2 and natural oxidisation. Estimates suggest that 68% of methane emissions at landfill were avoided in 2015, rising from 45% in 2009 and 1% in 1990.

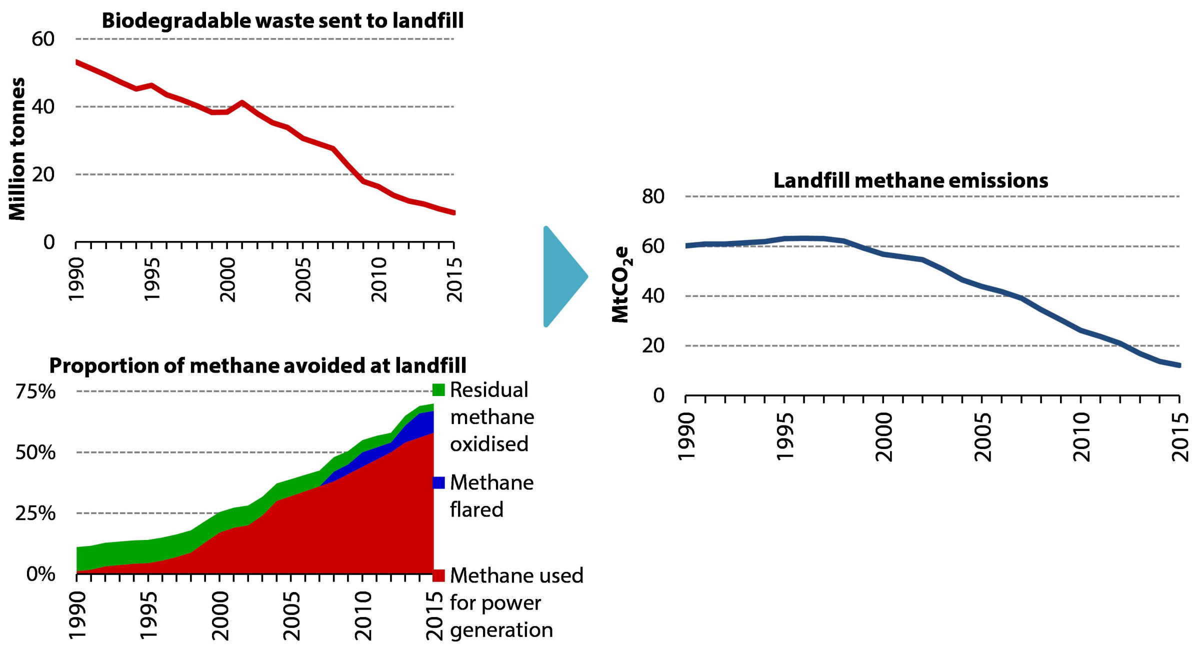
[84] WRAP (2017) *Household food waste in the UK.*

[85] A voluntary agreement bringing together organisations across the food system (from producer to consumer) to make food and drink production and consumption more sustainable.

- The proportion of methane captured for use in energy generation (mainly for electricity) rather than emitted is estimated to have averaged 58% in 2015, rising from 41% in 2009. In 2015 this generated 4.9 TWh of electricity[86] accounting for around 2% of total UK electricity generation.
- Around 10% of the methane generated at landfill sites is estimated to have been flared in 2015, rising from 4% in 2009.
- Residual methane that is oxidised at the landfill site is estimated to have averaged 3% in 2015, falling from 5% in 2009.

Overall, estimated landfill methane emissions have fallen by 80% since 1990 (Figure 7.2).

Figure 7.2. Biodegradable waste, methane emissions avoided at landfill sites and methane emissions from landfill (1990-2015)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015.*
Notes: Biodegradable waste and proportion landfill methane not avoided do not equal landfill methane emissions. Emissions also depend on methane yield from waste.

The estimated uncertainty level of waste emissions in 2015 (18 $MtCO_2e$) is high, around ± 39% at a 95% confidence interval compared with ± 2.7% for the economy as a whole. Uncertainty in landfill emissions is even higher at 48%.[87] Given the dominance of landfill emissions in the waste sector, and as set out in our report on quantifying GHG emissions[88], work should progress on addressing the uncertainties that exist in estimating emissions from this source. For example:

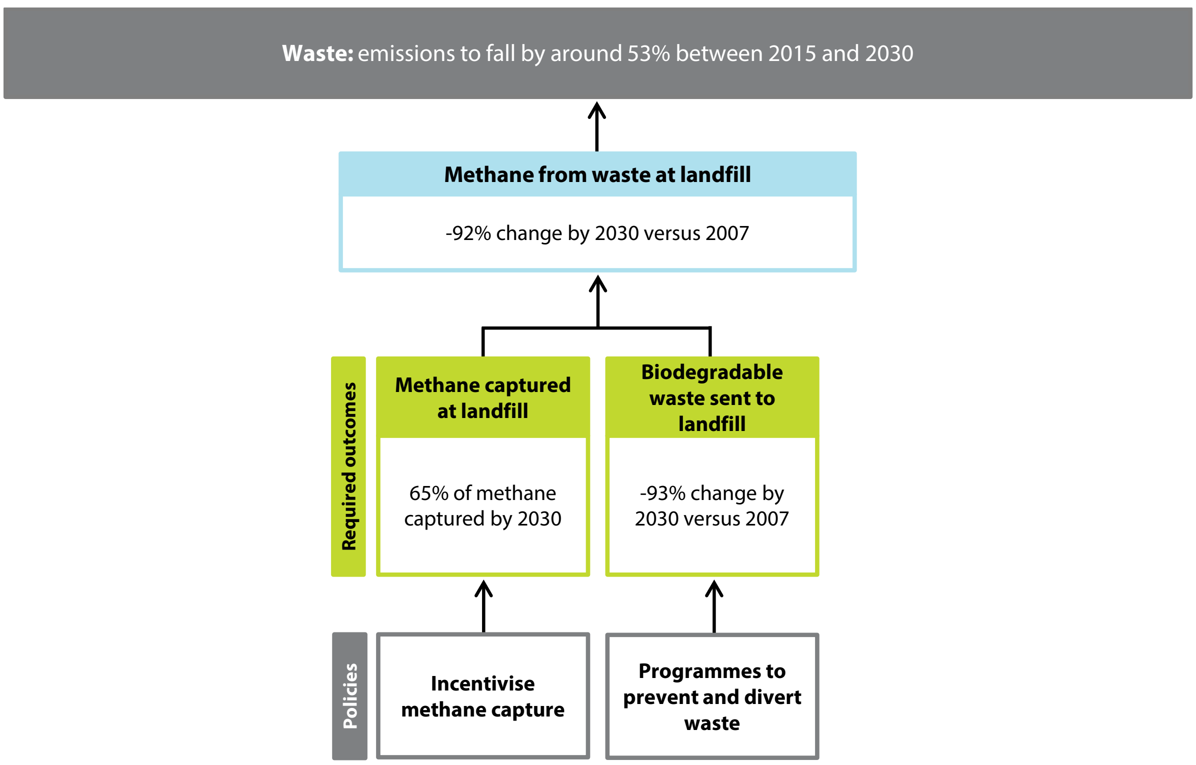
[86] BEIS (2016) *Digest of UK energy statistics 2016.*
[87] This is a 2014 estimate as 2015 uncertainty estimates for sub-sectors are not yet available.
[88] CCC (2017) *Quantifying Greenhouse Gas Emissions.*

- There is an imperfect understanding of the amount of methane emitted from various waste streams and over how many years it is emitted. Field and experimental observations exhibit wide variation (reflecting differences in how materials are mixed together, which affects moisture content and access of waste streams to oxygen). The yield and decay rate are also affected by real landfill conditions, which differ between and within sites.
- On fugitive emissions, Defra and the Environment Agency are working to better measure these emissions from landfill sites. For example, the Environment Agency is ascertaining whether the use of drones can accurately quantify a known release of methane emissions from landfill.[89] The results of this work could be used to develop additional site-specific data on landfill methane emissions.

Our analysis suggests that between 2015 and 2030, waste emissions could fall by 53% to 8.5 $MtCO_2e$ driven by measures to reduce landfill emissions. Our progress indicators for the sector cover reduced material going to landfill, and methane capture and flaring at landfill (Figure 7.3). In terms of policy actions, which we will also monitor, these should be driven by incentives to reduce household and commercial waste and incentives for landfill operators to capture methane.

In the future, we may want to consider how abatement from the other sources, particularly from wastewater treatment, can contribute towards meeting carbon budgets.

Figure 7.3. CCC indicators for the waste sector



Source: CCC analysis.

[89] Environment Agency (2017) *SC160006: Validation of landfill methane measurements from an unmanned aerial system.*

2. Recent progress in reducing emissions in the waste sector 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. We focus on the reduction of landfill emissions.

Government policy to reduce landfill emissions has focused on reducing waste, diverting biodegradable waste from landfill and capturing the methane from landfill sites:

- **Waste prevention.** Emissions can be further reduced through prevention, which also offers substantial upstream environmental and economic gains associated with resource efficiency.
- **Diversion of biodegradable waste from landfill.** There is potential to go significantly further in diverting biodegradable waste away from landfill and towards recycling, composting, anaerobic digestion (AD), mechanical biological treatment (MBT) and incineration with energy recovery.
- **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.

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. Action is being taken at the EU level mainly through the EU Landfill and Waste Framework Directive and national, devolved administration and local authority levels.

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.[90] Key indicators are on track for 2030 based on latest outturn data for 2015:

- Emissions from waste sent to landfill fell by 69% from 2007 compared with our indicator decrease of 67%.
- The amount of biodegradable waste sent to landfill has fallen by 69% since 2007, and is outperforming our indicative value of a 57% reduction.
- The proportion of methane captured at landfill has been increasing steadily and at 68% in 2015 is above our indicator value of 63%.

Although recent progress has been on track with our indicator framework, steeper reductions will be required to meet the cost-effective path of 8.5 $MtCO_2e$ by 2030 set out in our Fifth Carbon Budget Report.

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 2016 it had reached £84.40/tonne compared to £82.60/tonne a year earlier.

In addition to the landfill tax, waste prevention information, voluntary programmes, and regulations over landfill management have contributed to the overall reduction in landfill emissions.

[90] CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget.*

In the devolved administrations, the landfill tax was devolved to Scotland from 1 April 2015 and is a key component of Scotland's Zero Waste Plan. The rate set for 2016 matches that for England and by 2018 Wales will be able to set its own level. Other developments and proposals to reduce landfill emissions include:

- **Scotland.** In this year's Draft Climate Change Plan[91] the Scottish Government outlined its intent to phase out biodegradable municipal waste going to landfill a year ahead of the statutory ban that applies from 2021. By 2025 it wants the amount of waste sent to landfill to fall to 5%. The Plan also indicated the need to better manage emissions from existing closed and older operational landfill sites through innovative flaring technology. There is a target to support 12 closed sites by 2022. The Committee will comment on the draft Plan in our progress report on Scottish climate change mitigation later this year.
- **Wales** has the highest recycling rates in the UK (55% of municipal waste is reused, composted or sent for recycling in 2014/15), and the fourth best in Europe, as a result of meeting strong regulatory targets for waste reduction through the 'Towards Zero Waste' strategy. The target is to have 70% of all wastes recycled by 2025, and reduce waste going to landfill to 5% by the same timeframe.

Further detail is provided in Chapter 9 covering the devolved administrations.

3. Policy progress towards the fourth and fifth carbon budgets

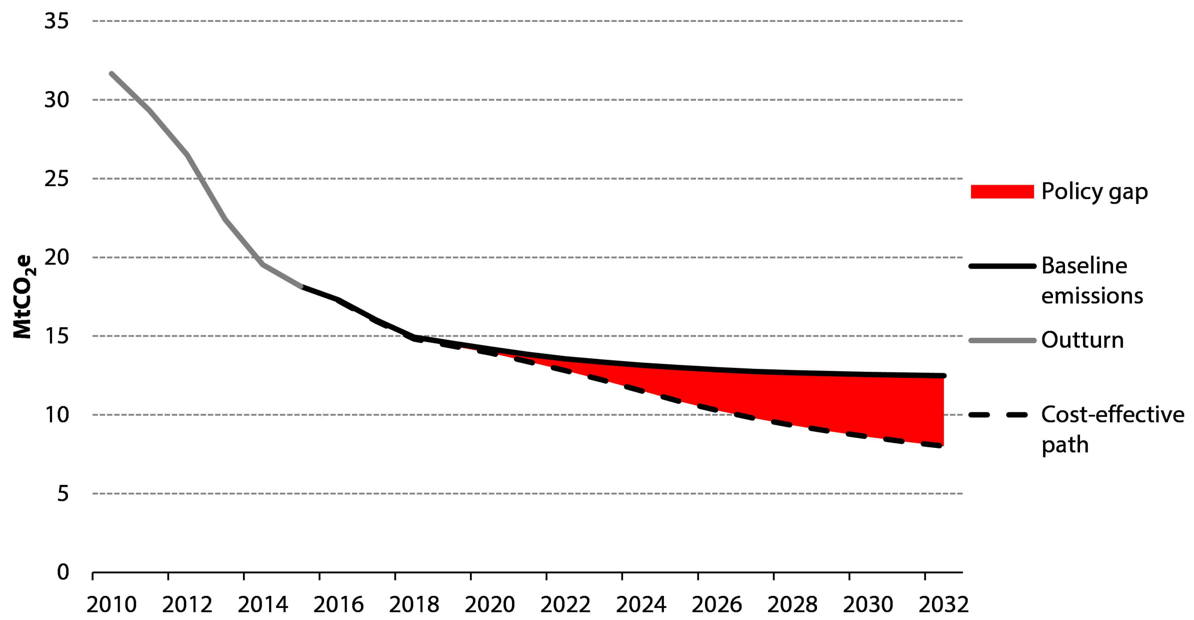
BEIS emissions projections suggest that waste emissions are expected to continue falling, albeit more slowly than in the past, without further policy, largely as a consequence of the landfill tax. In our fifth carbon budget advice, we estimated that stronger polices to divert biodegradable waste streams from landfill could reduce emissions by a further 4 $MtCO_2e$ by 2030. However, there are no plans in place to achieve this. Delivery mechanisms through the waste chain are therefore required in order to meet our assessment of the cost-effective path (Figure 7.4).

In last year's Progress Report, we cited the need for Government to publish specific actions and clear milestones to strengthen approaches through the waste chain; including separate waste collection, reducing biodegradable waste to landfill and improving methane capture rates at landfill sites where possible. This has not moved forward and must be addressed in the Government's proposals for meeting the fourth and fifth carbon budgets.

We will publish our assessment of the Government's proposals after they have been published.

[91] Scottish Government (2017) *Draft Climate Change Plan: The draft third report on policies and proposals 2017-2032.*

Figure 7.4. The Policy gap in the waste sector (2010-2030)



Source: BEIS (2017) *Final UK greenhouse gas emissions national statistics 1990-2015;* BEIS (2017) *Updated Energy and Emissions Projections 2016*, and CCC calculations.

Chapter 8: F-gases

Key messages and recommendations

Fluorinated gases accounted for around 3% of total UK emissions in 2015. 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-gases sector are:

- **Emissions from F-gases in 2015 were broadly flat**, which is short of the 2% fall in emissions estimated to be cost-effective in our fifth carbon budget central scenario. The main cause was slow progress in the reduction of aerosol emissions.
- **Existing regulation is expected to reduce F-gas emissions substantially**: The EU F-gas Regulation, which came into force in 2015 together with enforcement measures, aims to cut hydrofluorocarbons (HFCs) sales, the main source of emissions, by 79% from 2015 EU levels by 2030. It also introduces a series of new bans on the use of certain F-gases and strengthens checks on leaks.
- **There is likely to be potential for reductions to go further**. Last year, we recommended that the Government should review cost-effective opportunities to exceed regulatory minimums on F-gas abatement. The Government has not made progress on this.

We will assess the Government's plan for meeting the fourth and fifth carbon budgets against the following checklist (Table 8.1).

Table 8.1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets

F-gases emissions to fall by at least 68% between 2015 and 2030. This will require:	Stronger implementation required	New policy required	Strategy required
The UK to continue its inclusion in the F-gas Regulation or develop equivalent or stronger legislation in the UK.		✘	
The Government to investigate opportunities to go beyond the EU regulatory minimums on F-gases. Where evidence suggests that further cost-effective abatement is available, the Government should pursue policies to achieve this abatement.		✘	✘

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 three sections:

1. F-gas emissions trends and drivers

2. Progress in reducing F-gas emissions

3. Policy progress towards the fourth and fifth carbon budgets

1. F-gas emissions trends and drivers

Background

F-gas emissions were around 17 $MtCO_2e$ in 2015, accounting for around 3% of total UK GHG emissions (Figure 8.1). This share of total emissions has increased slightly since 2009. F-gas emission levels are 4% below 1990 levels.

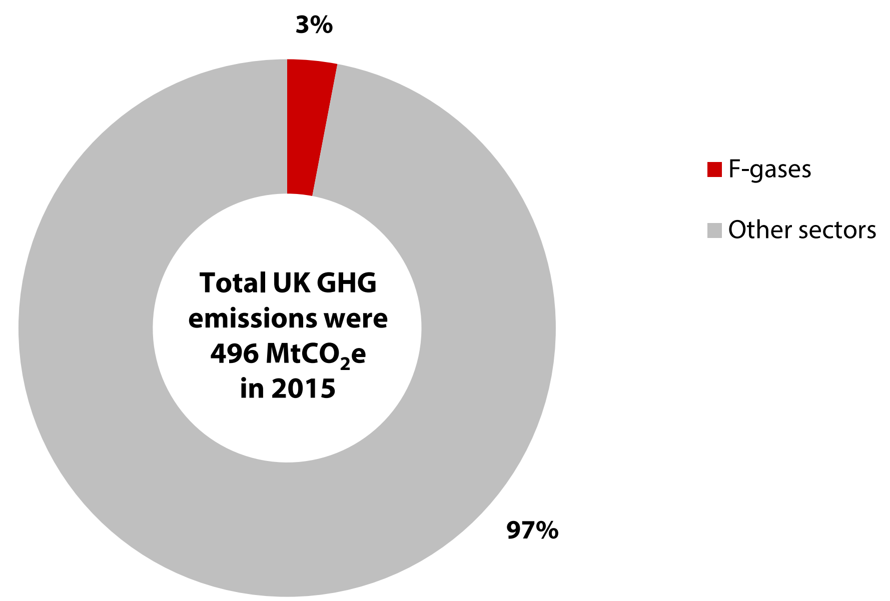
The main source of emissions is the leakage of F-gases from refrigeration and air-conditioning systems during their use, where F-gases are currently used as the main alternative to ozone-depleting CFCs. Other F-gas emissions come from their use in aerosols and metered-dose inhalers, which are applied for respiratory disorders (e.g. asthma), as well as in 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):

- **HFC** emissions (95% of the total) 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.
- **SF_6** emissions (3%) are mainly used in electrical insulation, magnesium casting and military applications.
- **PFC** emissions (2%) result mainly from the manufacture of electronics and sporting goods. They are also a by-product of aluminium and halocarbon production.
- **NF_3** emissions are currently very low and result from semi-conductor manufacturing.

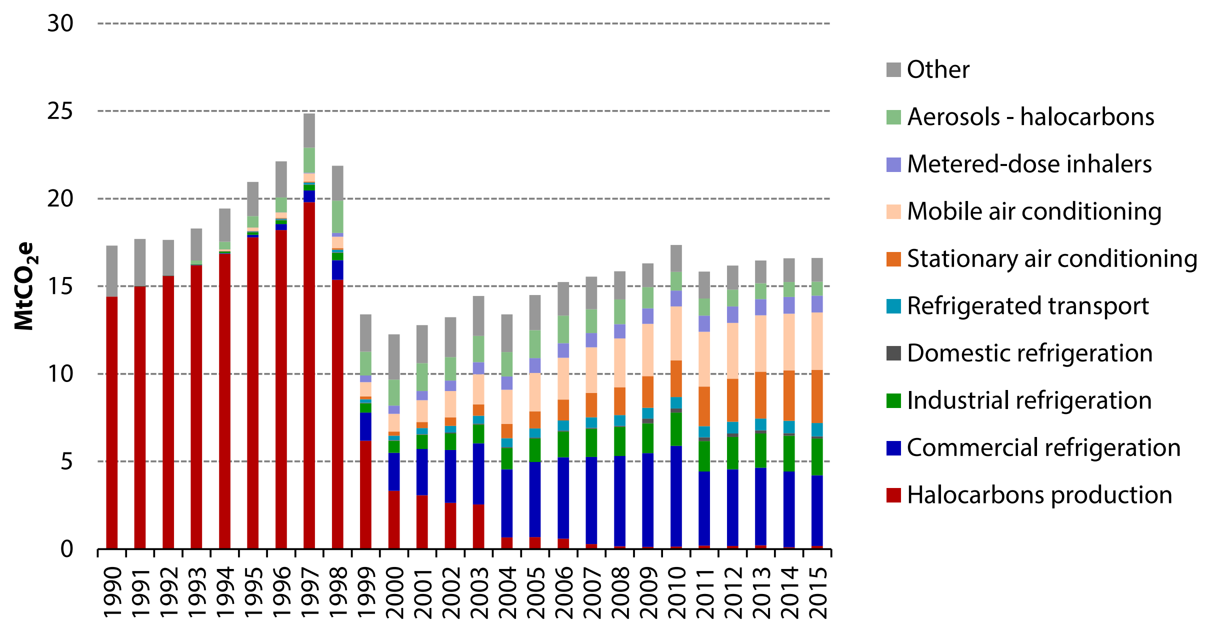
Total F-gas emissions peaked in 1997, reaching 25 $MtCO_2e$, when 80% of emissions were due to halocarbon production. Between 1997 and 2000, F-gas emissions dropped significantly as a result of the fitting of abatement equipment to the plants producing halocarbons. Since 2001, F-gas emissions have been 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 (2015)



Source: National Atmospheric Emissions Inventory (NAEI).

Figure 8.2. GHG emissions from F-gases by source and type of gas (1990-2015)



Source: National Atmospheric Emissions Inventory (NAEI).

Emission trends

In 2015, F-gas emissions stayed broadly flat, following average annual growth of 0.4% between 2009 and 2014. The main drivers behind these changes are demands for F-gases in refrigeration and air conditioning, together with the introduction of the 2006 EU F-gas regulation:

- **Stationary refrigeration (38% of the total).** The main source of F-gases fell by 4% between 2014 and 2015. Emissions reached a peak of 7.9 MtCO_2e in 2010 and showed an average 2% reduction in the period 2009-2014. The decline after 2009 is likely to be the result of the 2006 EU F-gas Regulation that aimed to replace F-gases with high Global Warming Potentials (GWPs) with lower-GWP refrigerants.
- **Mobile air conditioning[92] and refrigerated transport (24%).** These increased by around 2% in 2015. This is in line with the average annual growth of 2% between 2009 and 2014.
- **Stationary air conditioning (18%).** These have been growing strongly recently: a 6% increase in 2015 following 10% annual average growth over the period 2009-2014.
- **Aerosols and metered-dose inhalers (11%).** These decreased by around 3% in 2015, in line with falls over the period 2009-2014, which have been driven by a fall in emissions from aerosols.
- **Firefighting, foams, electrical insulation and other.** These rose by around 4% in 2015, but were broadly flat over the period 2009-2014.

In summary, while emissions from some sources (i.e. mobile and stationary air conditioning) increased in 2015 in line with their long-term trend, emissions from refrigeration stayed flat. This is likely to reflect the impact of EU regulation to control F-gas emissions.

2. Progress in reducing F-gas emissions

Cost-effective path to reduce F-gas emissions

Reducing F-gas emissions cost-effectively, from around 17 MtCO_2e in 2015 to around 5 MtCO_2e in 2030, will require the use of alternatives to F-gases in most applications. Many applications already have cost-effective alternatives to F-gases available, while some of the alternatives need further development to be commercially viable:

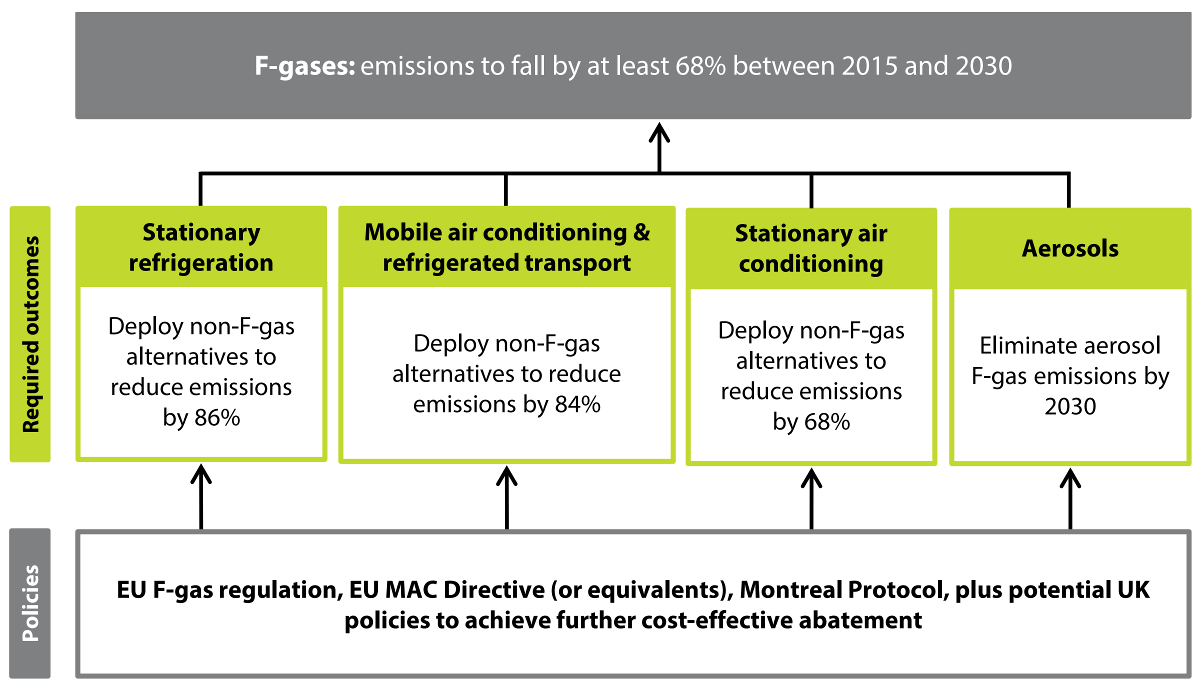
- **Refrigeration and stationary air conditioning** are most likely to have low-GWP refrigerants available (e.g. existing hydrocarbons or CO_2), which could reach 100% of sales by 2030 or earlier.
- **Mobile air conditioning** can use lower-GWP alternatives to current F-gases in many cases, although they are expected to have higher costs.
- **Aerosol use of F-gases** can be reduced by using lower-GWP alternatives, requiring small modifications to equipment only.
- **Metered-dose inhalers** are medical aerosols used to dispense drugs used for lung diseases such as asthma. There may be scope to reduce these emissions through low-GWP alternatives. Dry powder inhalers are a known alternative used in many countries for over 20 years, but these are generally more expensive and are not suitable for all patients.

[92] Air-conditioning systems for cars, light commercial vehicles, trucks, buses, coaches, trailers and railcars.

In addition to tracking abatement for existing sources of F-gas emissions, the uptake of heat pumps within our scenarios for heat decarbonisation could imply potentially significant increases in F-gas emissions.[93] It will therefore be important that heat pumps transition to using low-GWP refrigerants between now and 2030, after which deployment of heat pumps might accelerate considerably. Between now and 2030, heat pump uptake in our scenarios may add around 0.6 $MtCO_2e$ emissions by 2030 because of their use of HFCs as refrigerants, while saving 3 Mt in emissions from fossil fuel combustion.[94]

Figure 8.3 outlines changes to emissions in line with the central scenario from our fifth carbon budget, as well as expected policy drivers for this change. These changes reflect our understanding of the impacts of EU F-gas Regulation, which, if converted into UK law, would significantly reduce emissions from refrigeration and air conditioning. In future we will track progress in: Total F-gas emissions; Stationary refrigeration emissions; Mobile air conditioning and refrigerated transport emissions; Stationary air conditioning emissions; Aerosol emissions; Policy on F-gas regulations.

Figure 8.3. CCC indicators for the F-gas sector



Source: CCC analysis.

Current progress

The level of F-gas emissions is below our indicator pathway to meet future carbon budgets. However, this is only because the estimate of F-gas emissions for our start year (2014) has turned out to be above the outturn (rather than equal to the level in the start year). Emissions from F-gases did not fall in 2015. This fell short of the 2% fall in emissions outlined by our indicator

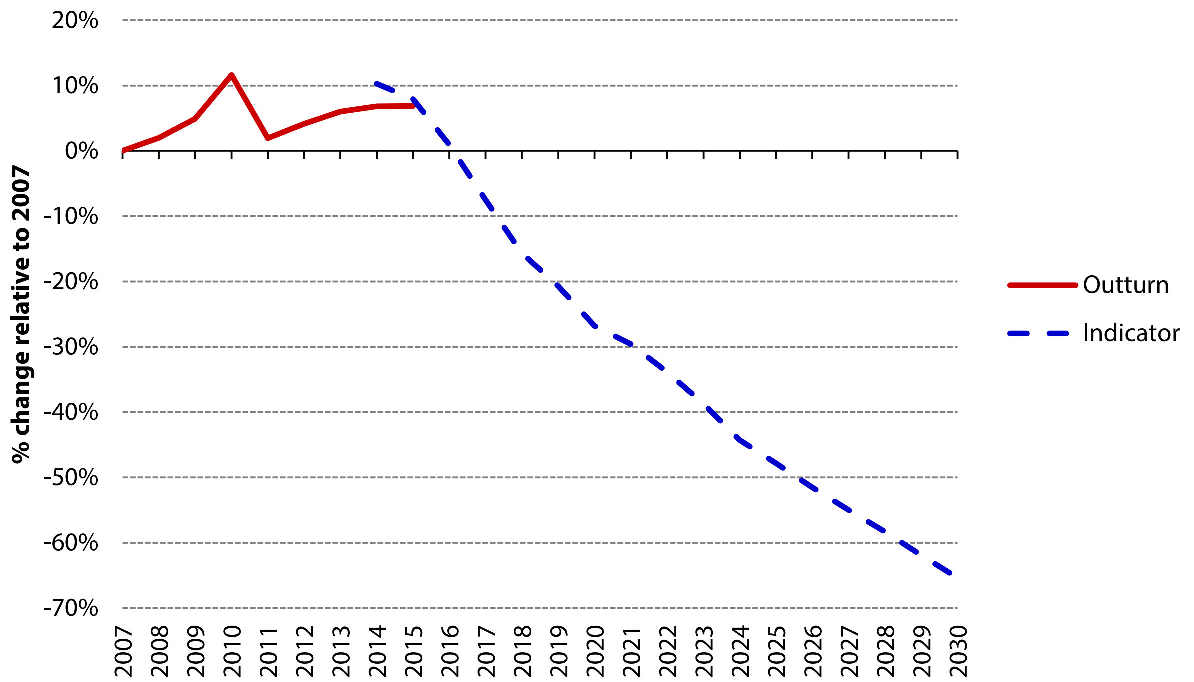
[93] Ricardo AEA (2013) *Current and Future Lifecycle Emissions of Key 'Low Carbon' Technologies and Alternatives*.
[94] See CCC (2015) *Sectoral Scenarios for the Fifth Carbon Budget*.

pathway to meet future carbon budgets (Figure 8.4). The main reason for the slower rate of reduction in 2015 was that aerosol emissions did not fall as fast as their indicator pathway.

Emissions from stationary refrigeration, mobile air conditioning and refrigerated transport, stationary air conditioning all fell at a rate in line with their indicator pathways.

Overall, progress (Table 8.2) broadly shows emissions below the indicators, with stationary refrigeration emissions slightly above its indicator. However, the broad trend in emissions since 2007 has been upwards and needs to be reversed. The rate of emissions reductions now needed to meet the indicator trajectory is quite steep, so considerable further progress is needed.

Figure 8.4. F-gas emissions indicator trajectory (2007-2030)



Source: NAEI, CCC analysis.

Table 8.2. Progress against the Committee's F-gas indicator (% change from 2007)			
Indicator	**2015 indicator**	**2015 outturn**	**2030 indicator**
Total F-gas emissions	+8%	+7%	-65%
Stationary refrigeration emissions	-7%	-6%	-87%
Mobile air conditioning and refrigerated transport emissions	+26%	+26%	-80%
Stationary air conditioning emissions	+118%	+118%	-29%
Aerosol emissions	-33%	-42%	-100%

Source: NAEI, CCC analysis.

3. Policy progress towards the fourth and fifth carbon budgets

This section outlines current policies on F-gases in the UK and the requirements for the Government's plan to meet the fourth and fifth carbon budgets.

UK policy

There are two main EU policies that are driving reduction in F-gas emissions. These are the Mobile Air Conditioning (MAC) Directive and the 2015 F-gas regulation:

- The MAC Directive focuses on emissions from air conditioning in new cars and vans, and has been in force since 2011. It requires new types of cars and vans to use substances with a GWP less than 150. It will require this for all new cars and vans produced from 2017.
- The F-gas regulation that came in to force in the UK in January 2015 introduced a number of new measures and strengthened the measures in 2006 regulation:
  - It caps the amount of HFCs that producers and importers are allowed to place on the EU market. Incumbent producers receive maximum emission quotas based on the previous quantities produced. In 2015 the cap matched the average of the market between 2009 and 2012. The allowed emissions will then be reduced incrementally, starting with a 7% cut in 2016 from the initial cap, stepping up to a 33% cut in 2018 and ultimately reaching a 79% cut by 2030. Some uses of HFCs are exempted from the regulation, including their use in metered-dose inhalers, manufacturing of semiconductors or military equipment.
  - 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.[95]
  - The regulation introduced a new ban for the maintenance and servicing of existing refrigeration appliances which will not allow HFCs with a GWP above 2,500 from 2020.

[95] Annex 3, EU (2014) *Regulation no. 517/2014 on fluorinated greenhouse gases*.

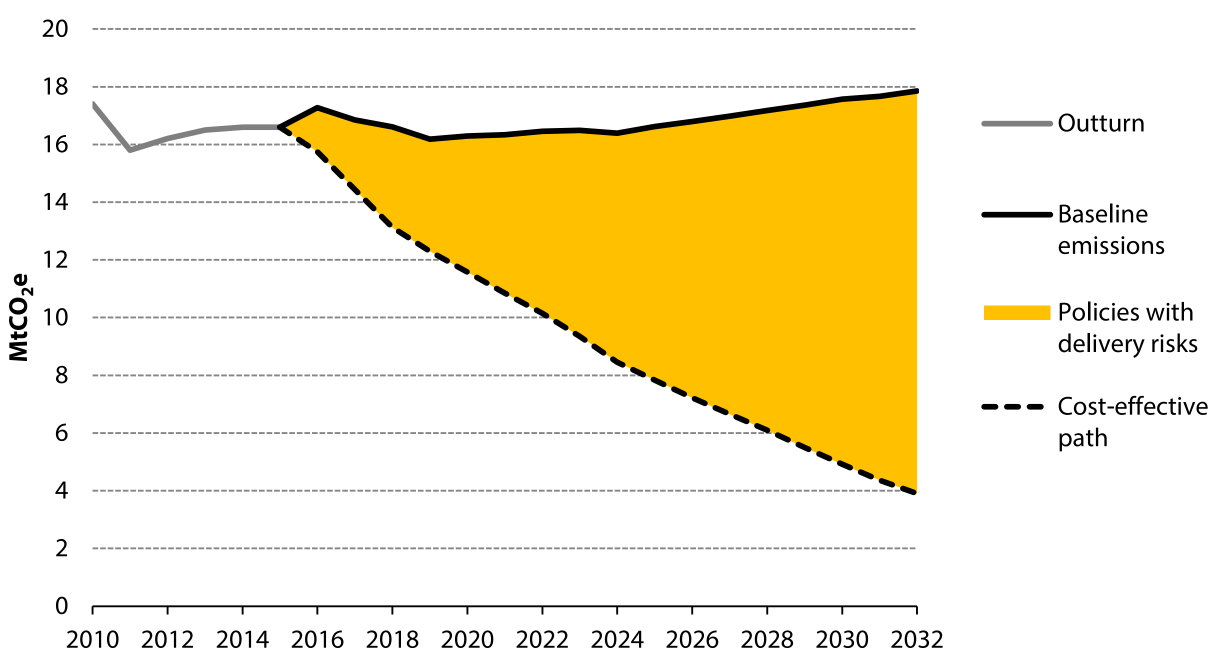
– The regulation also strengthens existing obligations in terms of leak checking and repairs, F-gas recovery and technician training.

The 2015 F-gas regulation aims to reduce GHG emissions from the use of HFCs. There is strong evidence showing that the phasedown of HFCs is cost-effective as most of the low-carbon alternatives are already available and are likely to deliver energy efficiency improvements in relevant appliances.[96] The other F-gases are not part of the phase down but they are expected to be affected by the requirements of the regulation on leak checking, F-gases recovery and training.

Our current cost-effective emission trajectory (Figure 8.5) is based on our understanding of the impacts of the 2015 F-gas regulation on UK F-gas emissions. By 2030, F-gas emissions are due to fall by 68% when compared to current 2015 total emissions. Some EU countries have introduced further measures to reduce the use of F-gases, including taxes, additional bans or funding for research and deployment of low-GWP alternatives.

The UK is also currently participating in international negotiations, looking for ways of controlling HFCs through an amendment of the Montreal Protocol. The UN countries have agreed to work together on a pathway for controlling the production and consumption of HFCs. Under the proposed amendment, HFCs in developed countries would be reduced through incremental targets up to a cut of 86% by 2036. If ratified, the amendment will come in to force in 2019. These plans are less stringent than the F-gas regulation up to 2030, but more ambitious beyond 2034, when there is currently no further target under the F-gas regulation. An extension of the F-gas regulation beyond 2030 will be considered by the EU in 2022.

Figure 8.5. The F-gases policy gap (2010-2032)



Source: UK National Atmospheric Emissions Inventory; BEIS (2016) *Updated emissions projections*; CCC analysis.
Notes: See Chapter 1 on the criteria to evaluate level of risk in current policies.

[96] See CCC (2015) *Sectoral Scenarios for the Fifth Carbon Budget*.

Policy progress

The UK's decision to leave the EU means there is uncertainty about the future of the F-gas regulation. If the F-gas regulation is converted into UK law as part of the Great Repeal Bill, it would require some amendment to achieve the intended outcomes. As a result there is a risk of under-delivery of cost-effective abatement of F-gas emissions.

Last year, we recommended the UK Government should seek opportunities to exceed EU regulatory minimums on F-gas abatement, where evidence suggests cost-effective and comparable alternatives exist. There has not been any new action from the UK Government over the last year on this (Table 8.3).

Policy recommendations

To address the risk of not delivering cost effective abatement towards the fourth and fifth carbon budgets the Government should aim to continue the UK's inclusion in the F-gas regulation, or develop equivalent or stronger legislation in the UK.

The Government should also investigate opportunities to go beyond the EU regulatory minimums on F-gases, including the impacts on overall EU F-gas emissions of the UK going further. Where evidence suggests that further cost-effective abatement is available, the Government should pursue policies to achieve this abatement.

Table 8.3. Assessment of policies to drive abatement options in F-gases

Abatement option	2016 policy		2017 policy assessment and updates	
Phasedown in the use of HFCs in refrigeration, mobile and stationary air conditioning.	Green	2015 F-gas regulation.	Amber	Great Repeal Bill proposed. This would convert 2015 F-gas regulation into UK law, but would require amendment in order for regulation to achieve intended outcome.
Cost-effective emissions reduction in F-gases not covered by the 2015 EU regulation.	Red	No review of evidence on further potentially cost-effective options.	Red	No review of evidence on further potentially cost-effective options.

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

Chapter 9: Devolved administrations

Key messages and recommendations

The devolved administrations have an important role to play tackling climate change. Their actions form part of meeting their own domestic objectives, as well as the UK's overall commitment. Scotland, Wales and Northern Ireland together accounted for 23% of UK emissions in 2015 (respectively 9%, 9%, and 4%), while they account for 16% of the UK's population and 13% of GDP.

Scotland has its own climate legislation, the Climate Change (Scotland) Act and has set annual targets to 2032. The Scottish Government is planning to bring forward new climate change legislation, on which the Committee advised in March 2017. The draft Climate Change Plan, setting out proposals and policies to meet targets to 2032, was published in January 2017. The Committee will comment on the draft Plan in our progress report later this year.

In Wales, the 2016 Environment (Wales) Act requires the legislation of emission reduction targets and the setting of carbon budgets. The Committee advised on the design of these targets and budgets in March 2017 and will advise on their levels in the Autumn.

Northern Ireland has emission reduction targets set by the Northern Ireland Executive. In May 2010, the Northern Ireland Executive agreed to a proposal by the Minister of the Environment to establish a cross-departmental working group on climate change. The Executive's Greenhouse Gas Action Plan was agreed and published in February 2011, outlining how each department in the Executive will contribute towards meeting the 2025 emission reduction target.

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 aspects of power policy, transport demand-side measures, energy efficiency, waste, agriculture and land use. In Wales, the 2017 Wales Act raised the threshold for large-scale energy consents from 50 MW to 350 MW, granting the Welsh Government more devolved powers. It is expected more powers will be devolved in line with recommendations of the Smith Commission and Silk Commission. 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.

Our key messages are:

- 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 around 3% in 2015, largely due to another fall in power sector emissions. Power emissions will have fallen again in 2016 due to the closure of Longannet coal-fired power station.[97] There was considerably less progress in reducing emissions in other sectors. Transport emissions have risen for the past two years, while very little progress is apparent in agriculture and non-residential buildings.
  - **In Wales**, emissions fell by around 1% due to a fall in industry emissions, while those in other sectors were broadly flat. This follows a period in which Welsh emissions have been rising gradually. Transport emissions have risen for two years in a row. In contrast to the UK as a whole, Welsh power sector emissions rose in 2015.
  - **In Northern Ireland**, emissions are broadly flat overall and in each sector.
- Urgent action is needed in those areas where devolved nations now have sufficient power to act. For example, action could be taken to address failures to meet tree-planting targets, on further incentives to improve energy efficiency and heating of buildings and on non-financial barriers to

[97] The emissions data presented in this Chapter are for 2015, the most recent available. The emissions data for 2016 at devolved administration level will be published in June 2018, and will include the impact of Longannet closing.

Key messages and recommendations

electric vehicles. Where policy areas are reserved, it is important to work with the UK Government to ensure that the overall framework is strong enough to drive the necessary emission reductions.

Table 9.1. Recommendations

Reductions in devolved administrations emissions by 2030 to meet their own targets and contribute to UK-wide carbon budgets will require:	**Stronger implementation required**	**New policy required**	**New strategy required**
Address non-financial barriers for electric vehicles, including further measures which could be implemented such as parking, use of priority lanes, raising awareness and public procurement.	×		
Further measures to ensure tree planting targets are met, with a jointly developed approach with stakeholders and other nations in UK.	×		
A stronger policy framework for agriculture emissions reduction across all nations to 2022, as current progress is not on track.	×	×	
Development of a heat strategy for Wales, for example within the upcoming energy strategy**:** build on UK evidence and approach to develop clear heat strategy for Wales including targets for increased uptake of low-carbon heat.			×
Development of a support mechanism for low-carbon heat in Northern Ireland, alongside policies to address fuel poverty, following the closure of the Northern Ireland Renewable Heat Incentive and Renewable Heat Premium Payment Scheme.		×	×

Introduction

In this chapter we review progress in the devolved administrations in 2015, and report on changes in emissions in each nation and in the different sectors of the economy. We also assess progress in key policy areas since our previous UK and Scottish progress reports in 2016.

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.

1. Devolved administrations overview

The devolved administrations have an important role to play in tackling climate change. Their actions form part of meeting their own domestic objectives, as well as the UK's overall commitment. 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.[98]

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 sets a long-term target to reduce emissions of greenhouse gases (GHGs)[99] 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 its draft Third Report on Proposals and Policies (draft Climate Change Plan) in January 2017. The Committee will comment on this in its Scottish Progress Report, due later this year (Autumn 2017). The Scottish Government has committed to introducing new climate change legislation, including a tighter 2020 target. In March 2017, the Committee provided advice on that Bill.[100] On 13 June 2017, the Scottish Government proposed that the Bill should contain a 2050 target for a 90% reduction in greenhouse gas emissions on 1990 levels.[101]
- **Wales** passed the Environment (Wales) Act in 2016, which includes its approach to addressing climate change as a key component. The 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. In April 2017, the Committee provided advice on the design of Welsh carbon targets,[102] and will advise on the level of carbon budgets in October 2017.
- **Northern Ireland** has emission reduction targets set by the Northern Ireland Executive. The Committee provided an update to the Executive on the Appropriateness of a Northern Ireland Climate Change Act in January 2016.[103]

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98 Energy policy is fully devolved to the Northern Ireland Executive.
99 Including emissions from international aviation and shipping.
100 CCC (2017) *Advice on the new Scottish Climate Change Bill.*
101 https://news.gov.scot/news/climate-change-ambitions
102 CCC (2017) *Advice on the design of Welsh carbon targets.*
103 CCC (2015) *The appropriateness of a Northern Ireland Climate Change Act – 2015 update.*

2. Emission trends and progress towards targets

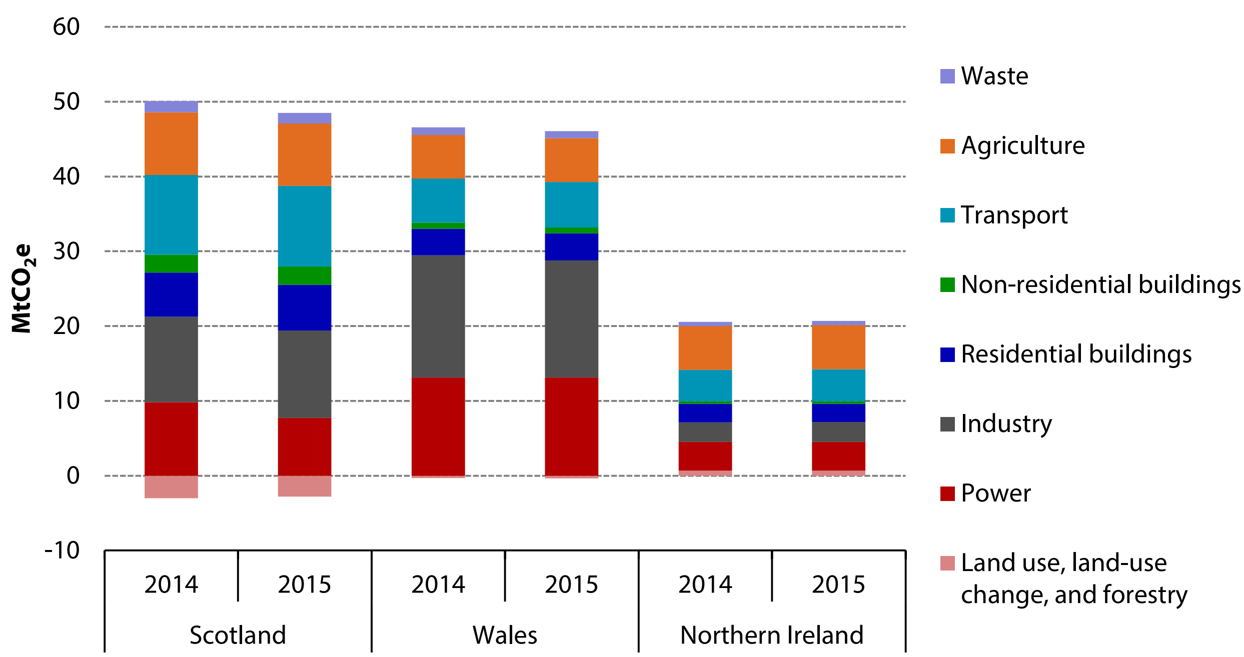
The latest UK emissions data are for 2016, but the latest data available for the devolved administrations are for 2015. We focus in this section on analysis of the change in emissions from 2014 to 2015 and the longer-term trend between 2009 and 2015.[104]

Scotland, Wales and Northern Ireland accounted for 23% of UK emissions in 2015 (respectively 9%, 9% and 4%), while they account for 16% of the UK's population and 13% of GDP.

Scottish emissions fell 2.9% in 2015, with an average decrease of 3.4% per year between 2009 and 2015, while Wales' emissions fell 1.2%, with an average increase of 0.5% per year between 2009 and 2015, and Northern Ireland emissions increased 0.6% with an average decrease of 0.3% per year between 2009 and 2015 (Figure 9.1). Greenhouse gas emissions decreased by 3.8% between 2014 and 2015 for the UK, with an average annual decrease of 2.9% between 2009 and 2015.

Scotland is on track to meet its own 2020 target, but neither Wales nor Northern Ireland are on track to meeting their near-term targets (Table 9.2).

Figure 9.1. Greenhouse gas emissions in devolved administrations by sector (2014 and 2015)



Source: NAEI (2017) *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2015.*

[104] Unless stated emissions data do not account for trading in the EU ETS and do not include emissions from international aviation and shipping.

Table 9.2. Devolved administrations targets and progress

	Targets: reductions from 1990 baseline	On track	Emissions change 1990-2015	Relative change in emissions 2014-2015	Average annual emissions change 2009-2015
UK	35% by 2020	Yes	-38%	-3.8%	-2.9%
Scotland	42% by 2020	Yes	-41% (net) -38% (actual emissions)	-3.0%	-3.4%
Wales	40% by 2020	No	-20%	-1.2%	+0.6%
Northern Ireland	35% by 2025	No	-18%	+0.6%	-0.3%

Source: NAEI (2017) Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2015
Notes: The latest UK emissions data considered elsewhere in this report are for 2016, but the latest data available for the devolved administrations are for 2015. These data (unless stated) do not account for trading in the EU ETS. The Scottish targets and emissions to date include Scotland's share of international aviation and shipping (IA&S) emissions, as these are included in the measure of Scottish emissions under the legislated targets - the explains the difference between the 38% reduction on 1990 emissions presented here and the 37% reduction excluding IA&S presented earlier. IA&S 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, and the Scottish Government has announced that it will bring forward a new Climate Change Bill, including a new 2020 target of reducing actual Scottish emissions by more than 50%. In March 2017, the CCC recommended that the level of such a 2020 target should be a 57% reduction on 1990 levels.

In **Scotland**, total emissions have fallen to 45.7 $MtCO_2e$, in 2015 mainly as a result of further falls in power sector emissions. Scotland met its annual target for 2015. Scottish emissions fell 39% between 1990 and 2015, the largest reduction in the UK:

- There were strong falls in 2015 in emissions from the power sector (-21%), and moderate falls in the land use, land-use change and forestry sector (-7%) and the waste sector (-4%).
- There was a moderate increase in emissions from residential buildings (+3%) and non-residential buildings (+1.5%) and from the transport sector (+1.4%).
- Emissions on the 'net' measure used under Scotland's existing emissions targets[105] rose by 0.8 $MtCO_2e$ in 2015, 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

[105] '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).

in the EU Emissions Trading System.[106] For 2015, the Net Scottish Emissions Account (NSEA) was 45.5 $MtCO_2e$, below the annual target of just under 46 $MtCO_2e$.

In **Wales**, total emissions decreased to 45.7 $MtCO_2e$ in 2015. This is a smaller fall in emissions than that in 2014. Emissions since 1990 have fallen 20%.

- In 2015, there was a mixture of small increases and small falls for most sectors with the overall fall in emissions (0.6 $MtCO_2e$) largely driven by the fall in industry emissions (0.7 $MtCO_2e$):
  - Emissions increased in a number of sectors: non-residential buildings (+4%), residential buildings (+2%) and transport (+2%).
  - Only the waste sector (-8%) and the industry sector (-4%) had falling emissions, whilst emissions in the power sector and in the agriculture sector were flat.
  - Between 2009 and 2015 emissions from power and industry rose by an average of 2% per annum.
- Wales has a (non-statutory) target to reduce greenhouse gas emissions by 40% from 1990 levels by 2020. In 2015, emissions were 20% lower than in 1990 (compared to 38% for the UK). On the basis of progress to date, the 40% target by 2020 is likely to be missed.
- Wales has a target to reduce annual emissions by an average 3% per annum (against a 2006-2010 baseline) in areas of devolved responsibility: transport, resource efficiency and waste, business, residential, agriculture and related land use, and public sector. For 2014, the most recent year for which data are available, this translates into a 12% reduction target against the baseline. The 2014 target was met, as there was a 6% reduction between 2013 and 2014, with relevant emissions now 20% below the baseline.

In **Northern Ireland**, emissions in 2015 increased to 20.7 $MtCO_2e$. 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 2015 fell in the waste (-6.5%) and buildings sectors (both residential (-1.9%) and non-residential (-3.6%)).
- Emissions in 2015 rose in the transport (+2.1%), land use, land-use change and forestry (LULUCF) (+1.9%), industry (+1.7%) and agriculture (+1.3%) sectors.
- Northern Ireland has a target to reduce emissions in 2025 by at least 35% compared to 1990 levels. In 2015, emissions in Northern Ireland were 18% 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.

Overall, emissions in the devolved administrations were collectively 28% below 1990 levels in 2015. The differences across the nations in part reflect the relative importance of different sectors at the devolved level.

There have been significant revisions to emissions data for all the devolved administrations, due to improvements in the methodology for estimating emissions mainly in the land use, land-use change and forestry (LULUCF) and waste sectors (Box 9.1).

[106] Scotland's share of EU ETS allowances increased in 2015 relative to 2014, due to an increase in the total number of allowances being auctioned at EU level, which reflects the timing of the 'backloading' initiative.

Box 9.1 Inventory revision in 2017

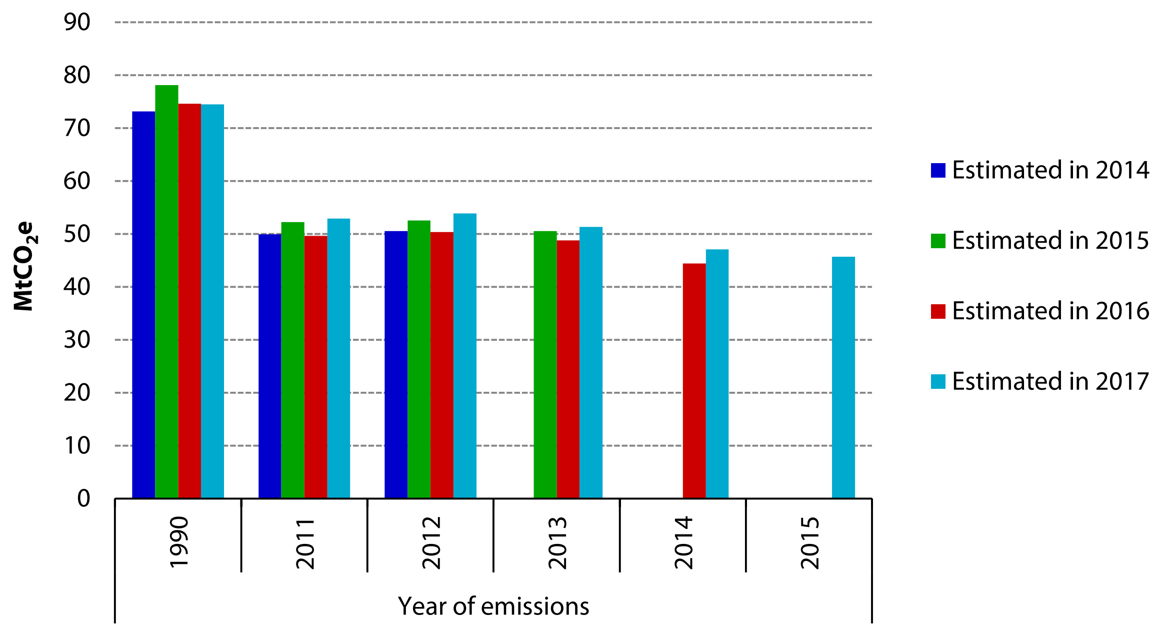
Inventory improvements are designed to increase the transparency, accuracy, consistency, comparability, and completeness of the inventory. Changes to the 2017 emissions inventory mainly affected the land use, land-use change and forestry (LULUCF) and waste sectors. New Scotland-specific data on waste management and forests on organic soil have allowed improved estimates.

- These revisions affect estimates of **Scottish** emissions to a significantly greater extent than for the other devolved administrations or the UK as a whole, due to the importance of the LULUCF sector in Scotland. As we highlighted in our recent report on *Quantifying Greenhouse Gas Emissions*,[107] estimates of Scottish emissions are more uncertain (±10%) than those for Wales (±3%), Northern Ireland (±7%) or the UK as a whole (±3%). The revision resulted in a downward revision to waste sector emissions and increased estimates of LULUCF emissions, due to a reduction in the estimated size of the carbon sink attributed to the forestry sector:
    - The estimate for Scottish emissions in 1990 is largely unchanged overall, due to offsetting changes: LULUCF emissions have been revised up by 3.8 $MtCO_2e$ from estimates in 2016, while waste emissions have been revised downward by 4.2 $MtCO_2e$ (-43%). The overall revision to estimated emissions for 1990 is a reduction of 0.2 $MtCO_2e$ (-0.2%).
    - The latest estimate of the LULUCF sink for 2014 is 3.2 $MtCO_2e$ smaller than was estimated in 2016. This is offset to a degree by a downward revision of 0.8 $MtCO_2e$ in waste emissions (-34%). The overall revision to estimated emissions for 2014 is an increase of 2.6 $MtCO_2e$ (5.9%).
    - Because emissions estimates for 1990 and 2014 have been impacted differently by these inventory changes, there have been significant changes in estimates of percentage reductions on 1990 levels. Last year's report stated that total Scottish emissions had fallen by 41% between 1990 and 2014; however, after the inventory change this reduction is now estimated at 37%.
    - The difference in revisions to 1990 and 2014 emissions is unusual. 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.
- The inventory changes affect estimates of 1990 **Welsh** emissions more than those for recent years:
    - LULUCF emissions in 1990 are now estimated to be 0.7 $MtCO_2e$ larger than the estimate made in 2016, while industry emissions are now estimated to be 0.2 $MtCO_2e$ smaller than the 2016 estimate.
    - Whilst the 1990 inventory estimate has been revised upwards by 0.3 $MtCO_2e$ (+0.5%), the emissions estimate for 2014 emissions was revised downwards by 0.1 $MtCO_2e$ (-0.3%).
    - As a result, rather than emissions in 2014 being 18% smaller than in 1990, as was estimated in 2016, following the revisions this reduction is now estimated to be 19%.
- For **Northern Ireland** the inventory changes revised emissions upwards in all years.
    - Estimates for 1990 are more strongly affected than emissions in 2014; the revised emissions estimates for 1990 are 2.3% higher whilst the 2014 emissions estimate is 1.1% higher.
    - The revision is driven mostly by changes to LULUCF emissions (0.5 $MtCO_2e$ increase for 1990; 0.3 $MtCO_2e$ increase for 2014). On 2016 estimates, emissions in 2014 were 17% below 1990 levels; as a result of the revision the reduction is now estimated to be 18%.

[107] CCC (2017) *Quantifying Greenhouse Gas Emissions*.

Box 9.1 Inventory revision in 2017

Figure B9.1. Revisions to Scottish emissions estimates between inventories published in 2014-2017



Source: NAEI (2014), NAEI (2015), NAEI (2016), NAEI (2017).
Notes: The chart shows how revisions to the greenhouse gas inventory affect estimates for previous years.

Source: NAEI, CCC analysis.

3. Power sector

Emissions, drivers and electricity generation trends

Progress in the devolved administrations is mixed. Power sector emissions decreased in Scotland whilst remaining unchanged in Wales and Northern Ireland in 2015 (Figure 9.2).

Emissions decreased significantly in Scotland (-21%), whilst they were flat in Wales and Northern Ireland:

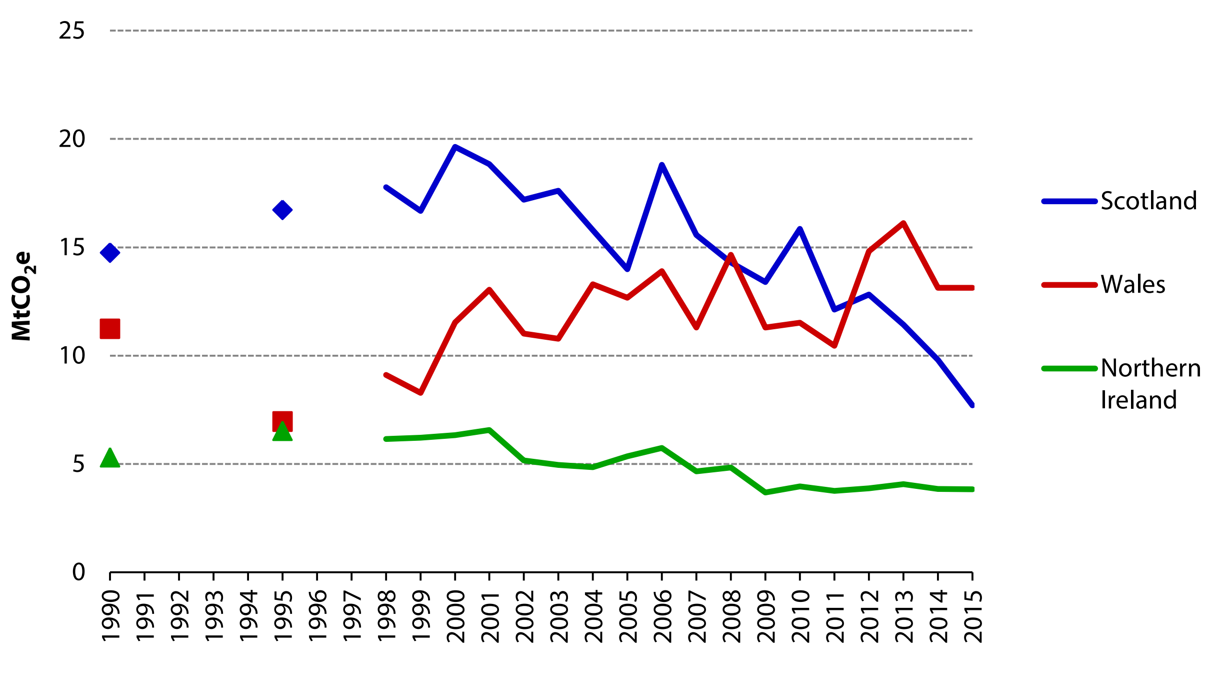
- **In Scotland**:
  - Emissions decreased to 7.7 $MtCO_2e$ in 2015 with an average annual decrease of 8.8% between 2009 and 2015.[108] Power sector emissions accounted for 17% of total Scottish emissions, having decreased by 48% between 1990 and 2015.
  - Coal and gas generation continued to decrease (-18% and -30% respectively), whilst renewable generation increased further (14%). Renewables in Scotland made up 42% of all generation, up from 38% in 2014 (Figure 9.3).

[108] Scotland's last large coal-fired plant, Longannet, closed in 2016. Due to this, power sector emissions will fall substantially in 2016 (for which data will be available in 2018).

- **In Wales**:
  - Power sector emissions remained at 13 $MtCO_2e$ in 2015, accounting for 29% of total Welsh emissions. They are 17% higher than 1990 levels.
  - Overall generation rose 17%, although Wales was again a net importer of electricity from England, as in 2014. Coal generation increased by 7% and there was a 44% increase in renewable generation. Nuclear generation almost doubled (99%) reflecting that Wylfa Nuclear Power Station, which had been out of operation for five months in 2014, operated most of 2015, before closing permanently on 30 December 2015.
- **In Northern Ireland**:
  - Emissions were unchanged at 3.8 $MtCO_2e$ in 2015, with an annual average increase of 0.7% between 2009 and 2015. Emissions are 28% lower than 1990 levels. The sector accounts for 19% of total Northern Irish emissions.
  - There was a small decrease in coal generation (2%) and a rise in renewable generation (32%). There was also an increase in gas generation (10%), which already makes up the largest share (48%) of total generation.

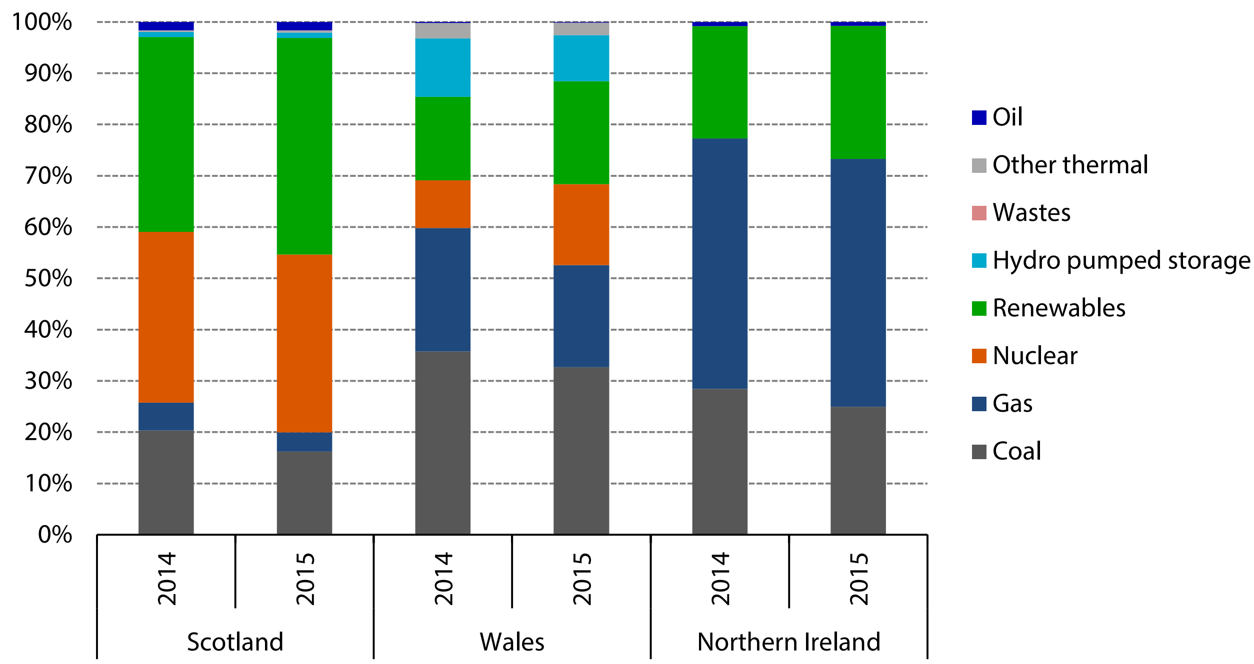
At the UK level, emissions decreased by 16% in the power sector between 2014 and 2015 with an average annual decrease of 6.1% per year between 2009 and 2015.

Figure 9.2. Power sector emissions in Scotland, Wales and Northern Ireland



Source: NAEI (2017).

Figure 9.3. Proportion of generation by fuel in Scotland, Wales and Northern Ireland (2014 and 2015)



Source: BEIS (2016) *Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2015.*

Progress and policy on renewable electricity

Renewable electricity generation decreased slightly in 2016, the most recent year for which data are available, due to lower load factors on wind, although there has been a general trend across the devolved administrations for an increase in renewable capacity (Figure 9.4). In 2016 the devolved administrations together accounted for 33% of UK renewable generation. The devolved administrations each have targets or milestones for renewables:

- **Scotland** accounted for 24% of UK renewable generation in 2016. Generation decreased by 10% from 2015 despite renewable capacity increasing by 11%, due to a UK-wide average reduction in wind speeds compared to 2015.
  - Scotland has a target for the equivalent of 100% of gross electricity consumption in 2020 to be met from renewables. In 2015 the share was 59% (up from 50% in 2014) - renewable sources grew largely due to the significant increase in operational wind sites.
  - As of May 2017, an additional 11.8 GW of renewable electricity projects are either in planning (3.1 GW), awaiting construction (6.3 GW) or under construction (2.4 GW). This is a slight decrease in the project pipeline: in 2015, a total of 13.3 GW additional capacity was either in planning (4.1 GW), awaiting construction (7.7 GW) or under construction (1.5 GW).
  - 10.9 GW of the 11.8 GW are wind projects, 4.2 GW offshore and 6.7 GW onshore. If 100% of this additional wind capacity were to be realised, it would increase generation from renewables by about 31 TWh per year, equivalent to an additional 92% of current

Scottish gross electricity consumption.[109] However, the renewable electricity targets remain challenging, as it is unlikely that all the projects consented will progress to the commissioning stage.

- **Wales** generated 5.2 TWh of renewable electricity in 2016, accounting for 6% of the UK's renewable generation in 2016. Large infrastructure planning is a reserved matter. Previously decisions over projects greater than 50 MW have been decided by the UK Planning Inspectorate,[110] but the 2017 Wales Act raised that threshold to 350 MW.
  - A target[111] to produce 7 TWh from renewables by 2020 is likely to be met. As of May 2017, there are 2.4 GW of projects in the pipeline, either in planning, awaiting construction or under construction. Of this 2.4 GW capacity are 40% onshore wind projects, 32% biomass projects, 13% solar and 13% tidal barrage and tidal stream projects.
  - Wales' largest onshore wind farm, Pen y Cymoedd (256 MW), is fully operational as of May 2017, and is expected to generate 700 GWh annually.
  - The independent Hendry review of tidal lagoons concluded in January 2017, backing Government support for a pathfinder tidal lagoon project at Swansea Bay in Wales, to test the potential long-term contribution of this technology to the UK's energy mix. The Government has not yet responded to the review.
- **Northern Ireland** accounts for 3% of the UK's renewable generation, generating 2 TWh in 2016. It has a target to produce 40% of electricity consumption from renewables by 2020. In 2016 the share was 25.4%, unchanged from 2015.
  - Wind continues to dominate renewable generation, accounting for 83% of all renewable generation in 2016, though this share is down from 90% in 2015.
  - Northern Ireland Renewables Obligation (NIRO) was closed in 2016 for new small-scale onshore wind (up to 5 MW) projects.
  - As of May 2017, there are 1.3 GW of projects in the pipeline, either in planning, awaiting construction or under construction. Of this 2.3 GW capacity, 70% are onshore wind projects and 20% are solar.

Scotland is leading the devolved administrations in terms of deployment of renewable power capacity. However, whilst Northern Ireland is making progress in solar PV and Wales is at the forefront of tidal lagoons, more is likely to be needed to ensure targets continue to be met.

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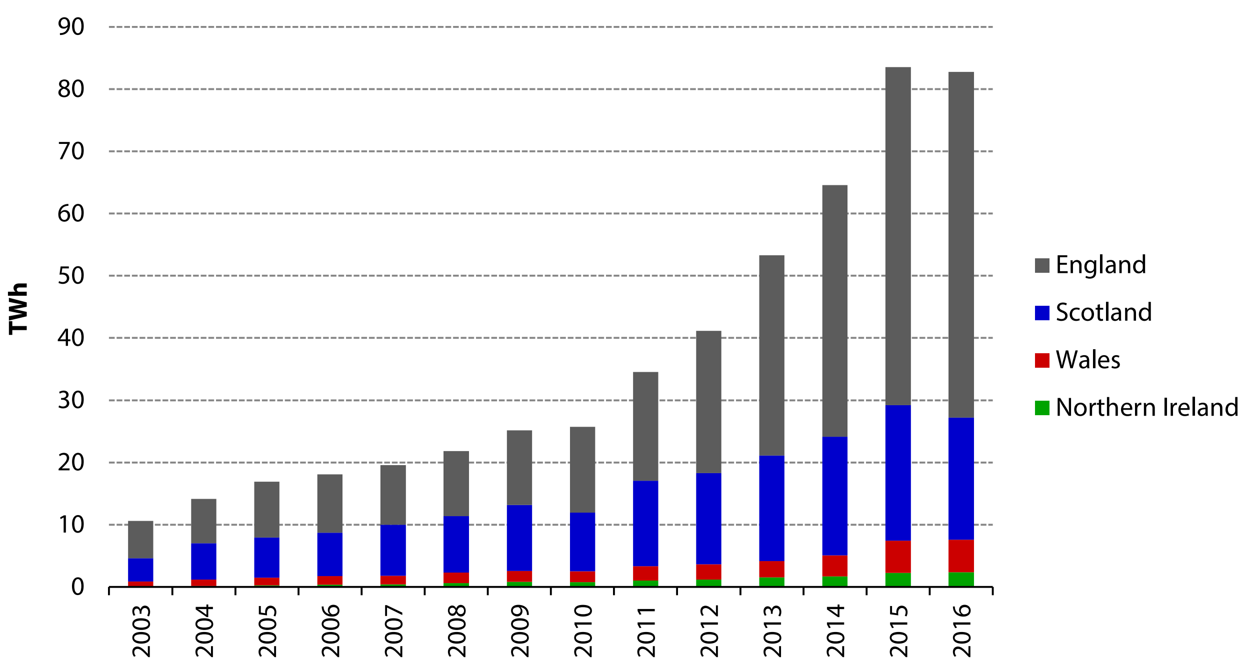
[109] Using a load factor for onshore wind of 26% and for offshore wind of 45%.

[110] The Silk Commission on devolution in Wales recommended that powers over large-scale energy consents (between 50 MW and 350 MW in size) become devolved to the Welsh Government by 2020.

[111] 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.

Figure 9.4. Renewable electricity generation in the UK (2003-2016)



Source: BEIS (2017) *Energy Trends 6.1 Renewable electricity capacity and generation.*

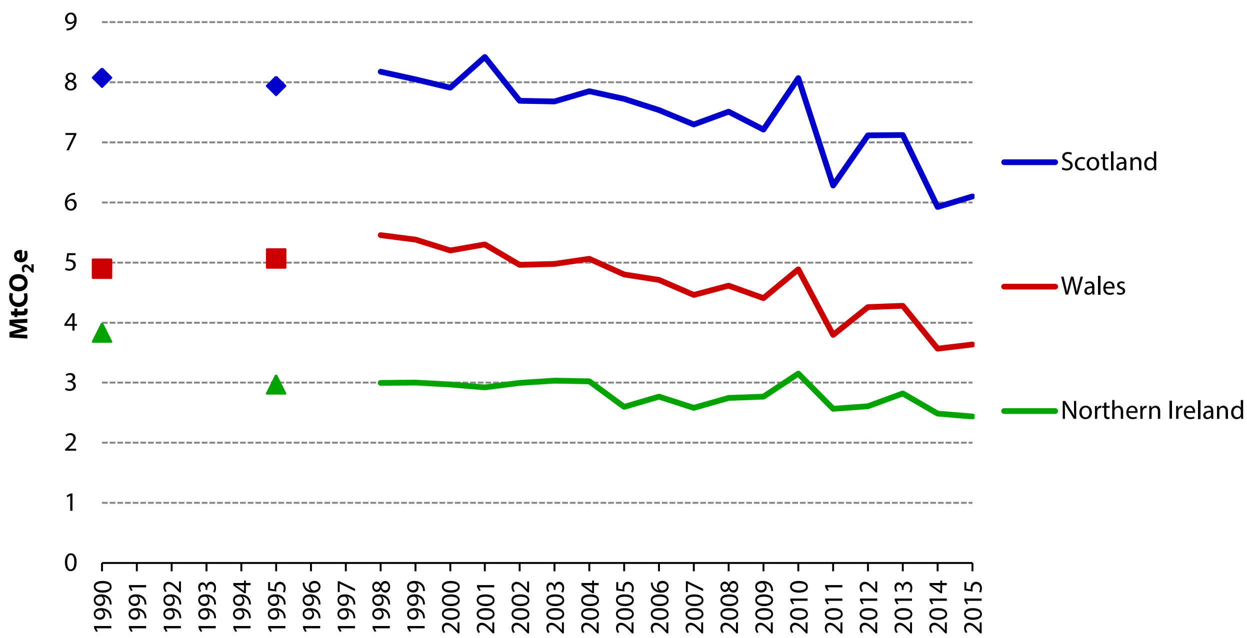
4. Buildings

Emissions from residential buildings

Direct residential emissions across the devolved nations increased by 2% in 2015 (Figure 9.5). This was in the context of a 4% increase in residential emissions at UK level, and reflects that the winter months of 2015 were colder than those in 2014:

- In Scotland, emissions from residential buildings accounted for 13% of total emissions and emissions were 25% lower than 1990 levels.
  - On an unadjusted basis, they increased by 3%, following a 17% decrease in 2014.
  - Allowing for the lower winter temperatures, residential emissions on a temperature-adjusted basis fell by 6% in 2015.
- In Wales, emissions from residential buildings accounted for 8% of total Welsh emissions and are 26% lower than 1990 levels.
  - On an unadjusted basis, they increased by 2% in 2015, following a 17% decrease in 2014.
  - Allowing for the lower winter temperatures, residential emissions on a temperature-adjusted basis fell by 4% in 2015.
- Emissions from residential buildings in Northern Ireland accounted for 12% of total emissions, and emissions were 37% lower than in 1990.
  - On an unadjusted basis, they decreased by 2% in 2015, continuing the decrease seen in 2014. This is despite lower average winter temperatures in 2015 than in 2014.

Figure 9.5. Residential emissions in Scotland, Wales and Northern Ireland (1990 - 2015)



Source: NAEI (2017).
Note: This chart presents outturn data, not adjusted to account for differences in winter temperatures across years.

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. Both Scotland and Wales have performed well compared to the GB average in terms of installations under the RHI. They have a greater proportion of installations than would be expected based on GVA (8% and 3% respectively) and housing shares (9% and 5%). As of December 2016, 20% of non-residential capacity was installed in Scotland and 9% in Wales and 20% of residential capacity accredited in Scotland, 7% in Wales. This reflects Scotland and Wales' larger share of off-grid homes – with 87% of all residential accreditation in Scotland from off-gas-grid properties (compared to 73% in GB overall).

In Scotland the Home Energy Scotland renewables loan scheme further supports funding under the RHI.

Scotland has implemented further policies to encourage the uptake of renewable heat. Progress is being made, from a low base:

- In 2015, an estimated 1.5 GW of renewable heat capacity was operational in Scotland, producing an estimated 4.1 TWh of useful renewable heat.[112] This represents a 47% increase in renewable heat capacity and a 37% increase in heat generated from renewable sources compared with 2014.

[112] Renewable heat technologies include biomass, biomass CHP, heat pumps, energy from waste and solar thermal.

- In 2014, Scotland generated 3.8% of its non-electrical heat demand from renewable resources. It is estimated that in 2015 around 5.5% of non-electrical heat demand came from renewable sources.
- The publication of the Scotland Heat Map[113] was accompanied by a further £7 million funding for the District Heating Loan Scheme in 2016-17, and the set-up of the Scottish Heat Networks Partnership Practitioner Group.

For **Wales**, heat generation from biomass boilers, heat pumps and biogas is increasing, largely due to the non-domestic RHI for farm and commercial activities. We recommended in 2016 that the Welsh Government develop a heat strategy and set a low-carbon heat target to encourage uptake, especially in residential buildings. There has not been any progress to date.

The Welsh Government has committed to setting new energy targets this year. We recommend that this includes consideration of low-carbon heat deployment, alongside low-carbon electricity.

To support the development of low-carbon heat in **Northern Ireland**, the Executive introduced its own RHI and Renewable Heat Premium Payment (RHPP) schemes, which are now both closed. The scheme was over-subscribed and there are reports that it was not managed properly. The Northern Ireland Executive is currently going through sensitive discussions about power sharing and reviews of its handling of the renewable heat incentive scheme. The Committee will have a more detailed discussion with Northern Ireland later this year.

Fuel poverty and progress in energy efficiency policy

Fuel poverty is a partially devolved issue, with each devolved administration having its own targets to eradicate fuel poverty, by 2016 in Scotland and 2018 in Wales and Northern Ireland. The devolved administrations place great emphasis on aligning climate change mitigation with wider social benefits, such as the reduction of fuel poverty. The devolved administrations continue to use the 10% definition,[114] rather than the Low Income High Cost (LIHC) measure used in England.

In 2015, 31% of households in Scotland were estimated to be in fuel poverty. For Wales, previous model projections have suggested 23% of households were in fuel poverty in 2016. For Northern Ireland, latest available data were for 2011 when 42% of households were in fuel poverty.

Reducing fuel poverty is more of a challenge in the devolved administrations than in England, reflecting factors including lower average incomes, a lower proportion of homes being on the gas grid, and a greater proportion of energy-inefficient properties. Energy efficiency policy is more comprehensive in the devolved administrations than in England:

- The main energy efficiency scheme, the Energy Company Obligation (ECO), is GB-wide (Chapter 3), but Scotland and Wales have devolved powers to develop their own schemes.
- Scotland and Wales have been successful in leveraging funding from the ECO. Their share of funding is higher than their share of the housing stock.

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113 http://www.gov.scot/heatmap

114 Under the '10% definition', a household is said to be in fuel poverty if it needs to spend more than 10% of its income on fuel to maintain an adequate level of warmth (typically defined as 21 degrees for the main living area and 18 degrees for other occupied rooms). Under the LIHC definition, a household is considered to be fuel poor if they have required fuel costs that are above average (the national median level) and were they to spend that amount, they would be left with a residual income below the official poverty line.

- In Northern Ireland, energy efficiency is fully devolved and the Executive has developed similar supplier schemes to GB, as well as their own additional policies.

Box 9.2 shows the range of policies to reduce fuel poverty that are in place in the devolved administrations, focusing on funding for energy efficiency for fuel-poor households. Data on fuel poverty in Northern Ireland needs updating to assess progress made on the 2011 fuel poverty strategy.

Box 9.2. Fuel poverty policies in the devolved administrations

In Scotland:

- In 2015, the fuel poverty rate was the lowest recorded since 2008 and fuel poverty declined from 35% to 31%, equivalent to a reduction in fuel-poor households of around 97,000 compared to 2014. This was due to a combination of factors: a substantial drop in the price of domestic fuel (accounting for 2.3 percentage points of the reduction), improved energy efficiency (1.3 percentage point reduction) and higher household incomes (0.6 percentage points).
- In April 2017 the Scottish Government announced a £30m interest-free loan scheme under the Home Energy Efficiency Programme Scotland supporting energy efficiency measures including solid wall insulation (internal and external), cavity wall, loft and roof insulation, draught proofing and boilers.
- In March 2017, the Energy Agency in Scotland published the interim results of an evaluation project to investigate the success of the Scottish Government-funded insulation schemes in alleviating fuel poverty.[115] Households receiving insulation in 2016 under the Area Based Schemes were monitored. The results show that fuel poverty decreased following the insulation works.

In Wales:

- The Well-being of Future Generations Act (legislated in April 2015), with clear mechanisms for reducing carbon emissions and tackling fuel poverty in Wales, should encourage government agencies to work together to deliver projects. The Welsh Government has announced a new strategy[116] for energy efficiency and addressing fuel poverty to 2026 as part of the Act.
- In 2011, the Welsh Government Warm Homes - NEST programme started to tackle fuel poverty, committing to a total investment of £120m to improve the energy efficiency of low-income households. Since its launch, NEST has improved the energy efficiency of over 23,700 homes of low-income households across Wales and £25.5m were invested in NEST in 2015-2016.[117]

In Northern Ireland:

- The most recent policy statement, 'Warmer Healthier Homes - a new Fuel Poverty Strategy for Northern Ireland', was published in 2011 and has not been updated since.
- The Department for Communities launched the Affordable Warmth Scheme, addressing fuel poverty in the private sector. The scheme provides grants for a range of energy efficiency measures, such as insulation, heating, replacement of windows and solid wall insulations.
- The Boiler Replacement Scheme closed to new applications in March 2016.

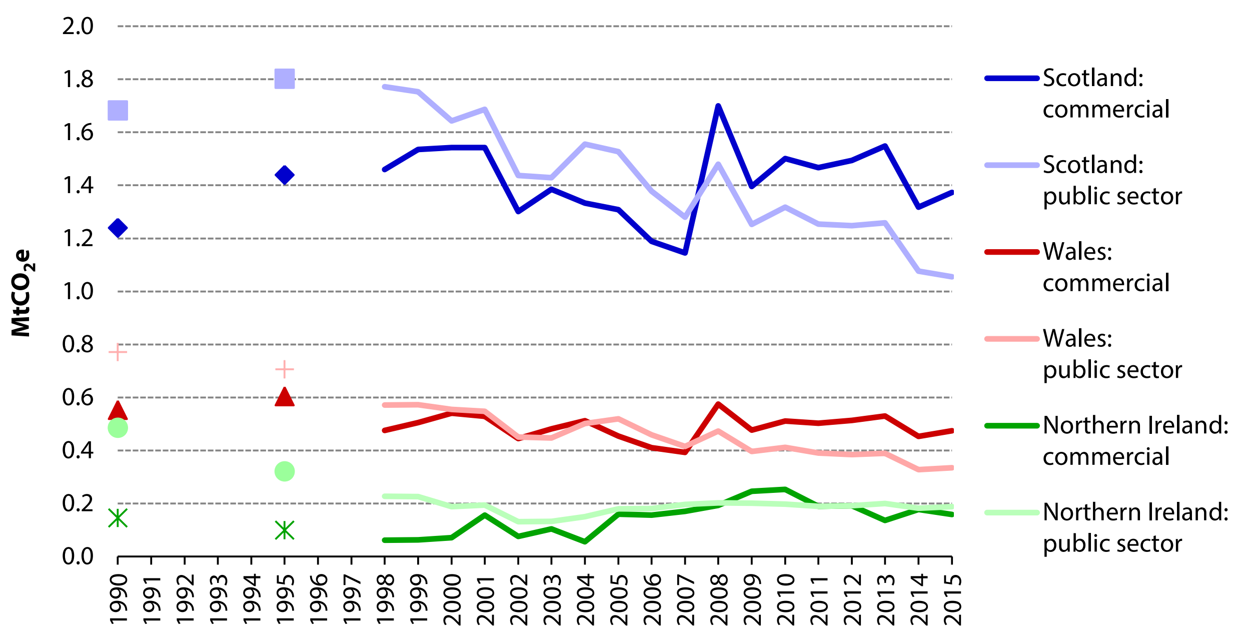
115 South and East Ayrshire (2017) *Area-based schemes wall insulation evaluation*.
116 Welsh Government (2016) *Energy Efficiency in Wales – A strategy for the next 10 years 2016–2026*.
117 Nest (2016) *Annual Report*.

Non-residential buildings

Emissions from non-residential buildings fell in Northern Ireland but rose in Scotland and Wales in 2015 (Figure 9.6):

- In Scotland, emissions from non-residential buildings rose by 1.5%, with emissions from commercial buildings increasing by 4% and those from the public sector decreasing by 2%. The non-residential buildings sector accounted for 5% of total Scottish emissions in 2015.
- In Wales, emissions from non-residential buildings increased by 3.7%, although it is a very small sector, accounting for 2% of total emissions in 2015. Emissions from commercial buildings increased 5% and those from the public sector increased 2%.
- In Northern Ireland, emissions from non-residential buildings decreased by 3.6%. This was due to a 10% decline in commercial buildings emissions. The non-residential buildings sector accounted for 2% of Northern Ireland emissions in 2015.

Figure 9.6. Non-residential buildings emissions in Scotland, Wales and Northern Ireland (1990-2015)



Source: NAEI (2017).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

5. Industry

Direct emissions from industry decreased in Wales in 2015, whilst they increased in Scotland and Northern Ireland (Figure 9.7), in the context of an overall 2.2% fall at UK level:

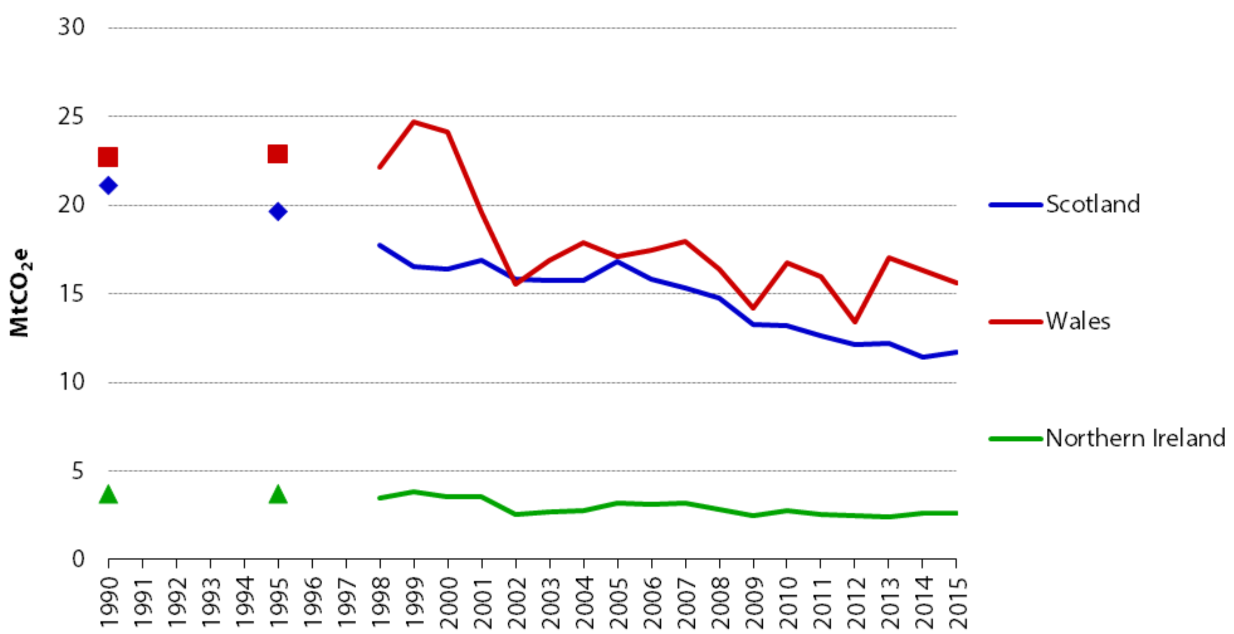
- In Scotland, emissions from industry increased by 2.4% in 2015, although they decreased by an annual average of 2.1% between 2009 and 2015. Emissions from the sector accounted for 26% of total Scottish emissions and have decreased 45% since 1990.

- In Wales, emissions from industry decreased 4.4% in 2015 to 15.6 $MtCO_2e$, but increased by an annual average of 1.6% between 2009 and 2015. Industry emissions in 2015 were 31% lower than 1990 levels, 34% of total Welsh emissions. Industry makes up a particularly large share of total emissions in Wales, mainly due to the Port Talbot steelworks. In 2015, EU ETS verified emissions for Port Talbot steelworks decreased by 9% (0.75 $MtCO_2e$) on 2014 levels, similar to the overall fall in Welsh industry emissions. This was followed by a further fall of 11% in 2016.[118]
- Emissions from industry in Northern Ireland accounted for 13% of total emissions in 2015 and increased by 1.7%, with an annual average increase of 1.3% between 2009 and 2015. They are 29% lower than in 1990.

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).[119]

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.

Figure 9.7. Direct industry emissions in Scotland, Wales and Northern Ireland (1990-2015)



Source: NAEI (2017).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

[118] Although overall emissions data for the devolved administrations for 2016 are not available, verified data for EU ETS installations are available.
[119] 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.*

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).

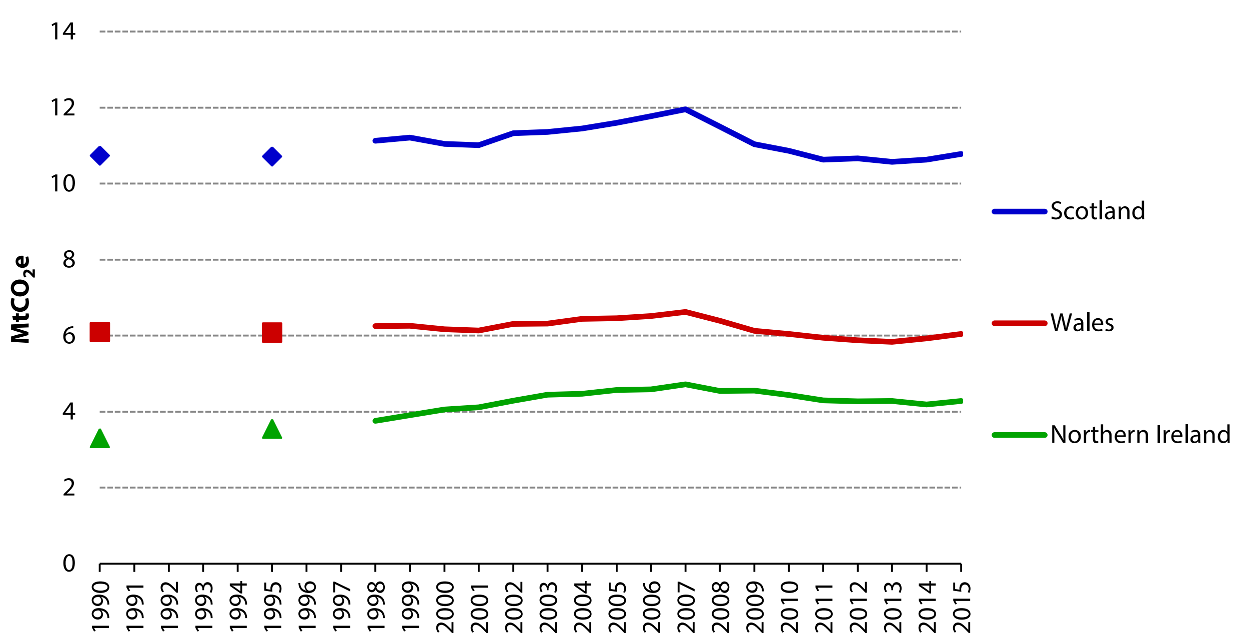
As part of the devolution settlement, air passenger duty (APD) will be devolved to the Scottish Government which plans to reduce APD by 50% from April 2018.

Emissions trends and drivers

Emissions from transport increased by 2% across the UK in 2015, a trend that is also present across the devolved administrations from 2014 to 2015 (Figure 9.8):

- In **Scotland**, transport emissions increased by 1.4% in 2015, the second consecutive annual increase, and were 10.8 $MtCO_2e$, slightly above the level in 1990. Transport emissions account for 24% of total emissions in Scotland in 2015, the same share as in the UK.
- In **Wales**, the transport sector accounts for a smaller share (13%) of overall emissions. Emissions from transport increased in 2015 by 2%, the second consecutive annual increase, with an annual average decrease of 0.2% between 2009 and 2015. Welsh transport emissions are only 1% lower than in 1990.
- In **Northern Ireland**, transport emissions increased by 2.1% in 2015, with an annual average decrease by 1% between 2009 and 2015, but were 29% higher than in 1990. Emissions from the sector were 21% of overall Northern Irish emissions in 2015. 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, despite increases in new-car efficiency in 2014 and 2015 (Table 9.3). The efficiency of new cars is driven by EU legislation; however, there has been some variation in progress towards achieving the EU's 2020 target of 95 gCO_2/km by 2020. Improvements in new-car efficiency in the devolved administrations are in line with those seen in England. However, as discussed at UK level in Chapter 5, evidence has continued to emerge that there is a large and growing gap between test-cycle and real-world emissions for new cars.
- The increase in vehicle-kilometres in 2015 in Scotland and Wales (1.2% and 1.3%) is slightly lower than in England at the same time (1.6%).

Figure 9.8. Transport emissions in Scotland, Wales and Northern Ireland (1990-2015)



Source: NAEI (2017).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Table 9.3. Change in vehicle-kms in 2015 and new-car efficiency 2016

	Road traffic	**Heavy Goods Vehicles**	**Cars**	**New car test-cycle efficiency 2016**	**Target for 95 gCO_2/km by 2020 on track?**
Scotland	1.2% increase	1.3% increase	0.7% increase	120.0 gCO_2/km (1% decrease from 2015)	No, Scotland is in line with UK average
Wales	1.4% increase	1.5% increase	1.8% increase	119.5 gCO_2/km (1% decrease from 2015)	No, even though more efficient than UK average
Northern Ireland (vehicle-km data for 2014)	0.3% decrease	No change	0.3% decrease	118.6 gCO_2/km (1% decrease from 2014)	No, but best efficiency in UK

Source: Scottish Government (2016) *Scottish Transport Statistics No 35*, Welsh Government (2016) *Road Traffic in Wales 2015*, Department for Transport (2016), The Society of Motoring Manufacturing and Traders Limited (2017).
Notes: Northern Ireland vehicle-km data for 2015 are not available until the end of June 2017.

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 94% of the total UK market in 2016). Sales of electric vehicles in Scotland accounted for 4% of UK sales in 2016, 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 2016).

Whilst sales of EVs in England in 2016 increased by 32%, they only increased slightly in Scotland and Northern Ireland (5% and 3%) and even decreased in Wales (-5%):

- In Scotland, 0.6% of car sales were EVs in 2016, the same as in 2015 (compared to 1.5% in England). The Electric Vehicle Loan scheme, that provides interest free loans up to £35,000 for the purchase of an electric vehicle, is open until March 2018.
- In Wales, 0.6% of car sales were EVs in 2016, down from 0.7% in 2015.
- In Northern Ireland, 0.8% of car sales were EVs in 2016, up from 0.7% in 2015.

Scotland 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 2017, there were 1,811 public charging points across Scotland (14.7% of total UK points), 141 more than in April 2016, an increase of 8.5%.[120]
- As of June 2017, Wales has 390 charging points, a share of 3.2% of UK charging points.
- Northern Ireland has 458 charging points as of June 2017, a share of 3.7% of UK charging points.

In terms of sales, progress continues to be slow in the devolved administrations. Barriers to EV uptake remain, both financial and non-financial. These are similar to those at a UK level and include costs, range anxiety, and lack of information. We recommend new, low-cost approaches to financing; on-street residential charge points; softer time-limited measures such as access to bus lanes and parking spaces; and raising awareness through public procurement.

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 each of the devolved administrations, and across the UK, since 2013.

In Scotland:

- Transport Scotland continues to fund Smarter Choices, Smarter Places with £5m in 2017/2018. Paths for All will continue to administer the programme.
- The third Cycling Action Plan, published in 2017, includes a new set of actions and outlines how the Scottish Government, local authorities and all key partners will respond to the needs of stakeholders to achieve active travel commitments.

[120] https://www.zap-map.com/statistics/

In Wales:

- The Safe Routes in Communities Grant provides funding to local authorities to improve how easy it is for people to travel around their communities, funding project such as footpaths, cycle paths or cycle facilities. In 2016/17, nearly £5.2m will be distributed across 20 different local authorities.

In Northern Ireland:

- The Travel survey Northern Ireland (2013-2015)[121] compares results from 2010-2012 to 2013-2015 and found that there has been no significant modal shift (change from one mode of travel to another).
- TravelwiseNI is an initiative to encourage the use of sustainable transport options such as walking, cycling, public transport or car sharing.

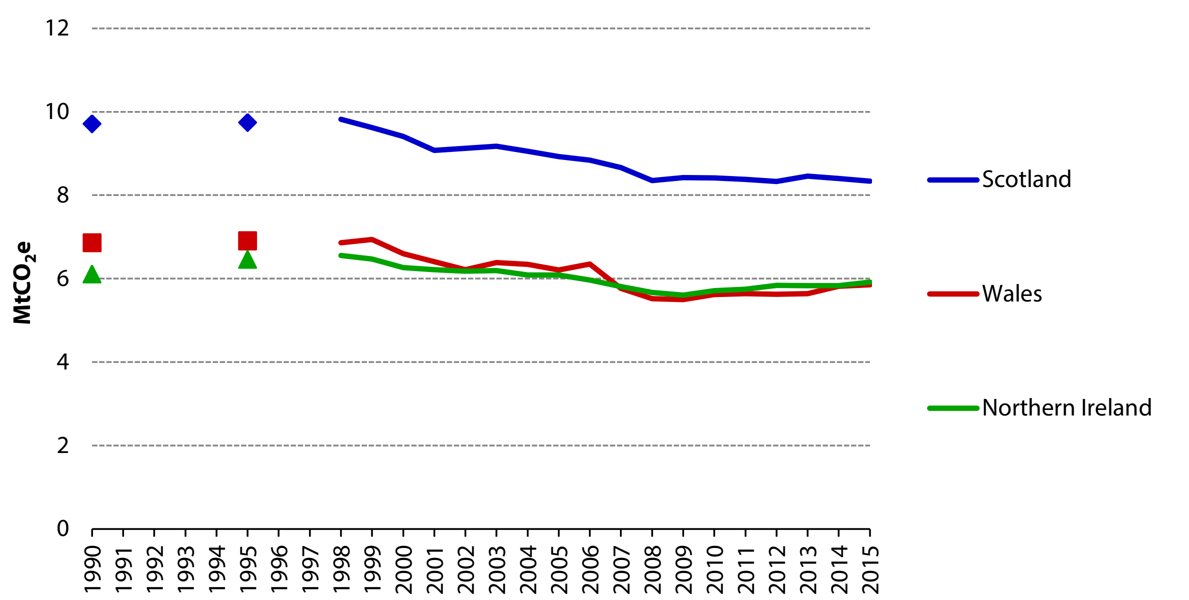
7. Agriculture and land use

Agriculture emissions and drivers

Emissions from agriculture were unchanged for the UK as a whole in 2015, but increased in Wales and Northern Ireland and decreased in Scotland (Figure 9.9).

There is considerable uncertainty over emissions from agriculture. Work at a UK level is expected to reduce that uncertainty over the coming years with the introduction of the Smart inventory. The level of uncertainty limits the scope for significant new initiatives at this stage. Despite this uncertainty around the level of emissions, the trend of emissions over time is generally more robust.

Figure 9.9. Agriculture emissions in Scotland, Wales and Northern Ireland (1990-2015)



Source: NAEI (2017).

[121] DRDNI (2015) *Travel Survey for Northern Ireland*.

Agriculture in the devolved administrations is relatively more important for emissions, and for the economy, than for the UK as a whole. This is especially the case for Northern Ireland where 2015 emissions were 29% of the total compared to 18% in Scotland, 13% in Wales and 10% at a UK level. In 2015:

- In Scotland, agricultural emissions decrease by 0.8%, with no overall change on average between 2009 and 2015, although they have reduced by 14% since 1990.
- Emissions from agriculture in Wales increased slightly by 0.6%, with an annual average increase of 1.1% between 2009 and 2015, and were 15% below 1990 levels.
- In Northern Ireland, emissions from agriculture increased by 1.3%, with annual average increases of 0.9% between 2009 and 2015, and are just 3% lower than they were in 1990.

Agricultural policy is a devolved matter. As in England, the devolved administrations place considerable emphasis on a collaborative approach with the farming industry. To date, policy approaches are voluntary, although the Scottish Government has announced its intention to regulate if significant progress is not made:

- **Scotland** has an emissions reduction milestone for agriculture of 1.3 $MtCO_2e$ from 2006 levels by 2020. In 2015 emissions had reduced 0.5 $MtCO_2e$ since 2006. However, assessment of progress is difficult due to changes in the methodology used to measure agricultural emissions since the target was set. The draft Climate Change plan sets out the Scottish ambition and milestones for this sector. The Committee will consider this further in our Scottish progress report, later this year.
- **Wales** has set a reduction target of between 0.6 $MtCO_2e$ (10% below 2008 levels) and 1.5 $MtCO_2e$ by 2020 in its 2010 Climate Change Strategy. However, assessment of progress is difficult due to changes in the methodology used to measure agricultural emissions since the target was set. Proposed emission reductions are being delivered through programmes such as Glastir.
- **In Northern Ireland**, in 2016 the Greenhouse Gas Implementation Partnership (GHGIP), a collaborative strategy between stakeholders and the Executive, published their second report, "Efficient Farming Cuts Greenhouse Gases - Implementation Plan 2016-2020 ".[122] The plan focuses on reducing carbon intensity through the increasingly efficient use of resources and practices.

Forestry and land use emissions

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 (see section 2), therefore the figures in this report are not directly comparable to those from previous years.

In Scotland in 2015 the sink decreased between 2014 and 2015, whilst in Wales the sink increased (Figure 9.10). In Northern Ireland, the LULUCF sector is a net emitter and emissions increased by 1.9%:

- In Scotland, the size of the carbon sink decreased to 2.8 $MtCO_2e$ in 2015, from 3.0 $MtCO_2e$ in 2014. However, the size of the sink increased between 2009 and 2015 by an annual average

[122] Agriculture and Forestry Greenhouse Gas Implementation Partnership (2016) *Efficient Farming cuts: Greenhouse Gases Implementation Plan 2016–2020.*

of 0.03 $MtCO_2e$. In 1990 the sector was a source of emissions equivalent to about 1.5 $MtCO_2e$. The carbon sink in Scotland represents 38% of the UK's total LULUCF sink.

- In Wales, the small sink (-1% of Welsh emissions) increased in 2015, by 0.04 $MtCO_2e$ to 0.34 $MtCO_2e$. Between 2009 and 2015 the sink has increased by an annual average of 0.02 $MtCO_2e$.
- In Northern Ireland, the sector was a net emitter in 2015, emitting 0.7 $MtCO_2e$, with an annual average increase of 0.01 $MtCO_2e$ between 2009 and 2015. The sector accounts for 3% of total emissions.

For the forestry sector, the devolved administrations have ambitious targets to increase the rates of forest planting; however current planting rates do not match those ambitions.

The devolved administrations should consider what further actions are needed to ensure tree planting targets are met. These could include introducing additional measures to incentivise planting. Any plan or strategy that is introduced should be developed and delivered jointly with key stakeholders and possibly with other nations.

- **In Scotland**, planting rates decreased in 2016 by 39% to 4,600 hectares (ha), missing the target of 10,000 ha new woodland each year.
  - As planting rates have decreased across all nations, Scotland still has the largest share of new planting in the UK at 84% in 2016.
  - The draft Scottish Climate Change plan sets more ambitious targets; the Committee will assess these in our Scottish progress report later this year.
- Following an 89% decrease in 2015, the planting rate in **Wales** remained at very low levels in 2016 (around 100 ha of new woodland). This is significantly off-track from the Welsh Climate Change Strategy aspiration to create 100,000 ha of new woodland between 2010 and 2030, which requires an average of 5,000 ha/year.
- In **Northern Ireland**, planting rates declined further to 100 ha in 2016, a decline of 50%.

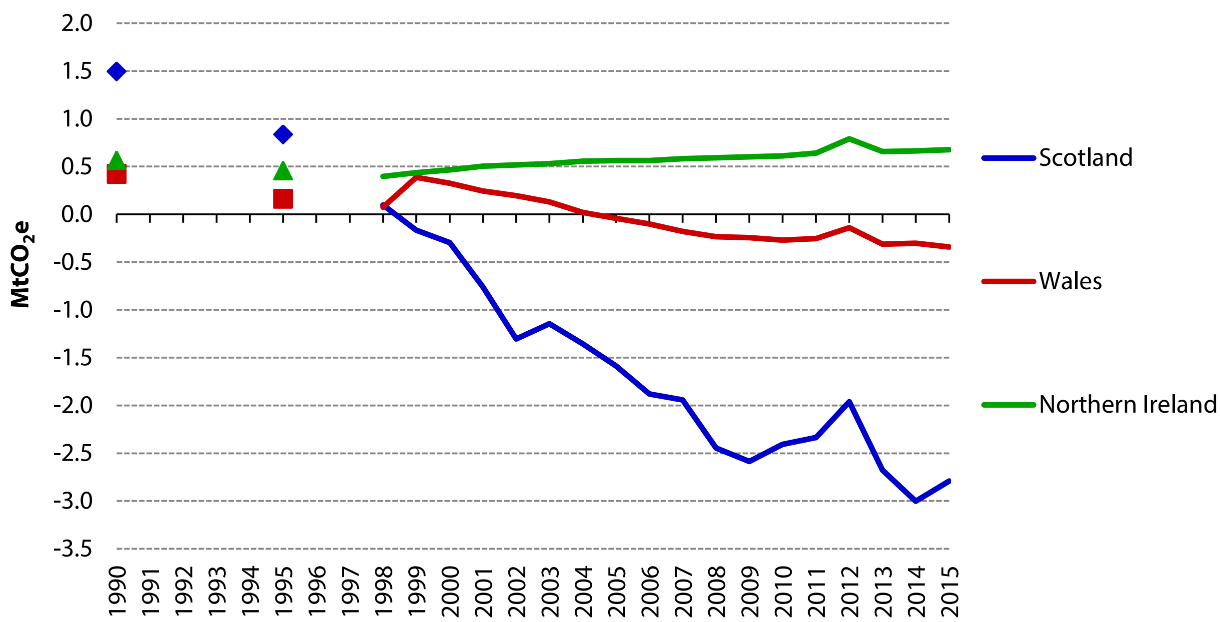
Emissions can also be absorbed into or released by soils. The LULUCF inventory currently only includes peatland emissions from lowland peat, mainly related to extraction for horticultural use. BEIS is currently in the process of incorporating the IPCC’s Wetland Supplement into the UK’s Inventory in time for 2018. This will capture emissions from upland as well as lowland peat, and carbon sequestration from restoration practices.

Peatlands in the devolved administrations account for large areas of land:

- Peatlands cover approximately 20% of land area in Scotland. They account for 60% of the UK’s peatlands and 4% of Europe’s total peat carbon store. 600,000 hectares of peatlands require restoration in Scotland. Scotland’s 2014 National Peatland Plan sets out proposals for research and awareness-raising.
- In Wales, around 25% of the land area is peat. The Resilient Ecosystems Fund has provided £165,000 to restore peatlands in Welsh Water’s two reservoirs.
- Peatlands cover 13% of Northern Ireland's land area but account for 42% of its soil carbon store. Around 80% of Northern Ireland’s peatlands have been degraded. Financial support has been given to restoration projects, largely through the Rural Development Programme.

The devolved administrations should encourage good practice in heather and grass burning to avoid damage to peatlands and ensure that detailed management plans are produced for restorations.

Figure 9.10. Emissions from land use, land-use change and forestry in Scotland, Wales and Northern Ireland (1990 - 2015)



Source: NAEI (2017).
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. Waste emissions account for only a small proportion of total emissions of Scotland, Wales and Northern Ireland (3%, 2% and 3% respectively). In 2015, emissions from waste decreased across all the devolved administrations (Figure 9.11), falling 4% in Scotland, 8% in Wales, and 6% in Northern Ireland, compared to 7% in the UK as a whole.

In Scotland:

- The recycling rate of waste from all sources has increased to 56.7%. The target for 2025 set out in the Zero Waste Plan is 70%.[123]
- Household recycling rates have increased in 2015 to 44.2%. The Zero Waste Plan set an interim target for 2013 of 50%. Despite a gradual increase in recycling rates, Scotland is still falling short of this target.
- The share of total waste from all sources sent to landfill decreased by 5.1% in 2015 to 37% of total waste. The Zero Waste Plan target for 2025 is 5%.

[123] Scotland revised the methodology of the measurement of the total tonnage of waste that was recycled in 2014. Prior to 2014, household waste composted that did not reach the quality standards set by PAS 100/110 was included in the recycling figures. Therefore, rates pre-2014 should not be compared with post-2014 rates.

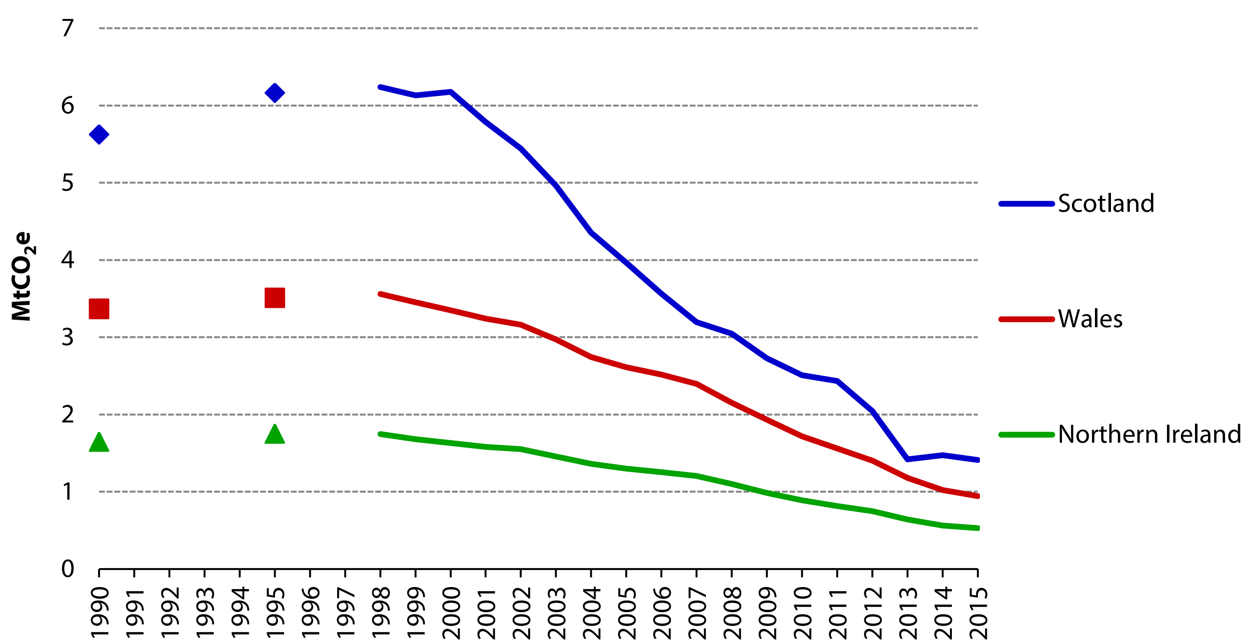
In Wales:

- Wales is leading in the UK regarding recycling rates. The percentage of waste reused, recycled or composted increased from 56.2% in 2014/15 to 60.2% in 2015/16.
- In its current waste strategy 'Towards Zero Waste' (2010),[124] the Welsh Government set a statutory target of recycling 70% of waste by 2024-25.
- Between 2013/14 and 2015/16 waste sent to landfill has reduced by 37%, reducing the share of waste sent to landfill to 18% in 2015/16.

In Northern Ireland:

- Northern Ireland has a recycling rate for municipal waste of 42% in 2015/16, a slight increase from 41% in 2014/15. The target for 2015 of 45% was missed.
- Household waste recycling rate in 2015/16 was also 42%.

Figure 9.11. Waste emissions in Scotland, Wales and Northern Ireland (1990 - 2015)



Source: NAEI (2017).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

[124] http://gov.wales/topics/environmentcountryside/epq/waste_recycling/zerowaste/?lang=en

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 3% in 2015. Power sector emissions declined again in 2015 and will fall again sharply in 2016 due to the closure of Longannet. There has been considerably less progress in reducing emissions in other sectors. There is a downward trend in buildings emissions, although as 2015 was colder than 2014 this did not immediately translate into lower emissions. Transport emissions in Scotland have risen in the past two years, while very little progress is apparent agriculture and non-residential buildings.
- In **Wales**, emissions fell by around 1% due to a fall in industry emissions, while those in other sectors were broadly flat. This follows a period in which Welsh emissions have been rising gradually. Transport emissions have risen for two years in a row. In contrast to the UK as a whole, Welsh power sector emissions rose in 2015.
- In **Northern Ireland**, emissions are broadly flat in all 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 has published a draft Climate Change Plan on how to meet the existing targets. It will be finalised in early 2018. It has also committed to another climate change bill, and has proposed that this includes a 2050 target for a 90% reduction on 1990 emissions. The Committee provided advice on the proposed bill in March 2017 and we will assess the policies and proposals in the draft Climate Change Plan as part of our Scottish progress report in September.

The Committee provided advice to the Welsh Government on the design of the emissions targets and carbon budgets under the Environment Act (Wales) in March 2017. We will advise on the levels of the targets and the first two carbon budgets in November, including an assessment of areas in which policies need to go further. Once these have been placed in legislation, Welsh Ministers are required to publish a report setting out their proposals and policies for meeting them.

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