Meeting Carbon Budgets – 2016 Progress Report to Parliament

Committee on Climate Change
June 2016

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Any enquiries related to this publication should be sent to us at communications@theccc.gsi.gov.uk

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Foreword

This report - reviewing progress towards meeting our carbon budgets and the 2050 emission reduction target - comes at a critical point in the development of climate policy in the UK. The Government is about to legislate the level of the fifth carbon budget (covering the years 2028-2032). It has committed to publication of an emission reduction plan, setting out how it expects to meet the targets, towards the end of the year.

Development of those plans takes place against the backdrop of the Paris Agreement in December last year, where the countries of the world agreed to increased ambition to tackle climate change. In particular, they agreed an aim to limit the rise in global temperature to well below 2°C, with efforts to hold it to 1.5°C. The Agreement demonstrates the need for countries to work together to meet mutually agreed ambitions.

In that context, the result of the UK referendum, to leave the EU, requires serious consideration. The UK's targets to reduce emissions - enshrined in legislated carbon budgets and the 2050 target - derive from UK legislation. We will still need to meet these targets. We will still need to find ways to reduce emissions. But some of our options for doing so may now be different. At this stage it is too early to say how the policy landscape will need to adapt, but we clearly need to come back to consider this further.

Within the UK there has been progress in reducing emissions. In 2015, emissions fell by 3% and they are now 38% below 1990 levels. Much of the progress, however, has been in the power sector. To meet emission reduction targets going forward, reductions will need to be broadly based, across all sectors of the economy.

The Government recognises this. It recognises that current policies are insufficient to meet the requirements of the fourth and fifth carbon budgets and keep us on a cost-effective path to the 2050 target. It has committed to producing its plans for how these budgets will be met before the end of the year. With that in mind, in this report we review recent progress, but we also set out requirements for the Government's emission reduction plan if it is to succeed in its ambition. We hope this will be helpful to the Government as it develops its thinking. We will return to assess the plan against those requirements in our Progress Report next year.

I am grateful to the Committee members for their help and guidance in producing this report, particularly to our new members - Nick Chater and Corinne Le Quéré - whose first report this is; and I am grateful to the Secretariat for their continued hard work.

Lord Deben
Chairman, Committee on Climate Change

The Committee

The Rt. Hon John Gummer, Lord Deben, Chairman

The Rt. Hon John Gummer, Lord Deben, was the Minister for Agriculture, Fisheries and Food between 1989 and 1993 and was the longest serving Secretary of State for the Environment the UK has ever had. His sixteen years of top-level ministerial experience also include Minister for London, Employment Minister and Paymaster General in HM Treasury. He has consistently championed an identity between environmental concerns and business sense. To that end, he set up and now runs Sancroft, a Corporate Responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues. Lord Deben is Chairman of the Committee on Climate Change, Valpak Limited, and the Association of Professional Financial Advisors.

Professor Nick Chater

Professor Nick Chater FBA is Professor of Behavioural Science at Warwick Business School, having previously held chairs in Psychology at Warwick and University College London (UCL). He is particularly interested in the cognitive and social foundations of rationality, and in applying behavioural insights to public policy and business. He has served as Associate Editor for the journals Cognitive Science, Psychological Review, Psychological Science and Management Science. He co-founded and is a Director of the research consultancy Decision Technology Ltd.

Professor Samuel Fankhauser

Professor Samuel Fankhauser is Co-Director of the Grantham Research Institute on Climate Change and Deputy Director of the ESRC-funded Centre for Climate Change Economics and Policy, both at the London School of Economics, and a Director at Vivid Economics. He is a former Deputy Chief Economist of the European Bank for Reconstruction and Development.

Professor Sir Brian Hoskins

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

Paul Johnson

Paul is the Director of the Institute for Fiscal Studies and is a visiting professor at UCL. He is widely published on the economics of public policy including tax, welfare, inequality and poverty, pensions, education, climate change and public finances. He is also one of the authors of the "Mirrlees review" of tax system design. Paul has previously worked at the Financial Services Authority and has been Chief Economist at the Department for Education and Director of Public Spending in HM Treasury, as well as Deputy Head of the UK Government Economic Service. He is a member of the council and executive committee of the Royal Economic Society and a member of the banking standards board. Paul has previously served on the council of the Economic and Social Research Council. He was a founder council member of the Pensions Policy Institute and in 2010 he led a review of the policy of auto-enrolment into pensions for the new Government.

Julia King, The Baroness Brown of Cambridge

Julia King DBE FREng, The Baroness Brown of Cambridge, is the Vice-Chancellor and Chief Executive of Aston University. After an academic career at Cambridge University, Julia held senior business and engineering posts at Rolls-Royce for eight years. She returned to academia as Principal of the Engineering Faculty at Imperial College, London, becoming Vice-Chancellor of Aston University in 2006. Julia advises Government as a member of the CCC, the Science and Technology Honours Committee and as the UK's Low Carbon Business Ambassador. She is a member of the World Economic Forum Global Agenda Council on Decarbonizing Energy, and was an inaugural member of the European Institute of Innovation and Technology's Governing Board. She is Chair of the Sir Henry Royce Centre for Advanced Materials, a non-executive Director of the Green Investment Bank and Offshore Renewable Energy Catapult. In 2015 Julia was elevated to the peerage as a crossbench peer.

Lord John Krebs

Professor Lord Krebs Kt FRS FMedSci ML was Principal of Jesus College Oxford from 2005-2015. Previously he held posts at the University of British Columbia, the University of Wales, and the University of Oxford, where he was lecturer in Zoology, 1976-88, and Royal Society Research Professor, 1988-2005. From 1994-1999, he was Chief Executive of the Natural Environment Research Council and, from 2000-2005, founding Chairman of the UK Food Standards Agency. He is a member of the U.S. National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences and the German National Academy of Sciences (Leopoldina). He was chairman of the House of Lords Science and Technology Select Committee from 2010 to 2014 and currently sits on the Energy and Environment Select Committee. He was President of the British Science Association in 2012.

Professor Corinne Le Quéré

Professor Corinne Le Quéré FRS is Director of the Tyndall Centre for Climate Change Research and Professor of Climate Change Science and Policy at the University of East Anglia (UEA). She conducts research on the interactions between climate change and the carbon cycle. She has authored multiple assessment reports by the Intergovernmental Panel on Climate Change (IPCC), and is a member of the Scientific Committee of the Future Earth research platform for global sustainability.

Professor Jim Skea

Professor Jim Skea has research interests in energy, climate change and technological innovation. He has been RCUK Energy Strategy Fellow since April 2012 and a Professor of Sustainable Energy at Imperial College since 2009. He was Research Director of the UK Energy Research Centre 2004-12 and Director of the Policy Studies Institute 1998-2004. He has operated at the interface between research, policy-making and business throughout his career. He is President of the Energy Institute and was elected co-Chair of IPCC Working Group III in 2015. He was awarded a CBE for services to sustainable energy in 2013 and an OBE for services to sustainable transport in 2004.

Executive Summary

This is the Committee's eighth annual report to Parliament on progress towards meeting the statutory carbon budgets and the 2050 target to reduce greenhouse gas emissions by at least 80% relative to 1990. It comes at an important time in the policy cycle: the Climate Change Act requires the Government to set the emissions limit for 2028-2032 through the fifth carbon budget by the end of June and then publish 'proposals and policies' for meeting it.

Emissions have fallen by 13% in the last three years to 38% below 1990 levels in 2015. However, almost all the fall in emissions has been in the power sector, as a result of reduced use of coal and increased generation of electricity from renewables. Emissions reduction in the power sector alone, or any single sector, will not be enough to meet the fourth, or recommended fifth, carbon budgets or the 2050 target. Furthermore, current policies are not sufficient to continue the good progress to date or broaden it to other sectors.

The Government has recognised that current policies are not sufficient and has committed to publish its plans to meet the fourth and fifth carbon budgets by the end of this year. This Progress Report sets out the areas where policy should be developed and strengthened in that 'emissions reduction plan' (summarised in Table 1). We will assess the Government's plans against these criteria in our 2017 Progress Report.

Internationally, the Paris Agreement was reached in December 2015. This reflects and marks significant global progress in the last year and demonstrates that UK efforts are part of international action. The aims of the Agreement (i.e. to limit the rise in global temperatures to well below 2°C, to pursue efforts to hold it to 1.5°C and to reach net zero emissions in the second half of the century) are more ambitious than the basis of the UK's statutory target for 2050 (which aims to limit temperature rise to around 2°C, implying a very low risk of a 4°C change). We will assess further the implications of this for UK climate policy in a report to be published later this year, in time to feed into the Government's emissions reduction plan.

The recent vote to leave the European Union does not change the UK's requirement to reduce emissions nor the required levels of reduction, which were legislated by the UK Parliament. However, it could have an impact on how the UK carbon budgets are met. Insofar as the Leave vote leads to a removal or weakening of policies that derive from the EU (e.g. new car emissions standards, the EU Emissions Trading System, Directives on waste and F-gases), UK policies will have to be developed that meet the UK commitments. It is too early to say what the impact of the vote will be or how UK policy should seek to evolve – the Committee will publish an analysis of this issue in the autumn.

Progress in reducing emissions

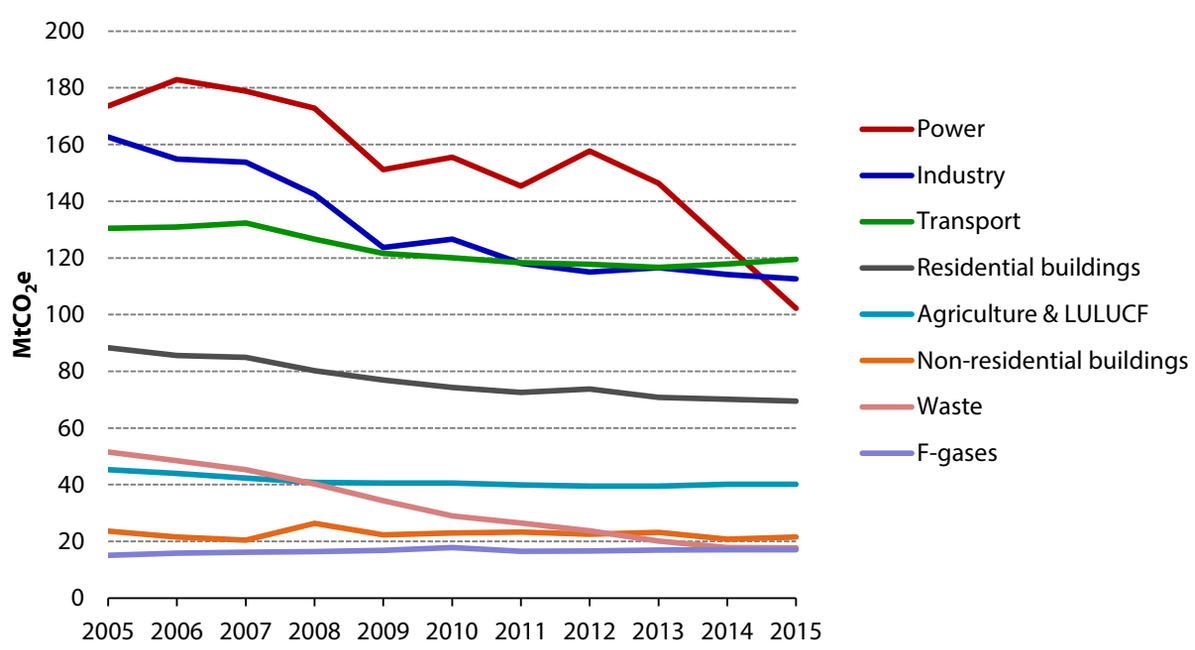
Emissions fell by 3% in 2015, relative to 2014, to 497 $MtCO_2e$. Emissions are below the annual average permitted by both the second and the third carbon budgets (2013-17 and 2018-2022). However, the current rate of progress cannot be sustained solely through reductions in emissions in the power sector, which have driven progress in recent years (Figure 1):

- The fourth carbon budget and the fifth carbon budget recommended by the Committee require that emissions are reduced by an average of 10 $MtCO_2e$ (2-3%) per year across the economy from 2015 to 2030. That would result in a 57% reduction in emissions by 2030 relative to 1990 and keep the UK on the lowest cost path to the 2050 target.

- Whilst emissions have fallen by an average of 4.5% a year since 2012, this has been almost entirely due to progress in the power sector, particularly reduced use of coal as Government policies have driven an expansion of renewable generation.
- There has been almost no progress in the rest of the economy, where emissions have fallen less than 1% a year since 2012 on a temperature-adjusted basis. That is because there has been slow uptake of low-carbon technologies and behaviours in the buildings sector (i.e. low rates of insulation improvement, low take-up of low-carbon heat) and improved vehicle efficiency has been offset by increased demand for travel as the economy has grown and fuel prices have fallen. There is also minimal evidence of progress in the industrial and agriculture sectors.
- Progress will need to be broader to meet the recommended fifth carbon budget and to prepare sufficiently for 2050. For example, while the complete replacement of coal-fired generation with low-carbon generation in the power sector is an important part of our scenarios, this would provide less than half of the total emissions reduction required by 2030.

The Government's emissions reduction plan for the fourth and fifth carbon budgets must lay the foundations for progress across the economy.

Figure 1. Progress reducing emissions since 2012 has been almost entirely due to the power sector



Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.
Notes: Chart shows temperature-adjusted emissions in power, residential and non-residential buildings. This smooths out the large changes in heating emissions between years with mild and cold winters to give a clearer impression of genuine progress.

The need for stronger low-carbon policies in the emissions reduction plan

The carbon budgets set the direction for the UK's low-carbon transition. Firm policies in specific areas are then needed to deliver the carbon budgets. Investors have been clear that current uncertainty over future climate policy is holding back investment and increasing costs.[1]To meet the Government's stated objective of meeting its climate commitments at the lowest cost to consumers that uncertainty must be removed.

Table 1 sets out the full set of areas that must be addressed to keep the UK on the lowest cost path to meet its statutory targets. In some areas elements of the required policy are in place or planned but require stronger implementation if they are to succeed. In other areas new policies are required. We identify a gap of around 100 $MtCO_2e$ (47% of the required emissions reduction) between Government plans and the path required to meet the recommended fifth carbon budget in 2030 (this gap is shown in red in Figure 2).[2]

In our 2015 Progress Report, we identified four main recommendations to ensure that progress will continue on electricity, buildings, transport and infrastructure. In part the policy gap reflects mixed progress in developing the policy framework in those areas in the last year:

- **Some areas have progressed**, for example: funding available for offshore wind has been extended to 2026, for renewable heat to 2020/21 and for electric vehicles to 2018.
- **There have been backward steps in other areas:** cancellation of the Commercialisation Programme for carbon capture and storage (CCS), a reduction in funding for energy efficiency and cancellation of the zero carbon homes standard.
- **Other priorities have not moved forward:** no further auctions have been run or planned for the cheapest low-carbon generation (e.g. for onshore wind and solar in windy/sunny sites that are locally acceptable), there is no action plan for low-carbon heat or energy efficiency and there are no vehicle efficiency standards beyond 2020.

Given the need for progress across the economy, it is important that policy gaps are addressed in all areas. This will ensure the UK can meet its legislated targets in the lowest cost way, while maximising the opportunities these bring for UK businesses. Particular priorities are:

- **Heat in buildings**
  - Progress improving the energy efficiency of buildings has stalled since 2012: annual rates of cavity wall and loft insulation in 2013-2015 were 60% down and 90% down respectively on annual rates in 2008-2012. Take-up of heat pumps and low-carbon district heating remains minimal: less than 0.5% of heat demand in 2015.
  - Clear, consistent and credible policies are needed across these areas that are attractive to owners and landlords of both homes and workplaces, that overcome behavioural barriers and that can build up skills and supply chains. Progress in lower cost segments (i.e. in new buildings and those off the gas grid) should be prioritised.
  - We will publish a detailed assessment of options for accelerating progress in the buildings sector later in 2016.
- **Transport policy beyond 2020**

[1] E.g. Energy and Climate Change Select Committee (2016) *Investor confidence in the UK energy sector inquiry*.
[2] The lowest cost path to the fifth carbon budget (2028-2032) and the 2050 target is likely to involve steady reductions in emissions. We therefore track progress against that path, even though emissions are already below the third carbon budget for 2018-2022.

  - Policy measures are in place which have improved the efficiency of new cars and vans and can be expected to continue to do so to 2020, provided there is appropriate testing.
  - Policy will need to be extended through the 2020s, with stretching standards for vehicle CO_2 emissions based on real-world driving, tested by independent authorities.
  - The extended standards should require an increasing share of electric vehicles, supported by action to develop the charging infrastructure and address cost barriers while these remain. This would bring important co-benefits in improved air quality (and potentially in grid balancing), as would measures to moderate demand for travel.

- **Carbon capture and storage (CCS).** CCS is of critical importance to meet the UK's climate targets at least cost, and requires a strategic approach to its development.
  - A number of options to reduce emissions that are being actively considered by Government and industry depend on CCS (e.g. use of hydrogen in heating and transport; the 'action plans' for industry). CCS is also likely to have a key role in the longer term (e.g. in combination with sustainable bioenergy and for seasonal/flexible power generation).
  - There is no strategy for the development of CCS following the cancellation of the Commercialisation Programme in November 2015. Lessons learnt in that process enable a more strategic approach to be adopted, which can support commercialisation of CCS at a lower overall cost to the consumer and taxpayers.
  - The new approach should have separate support for the capture plants and for the infrastructure for transporting and storing CO_2, reflecting their different technical and economic characteristics. It should be based around shared infrastructure for CCS 'clusters' in areas of industrial activity and requires a new funding mechanism for industrial CCS, to operate alongside contracts for difference for power plants. To access lower costs of capital, risks should be allocated to the party best able to manage them (including Government in the case of policy risk, such as the carbon price).

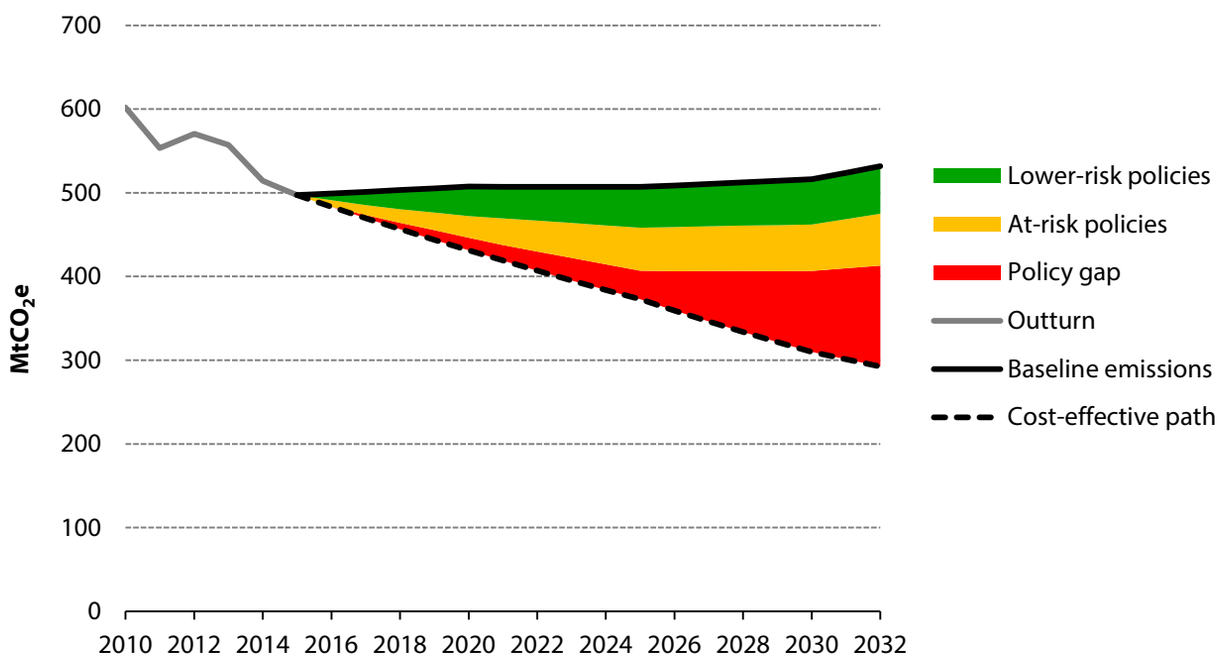
- **Mature low-carbon generation**
  - Effective policy has been developed to support mature renewable electricity generation (e.g. onshore wind and solar) through contracts for difference allocated by competitive auctions. The first auction in 2015 was successful, and further projects are available without subsidy beyond the Government's published carbon values (i.e. £78/tCO_2 in 2030).
  - However, no further auctions have taken place and none are planned. Excluding these technologies increases the cost of meeting the UK's carbon targets.
  - The Government should provide a route to market for the cheapest low-carbon generation technologies, for example by defining the price at which it would consider low-carbon generation to be subsidy-free and running auctions to reveal the cheapest projects below that price.

Progress in each of these sectors, and in other areas such as agriculture and industry, will be helped by innovations, including new and improved products. The Government's plan to meet the fourth and fifth carbon budgets should include consideration of different ways to promote innovation: for example, the role of pilots and other smaller-scale deployment, larger-scale deployment and research and development. The plan should set out how technological and product innovations (e.g. efficient low-carbon heating systems, new vehicles, new ways of growing food) and demand-side innovations (e.g. smarter temperature control systems for homes and offices) will be supported. The Government's plan should consider the best ways to

promote new innovation in the UK, and how to adopt quickly innovations from elsewhere in the world. The plan needs to consider when different types of innovations are likely to be delivered (e.g. within the next decade, in the 2030s, after 2050) in order to assess their potential contributions to the fourth and fifth carbon budgets, to the 2050 target or to the longer-term, post-2050, ambitions set out in the Paris Agreement.

There are various ways to meet carbon budgets, with scope for the Government to adopt a different balance of effort from the one we have proposed. However, reduced effort in one area must be compensated by increased effort elsewhere. The goal should be to meet carbon budgets through action in the UK. Flexibilities available under the Climate Change Act (e.g. use of credits, banking of over-performance) should only be used to deal with unexpected difficulties, not as an alternative to domestic action. We will assess the overall balance of effort in the emissions reduction plan in our 2017 Progress Report.

Figure 2. Assessment of current policies against the cost-effective path to meet carbon budgets and the 2050 target



Source: DECC (2015) *Updated energy and emissions projections*; CCC analysis.
Notes: 'Lower-risk policies' (green) are those that aim to address known barriers and have sufficient funding and ambition to deliver with reasonable confidence. 'At-risk policies' (amber) either lack sufficient funding, do not address known barriers or have important design elements still to be confirmed. No funded policies exist to close the 'policy gap' (red), even though the Committee's scenarios identify abatement options to do so that are on the lowest cost path to meet the carbon budgets and the 2050 target. 'Baseline emissions' is the likely path of emissions in the absence of policy effort.

Table 1. Policy requirements for the Government's plan to meet the fourth and fifth carbon budgets		
Policy requirement	**New policy required**	**Stronger implementation required**
<u>Power</u> (21% of 2015 emissions): Emissions intensity to fall by around 75% (to below 100 gCO_2/kWh) between 2015 and 2030, with options developed to allow near-zero emissions by 2050		
A strategic approach to carbon capture and storage deployment in the UK	✗	
An approach to bring forward the cheapest low-carbon generation (e.g. auctions for generation from onshore wind, solar and sustainable biomass)	✗	
Support for offshore wind as costs are driven down, based on funding and cost goals announced in the 2016 Budget		✗
Plans for flexibility options (e.g. storage, interconnection, demand response), including rapid development of market rules to ensure that revenues available to these options reflect their full value to the electricity system		✗
Contingency plans for delay or cancellation of planned projects, for example new nuclear power plants	✗	
<u>Buildings</u> (18% of 2015 emissions): Emissions to fall by around 22% between 2015 and 2030, with options developed to allow near-zero emissions by 2050		
Clear, consistent and credible policies to drive deployment of heat pumps and district heating, including: immediate action to address barriers (e.g. upfront cost, low awareness) alongside the Renewable Heat Incentive and development of a more comprehensive policy package to drive the higher uptake needed in the long run	✗	
Standards to ensure new-build properties are highly energy efficient and use low-carbon heating systems by default	✗	
A stronger policy framework to drive residential energy efficiency improvement by addressing gaps and strengthening existing policies, including: addressing behavioural factors for the able-to-pay, increased funding for fuel poor households, an effective approach to the private-rented sector	✗	✗
More progress on improving the energy efficiency of non-residential buildings, including: a consolidated reporting mechanism for commercial and public buildings, new emissions reduction targets for the public estate, new policies to support SMEs in England	✗	✗
<u>Industry</u> (23% of 2015 emissions): Emissions to fall by around 20% between 2015 and 2030		
An overall approach to long-term industrial decarbonisation, developing existing 'Roadmaps' into specific actions and milestones and extending coverage to other industrial sectors		✗
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	✗	

A stronger policy framework for industrial energy efficiency, including reviewed Climate Change Agreements and an effective reporting mechanism		✗
<u>Domestic transport</u> (24% of 2015 emissions): Emissions to fall by around 43% 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 achieve a high uptake of electric vehicles by 2030, of around 60% of new sales, including: direct or indirect financial support until costs are driven below conventional vehicles, and development of a national network of charge points		✗
Policy to increase uptake of sustainable biofuels to around 8% (by energy) by 2020		✗
Policies to reduce emissions from HGVs, including vehicle efficiency improvements based on 'real-world' testing, driver training, more efficient logistics, modal shift to rail and development of ultra-low emission technologies, such as electric and hydrogen options	✗	
National and local policies to reduce demand for car travel, sufficient to deliver car-km reductions of around 5% below the baseline trajectory, including through shifts to public transport, cycling and walking	✗	✗
A plan to limit UK aviation emissions to around 2005 levels by 2050, implying around a 60% potential increase in demand, supported by strong international policies	✗	
<u>Agriculture, land use, land-use change and forestry</u> (8% of 2014 emissions): Emissions to fall by around 15% between 2014 and 2030, and afforestation rate to increase to 15,000 hectares per year		
The new Smart Inventory to be introduced in 2017		✗
A stronger policy framework for agriculture emissions reduction across all nations, both to 2022, as current progress is not on track, and after 2022; that should move beyond the current voluntary approach of providing information and advice	✗	✗
Addressing financial and non-financial barriers to increase afforestation and agro-forestry		✗
<u>Waste</u> (3% of 2014 emissions): Emissions to fall by around 50% between 2014 and 2030		
Strengthened approaches through the waste chain, including waste prevention, separate collections (e.g. of food waste), diverting biodegradable waste from landfill and increased methane capture at landfill sites	England N Ireland	Wales Scotland
<u>F-gases</u> (3% of 2014 emissions): Emissions to fall by at least 70% between 2014 and 2030		
Monitoring, implementation and enforcement of the existing F-gases regulation		✗
Seeking cost-effective opportunities to reduce F-gas emissions further than existing legislation requires, including assessing and addressing barriers to action	✗	

Notes: (1) In some areas success will need both new policies and stronger implementation of existing plans/ policies – in these cases both columns are checked. In all cases plans and policies, whether new or existing, will need to be strongly implemented. (2) The latest non-CO_2 data is for 2014.

Progress in the devolved administrations

The devolved administrations have an important role to play in achieving the UK's carbon budgets. Scotland, Wales and Northern Ireland together account for 22% of UK emissions (9%, 9%, and 4% respectively in 2014, the latest year for which data are available), while they account for 16% of the UK's population and 13% of GDP.

The devolved administrations have each adopted their own targets to reduce emissions. Scotland has passed its own Climate Change Act and has legislated ambitious annual targets, while in Wales and Northern Ireland targets have been set by the devolved governments. The Welsh Government will legislate emission reduction targets and is due to set carbon budgets, required by their new 2016 Environment (Wales) Act. The new government in Scotland has pledged to bring forward a new Climate Change Act for Scotland that is likely to be more ambitious than the current one.

Additional powers are also being devolved. Where relevant powers are already devolved, these are often used more actively than for the UK as a whole. For example:

- Scotland, Wales and Northern Ireland have allocated tax-payer funds to support uptake of energy efficiency measures in buildings and work with local authorities on area-based delivery. Scotland has also made energy efficiency a national infrastructure priority.
- Scotland and Northern Ireland have improved local provision of electric vehicle charging infrastructure, while all three devolved nations have developed active travel policies (e.g. to encourage walking and cycling as a transport choice).
- Scotland, Wales and Northern Ireland have more active waste policies, with ambitious recycling targets and separate collections for food waste. Scotland is implementing bans on biodegradable waste being sent to landfill, and Wales has a strategy to move towards a zero waste economy.
- Although current rates of tree planting are falling short, the devolved administrations have planted more trees and have more ambitious goals than England, supported by detailed strategies and some funding.

Many of these initiatives have been introduced recently, meaning evidence of their relative success is currently limited. The Committee will continue to monitor progress to ensure that effective approaches can be adopted more widely.

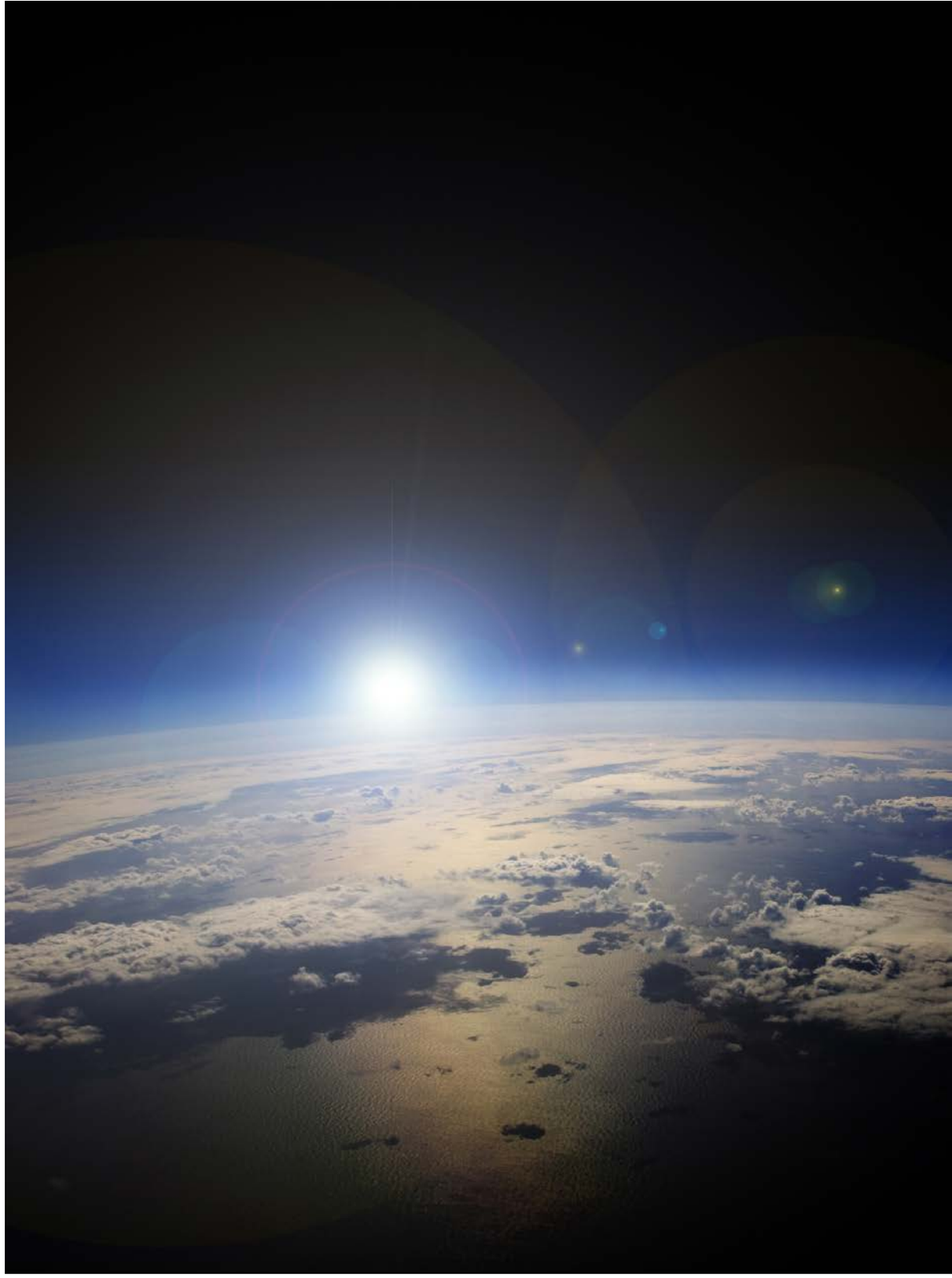
To stay on track to the stretching devolved targets policy strengthening will be required. That should drive increased take-up in the low-carbon heat markets, increased tree planting, and incentives for emissions reduction in agriculture, areas where many policy and funding levers are devolved. We will provide more detailed assessments in our reports and advice to the devolved administrations.

Next steps

Later this year, the Committee will publish further advice to help inform the Government's emissions reduction plan: on the implications of the Paris Agreement for UK targets and on actions and the challenge for decarbonising the UK's building stock. We will also publish our assessment of the implications of leaving the European Union.

In our 2017 Progress Report, we will assess the Government's plans based on the criteria set out in this report (Table 1) and elaborated in those further reports.

The rest of this report begins with a chapter giving an economy-wide view of progress, followed by chapters on individual emitting sectors of the economy. The report is supported by a technical annex, which includes data on all indicators of progress tracked by the Committee.



Chapter 1: Economy-wide progress

Key messages and recommendations

This Progress Report fulfils our statutory duty under the Climate Change Act. It sets out our view on progress made towards meeting the statutory carbon budgets and the 2050 target (i.e. to reduce UK greenhouse gas emissions by at least 80% relative to 1990). It assesses the policy risks around delivering these, and identifies key areas for the Government to address in its emissions reduction plan for meeting the fourth and recommended fifth carbon budgets, to be published later this year.

The recent vote to leave the European Union does not change the UK's requirement to reduce emissions nor the required levels of reduction, which were legislated by the UK Parliament. However, it could have an impact on how the UK carbon budgets are met. Insofar as the Leave vote leads to a removal or weakening of policies that derive from the EU (e.g. new car emissions standards, the EU Emissions Trading System, Directives on waste and F-gases), UK policies will have to be developed that meet the UK commitments. It is too early to say what the impact of the vote will be or how UK policy should seek to compensate – the Committee will publish an analysis of this issue in the autumn.

Our key messages for the economy as a whole are:

- **UK emissions fell by 3.4% in 2015 but progress was unbalanced.** The reduction was almost entirely due to increased low-carbon electricity generation, which displaced fossil fuels (primarily coal). There was no significant progress in other sectors, and emissions increased in transport and buildings.
- **There has been mixed progress developing the policy framework to drive emissions reduction.** In our 2015 Progress Report, we identified four main recommendations to ensure that progress on electricity, buildings, transport and infrastructure will continue. Some areas have progressed (e.g. funding available for offshore wind has been extended to 2026, renewable heat to 2020/21 and for electric vehicles to 2018) but there have been backward steps in other areas (e.g. cancellation of the Commercialisation Programme for carbon capture and storage (CCS), a reduction in funding for energy efficiency and cancellation of the zero carbon homes standard). Other priorities have not moved forward: no further auctions have been run or planned for the cheapest low-carbon generation (e.g. for onshore wind and solar in windy/sunny sites that are locally acceptable), there is no action plan for low-carbon heat or energy efficiency and there are no vehicle efficiency standards beyond 2020.
- **Policy strengthening will therefore be required to meet the fourth and fifth carbon budgets.** The Climate Change Act puts a duty on the Secretary of State for Energy and Climate Change to bring forward 'proposals and policies' to meet carbon budgets. The Government has committed to publishing their plans by the end of the year. In this report we identify that there is a gap of around 100 $MtCO_2e$ (47% of the required emissions reduction) between current Government plans and the path required to meet the recommended fifth carbon budget in 2030. That is additional to around 55 $MtCO_2e$ of emissions reduction targeted by existing plans and policies that we consider as being at risk unless these plans are implemented more strongly. This Progress Report sets out the areas where policy should be developed and strengthened in the Government's 'emissions reduction plan' (summarised in the Executive Summary and set out in detail in individual chapters). We will assess the Government's plans against these criteria in our 2017 Progress Report.

Internationally, the Paris Agreement was reached in December 2015. This reflects and marks significant global progress in the last year and demonstrates that UK efforts are part of international action. The aims of the Agreement (i.e. to limit the rise in global temperatures to well below 2°C, with efforts to hold it to 1.5°C and to reach net zero emissions in the second half of the century) are more ambitious than the basis of the UK's statutory target for 2050 (which aims to limit temperature rise to around 2°C, implying a very low risk of a 4°C change). We will assess further the implications of this for UK climate policy in a report later this year, in time to feed into the Government's emissions reduction plan.

In this chapter we review progress across the whole economy, including policies that affect multiple sectors. The focus is on reducing emissions; our 2015 Progress Report also considered the adaptation actions required to prepare for the impacts of climate change. We continue to assess progress on adaptation through the Adaptation Sub-Committee. This report takes a consistent approach and considers climate resilience in important areas of overlap. We will return in more detail to this in our Progress Report next year as required by the Climate Change Act.

We summarise the analysis that underpins our key messages in five sections:

1. Overview of greenhouse gas emissions

2. Underlying progress in reducing greenhouse gas emissions

3. Meeting carbon budgets and preparing for the 2050 target

4. Contribution of infrastructure and innovation towards meeting carbon budgets

5. The Paris Agreement and implications for carbon budgets

The remainder of the report then addresses progress and priorities across the sectors of the economy and in the devolved administrations:

- Chapter 2 - Power
- Chapter 3 - Buildings
- Chapter 4 - Industry
- Chapter 5 - Transport
- Chapter 6 - Agriculture and land use, land-use change and forestry
- Chapter 7 - Waste
- Chapter 8 - F-gases
- Chapter 9 - Devolved administrations

1. Overview of greenhouse gas emissions

In accordance with the Climate Change Act, we track progress on UK domestic emissions of six main greenhouse gases (GHGs): carbon dioxide, methane, nitrous oxide and three fluorinated gases (F-gases).[1] We also report on emissions in the devolved administrations (Chapter 9) and from international aviation and shipping. International aviation and shipping emissions are currently not formally included in carbon budgets but are an important part of the 2050 target and we consider them in Chapter 5 – Transport.

Based on provisional statistics, UK domestic GHG emissions were 497 $MtCO_2e$ in 2015, a fall of 3% compared to 2014 (4% after adjusting for differences in temperature between years). This implies emissions fell to 38% below 1990 levels[2] (Figure 1.1 and 1.2). We estimate the level of the 'net carbon account' - which is used under the Climate Change Act to judge progress against

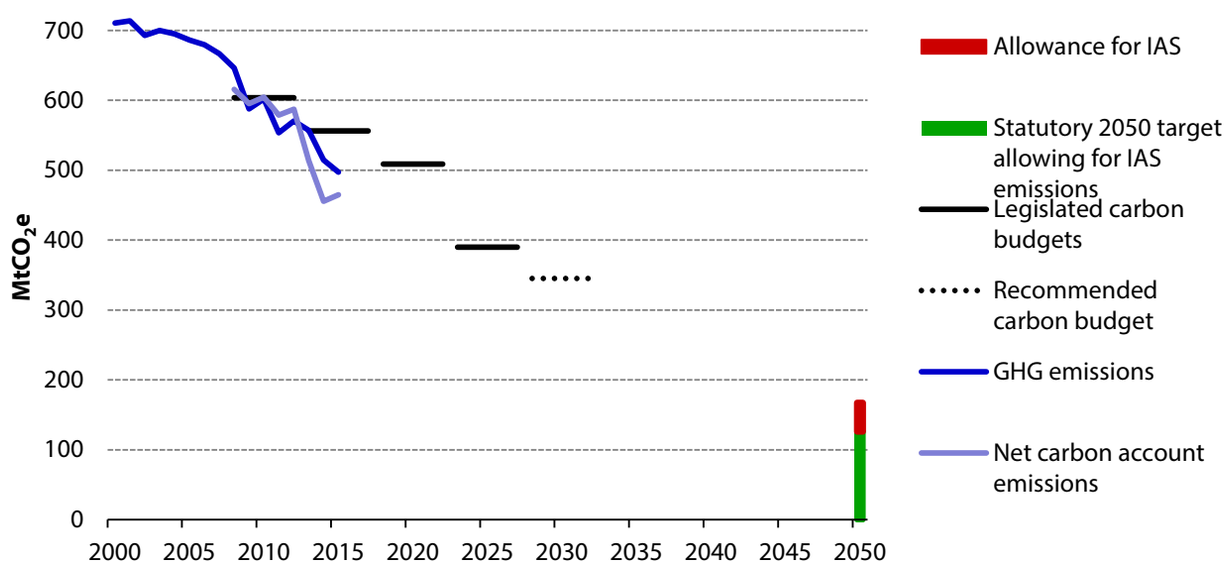
[1] The UK inventory also covers emissions from nitrogen trifluoride, which were less than 0.01 $MtCO_2e$ in 2014.
[2] Or, if including international aviation and shipping emissions at the level most recently estimated, in 2014, 35% below 1990 levels.

carbon budgets and adjusts for trading of emissions allowances in international markets - was 465 $MtCO_2e$ in 2015, an increase of 2% against 2014.

For the first time since the introduction of carbon budgets, in 2015 the power sector was not the largest source of emissions (Figure 1.3). Transport emissions made up the largest share (24%), followed by industry (23%), power (21%) and buildings (18%). A split for non-CO_2 emissions across sectors is not yet available for 2015 but total emissions from agriculture and land use, land-use change and forestry (LULUCF) are estimated to be around 8% of total emissions, followed by waste (4%) and F-gases (3%).

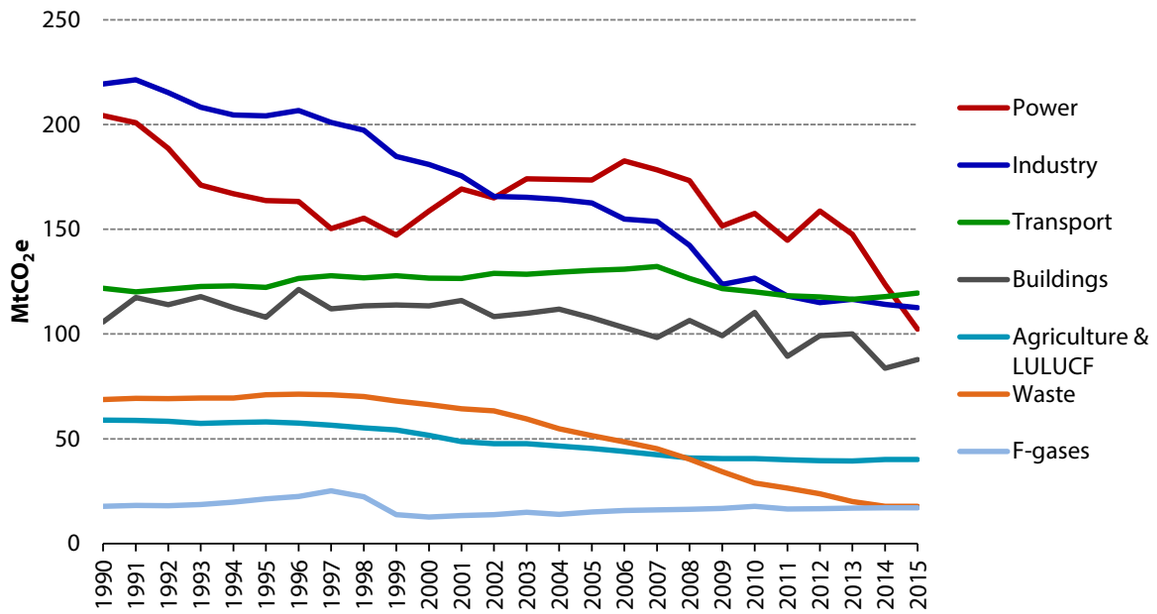
Overall, emissions are now below the average annual level required to meet the second and third carbon budgets (covering 2013-2017 and 2018-2022 respectively). However, further substantial reductions in emissions will still be needed in order to meet the level of the fourth carbon budget, which requires a 51% reduction by 2025 relative to 1990, and the fifth carbon budget, to be legislated by the end of June 2016, for which the Committee have recommended a 57% reduction by 2030.

Figure 1.1. UK GHG emissions compared to legislated carbon budgets and the 2050 target



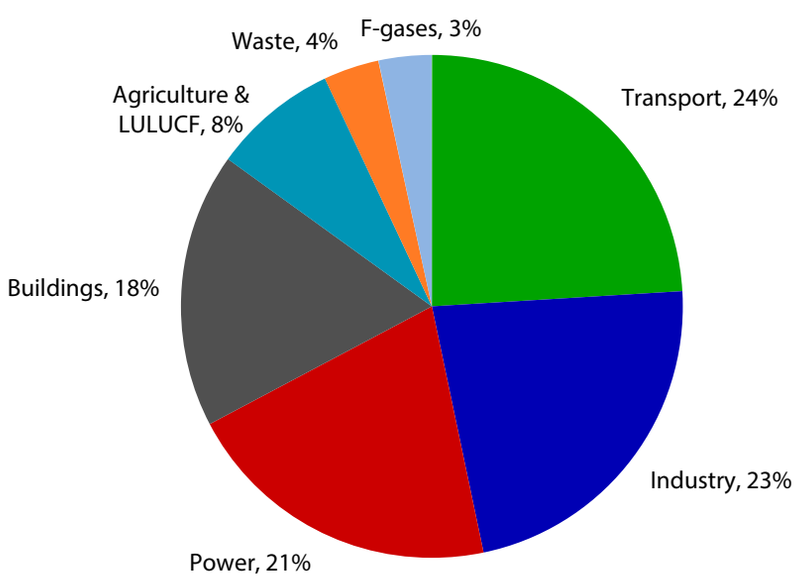
Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.
Notes: GHG emissions are shown on a total (gross) basis, while carbon budgets represent the emissions under the net carbon account; IAS stands for international aviation and shipping.

Figure 1.2. UK GHG emissions by sector since 1990



Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.

Figure 1.3. UK domestic GHG emissions by sector in 2015



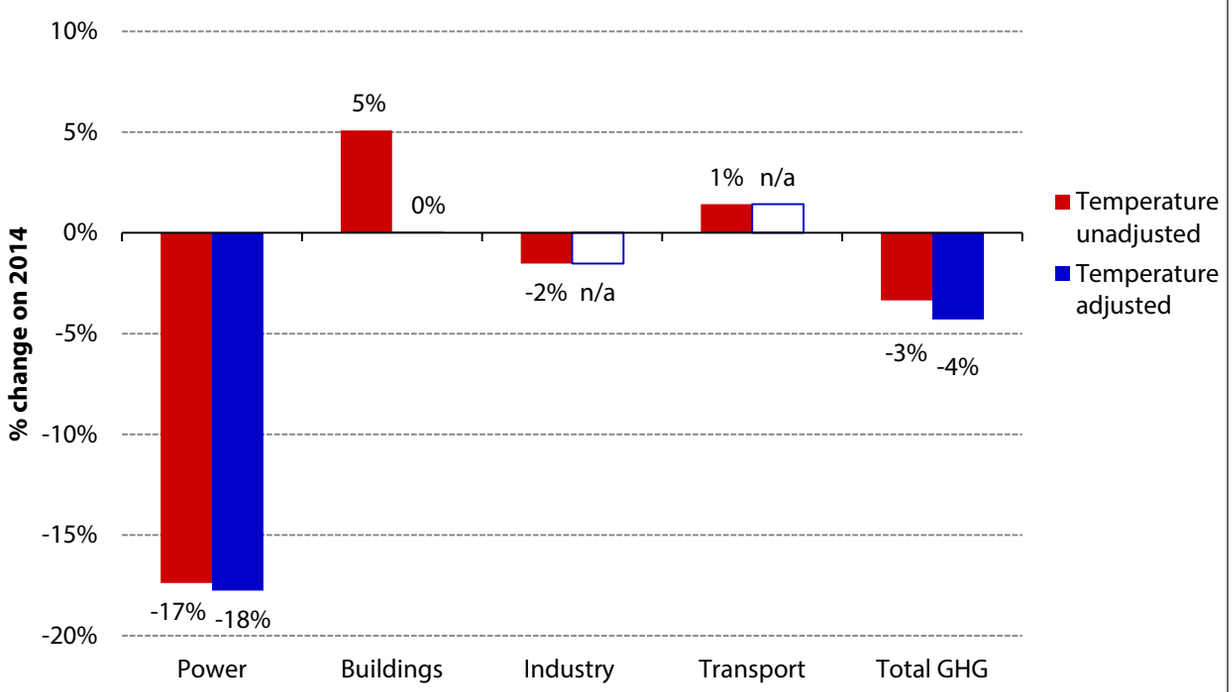
Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.
Notes: Estimates of non-CO_2 gases are based on an assumption that emissions in 2015 will be the same as in 2014 and are spread across the sectors as in 2014 final GHG statistics. Totals may not sum to 100 due to rounding.

The main reason for the fall in emissions in 2015 was a 17% decrease in power sector emissions. This is a much larger fall than in most previous years, which averaged 4% annually in the period 2009-2014. There was no significant progress in 2015 in other sectors and emissions increased in transport and buildings (Figure 1.4):

- The significant fall in power emissions was due to an increase in low-carbon electricity generation which displaced fossil fuels (primarily coal):
  - There was a structural increase in renewable generation (33%) as well as a cyclical increase in nuclear generation (10%), while the share of fossil fuels fell by 13%.
    - In particular, use of coal - the most carbon-intensive fuel source - fell by 24%. Coal generation was replaced by increased low-carbon generation.
    - Coal is facing worsened economics, as well as air quality regulations, both of which are having a long-term impact on its use. In future use of coal is expected to continue to fall: of 20 GW of coal capacity on the system at the end of 2014, 9 GW has since either closed or announced closure and the Government has announced its intention to phase out coal use entirely by 2025.
  - Electricity demand was flat, while the share of imported electricity increased by 2%. Imported electricity is not a part of the UK's domestic carbon budgets but is covered by the EU Emissions Trading System.
- In all other sectors aside from power (i.e. covering 79% of total emissions), there was no significant reduction in emissions, and in transport and buildings emissions increased:
  - **Transport** emissions increased by 1%, following an annual average decrease of 0.6% over the period 2009-2014. The impact of growing road travel demand outweighed improvements in the fuel efficiency of new vehicles.
  - **Buildings** emissions increased by 5%. This is likely to reflect the colder average temperatures in 2015 compared to 2014, leading to higher heating demands: temperature-adjusted emissions show no change. This adjustment implies overall economy-wide emissions would have fallen by 4.3% compared with an unadjusted 3.4%. It follows an average annual decrease in building emissions of 3.3% over the period 2009-2014 driven mainly by boiler replacements, with more efficient condensing boilers and cavity wall and loft insulations in residential buildings.
  - **Industry** emissions fell by 1.5%. However, provisional statistics for industry have been subject to substantial revisions in previous years, so we do not place a high reliance on these data. The average decrease in emissions over the period 2009-2014 was around 1.6% per year, which is likely to have been due to some efficiency improvement in energy-intensive industry and impact of the recession.
  - **Other non-CO_2** emissions, which include agriculture, waste and F-gases, are highly uncertain and are assumed to be flat in 2015 in the provisional statistics. The 2014 final figures show a 1.6% reduction compared with 2013, following an average annual reduction of 3.9% between 2009 and 2013.

Altogether, progress has been very unbalanced across sectors. The drop in emissions is almost entirely due to falling power sector emissions. This is part of the long-term reduction that is necessary in order to meet the 2050 target, but progress across all sectors will be needed in future to be on track to 2050 and to meet the fourth, and recommended fifth, carbon budgets.

Figure 1.4. Change in UK domestic GHG emissions between 2014 and 2015



Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.
Notes: Estimates of non-CO_2 gases are based on an assumption that emissions in 2015 will be the same as in 2014 and thus we do not report on 2014-15 change in the case of agriculture, waste and F-gases. Emissions for industry and transport are not temperature adjusted.

Meeting carbon budgets

In 2015 UK emissions fell by 3.4% (4.3% when adjusting for temperature variation). However, under the Climate Change Act performance against carbon budgets is measured by the 'net carbon account' (Box 1.1). We estimate net carbon account emissions increased by 2% in 2015. This reflects a lack of progress in reducing emissions outside of the power sector:

- The net carbon account is determined by the number of allowances allocated to the UK under the EU Emissions Trading System (ETS) cap for those sectors covered (the 'traded sector', i.e. power and energy-intensive industry), and by actual emissions in sectors not covered by the EU ETS (the 'non-traded sector', i.e. transport, buildings, agriculture, waste and F-gases).
- We estimate that the net carbon account was 465 $MtCO_2e$ for 2015. This is a 2% increase on 2014, but still 16% below the average annual level required to meet the second carbon budget and 9% below the level required to meet the third carbon budget.

- The increase in the level of the net carbon account reflects both changes in the UK's allocation of allowances under the EU ETS cap and a lack of progress in reducing emissions in sectors outside power generation, which is covered by the EU ETS (Figure 1.5).
  - Allowances allocated to the UK under the EU ETS increased by 3% in 2015. This compares to actual emissions which fell by 11% in covered sectors. In future the number of allowances allocated to the UK under the EU ETS will generally fall, in line with the falling EU-wide cap; the increase in allowances allocated to the UK in 2015 reflects the timing of the 'backloading' initiative (Box 1.2).
  - Emissions in sectors not covered by the EU ETS (i.e. transport, buildings, agriculture, waste and F-gases) increased by 1.5% in 2015.

Overall, meeting the second and third carbon budgets is not an indicator of being on track for meeting the fourth and recommended fifth carbon budgets and the 2050 target. These require emissions to fall in buildings, transport and agriculture, rather than just in the power sector. The 1.5% increase in non-traded sector emissions (i.e. actual emissions from sources outside the EU ETS) in 2015 compares to a 3% annual reduction required to be on track to 2050. We review the progress against our estimate of the cost-effective path in section 3.

Given the vote to leave the EU, the UK's future role in the EU ETS is uncertain. If the UK were to no longer participate in the EU ETS then this would have implications for carbon budget accounting. We will publish a more detailed analysis of this issue in the autumn.

There are various ways to meet carbon budgets, with scope for the Government to adopt a different balance of effort from the one we have proposed. However, reduced effort in one area must be compensated by increased effort elsewhere. The clear goal should be to meet carbon budgets through action in the UK. Flexibilities available under the Climate Change Act (e.g. use of credits, banking of over-performance) should only be used to deal with unexpected difficulties, not as an alternative to domestic action.

We have also noted previously that the EU ETS is not effectively supporting the transition to a low-carbon economy and requires reform. There has been minimal progress on that in the last year (Box 1.2). Carbon pricing is an important pillar of climate policy. If the UK were to leave the EU ETS following the vote to leave the EU then an alternative instrument would need to be developed.

Box 1.1. The Net Carbon Account

Under the Climate Change Act, performance against carbon budgets is measured by the net carbon account. This is calculated by adding:

- The UK share of the EU Emissions Trading System (EU ETS) cap and;
- Actual emissions from sources outside the EU ETS (i.e. the 'non-traded sector')

The net carbon account will be different from the actual UK emissions as those sources of emissions covered by the EU ETS (i.e. the 'traded sector') typically will not equal the UK's share of the EU ETS emissions cap. Where actual emissions are above the level of the cap the UK is effectively a net buyer of allowances; where below, a net seller.

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

For 2015, we estimate the net carbon account to be 465 $MtCO_2e$:

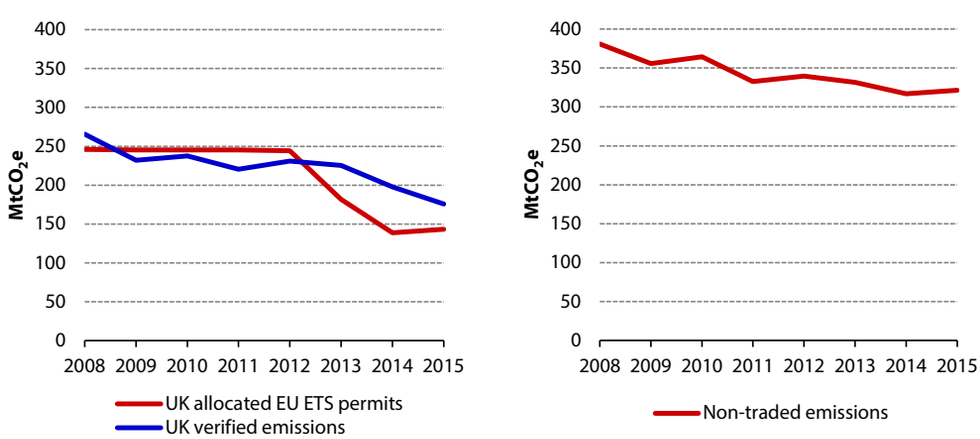
- We estimate that the UK share of the EU ETS cap was 143 $MtCO_2e$. That is lower than the actual emissions from UK sources covered by the EU ETS (176 $MtCO_2e$) - see Figure 1.5. This implies the UK was a net buyer of allowances.
- Non-traded emissions were 321 $MtCO_2e$.

The net carbon account (465 $MtCO_2e$) was therefore lower than the UK's actual emissions (497 $MtCO_2e$) in 2015.

Given the vote to leave the EU, the UK's future role in the EU ETS is uncertain. If the UK were to no longer participate in the EU ETS then this would have implications for carbon budget accounting. We will publish a more detailed analysis of this issue in the autumn.

Source: European Environment Agency EU ETS data viewer; DECC (2016) *Provisional GHG statistics for 2015*; CCC calculations.

Figure 1.5. UK GHG emissions in traded (left) and non-traded sectors (right)



Source: European Environment Agency EU ETS data viewer; DECC (2016) *Provisional GHG statistics for 2015*; CCC calculations.

Box 1.2. Developments in the EU ETS

The EU Emissions Trading System (EU ETS) covers emissions from power, industry and flights within Europe. The purpose of the EU ETS is to set a sufficiently ambitious overall cap so that EU traded sector emissions decrease in line with the EU's targets (i.e. a 20% reduction by 2020 below 1990 levels, 40% by 2030, and 80-95% by 2050), while allowing for differences in the relative cost-effectiveness of reducing emissions across Member States.

Since the financial crisis emissions have been consistently below the level of the cap. The market value of allowances is therefore very low and currently does not provide a significant long-term incentive to reduce emissions.

In order to restore the value of the EU ETS as a policy instrument, the cap to 2030 must constrain emissions sufficiently to ensure adequate progress to 2050. If the UK remains part of the EU ETS following the Leave vote then the Government should continue to push for reforms consistent with this aim. A range of measures have been implemented, and further options are available and have been proposed:

- **Backloading**. This is an EU-wide initiative that is currently being implemented and involves withholding allowances from auctioning (400m in 2014, 300m in 2015 and 200m in 2016). The allowances are then returned to the market before 2020 and placed in the market stability reserve (see below). Because the allowances are not permanently cancelled the impact on price has been limited, but it has caused the UK's net carbon account to be lower than previously expected.
- **Market Stability Reserve.** This was agreed in 2015 and will be established in 2018 and start operating in January 2019. The purpose is to address the surplus of allowances that has built up and to improve the resilience of the system to shocks.
- **Price corridor.** In order to provide greater certainty about the price signal, France has stated that it will join the UK in establishing a minimum price floor (at €30/tonne). These unilateral measures could depress the EU ETS price further. However, if adopted EU-wide, a price corridor for the EU ETS, similar to that in other trading systems around the world, would provide greater certainty about the future price signal.
- **Tightening the 2030 target.** The current trajectory for the EU cap is consistent with the EU 2030 target of at least a 40% reduction in emissions. However, this is at the lower end of ambition compared to the cost-effective path to the EU's 2050 objective and below estimates of a 'fair' EU share of a global 2°C pathway.[3] The EU should therefore be prepared to raise its ambition through the Paris Agreement as a contribution to closing the global emissions gap in 2030 (section 5); any tightening of the EU ETS cap should also be accompanied by a tightening of UK carbon budgets. The UK Government has previously suggested a 50% reduction for the EU by 2030.

2. Underlying progress in reducing greenhouse gas emissions

Our approach to monitoring progress

Carbon budgets have been set to reflect our estimate of the most 'cost-effective' path to the 2050 target. Our cost-effective path is designed to represent the lowest cost way of meeting the 2050 target, taking into account the full range of criteria set out in the Climate Change Act (including impacts on energy security, competitiveness, fuel poverty and the fiscal balance). It reflects a realistic take-up of relatively low-cost technologies (e.g. incremental improvements in energy efficiency of buildings and vehicles) as well as those required to prepare effectively for

[3] See CCC (2015) *The scientific and international context for the fifth carbon budget,* Chapter 3 Section 3.

meeting the 2050 target (e.g. increasing uptake of heat pumps and electric vehicles, deployment of carbon capture and storage).

Since our first Progress Report to Parliament, we have monitored actions needed to be on that cost-effective path using a set of headline, implementation and policy indicators:

- **Headline indicators.** These directly measure reductions in emissions, economy-wide and across sectors.
- **Implementation indicators.** These measure actions designed to reduce emissions such as total renewable generation in power, proportion of heat from low-carbon sources or uptake of ultra-low emission (e.g. electric) vehicles.
- **Policy milestones.** These track whether an appropriate framework is set to enable future reductions in emissions.

Our indicators are based on our best assessment of the technologies and behaviours required to meet carbon budgets and the 2050 target at lowest possible cost. However, it is important to keep in mind that they are subject to uncertainty over technology developments, cost reductions and behaviour change. There is also room for policy choices on the preferred mix of technologies and measures. The indicators, therefore, are neither prescriptive nor exhaustive:

- Lack of performance in one sector can be met by outperformance in other sectors.
- Alternatively, some technologies or behaviours could become more cost-effective than current best evidence suggests.

By the end of 2016 the Government will set out its emission reduction plan for meeting the fourth and fifth carbon budgets. If lower action is planned in some areas than implied by our indicators then that must be compensated by increased effort elsewhere. The Government's plan must set out how its proposals overall are consistent with carbon budgets and with the cost-effective path to the 2050 target.

Progress adopting low-carbon technologies and behaviours

Table 1.1 summarises the underlying progress against our indicator framework, with further details set out in each sector chapter. Overall, we find evidence that good progress has been made in some areas (e.g. power), but limited progress in many others (e.g. buildings, transport, industry, agriculture):

- **Power (21% of emissions).** Investments in low-carbon power generation have been proceeding as required. They are likely to continue this to 2020, but only offshore wind has clarity beyond 2020. Longer-term development of low-carbon capacity is at risk and not consistent with achieving carbon intensity of below 100 gCO_2/kWh by 2030:
  - Average carbon intensity fell by 18% to 371 gCO_2/kWh in 2015.
  - Current investment in renewable capacity is in line with our indicators, with renewable generation representing 26% of total UK generation, up from 5% in 2007.
  - Up to 2020, a sufficient number of projects are under construction or have been contracted under Electricity Market Reform in order to meet our indicators.
  - However, the cancellation of CCS funding and delays in nuclear new build illustrate increased risks beyond 2020.

- **Buildings (18% of emissions).** There is a lack of progress across the board in buildings, with insufficient uptake of low-carbon heat and insulation, and a failure to make any meaningful reduction in non-residential buildings emissions in recent years:
  - In 2014, low-carbon heat accounted for only 2.5% of heating supply - less than 0.5% of what is required to 2020. Within this, heat pumps and low-carbon district heating were particularly low, around a third of demand.
  - Recent policy changes for home insulation have resulted in stalled progress since 2012, with the rate of uptake falling further in 2015. There have been significant setbacks in policies for able-to-pay homes, private-rented sector and new-build properties.
  - Non-residential buildings emissions increased 6% in 2015, with limited information available on actual installations of insulation or other improvements in thermal efficiency.
- **Transport (24% of emissions).** Transport emissions increased by 1% in 2015, making it the largest emitting sector. Whilst the market for electric vehicles (EVs) is beginning to grow, there is an urgent need to reform vehicle testing procedures and develop new vehicle CO_2 targets beyond 2020 to meet our indicators for improving the efficiency of new vehicles towards 50 g/km for cars and 60 g/km for vans by 2030 and increasing the share of ultra-low emission vehicles (such as EVs) to 60% of sales by 2030:
  - New car and van CO_2 intensity has improved but more slowly than our indicator and there is evidence that the gap between real-world and test-cycle emissions has continued to grow.
  - Sales of EVs increased by 87% in 2015 and continue to outperform our indicator, but still represent a small (0.9%) proportion of new car sales. The global outlook for EVs is increasingly positive, with battery costs falling more rapidly than previously expected.
- **Industry (23% of emissions) and agriculture (8% of emissions in 2014).** Underlying progress is harder to track in industry and agriculture where there is limited data availability on low-carbon investments and practices. In industry, low-carbon heat accounted for 5% of total heat demand in 2014, above our indicator of 3.2%.
- **Waste (4% of emissions in 2014).** The sector is broadly meeting our indicators:
  - Biodegradable waste sent to landfill has fallen by around 49% since 2007, close to our indicator of a 50% reduction.
  - 66% of methane is captured at landfill sites, slightly ahead of our indicator of 62%.

Table 1.1. Underlying progress in 2015			
Sector		**Indicator**	**Outturn (UK)**
Power	Total renewable generation	66.1 TWh	77.3 TWh
	Renewable capacity: onshore wind	8.9 GW	9.1 GW
	Renewable capacity: offshore wind	5.1 GW	5.1 GW
Buildings	Low-carbon heat*	2.7% of heat demand	2.5% of heat demand
	Loft insulation	6.2m (cumulative)	6.0m (cumulative)
	Cavity wall insulation	3.4m (cumulative)	3.3m (cumulative)
	Solid wall insulation	0.3m (cumulative)	0.3m (cumulative)
	A++ rated cold appliances*	9% of total stock	1% of total stock
	A+ rated wet appliances*	24% of total stock	16% of total stock
	A-rated boilers	7.8m	10.6m
Industry	Low-carbon heat*	3.2% of total heat demand	5.0% of total heat demand
Transport	New car CO_2	119 g/km	121 g/km
	New van CO_2	175 g/km	179 g/km
	Electric vehicles (new sales)	10,425	28,342
Waste	Biodegradable waste sent to landfill*	50% (fall from 2007)	49% (fall from 2007)
	Methane captured at landfill*	62%	66%

Source: Multiple sources: see technical annexes.
Note: *Numbers for 2014. Solid wall, cavity wall and loft insulation indicators have all been updated and rebased to actual uptake in 2014.

3. Meeting carbon budgets and preparing for the 2050 target

In section 1 we set out that the UK is on track to meet the second and third budgets. In this section we focus on whether the UK is on track to the fourth and recommended fifth carbon budgets and the 2050 target.

Assessment of 2015 recommendations

In our 2015 Progress Report, we identified four main recommendations to ensure that progress on electricity, buildings, transport and infrastructure will continue. Our assessment of progress against these is set out in Table 1.2.

Overall, we find that:

- Some areas have progressed (e.g. funding available for offshore wind has been extended to 2026, renewable heat to 2020/21 and for electric vehicles to 2018).
- There have been backward steps in other areas (e.g. cancellation of the Commercialisation Programme for CCS, a reduction in funding for energy efficiency and cancellation of the zero carbon homes standard).
- Other priorities have not moved forward: no further auctions have been run or planned for the cheapest low-carbon generation (e.g. for onshore wind and solar in windy/sunny sites that are locally acceptable), there is no action plan for low-carbon heat or energy efficiency and there are no vehicle efficiency standards beyond 2020.

Table 1.2. Assessment of 2015 recommendations

2015 recommendation	Assessment	Commentary
Electricity: Ensure the power sector can invest with a 10-year lead time.	Partially met	Funding for offshore wind extended to 2026 but not for other low-carbon technologies.
Buildings: Develop plans and policies that deliver low-carbon heat and energy efficiency.	Minimal progress with backward steps	Although the existing Renewable Heat Incentive was extended to 2020/21, there is still no long-term coherent strategy that will deliver ongoing efficiency improvement and a large-scale shift to low-carbon heating. Scrapping of the zero carbon homes policy means there is now a further gap on new homes.
Transport: Maintain support for the up-front costs of electric vehicles.	Partially met	Funding extended to 2018 but no clarity post-2020.
Infrastructure: Make decisions that help reduce emissions (e.g. to develop carbon capture and storage, provide infrastructure support for heat networks and electric vehicles).	Some progress with backward steps	Commercialisation Programme for carbon capture and storage cancelled, but electric vehicle charging infrastructure broadly on track and new funding for heat networks.

Emission reductions from current policies and the policy gap

In order to assess progress against the legislated fourth, and our recommended fifth, carbon budgets we:

- Review Government plans to reduce emissions against our cost-effective path.
- Evaluate the policies based on criteria (Box 1.3) that allow us to judge whether the policies are expected to deliver (i.e. 'low risk') or at risk of failing to deliver (i.e. 'at risk', either due to design and delivery problems, or because of lack of funding).
- Identify areas where there is no policy to drive emissions reduction but there is a need for one (i.e. there is a 'policy gap').

Box 1.3. Criteria to evaluate level of risk in current policies

The criteria that we have used 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 we have classified them as 'lower risk', whereas if they fail any one of the criteria we classify them as 'at risk'.

We compare Government policies, and related emission reduction potential, against our cost-effective path to meet the recommended fifth carbon budget. This includes abatement options in 2030 across the sectors which are either cost-effective (i.e. that can reduce emissions at a cost less than the Government's published carbon values, which reach £78/tCO_2e in 2030) or required to be on track to the 2050 target. Table 1.3 reports the impact of the main measures in our scenarios for meeting carbon budgets.

Table 1.3. Emissions reduction potential in 2030 to meet the recommended fifth carbon budget

Sector and 2015 emissions	Abatement option	Emission savings in 2030	
		$MtCO_2e$	% of total savings
Power 102 $MtCO_2e$	Improved efficiency of electricity use	**71**	**35%**
	CCS commercialisation to 2030		
	Offshore wind to 2025		
	Other low-carbon generation to 2030		
Domestic transport 120 $MtCO_2e$	Ultra-low emission cars and vans	25	13%
	Improved efficiency of cars and vans	17	8%
	HGVs - improved efficiency, ultra-low emission	9.5	5%
	Biofuels increased to 10% penetration	7.5	4%
	Reduced travel demand	3	2%
	Other actions in transport	2.5	1%
	Total domestic transport	**65**	**32%**
Buildings 88 $MtCO_2e$	Low-carbon heat, incl. biomethane to gas grid	15	7%
	Residential energy efficiency	6	3%
	Public and commercial energy efficiency	5	2%
	Total buildings	**26**	**13%**
Industry 113 $MtCO_2e$	Improved energy efficiency	5	2%
	Fuel switching	3.5	2%
	CCS commercialisation to 2030	3	1%
	Low-carbon heat, incl. biomethane to gas grid	2.5	1%
	Total industry	**14**	**7%**
F-gases 17 $MtCO_2e$	Phasedown of HFC use	**12**	**6%**
Agriculture & land use 40 $MtCO_2e$	Afforestation and agro-forestry	2.5	1%
	Crops and soils measures	2	1%
	Livestock measures	2	1%
	Other actions in agriculture	3.5	1%
	Total agriculture and land use	**10**	**5%**
Waste 18 $MtCO_2e$	Reduced biodegradable waste to landfill and increased methane capture	**4**	**2%**

Source: DECC (2016) *Provisional GHG statistics for 2015;* CCC analysis.
Notes: 2015 emissions are provisional. Totals may not sum due to rounding.

Assessment of emissions reduction from lower-risk and at-risk policies

Current and planned policies aim to deliver 110 $MtCO_2e$ of emissions abatement in 2030. However, we estimate that around 50% of that abatement is at risk in 2030, of which around 60% is in the non-traded sector:

- In the non-traded sector we estimate that roughly 65% of abatement due to Government policies is at risk in 2030.
  - Lower-risk policies are expected to deliver an average annual reduction of 23 $MtCO_2e$ over the fifth carbon budget period. This includes the Renewable Transport Fuels Obligation.
  - At-risk policies could deliver an average annual reduction of 44 Mt over the fifth carbon budget. This include policies to improve fuel efficiency of cars and vans (for which testing does not currently reflect real-world conditions), the Renewable Heat Incentive (which does not address the behavioural barriers to uptake) and the Energy Savings Opportunity Scheme (where there is uncertainty over the actions that will be taken to realise emissions savings). Government should improve these policies so that they can fully deliver the anticipated emission reduction over the period.
- In the traded sector, we estimate that around 30% of abatement targeted by Government policies is at risk in 2030. This will affect actual emissions but not the net carbon account and therefore not carbon budgets. However, real long-term reductions in actual emissions are important to prepare sufficiently for the 2050 target.
  - Lower-risk policies are expected to deliver average annual reductions of 31 Mt over the fifth carbon budget period. These include the Renewable Obligation and Contracts for Difference that have been already signed.
  - At-risk policies are targeting an additional 13 Mt of average annual emissions reduction over the recommended fifth carbon budget. These include policies such as the contract offered to new nuclear plant but for which no firm decision has yet been made and the Renewable Heat Incentive in industry (where there are significant remaining barriers for uptake of heat pumps in large-scale projects).

Even with full delivery of at-risk policies, the current level of ambition will not deliver the level of emission reduction required to meet the recommended fifth carbon budget and to be on track to the 2050 target.

The policy gap

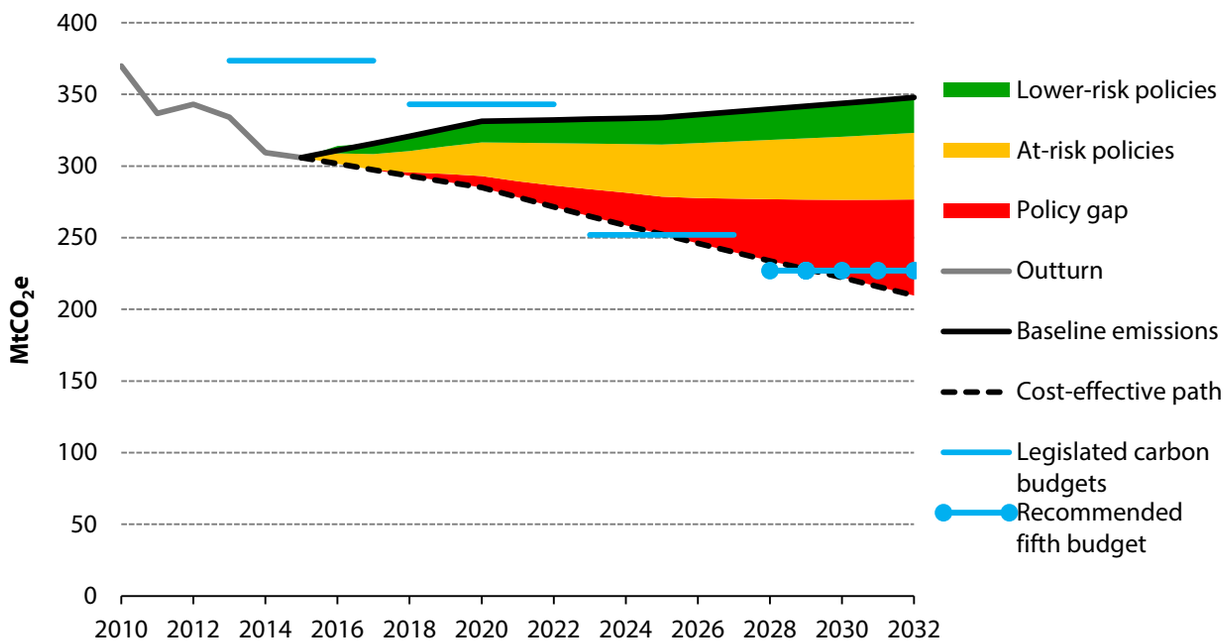
We estimate that there is a policy gap of around 100 $MtCO_2e$ for the UK to be on the cost-effective path and meet the recommended fifth carbon budget in 2030, of which 54 Mt is in the non-traded sector. The policy gap amounts to 47% of the total emissions reduction needed to be on the cost-effective path to meeting the recommended fifth carbon budget.

- Figure 1.6 sets out the expected level of emission reduction from current policies and the policy gap to the recommended fifth carbon budget in the non-traded sector. We estimate that there is a policy gap of around 54 Mt in 2030 (45% of the emissions reduction needed) to our recommended fifth carbon budget.

- Figure 1.7 presents our assessment of current policies and policy gap to the recommended fifth carbon budget for the traded sector. Our assessment shows that there is a policy gap of around 43 Mt in 2030 (50% of the emissions reduction needed) to meet the emissions path for the recommended fifth carbon budget.

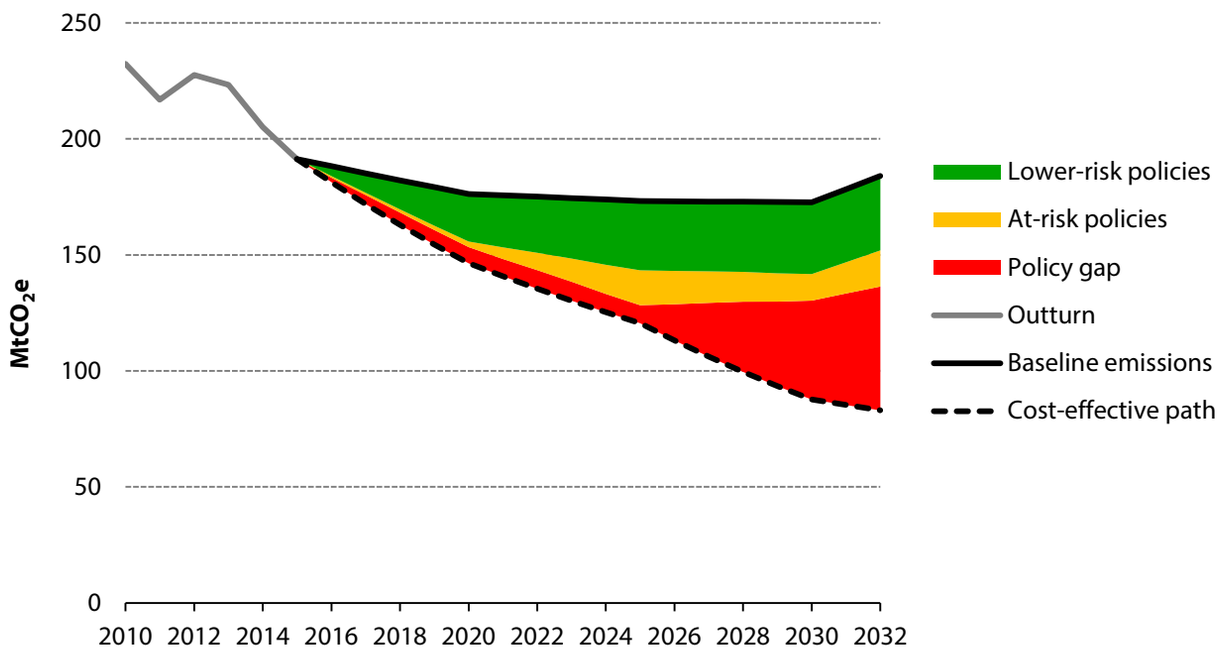
While the UK is on track to meet its second and third carbon budgets, there is a substantial policy gap across sectors in the 2020s. The Government will need to develop new policies in order to meet the fourth and recommended fifth carbon budgets at lowest possible cost and be on track to the 2050 target.

Figure 1.6. Assessment of current and planned policies against the cost-effective path for emissions (non-traded sector)



Source: DECC (2015) *Updated energy and emissions projections 2015*; CCC analysis.
Notes: Allowed non-traded emissions are estimated.

Figure 1.7. Assessment of current and planned policies against the cost-effective path for emissions (traded sector)



Source: DECC (2015). *Updated energy and emissions projections 2015*; CCC analysis.
Notes: Shows the cost-effective path for actual emissions in the traded sectors. This is not directly comparable to carbon budgets, which are based on net emissions for the traded sectors (see section 1).

Need for the Government's emission reduction plan to address the policy gap

Our review of Government policies indicates that there is a substantial policy gap across most sectors of the economy to meet the fourth and recommended fifth carbon budgets, which amounts to around 100 $MtCO_2e$ in 2030 or 47% of the total emissions reduction required. A further 55 $MtCO_2e$ of existing ambition is at risk. The Government's emission reduction plan will need to address both these issues to put the UK on track to meet future carbon budgets and the 2050 target.

Table 1 in the Executive Summary summarises the areas to tackle, while the sectoral chapters provide more detail on specific recommendations.

It should be a priority for the Government's emissions reduction plan to set out a strategy beyond 2020 as well as details on policies that will be consistent with meeting the fourth and recommended fifth carbon budgets and the 2050 target at lowest possible cost. We will review the Government's emissions reduction plan against the recommendations in our Progress Report to Parliament in 2017.

4. Contribution of infrastructure and innovation to meeting carbon budgets

The impact of infrastructure on meeting carbon budgets

Infrastructure plays an important role in enabling economic activity in a modern, well-connected society. There are various definitions of infrastructure, but we focus specifically on power, heat, CO_2 and transport networks and their associated components. Many low-carbon technologies needed to meet carbon budgets and the 2050 target will require new infrastructure or upgrades to existing infrastructure to allow their use at scale. Investment in new infrastructure can support economic growth and the transition to a low-carbon economy.

In this section we outline the infrastructure required to meet carbon budgets and the extent to which current plans for infrastructure development meet these requirements at a national level and across the devolved administrations. We also consider the potential impacts of planned new infrastructure on emissions, concluding that the increase in some areas is likely to be small and manageable, whereas more evidence is needed to assess the scale of the increase in others.

Development of infrastructure in the UK

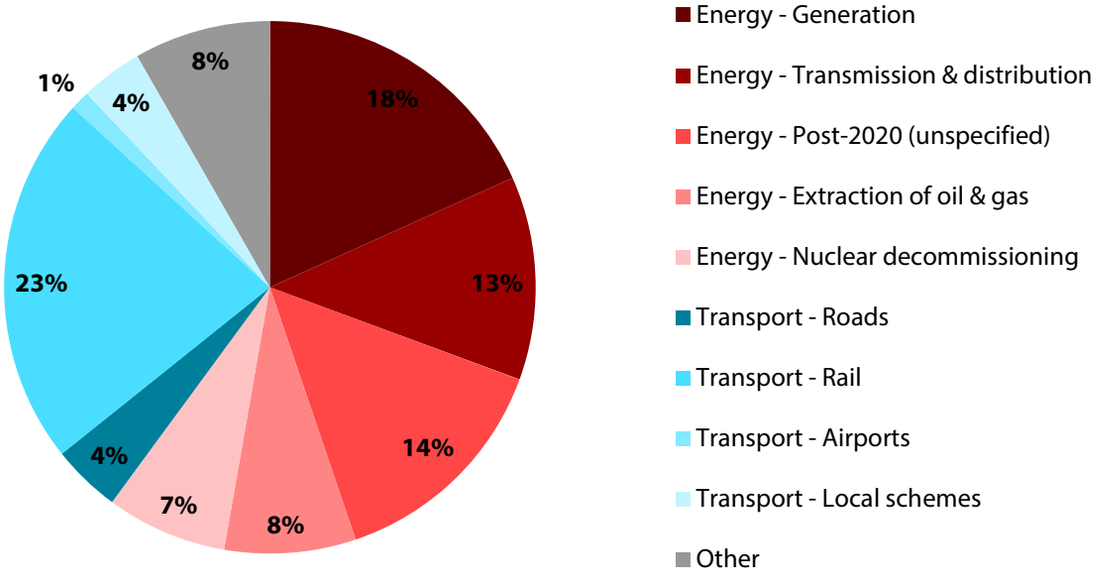
The Government has set out plans for development of infrastructure in the UK in its National Infrastructure Delivery Plan (NIDP):

- The NIDP describes all firm and committed public and private investment in infrastructure projects over £50 million from 2016/17.
- Planned investment in economic infrastructure totals £425 billion, the majority of which is allocated to energy and transport projects (Figure 1.8).

The Government has also established two new bodies to develop short-term and long-term plans for the UK's infrastructure:

- **The Infrastructure and Ports Authority (IPA)**. The role of the IPA is to support the delivery of infrastructure projects set out in the NIDP, with a focus on projects being delivered in the next five years. The IPA will also update the NIDP on an annual basis.
- **The National Infrastructure Commission (NIC)**. The NIC's role is to provide a strategic assessment of the UK's infrastructure needs over the next 10 to 30 years. The need to meet carbon budgets and the 2050 target and to adapt to the impacts of climate change will be key issues for the NIC to consider (Box 1.4).

Figure 1.8. Planned investment in economic infrastructure in the National Infrastructure Pipeline



Source: Infrastructure and Ports Authority (2016) *The National Infrastructure Pipeline.*
Notes: "Other" includes science and research, communications, waste, water and flood defences.

Box 1.4. The role of the National Infrastructure Commission

The National Infrastructure Commission (NIC) was established in 2015 to provide an independent assessment of the UK's strategic infrastructure requirements over the next 10 to 30 years. The NIC has identified climate change as a key issue for its assessment:

- The NIC will publish a National Infrastructure Assessment (NIA) every five years, starting in 2017. The NIA will provide a high-level, long-term context for infrastructure decisions, taking account of interactions between sectors and the potential impact of technological change. A key output of the NIA will be a set of recommendations for strategic priorities over the next 5-10 years.
- The recent NIC report on "Smart Power" highlighted the need for infrastructure to help the power system "modernise and decarbonise" in the context of the 2050 target.
- In its recent consultation on the scope of the NIA, the NIC recognised the necessity of meeting long-term carbon targets and the central role of climate change mitigation in planning the infrastructure mix for 2050.

The NIC has also published reports on "High Speed North" and "Transport for a World City" (i.e. CrossRail) and has been tasked with considering the Oxford-Milton Keynes-Cambridge corridor and 5G development.

Source: NIC (2016) *National Infrastructure Commission: consultation*; NIC (2016) *Smart Power*; NIC (2016) *National Infrastructure Assessment: consultation document.*

Infrastructure required for meeting carbon budgets

Investment in new infrastructure is crucial to support the decarbonisation of the power sector, transport, buildings and industry. This includes:

- Low-carbon electricity generation capacity sufficient to meet UK demand and a carbon intensity of generation of below 100 gCO_2/kWh in 2030.
- CO_2 pipes and storage infrastructure to support a significant roll-out of carbon capture and storage (CCS) in both electricity generation and industry.
- Electric vehicle recharging infrastructure sufficient to facilitate full roll-out of electric vehicles, including a nationwide network of charge points in public places, and across the strategic road network.
- Electricity transmission and distribution infrastructure to accommodate increased renewables capacity and additional demand from heat pumps and electric vehicles.
- Smart grid infrastructure capable of supporting an increase in demand-side response and maximising the efficiency of the transmission and distribution networks.
- District heating infrastructure that can support low-carbon heat delivered to industry, commerce, public buildings and homes.
- A plan for the future of the gas grid, developed alongside plans for future reductions in consumption of fossil natural gas and potential increases in consumption of hydrogen.
- Public transport infrastructure, to support a shift away from car travel to less carbon-intensive modes such as walking, cycling, bus and rail.

Progress in delivering the required level of infrastructure across each of these areas is varied (Table 1.4). More detailed assessments are provided in the relevant sector chapters of this report (Chapter 2 - Power, Chapter 3 - Buildings, Chapter 5 - Transport).

In some cases, such as district heating and electric vehicle recharging infrastructure, projects can be relatively small-scale and are therefore not fully covered by the NIDP, which focuses on nationally significant schemes. In such cases, we have produced our own assessment of the scale and sufficiency of current and planned investment. In future, the Government should consider widening the scope of the NIDP to include more detail on smaller-scale infrastructure if it plays an important role in the Government's emission reduction strategy.

A wider definition of infrastructure would also include measures to decarbonise buildings (e.g. Scotland has made buildings a national infrastructure priority). We do not define these measures as infrastructure but they are covered in Chapter 2 - Buildings.

Improved flood defences, resilience of existing infrastructure and infrastructure investment to address regional water scarcity and other impacts of ongoing climate change are also needed. This will be covered by the Adaptation Sub Committee in its forthcoming Climate Change Risk Assessment.

Table 1.4. Infrastructure required for meeting carbon budgets

Infrastructure	Planned investment	Assessment
Low-carbon electricity generation	£26 billion of public and private investment before 2021, with more than £40 billion beyond that.	Amber — Post-2020 funding unclear, particularly for CCS, onshore wind and solar. Decisions on new nuclear also yet to be confirmed.
CO_2 pipes and storage infrastructure	No plans as CCS is not currently part of Government policy.	Red — Government needs to implement a new approach for CCS.
Electric vehicle charging infrastructure	£15 million of Government funding for a national network of EV rapid charge points with additional investment from the private sector.	Amber — Broadly consistent with CCC scenarios but no strategy for on-street residential charging.
Electricity transmission and distribution infrastructure	£30 billion before 2021, with more than £10 billion beyond that. At least 9 GW of additional interconnector capacity.	Green — Broadly consistent with CCC scenarios.
Smart grid infrastructure	£6 billion for smart meter roll-out. Ofgem to open up a further £100 million for innovation competition.	Green — Broadly consistent with CCC scenarios.
District heating infrastructure	£320 million of investment support to leverage funding for up to 200 heat networks.	Amber — More information needed to assess whether funding is consistent.
Plan for the gas grid	Ongoing investment managed by Ofgem through the RIIO framework – currently ~£2 billion per year.	Amber — More work needed on the impacts of carbon budgets and to develop hydrogen as an option.
Public transport infrastructure	Not possible to split out spending on public transport as funds are often allocated to mixed schemes.	Amber — More transparency needed to assess whether funding is sufficient.

Source: Infrastructure and Ports Authority (2016) *The National Infrastructure Pipeline*; CCC analysis.
Notes: Green = broadly consistent with CCC scenarios; Amber = Uncertain; Red = Not consistent.

Infrastructure in the devolved administrations

In Scotland, Wales and Northern Ireland, over £19 billion of combined 'block grant' has been allocated from the UK for investment into infrastructure. This is managed by the devolved administrations to deliver infrastructure investment in areas of devolved responsibility, which include flood defences, roads, airports, local transport, water, housing and waste disposal.

The devolved administrations have each published infrastructure plans which emphasise the potential contribution of the plans towards climate change targets and renewable energy:

- The Scottish Infrastructure Investment Plan 2015 includes plans for investment in all travel modes, including rail electrification, a feasibility study for CCS and moves towards a circular economy. It also designates energy efficiency as a National Infrastructure Priority.
- The Welsh Infrastructure and Investment Plan aims to drive improvements in the energy performance of buildings and processes to tackle fuel poverty and to deliver a low-carbon future.
- Northern Ireland's Investment Strategy 2011-2021 (due for an update in 2016) states support for significant investment in the electricity grid and interconnections, aims to increase renewable energy, and supports major programmes for home insulation and smart metering to reduce energy demands.

The impact of planned infrastructure on meeting carbon budgets

Concerns have been raised over the possible impacts of planned infrastructure spending on meeting carbon budgets, including:

- **Embodied emissions:** Emissions of GHGs at each stage in the value chain of infrastructure provision, from extraction of raw materials, through transport and processing of materials, to construction.
- **Demand for fossil fuels:** Certain types of infrastructure that increase capacity, such as road building or airport expansion, could result in higher levels of demand and emissions than would have otherwise occurred.
- **Supply of fossil fuels:** There is continued investment in infrastructure for the extraction of fossil fuels that contribute to GHG emissions.

Any increase in emissions arising from new infrastructure must be offset by additional abatement. In some cases, such as planned investment in the road network, increases are likely to be relatively small based on current evidence. In other cases, such as provision of additional runway capacity at airports, future increases in demand will have to be managed to stay on track to the 2050 target. More work is needed to understand the overall impact of planned infrastructure on emissions, and further information on this is set out in the Technical Annex.

Under the Infrastructure Act 2015, we have a duty to advise the Secretary of State for Energy and Climate Change on whether the extraction of onshore petroleum (including shale gas) is consistent with carbon budgets. We delivered our advice on 30 March 2016 and the Secretary of State must lay the Committee's report before Parliament alongside the Department's official response 'as soon as is practicable' after 1 April 2016.

Innovation to support the transition to a low-carbon economy

Innovation will be critical for developing and deploying low-carbon technologies in order to meet carbon budgets, the 2050 target, and to further reduce emissions beyond 2050.

Our 2010 review of low-carbon innovation[4] identified three phases of the innovation process:

- **Research and development (R&D).** This involves basic research and development for specific technologies, culminating in demonstration of feasibility.
- **Demonstration.** This involves large-scale demonstration of technologies at the pre-commercial stage in order to test and improve designs and establish costs.
- **Deployment,** leading to technologies which are considered 'commercially proven' and achieving economies of scale and cost reductions.

The time taken to pass through these stages in the product development process can be significant, particularly in the context of the 2050 target and the long asset lives of many key technologies. This therefore suggests that deployment of currently known technologies will be required to ensure the 2050 target can be met at reasonable cost (Box 1.5).

Box 1.5. The importance of deployment in the 2020s

Deployment of currently known technologies through the 2020s will be of critical importance to meeting the 2050 target, given the time frames for innovation, the time remaining to 2050, and the role of deployment in the innovation process:

- **Innovation time frames.** The UK Energy Research Centre (UKERC) recently reviewed evidence on the time new technological innovations take to reach commercial maturity. Across the 14 innovations considered, the average time from invention to commercialisation was 39 years. The shortest time was 19 years (rechargeable lithium-ion batteries for consumer electronics) and the longest was 70 years (the car). For energy generation technologies the average time was significantly longer, at 48 years, due to a longer market deployment and commercialisation phase.
- **Time frame to meet the 2050 target**. There are 34 years left until 2050, a relatively short period in the context of assets which may have lives of up to 30 years or more. To effectively decarbonise electricity generation, transport and heat – taking into account stock turnover – it will be necessary to decarbonise all new investment by around 2020 for electricity (with the exception of back-up and balancing plant) and by 2035 for both transport and heat.
- **Role of deployment in the innovation process.** Given the time available to meet the 2050 target, the long lifetimes of many relevant assets and the need to decarbonise new investments well before 2050, this suggests the target will require deployment of currently known technologies. Deployment of these technologies at scale will drive innovation and learning to reduce costs. It provides manufacturers, installers and developers with the experience to successfully identify remaining barriers to commercialisation. Deployment of specific technologies will also be required to unlock wider low-carbon innovation opportunities (e.g. deployment of CCS is important in power and industry, and supports further decarbonisation options using hydrogen in transport, buildings and industry, roll out of heat networks, use of heat pumps, and bioenergy in conjunction with CCS).

Government involvement is important to ensure limited resources are targeted at strategically important technologies, including where these:

- Prepare for greater ambition post-2050 including the challenge of net negative emissions.
- Are likely to be important for achieving the 2050 target.

[4] CCC (2010) *Building a low-carbon economy - the UK's innovation challenge.*

- Are unlikely to be realised in the market without government support (e.g. due to a range of market failures which could include uncertainty and imperfect information around risks of failure, spill-over benefits which are not reflected in product prices, and high fixed costs of infrastructure acting as barriers to entry). This implies additionality of public funding (i.e. where public funding supports projects which would not have gone ahead otherwise).
- Leverage areas of particular UK advantage (e.g. where the UK is well placed to contribute to low-carbon innovation given its natural resources, skills or engineering capability).
- Complement international innovation activity, recognising aspects of innovation that will be driven globally and those that will be driven more locally.

Our Innovation Review identified priorities for UK innovation support, in line with these criteria. Our assessment is that the UK should:

- **Develop and deploy** offshore wind, CCS for electricity generation and industry, marine, smart grids, aviation, and electric vehicle technologies.
- **Deploy** nuclear and heat pumps.
- **Research and develop** advanced solar PV, energy storage, hydrogen fuel cell vehicles, advanced biofuels, and technologies in agriculture and industry.

Government support for innovation is currently spread across a range of policies and initiatives, including the global 'Mission Innovation' as well as domestic measures:

- **Mission Innovation** was announced at the UN climate conference in Paris in 2015 and had its inaugural ministerial meeting in June 2016 in San Francisco. It is a global initiative under which 20 countries (including the UK, US, China, Germany and Japan) committed to double their clean energy research and development by the end of the five years to 2020.
- **UK public funding** provides both direct and indirect support for low-carbon innovation.
  - Direct support is given through government programmes and government-funded bodies. In the 2015 Spending Review, funding for DECC's innovation programme was doubled to £500m over five years (including £250m for nuclear innovation and small modular reactors). Central government funds a range of innovation programmes (e.g. the Energy Entrepreneurs Fund for small and medium-sized enterprises). There are also a range of publically funded bodies which directly support low-carbon innovation, including Innovate UK, the Energy Systems Catapult, the Energy Technologies Institute and the Research Councils.
  - Indirect support is given through a range of government policies giving incentives for take-up of low-carbon technologies. These include, for example, grants for electric vehicles, incentives for low-carbon heat (e.g. heat pumps), and contracts for difference for low-carbon electricity generation technologies (e.g. offshore wind).

These measures are positive and cover a range of technologies. However, there is no clear overarching strategy for government low-carbon innovation spending. An effective low-carbon innovation strategy should set out a coherent overall approach to government spending, ensuring that this is targeted at strategically important technologies (e.g. as identified above). Compared to the areas we have identified as priorities, there are clear strategic gaps in the Government's innovation programme. For example, the recently cancelled Commercialisation Programme for CCS leaves a key gap in the UK's energy portfolio that is unlikely to be filled by R&D and international activity alone (see Chapter 2 - Power), and policy to deploy low-carbon heat requires strengthening given current low levels of uptake.

The Government should therefore develop strategies to fill these gaps, starting with an approach to developing, demonstrating and deploying CCS in electricity generation and industry.

The Government's plan to meet the fourth and fifth carbon budgets should include consideration of different ways to promote innovation: for example, the role of pilots and other smaller-scale deployment, larger-scale deployment, research and development and other measures. The plan should set out how technological and product innovations (e.g. efficient low-carbon heating systems, new vehicles, new ways of growing food) and demand-side innovations (e.g. smarter temperature control systems for homes and offices) will be supported. The Government's plan should consider the best ways to promote new innovation in the UK, and how to adopt quickly innovations that are created elsewhere in the world. The plan needs to consider when different types of innovations are likely to be delivered (e.g. within the next decade, in the 2030s, after 2050) in order to assess their potential contributions to the fourth and fifth carbon budgets, to the 2050 target or to the longer-term, post-2050, ambitions set out in the Paris Agreement.

5. The Paris Agreement and implications for carbon budgets

The Paris Agreement was reached in December 2015 and the Government had a constructive role in achieving this. It reflects and marks significant international progress but its impact depends on the ability of countries to ratify it and then implement their commitments. Progress was also made in a wide range of other areas agreed at Paris but not formally contained in the Agreement (e.g. Mission Innovation). In this section we set out the aims and status of the Agreement, and our advice on the implications for UK carbon budgets.

The aims and status of the Agreement

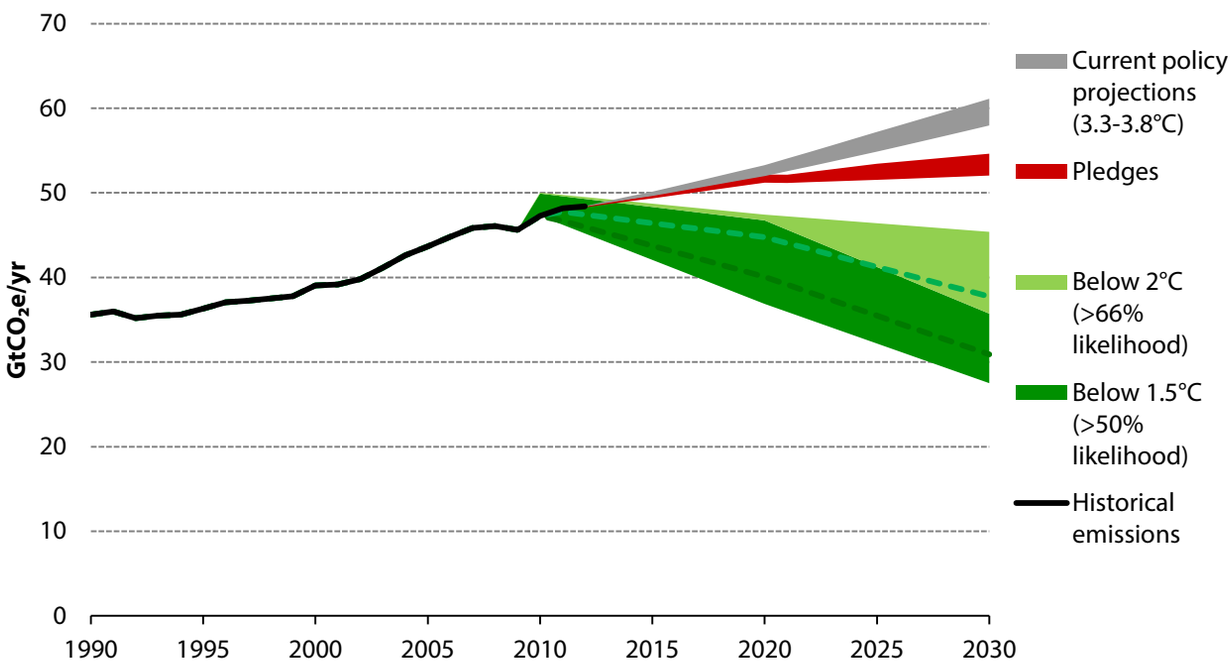
Under the Agreement, countries:

- Agreed to aim 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.
- Aimed to undertake rapid reductions in emissions to reach net zero global emissions of greenhouse gases in the second half of the century.
- Made pledges to control and reduce emissions.
  - For example, the EU pledged to reduce its emissions by 40% below 1990 by 2030. In total these pledges now cover over 99% of global territorial emissions (i.e. excluding international aviation and shipping).
  - In aggregate, achievement of the pledges would lower emissions compared to previous expectations, but are not yet consistent with what would be required to limit global temperature increase to 2°C or below (Figure 1.9).
- Agreed to introduce a five-yearly system to review pledges and raise ambition, recognising that the current ambition in aggregate falls short of the level required to meet the agreed temperature limits.

Since the Agreement was made in Paris the ratification process has begun. To enter into force, 55 countries accounting for 55% of global GHG emissions need to formally ratify the Agreement. As of May 2016 there are 177 signatories to the Agreement, 17 States (accounting for 0.04% of

global GHG emissions) have ratified and major emitters including China, the US and India (together around 40% of global emissions) have announced they plan to ratify in 2016.

Figure 1.9. Effect of the UN pledges on global emissions pathways



Source: Climate Action Tracker.
Notes: Solid red line reflects best estimate of impact of pledges. Green areas denote 10th to 90th percentile range of modelled cost-effective paths to meet temperature limits, with dashed lines reflecting median values.

Implications for carbon budgets

In January 2016 we wrote to the Secretary of State with our assessment of the implications of the Paris Agreement for the fifth carbon budget.[5] Our advice was that our fifth carbon budget recommendation is sufficient at this time, although a tighter budget may be needed in future:

- The Paris Agreement is more ambitious than the basis of the UK's statutory target for 2050, which was a global path to hold central estimates of temperature rise to close to 2°C by the end of the century (implying a very low risk of a 4°C rise). It also commits to zero net global emissions in the second half of the century.
- The measures underpinning our proposed fifth carbon budget are on the cost-effective path to the existing UK 2050 target, and keep open the possibility of deeper reductions should these become appropriate.
- The level of the fifth carbon budget was determined in part by EU ambition. Our proposal would support an increase in EU ambition for 2030, since it exceeds the UK's likely obligation under the current EU 2030 package. Raised EU ambition would be consistent with the need for all parties to increase ambition to deliver the goals of the Paris Agreement.

[5] Available at: https://www.theccc.org.uk/publication/implications-of-the-paris-agreement-for-the-fifth-carbon-budget/

- We identified further measures which could enable lower UK emissions over the fifth carbon budget period (2028-32). Even under our proposed budget it is sensible to keep these in play as a contingency for policy under-delivery or higher energy demand. It may be appropriate to commit to these in future through a tighter budget, for example if the EU and other nations commit to action consistent with the new ambition, or if the UK 2050 target is tightened.

We also committed to assess further the implications of the increased ambition in the Paris Agreement for UK climate policy, including for the UK's 2050 target and beyond. We will publish this report later this year, in time to feed into Government plans being developed to meet carbon budgets. We will also publish in the autumn our assessment of the implications of the UK leaving the EU for carbon budgets and how they are met.

Chapter 2: Power

Key messages and recommendations

In this chapter we report on carbon dioxide (CO_2) emissions from the electricity system and progress made to date in securing reductions. We also set out our recommendations and priorities for the Government's emissions reduction plan, due later this year.

The vote to leave the EU may have some impact on how power sector decarbonisation is achieved. A number of EU policies currently contribute to emissions reduction in the power sector, such as the Renewable Energy Directive, the EU Emissions Trading system (ETS), the Large Combustion Plant Directive, the Industrial Emissions Directive and the EU Third Energy Package. To meet the UK's power sector decarbonisation requirements it may be necessary to develop new policies, or adapt existing policies, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU agreements in this chapter should be read to indicate areas that future policies will need to cover to achieve similar objectives, and we will set out our view on how this should best be achieved in the coming months.

Our key messages for the power sector are:

- **There was strong progress in reducing power sector emissions in 2015, continuing the strong progress in previous years.** Emissions fell 17% in 2015 and are now 33% below 2009 levels, and 50% below 1990.
- **This reduction has resulted from the expansion of renewable generation alongside a reduction in demand since 2009.** The share of generation coming from renewables has increased from 7% in 2009 to 26% in 2015, while electricity demand has fallen by 5% over the same period. Generation from fossil fuels has fallen from 74% to 54% over the same period, with coal generation decreasing from 28% to 24%.
- **Progress is set to continue to 2021.** The enabling framework for delivering low-carbon power capacity is in place and proved effective in 2014/15, with new contracts signed to deploy up to 30 TWh of additional renewable generation by 2021 (bringing total expected renewable generation to around 115 TWh). These will displace fossil fuel generation and reduce the emissions intensity of the power sector from around 370 gCO_2/kWh in 2015 to around 200-250 gCO_2/kWh in 2020.
- **Significant risks remain beyond 2020.**
  - Although the enabling framework for delivering low-carbon power is in place, no further contracts were signed in the last year and no auctions are planned for the future, leaving no route to market for mature low-carbon generation (e.g. onshore wind, solar or biomass) not already under construction.
  - The Government has announced funding for less mature low-carbon generation (including offshore wind) to 2026, which is welcome but requires very stretching cost reduction and at best will support the minimum ambition we have proposed for offshore wind. Hinkley Point C, a large nuclear power station, was offered a contract in 2013, though a final investment decision has been delayed.
  - There is currently no strategy for the development of Carbon Capture and Storage (CCS).
- **These areas must be progressed** alongside the Government's announced phase-out of coal by 2025 in order to meet the Government's stated objectives: providing secure energy supplies while meeting its climate commitments at the lowest cost to consumers. The Government's emissions reduction plan at the end of the year must deal with these issues.

Table 2.1 sets out the criteria against which we will assess the Government's emissions reduction plan and our assessment of current policy, covering the full set of areas that must be addressed to keep the UK on the lowest cost path to meet its statutory targets. In some areas elements of the required policy

are in place or planned but require stronger implementation if they are to succeed. In other areas new policies are required. We identify a gap of around 31 $MtCO_2$ (44% of the required reduction in emissions) in 2030 between Government plans and the cost-effective path to meeting the 2050 target in 2030 (Figure 2.7).

Table 2.1. Power sector priorities for the Government's emissions reduction plan

Power sector emissions intensity to fall by around 75% between 2015 and 2030 (from 370 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:	**New policy**	**Stronger implementation**
A strategic approach to carbon capture and storage deployment in the UK. 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. Proposals should be made by the end of 2016 for an approach that enables contracts for capture facilities to be awarded this parliament.	✗	
An approach to bring forward the cheapest low-carbon generation. By 2020, some future wind or solar projects could generate power at lower cost than the full social cost of new gas-fired plants (i.e. the cost of gas-fired power with emissions valued at a target-consistent carbon price across its lifetime). Such projects should be offered a route to market, with long-term contracts at a price that implies no additional subsidy.	✗	
Support for offshore wind as costs are driven down. Three 'pot 2' Contract for Difference auction rounds, with eligibility granted to a number of technologies including offshore wind, have been announced this Parliament. DECC should ensure that sufficient funding is available in these auctions to support cost reductions in offshore wind.		✗
Plans for flexibility options (e.g. storage, interconnection, demand response), including rapid development of market rules to ensure that revenues available to these options reflect their full value to the electricity system.		✗
Contingency plans for delay or cancellation of planned projects, for example new nuclear power plants. This would require alternative low-carbon technologies to increase their contribution, while ensuring sufficient firm capacity and flexibility to meet demand. Options include tidal lagoons and further expansion of offshore wind, possibly complemented with interconnectors and/or storage.	✗	

Notes: In some areas there are elements of new policies needed and elements needing stronger implementation of existing policies – in these cases both columns are checked. In all cases policies will need to be strongly implemented, both new and existing.

Introduction

In this chapter we review progress in decarbonising the UK power sector in 2015, including progress investing in new low-carbon power generation and associated infrastructure. We outline priorities for taking forward the policy framework to ensure 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. Overview of emissions

2. Performance against the Committee's progress indicators

3. Forward look and policy gap

1. Overview of emissions

Emissions in 2015

Power sector CO_2 emissions (25% of total UK CO_2 emissions) fell 17% in 2015 to 102 $MtCO_2$, 50% below 1990 levels. This follows an average annual decrease of 5% over the period 2009-2014 (Figure 2.1). Emissions in 2015 were in line with our indicator trajectory (see Figure 2.2, and section 2 for an explanation of our indicators).

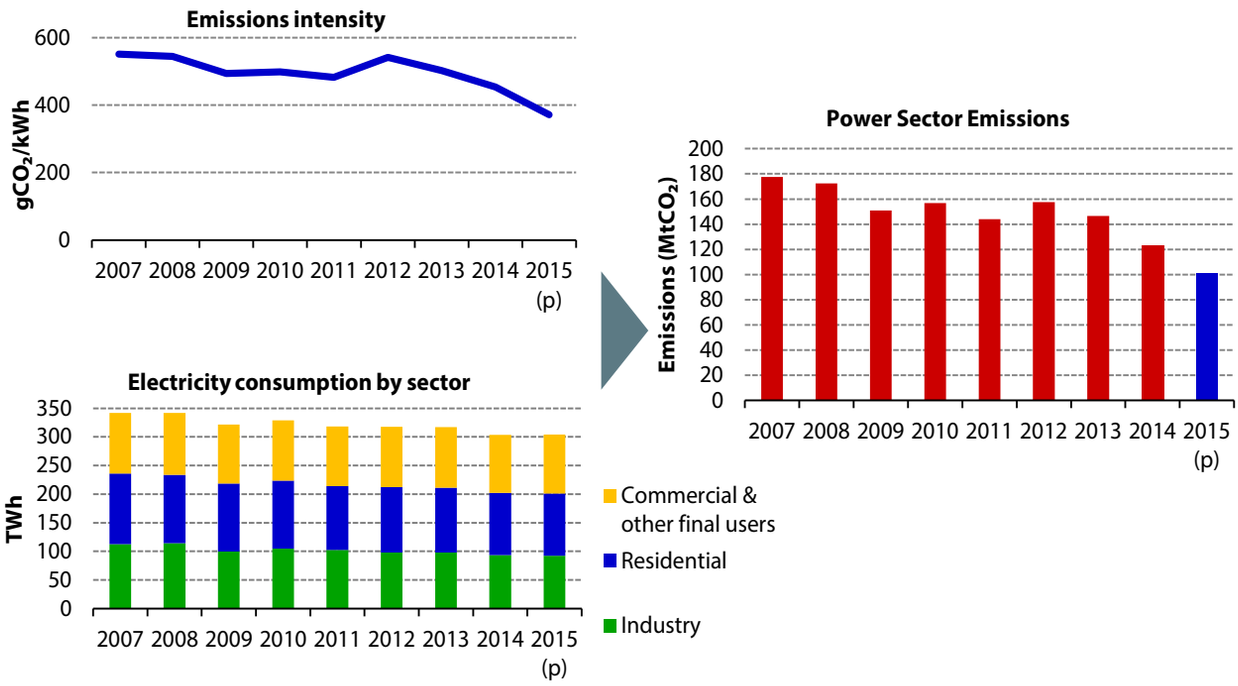
The year-on-year reduction is due largely to an 18% decrease in the emissions intensity of the power sector to 371 gCO_2/kWh. Renewable and nuclear generation increased, meeting almost half of demand in 2015, while coal generation decreased:

- Renewable generation increased by 28% to 77 TWh (26% of generation), due to an increase in renewable capacity, and higher than average load factors for wind output. This compares to generation of 24 TWh in 2009, rising to 60 TWh in 2014. Within the 2015 figure, wind made up 53% of renewable generation, and biomass accounted for 33%, with the remainder coming from solar photovoltaic (PV) and hydroelectricity.
- Coal generation fell by 24% to 72 TWh (24% of generation). This continued a longer-term trend reflecting a range of economic factors. In addition to a reduction in gas prices and the costs of complying with European legislation (e.g. Industrial Emissions Directive), the UK's Carbon Price Floor increased from £9.5/tCO_2 to £18/tCO_2 in April 2015. The increase in the Carbon Price Floor increased the cost of coal generation by more than the cost of gas generation, reflecting the higher CO_2 intensity of coal generation over gas generation[1] (around an £8/MWh increase for coal, compared to a £3/MWh increase for gas). Of the 20 GW of coal that was on the system at the end of 2014, 0.65 GW converted to biomass and 9 GW has either closed in 2016 or announced it will close by 2020. Coal generation continues to fall in 2016, with average load factors of 28% this year, down from 43% in 2015, and an average of 50% between 2010-2015.
- After outages at two nuclear stations in the second half of 2014, nuclear output increased by 10%, to 64 TWh. This represented 22% of UK generation, compared to an average of 19% between 2009-2014.
- Output from gas remained broadly unchanged, at 87 TWh (29% of generation, compared to an average of 35% between 2009-2014).

[1] The CO_2 intensity of coal is around 900 gCO_2/kWh, and that of gas around 350 gCO_2/kWh.

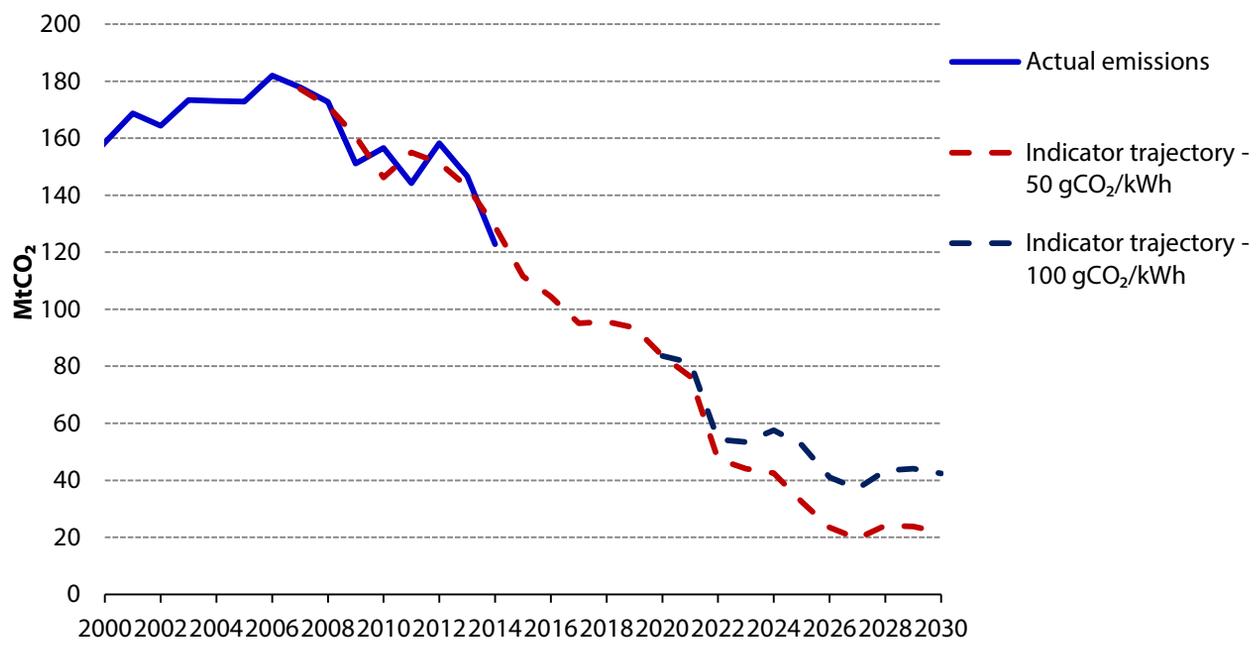
Between 2009 and 2015 the increase in renewables capacity has resulted in an increasing share of renewable generation, from 7% to 26%, and a corresponding decrease in fossil-fired generation, from 74% to 54% over the same period. Further deployment of renewables will continue to push fossil fuels out of the electricity system (see section 2).

Figure 2.1. Emissions intensity of electricity supply, electricity demand and CO_2 emissions from the power sector (2007-2015)



Source: DECC (2016) *Energy Trends*; DECC (2016) *UK Greenhouse Gas Emissions 1990-2015 (provisional)*; CCC calculations.
Notes: Emissions intensity is UK based useable generation, i.e. excluding losses. Electricity consumption includes imported power. 2015 data are provisional.

Figure 2.2. Actual power sector emissions compared with our indicator trajectory (2000-2030)



Source: DECC (March 2016) *Energy Trends*; DECC (March 2016) *Provisional 2015 results for UK greenhouse gas emissions and progress towards targets*; CCC calculations.

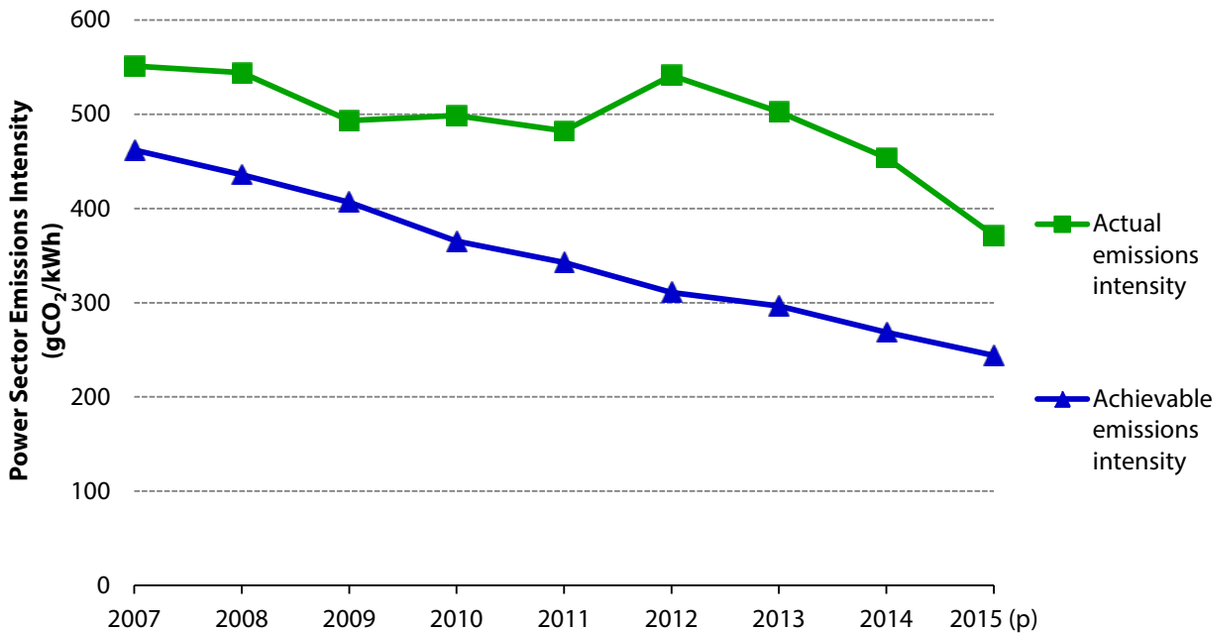
Achievable Emissions Intensity

In order to identify underlying progress we also track the Achievable Emissions Intensity (AEI) of the power system – 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). AEI improved by 9% to 244 gCO_2/kWh in 2015 due to increased deployment of wind, biomass and solar capacity. The AEI of the power sector has improved by around 8% per year since 2009.

At 371 gCO_2/kWh, the actual emissions intensity of the UK power sector is now below the AEI in 2007 (462 gCO_2/kWh). There is sufficient low-carbon capacity to meet almost half of demand in a typical year, and sufficient gas capacity to meet most of the remainder (there are a small number of peak hours during the winter when coal capacity would still be needed, covering less than 0.1% of generation). Additional gas capacity may be required in a backup role, to ensure system security.

If the grid had been dispatched in this way in 2015 then UK power sector emissions would have been 35 $MtCO_2$ (34%) lower. Actual UK Emissions have been far higher than achievable emissions in recent years, because of coal generation. However, these are converging as the low-carbon share increases and as coal comes off the system (outturn emissions in the period 2012-2014 were on average 80% higher than AEI) and we would expect this trend to continue, in particular as the carbon price faced by generators rises (Figure 2.3).

Figure 2.3. Achievable emissions intensity (2007-2015)



Source: CCC Calculations based on DECC (March 2016) *Energy Trends*.
Notes: Achievable emissions intensity 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 UK based useable generation, i.e. excluding losses.

2. Performance against the Committee's progress indicators

The Committee's approach to tracking progress

We track progress in the power sector against our detailed indicator framework, which we set out in our first Progress Report in 2009 and revised in our 2014 Progress Report. Our power sector indicators cover the overall policy framework, deployment of low-carbon capacity (renewables, nuclear and carbon capture and storage) and the infrastructure required to support a low-carbon power sector (e.g. interconnection)[2]:

- **Policy:** We monitor Government's progress in implementing new market arrangements to incentivise low-carbon investment and reduce emissions in the UK power sector.
- **Renewables:** We monitor actual deployment of capacity and resulting generation as well as progression through the project development cycle, including planning.
- **Nuclear:** We monitor progress towards building a new generation of plants, including indicators on planning and regulation.
- **CCS:** Our indicators, developed prior to the cancellation of the UK's CCS Commercialisation Programme in 2015, focus on development of demonstration projects and preparation for wider rollout in the 2020s. CCS is also relevant to industrial decarbonisation (see Chapter 4).

[2] A full set of indicators is provided in the technical annex.

- **Infrastructure:** We monitor development of the transmission network (required reinforcement, access to the network, investment in the onshore and offshore grid, interconnection), and progress with rolling out smart meters and developing/procuring Demand-Side Response (DSR) capabilities.

Our indicators would, if met, put the UK on the path to a power sector that is largely decarbonised by 2030, based on a portfolio of options and with the potential to support decarbonisation of other sectors such as heat and transport. As set out in Chapter 1, our indicators are neither prescriptive nor exhaustive:

- Lack of performance in one sector can be met by outperformance in other sectors.
- Alternatively, some technologies or behaviours could become more cost-effective than current best evidence suggests.

Developments in the electricity market arrangements

Feed-in-Tariffs and the Renewables Obligation

Feed-in-Tariffs (FiTs) covered around 5 TWh of the 77 TWh of renewable generation in 2015, while the Renewables Obligation (RO) covered the remaining 72 TWh. In 2015 the Government introduced changes to the FiT and RO support mechanisms, with the aim of reducing spending under the Levy Control Framework (Box 2.3):

- **Feed-in-Tariffs**
  - Removal of "pre-accreditation" under the scheme, such that tariffs are now applicable from the date of installation, rather than the date of accreditation (though pre-accreditation was reintroduced for anaerobic digestion). Installers under FITs now risk receiving lower than expected tariffs in the event of delays to installation, as tariffs decrease over time, and may decrease significantly in the event of further tariff degression if existing deployment caps are breached.
  - Change in tariffs: e.g. from 11p/kWh for solar projects up to 10 kW in capacity at the start of 2015 to less than 4 p/kWh from 2016 onwards.
- **Renewables Obligation**
  - Early closure of the RO to sub-5MW solar. Following closure to solar projects above 5MW last year, this change essentially removes all price support beyond April 2016 for large-scale (>1MW) solar projects under the RO (around 1 GW of projects are expected to commission during grace periods). While sub-5MW solar projects can still accredit under FiTs, expected revenues under these are lower than they were under the RO.
  - Closure of the RO to onshore wind in 2016, one year early. However, there is a grace period up to April 2018 for onshore wind developers who had committed significant investment by the date of the announcement. This is important to avoid retrospective policy change, with around 2.5 GW of projects expected to deploy in the grace period. Along with the strong deployment to date, this is likely to keep onshore wind on track to our indicators for 2020 (Box 2.3).
  - Removal of "grandfathering" (fixing of the level of subsidy accruing to the generator) for biomass conversion projects. Project developers now risk receiving lower than expected revenues for electricity generated.

Despite the reductions in Government support, we estimate that sufficient onshore wind capacity, and renewable generation capacity overall, is under construction that generation from these sources is likely to remain in line with our indicators (Box 2.3).

In the longer term, low-carbon generation will be secured by contracts for difference. However, as there are currently no planned auctions for contracts for difference for large-scale solar or onshore wind projects, the changes to the FiTs and RO have eliminated the only route to market for these projects (see below).

It is important to adjust subsidies in line with falling technology costs. Indeed, mature low-carbon technologies are likely to no longer require subsidies by 2020, beyond a value of carbon consistent with the UK's climate targets (see section 3). Such adjustments should be made in a predictable, transparent way which developers can anticipate and understand. Commentators have suggested that the 2015 changes to FiTs and the RO have increased policy risk, resulting in higher cost of capital.[3]

Contracts for difference

Through the April 2015 Contracts for Difference auction, and under the Final Investment Decision Enabling regime, contracts have been signed for 6.5 GW of projects to come online by 2021. More than 3.4 GW of these projects have now passed their first contractual milestone, increasing confidence that these will be delivered. However, one offshore wind project (0.5 GW) is currently contesting a CfD that was cancelled after it failed its first financial delivery milestone. It was originally expected that these projects would deliver around 28 TWh of generation per year; latest information on load factors indicates broadly this level of delivery, around 30 TWh per year (28 TWh without the contested offshore wind contract).

However, there have been no further auction rounds, so the project pipeline for large-scale renewables is unchanged from our assessment in last year's Progress Report (see Technical Annex).

In our 2015 Progress Report to Parliament we recommended that the Government extend funding under the Levy Control Framework to 2025, whilst providing transparency over how this level of funding would change in response to gas and carbon price fluctuations. Although the Government, in its response to our 2015 Progress Report, indicated it would do this, further information on the future of the Levy Control Framework has now been pushed back to the 2016 Autumn Statement.[4]

In the 2016 Budget the Government announced CfD funding beyond 2020 for the first time, with up to £730m in funding per year across three auction rounds this parliament for 'Pot 2' technology projects including offshore wind, commissioning between 2021 and 2026 (Box 2.1). The first auction, to be held in 2016, has been allocated £290m in funding per year.

In addition, the Government has indicated that funding will be available for the Hinkley Point C nuclear power station, which is expected to commission in the 2020s; Hinkley was first offered a contract in 2013 but has not yet taken a Final Investment Decision (see below).

[3] EY (September 2015) *Renewable Energy Country Attractiveness Index*. Available at: www.ey.com
[4] HMT (2016) *Budget 2016*. Available at: www.gov.uk

Box 2.1. Contract for Difference auctions

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, Scottish Island onshore wind, tidal stream, wave, "Advanced Conversion Technologies"[5], and Biomass Combined Heat and Power (CHP)
- **Pot 3:** Biomass conversion

The Government may also include maxima and minima capacity levels on technologies competing within the auction rounds, in order to limit or encourage their deployment, and throughout the entire delivery period. For example, the Government set a minimum of 100 MW for wave and tidal stream technologies to come online by 2018/19.

The first CfD auction took place in April 2015, allocating around £300m per annum of funding for 2 TWh of Pot 1 technologies and 6 TWh of Pot 2 technologies to come online by 2021. An additional 20 TWh of contracts had already been allocated to offshore wind, biomass conversion plants and dedicated biomass plants via the Final Investment Decision Enabling Regime.

The next CfD auction will be for 'Pot 2' technologies only, and will take place in the second half of 2016.

Capacity market auctions

It is not in the Committee's remit to assess the effectiveness or efficiency of the capacity market in meeting its aim of ensuring security of supply for UK electricity. However, we do monitor new plants entering under the capacity market and the retirement of existing plants, given the potential for these to affect UK carbon emissions.

The second auction in the Capacity Market finished in early 2016 (Box 2.2).

The first two capacity market auctions have contracted 2 GW of small-scale generation plant (mostly diesel- or gas-fuelled).[6] These plant are more carbon-intensive than a large gas plant and are not subject to emissions constraints under the EU ETS.[7] While commentators have expressed concern, it is likely that they would run at very low load factors, and produce very low emissions in aggregate.

- These plants have higher running costs so are likely to dispatch after low-carbon plants and large-scale gas plants.
- This will limit their running hours to generating less than 1 TWh per year, with emissions implications of less than 0.5 $MtCO_2$.

The Government proposes to introduce air quality limits on new plant in the capacity market, and to review some of the 'embedded benefits' these plants receive for being connected to the electricity distribution system rather than the electricity transmission system. We will continue to closely monitor the emissions implications of embedded generation.

[5] Gasification or pyrolysis of gaseous and liquid fuels derived from biomass or waste.
[6] Sandbag (2015). *UK Capacity Market Results* based on National Grid (2015) *Capacity Market Provisional Auction Results*. Available at: www.sandbag.org.uk
[7] It is unclear if the UK will remain part of the EU ETS following the Leave vote.

Box 2.2. Capacity market auctions

Under the Energy Act (2013) the Government introduced capacity payments for electricity generators in order to ensure security of supply, and incentivise new capacity development in the power sector. Generators operating under schemes such as Feed-In-Tariffs, the Renewables Obligation or Contracts-for-difference are ineligible for capacity market contracts.

Capacity market contracts are awarded via annual capacity market auctions for delivery four years ahead of the auction date (e.g. an auction for delivery in 2019/20 was held in 2015/16). An additional auction will be held one year before each delivery date, for a smaller amount of capacity. Entrants are able to bid for three types of contract:

- **1 year contract:** existing capacity
- **3 year contract:** refurbishing capacity that can demonstrate refurbishment spend of £130/kW
- **15 year contract:** new build capacity that can demonstrate spend of £255/kW

The contracts are paid for capacity only, regardless of when the plant generates. The auctions are 'pay-as-clear', i.e. all bidders are paid the highest price awarded a contract in an auction round, capped at £75/kW/year.

The first capacity market auction was in 2014/15 for delivery in 2018/19; auctions will now continue on an annual basis.

Closure of coal power stations

Of the 20 GW of coal capacity that was on the system at the end of 2014, 9 GW has either closed in 2016 or declared that it will close before 2020. One 0.6 GW unit at Drax converted to biomass. 9 GW of the remaining 10 GW are contracted under the capacity market in 2019/20.

In November 2015 the Government stated its intention to deliver new gas-fired power stations, and announced the launch of a consultation on proposals to close all unabated coal-fired power stations by 2025, provided sufficient new gas capacity can be brought forward through the capacity market.

The primary function of the capacity market is to deliver security of supply, rather than decarbonisation of the power sector. Our indicators therefore do not cover new plant contracted under the capacity market. Instead, our indicators cover low-carbon capacity and generation, which are necessary to deliver deep decarbonisation of the power sector.

Delivery of new gas capacity to ensure security of supply is consistent with our power sector scenarios provided it runs at low load factors, and provided low-carbon capacity continues to expand alongside it. Ideally, new gas capacity should be located in areas with potential for future retrofit with CCS.

Deployment of renewable generation capacity

In this section we consider progress and delivery risks for onshore wind, offshore wind, biomass and solar generation capacity.

Total installed renewable generation capacity reached 30 GW in 2015. As a result, around 26% of electricity generated (77 TWh) was from renewables, up from 20% (60 TWh) in 2014 and 5% (19 TWh) in 2007. This compares to our indicator for 2015 of 68 TWh.

Contracts have been signed for around 6.5 GW of renewable capacity to come online by 2021, capable of generating 28 TWh of electricity. Together with projects expected to connect under

the old regime (the Renewables Obligation) this would result in around 115 TWh of renewable generation in 2020, broadly in line with our indicator trajectory, despite policy changes aiming to limit roll-out (Box 2.3).

Progress across the technologies is summarised in Table 2.2, with additional detail in the Technical Annex.

Solar PV

3.5 GW of solar PV capacity was deployed in 2015, bringing total capacity to just over 9 GW. There is an additional 1 GW of large-scale solar PV under construction, which is expected to connect during the grace periods of the Renewables Obligation.

Solar costs in the UK have fallen quickly and capacity has expanded. Solar accounted for 7 TWh (2%) of generation in 2015[8] following rapid expansion in the past few years. This is split between large-scale ground-mounted installations (approximately 65% of total PV generation), which are relatively cheap with costs similar to those for onshore wind (i.e. new installations could be deployed at around £80/MWh), and smaller rooftop installations (35%), which despite falling costs remain relatively expensive (e.g. in 2015 these received feed-in tariffs up to £140/MWh, not including export tariffs).

However, as no further CfD auction rounds have been announced for Pot 1 technologies (see Box 2.1), and reforms to Feed-In-Tariffs and the Renewables Obligation only allow for small-scale solar deployment, there is no route to market for large-scale solar PV beyond 2016.

Box 2.3. Expected deployment to 2020/21 and its impact on the Levy Control Framework

During the past year the Government has made a series of policy announcements aiming to reduce spend under the Levy Control Framework, under which expenditure in 2020/21 under Feed-in-Tariffs, the Renewables Obligation and Contracts for Difference is capped at £7.6bn per annum (in 2011/12 prices). A 20% overspend 'headroom' applies to the LCF cap, but if the cap is breached in any year then the Government must demonstrate how it will reduce spend in future years.

In July last year the Office for Budget Responsibility (OBR) predicted a £1.5bn (20%) overspend in 2020/21, as a result of: higher than expected capacity being built under FITs and the RO, lower wholesale electricity prices due mainly to lower expected gas prices along with the freezing of the carbon price floor, and offshore wind projects producing more energy than was expected.

The Government announced policy changes to Feed-in-Tariffs and the Renewables Obligation that it estimated would save £0.8bn per year by 2020/21.

OBR now estimate that overspend due to FiTs, RO and CfDs will be 14% above the £7.6bn cap in 2020/21, within the 20% headroom. Independent consultancies (e.g. Cornwall Energy) are forecasting LCF costs at below the £7.6bn cap in 2020/21; Cornwall's estimates are £0.9bn per year below for the RO and £0.2bn per year below for CfDs in 2020/21.

Using the OBR's LCF forecast, we estimate total spending under the LCF will account for around £85 on an average dual-fuel household's annual electricity bill of £435 in 2020. Of this, we estimate the overspend will account for around £10.

It is important to note that spending under the LCF does not, in principle, represent an estimate of the total cost to consumers of policies covered by the LCF:

- Policies covered by the LCF reduce the wholesale price due to increased generation from the low-

[8] Of which we estimate about 70% was exported to the electricity grid in 2015.

Box 2.3. Expected deployment to 2020/21 and its impact on the Levy Control Framework

marginal-cost renewable generation they deliver (the merit order effect). We estimate that this effect will reduce the average consumer bill by up to £7 in 2020.

- Separately, these policies also result in additional costs to the electricity system associated with the intermittency of renewable generation, including additional costs for backup generation, reserve and response. We estimate that these costs will increase the average consumer bill by up to £7 in 2020, roughly offsetting the impact of the merit order effect.

Furthermore, we estimate that the lower gas price now expected compared to when the LCF was set will reduce the average annual household electricity bill by £75 in 2020, alongside a reduction in gas bills for dual-fuel households of around £195 in that year (from around £515 to around £320).

We expect these changes to have a limited impact on our indicators for renewable generation to 2020, given that deployment of onshore wind will continue under grace periods, and solar deployment over the past few years has exceeded our indicators:

- 9.1 GW of onshore wind was installed by the end of 2015. Additionally there is 2.5 GW of onshore wind under construction (and expected to connect during the RO grace periods) as well as 0.75 GW that was awarded contracts in the first CfD allocation round. We expect total installed onshore wind capacity to generate 29 TWh by 2020, broadly in line with our indicators.
- In 2014, we estimated that with steady deployment of solar PV to 2020, installed capacity would reach 10 GW in 2020. 9 GW of capacity had been installed by the end of 2015, with an additional 1 GW of solar PV projects above 1 MW in size either under construction, or awarded a contract under the first CfD allocation round. We therefore expect solar PV deployment to be in line with our indicators.

Source: OBR (2015/16) *Economic and Fiscal Outlook*. Available at: www.budgetresponsibility.org.uk; Cornwall Energy (2016) *Levy Control Framework Outlook*. Available at: www.cornwallenergy.com; CCC Analysis.
Notes: All numbers are in £2011/12 prices. We only include policies under the LCF that are directly relevant to low-carbon generation: Feed-in-Tariffs, the Renewables Obligation and Contracts for Difference.

Table 2.2. Deployment of renewables in 2015

Technology (% of UK Generation in 2015)	Installed Capacity in 2015 (GW)	Of which, capacity added in 2015 (GW)	Further capacity in Pipeline to 2020[1] (GW)	Expected capacity and generation in 2020	CCC indicator generation in 2020	Current cost estimates (£/MWh)[2]
Onshore wind (8%)	9.1	0.6	3.4	12.5 GW, 29 TWh	30 TWh	≤£80
Offshore wind (6%)	5.1	0.6	5.8	10.9 GW, 43 TWh	36 TWh	≤£115
Biomass (9%)	3.2	0.6 (0.9 retired)	1.5	4.6 GW 32 TWh	24 TWh	£87
Solar PV (2%)	8.9	3.5	1	9.9 GW, 8 TWh	-	≤£80
Wave (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	£200-300
Tidal stream (<1%)	<0.1	0	<1	<0.1 GW, <1 TWh	-	£100-200
Tidal lagoons (0%)	0	0	0	0	-	£115

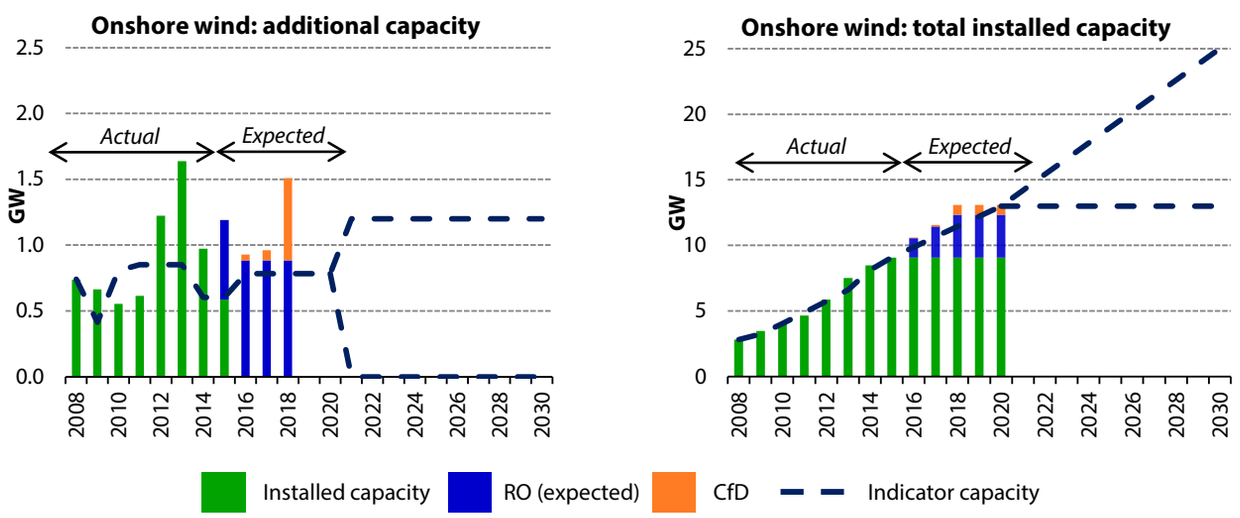
Source: DECC (March 2016) *Energy Trends*, Low Carbon Contracts Company (2016) *CfD Register*, CCC Analysis.
Notes: 1. Awarded a CfD, or expected to deploy under the Renewables Obligation. Note this includes the Neart Na Goithe offshore wind farm (0.45 GW), which is currently contesting a cancelled CfD.
2. Onshore wind, offshore wind and solar costs represent recent CfD auction prices; other values are levelised costs drawn from our 2015 *Power Sector Scenarios* report.
3. For reference, in our 2015 *Power Sector Scenarios* report we estimated levelised costs for current new build CCGT costs to be £65-75/MWh (the lower end of the range reflects a market carbon price forecast, the upper end of the range reflects a 'target-consistent' carbon price forecast). For more information see: CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
4. Load factors for renewable technologies range from around 10% for solar PV, to 80% for biomass. Wind load factors are around 30% (onshore wind) and 40% (offshore wind).

Onshore wind

0.6 GW of onshore wind capacity was deployed in 2016, bringing total capacity to just over 9 GW (Figure 2.4). There is an additional 3.4 GW of onshore wind in the pipeline, which is expected to begin operation by the end of 2020.

However, as no further CfD auction rounds have been announced for Pot 1 technologies (see section 2.2, above), there is no route to market for onshore wind beyond the end of the Renewables Obligation period in 2018.

Figure 2.4. Onshore wind: annual additional and cumulative capacity against our indicators (2008-2030)



Source: DECC (March 2016) *Energy Trends*; Pöyry (2013) *Technology Supply Curves for Low-Carbon Power Generation*; CCC estimates.
Notes: 2015 data are provisional. The divergence in indicators beyond 2020 reflects uncertainty around which low-carbon technologies will be cost-effective in a future generation mix: the lower end of the range indicates no further deployment beyond 2020 (e.g. due to cost, political and public acceptability considerations), the upper end of the range indicates continued deployment due to favourable costs compared with other technologies.

Offshore wind

0.6 GW of offshore wind capacity was deployed in 2016, bringing total capacity to just over 5 GW (Figure 2.5). There is an additional 5.8 GW of offshore wind in the pipeline, which is expected to begin operation by the end of 2020.

The three CfD auction rounds for 'Pot 2' technology projects commissioning between 2021 and 2026 announced in the 2016 Budget potentially offers offshore wind a route to market. They could be sufficient for up to 6 GW of capacity, provided offshore wind is not crowded out by other eligible technologies:

- We estimate the £730m per annum funding could support 3-6 GW of offshore wind deployment between 2021-2026, depending on uncertainties around gas and carbon prices.[9]

[9] Based on DECC (2015) *Energy and Emissions Projections* and DECC (2016) *2016 Interim Fossil Fuel Price Assumptions*. Available at: www.gov.uk

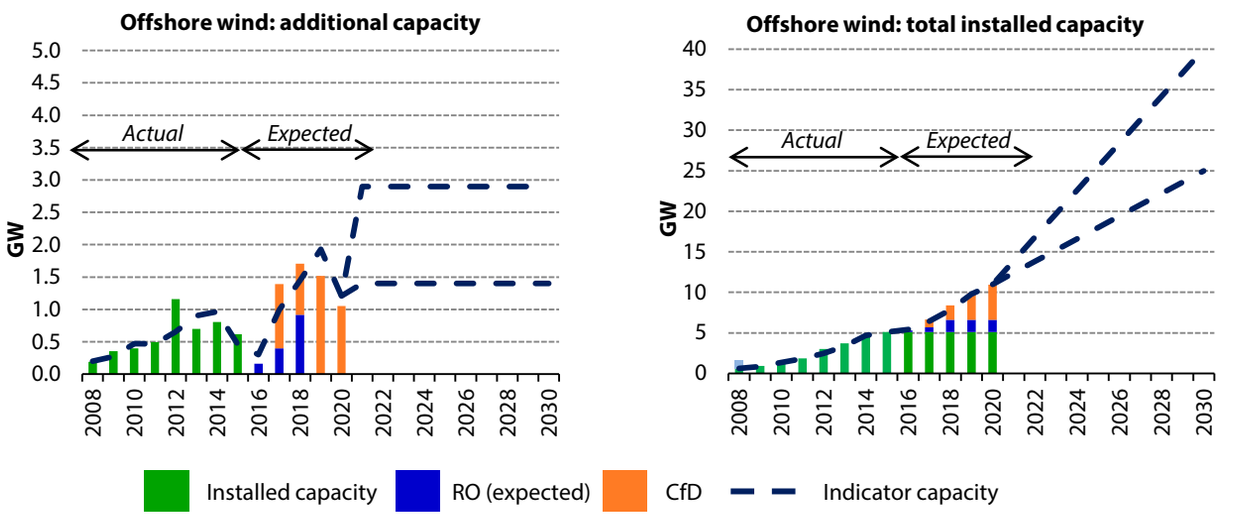
- Auction prices in this round are subject to a cap, which decreases from £105/MWh in 2021 to £85/MWh in 2026. This cap represents a challenging but feasible level of cost reduction.
  - Work carried out by BVG for the CCC last year estimated that levelised costs could decrease to around £86/MWh by 2030, equivalent to a strike price of around £95/MWh.[10]
  - Recent announcements from several offshore wind developers indicate that this level of cost reduction is possible.[11]
- However, the Government has not signalled the amount of funding to be allocated to individual technologies. Should other Pot 2 technologies (Scottish Island onshore wind, tidal stream, wave, Advanced Conversion Technologies, Biomass CHP) secure contracts for a large number of projects, the remaining available funding would support less offshore wind, putting commercialisation of this technology at risk.

The Government should work with the industry to ensure the policy environment is supportive of cost reduction (e.g. in finalising the auction rules). It should also ensure that sufficient budget is available for offshore wind to support a scale of deployment consistent with cost reduction (e.g. through use of technology minima or maxima in the auctions).

[10] 'Balanced scenario' from BVG Associates (2015) *Approaches to cost reduction in offshore wind*. Available at: www.theccc.org.uk

[11] E.g. WindEurope (2016) *Offshore wind can reduce costs to below €80/MWh by 2025*. Available at: www.windeurope.org

Figure 2.5. Offshore wind: annual additional and cumulative capacity against our indicators (2008-2030)



Source: DECC (March 2015) *Energy Trends*; Pöyry (2013) *Technology Supply Curves for Low-Carbon Power Generation*; CCC estimates.
Notes: 2015 data are provisional. Volatility in offshore wind additional capacity indicator to 2020 reflects expected dates that specific projects in pipeline commence operation. The divergence in indicators beyond 2020 reflects uncertainty around which low-carbon technologies will be cost-effective in a future generation mix: the lower end of the range indicates no further deployment beyond 2020 (e.g. due to cost, political and public acceptability considerations), the upper end of the range indicates continued deployment due to favourable costs compared with other technologies.

Biomass

Electricity generated from biomass feedstocks has increased from 9.6 TWh in 2009 to 25 TWh (around one third of renewable generation) in 2015, mostly due to coal stations converting to biomass (biomass conversion units at Drax accounted for 38% of total generation from biomass). Between 2014 and 2015 generation from biomass increased by 28% (6 TWh) due to a third coal unit at Drax (0.65 GW) being converted to biomass, and an increase in capacity and generation from smaller-scale Anaerobic Digestion and energy from waste plants (0.2 GW, 0.8 TWh).

For biomass to offer genuine emissions savings, the feedstock must come from sustainable sources. The Government's new biomass sustainability criteria (Timber Standard for Heat & Electricity) came into effect in Autumn 2015. This requires generators receiving incentives under the Renewables Obligation, Renewable Heat Incentive (RHI) and Contracts for Difference (CfDs) to demonstrate that biomass is sourced from forests that are being managed in a way to maintain or enhance carbon stocks.

Deployment of new nuclear generation

Nuclear generation is an important source of baseload power generation, providing 22% of UK generation in 2015. In early 2016, EdF announced plant life extensions to 3.6 GW of its 9 GW fleet. This can be expected to increase low-carbon generation during the 2020s. However, of the existing 9 GW nuclear capacity on the system, 8 GW is set to come offline over the next 15 years. A continued contribution of nuclear power to low-carbon electricity generation therefore relies on a programme of nuclear new build.

The nuclear new build programme remains subject to serious delays, particularly over Hinkley Point C, though there has been some progress on other new build projects:

- A final investment decision on Hinkley Point C, the first new build nuclear plant, was originally expected in 2012. EdF have indicated that this is now expected in 2016, though there remains considerable uncertainty around the timing of the decision, and the prospects for successful delivery of the project following the decision.
- Other new build nuclear projects being developed by Nugen and Horizon continue to make progress with planning, and gaining approval for their reactor designs (which are different from EdF's design). However, Nugen's proposed commissioning date has shifted from 2023 to 2025. These projects are now aiming to make final investment decisions in 2018 and 2019 respectively, with the aim of coming online in the mid-2020s.

The Government has also announced the development of a roadmap for small modular reactors (SMRs) in the UK, which will aim to summarise the evidence to date on SMRs, and assess the policy framework and potential SMR pathways for the UK. In addition, the Government will provide £250m of innovation funding to identify the best value SMR design for the UK.

SMRs could provide a useful alternative delivery model for new nuclear and may bring some further benefits (Box 2.4). However, they are an immature technology that has not been deployed commercially to date anywhere in the world. They are unlikely to make a material contribution to UK electricity supplies before 2025 and should not be considered as a firm contingency option until costs, benefits and deliverability in the UK has been appraised.

Box 2.4. Small modular reactors for nuclear power

Small modular reactors (SMRs) refer to nuclear power reactors between 10-300 MW in size (compared to around 1 GW for large-scale reactors) and have the potential to provide both low-carbon heat and power in the UK. There are currently around 45 SMRs under development around the world, however no designs have yet been deployed commercially, making the deliverability of SMRs in the UK unlikely in the near term. The key characteristics of SMRs are described below:

- **Cost/deliverability**
  - "Economies of multiples" resulting from factory production may have the potential to reduce costs (though large-scale reactors have inherent economies of scale).
  - Shorter build time may reduce cost of capital and interest paid on debt during construction.
  - It is uncertain whether SMRs could compete on costs with new build large-scale nuclear power when providing baseload generation.
- **Heat:** potential for district heating as SMRs can be sited closer to demand and further from water (more efficient water use, and smaller amounts) and smaller scale allows more manageable, heat loads.
- **Potential for increased flexibility in output:** operators would have control over the output of multiple reactors output, rather than just one, and the ability to spill steam is being built into some designs.
- **Timeline:** Reactors are currently at the prototype stage. Deployment is not expected before 2025.
- **Location:** Could be located on non-nuclear brownfield sites closer to centres of demand (contingent on public acceptability, which could be a constraint on deployment) and further from water sources, due to lower cooling requirements. However, it is likely that SMRs will be initially

Box 2.4. Small modular reactors for nuclear power

sited at existing nuclear sites.

- **International Deployment:** SMRs for commercial power generation have not been deployed to date. Uncertainty remains around their commercial viability.
- **Regulation costs:** Likely to have similar regulation costs, as they will have to go through the UK's Generic Design Assessment process, which typically takes around 4-5 years. They are also likely to have similar insurance costs to large-scale reactors.
- **Safety:** Some designs incorporate passive safety features, meaning that plants can be shut down automatically without releasing radioactive material (some new large-scale designs also include this).
- **Decommissioning:** Standardisation of reactor designs may make SMRs easier to decommission than large-scale reactors, but then would still require the same long-term waste disposal facilities as large-scale reactors.

Source: ETI (2015) *The role for nuclear within a low carbon energy system*, ECIU (2016) *Small Modular Nuclear Reactors.*

Cancellation of the Carbon Capture and Storage (CCS) Commercialisation Programme

Carbon Capture and Storage (CCS) is likely to be a crucial part of a least-cost path to decarbonisation in the UK, and globally (Box 2.5). In our first report in 2008 we set out that CCS urgently needs to be proven and commercialised in the UK, and our original indicators reflected this with the first plant coming online in 2014 and multiple plants by 2020. Following years of slow progress, in our 2015 Progress Report we reported that two CCS projects (White Rose in Yorkshire, a 304 MW oxy-fuel coal project, and Peterhead in Aberdeenshire, a 340 MW post-combustion CCGT retrofit) were aiming to conclude their Front End Engineering and Design (FEED) studies and take positive investment decisions in 2015 under the £1bn CCS Commercialisation Programme. However, in November 2015, the Government announced that the Commercialisation Programme funding would no longer be available.

Despite the importance of CCS to meeting the UK's 2050 target and subsequent commitments, there is now no strategy to develop CCS in the UK. This must be addressed urgently if the UK carbon targets are to be met at least cost (see section 3).

Box 2.5. Value of CCS in meeting the UK's emissions reduction targets

Carbon capture and storage (CCS) is of critical importance in meeting the UK's carbon targets at least cost and in fulfilling the ambition of the Paris Agreement. This is because there are limited, if any, low-carbon alternatives to CCS in a number of applications in the 2030s, 2040s and beyond:

- CCS is the only option to reduce emissions from segments of important industrial sectors, including steel, cement and chemicals;
- Combined with bioenergy it could deliver 'negative emissions' that will likely be needed to meet the longer-term objective from Paris of achieving "net zero" emissions;
- Combined with gas-fired power generation it could allow for flexible 'mid-merit' power generation to help security of supply, with recoverable heat available for heat networks; and
- CCS currently appears to be the lowest cost route to low-carbon hydrogen, which could help to reduce emissions in difficult areas such as heating and HGVs.

Without the reduction in emissions delivered by CCS, meeting the 2050 target would require full decarbonisation of every building and every vehicle in the stock by 2050, or closing down of heavy industry. The Energy Technologies Institute have estimated that delaying CCS commercialisation for ten years would increase the cost of reducing GHG emissions by £1-2bn per year throughout the 2020s, increasing to £4–5bn per year in 2040.[1]

CCS would also provide a clear future for important domestic industries such as steel, chemicals and cement that is consistent with the UK's long-term climate goals.

Source: 1: ETI (2016) *ETI analysis of the UK energy system design implications of delay to deployment of carbon capture and storage (CCS) in the UK*. Available at: http://www.parliament.uk/documents/commons-committees/energy-and-climate-change/ETI-letter-to-Chair-on-Future-of-CCS.pdf

Delivering system flexibility

A significant conclusion from our 2015 report *Power Sector Scenarios for the Fifth Carbon Budget* was that a decarbonised power sector in 2030 will require a significant increase in the flexibility of the UK's electricity system.

As more inflexible and/or variable low-carbon generation (i.e. nuclear and renewables) are added, flexibility over the timing of electricity generation and demand is important to ensure power is always available when needed and that variable renewable generation can be accommodated and security of supply maintained. Flexibility is needed across different timescales (frequency response, reserve, balancing), and can be provided by both generation and demand-side assets. Policy and market design must therefore ensure that flexibility services, including demand-side options, can enter the market and compete effectively.

We therefore monitor progress in the installation of smart meters (which can support increased flexibility through demand-side response), participation of demand-side response in various markets, interconnection with Europe, and electricity storage:

- **Smart meters:** Smart meters provide more accurate information to energy users and utilities about their consumption and facilitate consumers changing the time at which they use electricity. Delays in setting up the Data and Communications Company (DCC, the organisation tasked with managing the smart meter programme's data infrastructure) mean that deployment to date has not yet achieved the rates of average annual installation required to achieve the Government's target to have a smart meter in every UK home by 2020. At the end of 2015, just over 1.2m smart electricity meters were operating in residential

homes, representing around 5% of domestic properties. The Government have stated that the DCC will go live in the second half of 2016, and that wide-scale rollout can begin shortly afterwards, with completion still expected by the end of 2020.

- **Demand-side response:** The concept of shifting electricity demand (e.g. away from peak time periods such as 4-7pm on a winter evening) is known as Demand-Side Response (DSR). DSR can help manage large volumes of variable renewable generation and can significantly reduce the overall cost of a decarbonised system (e.g. by shifting demand to off-peak periods with higher renewable output). DSR is already present in several UK markets - largely driven by take-up in the industrial and large commercial sectors - and market reforms are being put in place to enable real time billing in the residential sector:
  - 0.8 GW of demand-side response has been awarded capacity contracts for 2018/19 under the first Transitional Arrangements auction. At least 40% of this was from demand-side aggregators who manage electricity loads in the commercial and industrial sectors.
  - National Grid's Demand Side Balancing Reserve contracted 0.4 GW of response for winter 2015/16. However, around three quarters of this was provided by distribution-level fossil generation, and the remaining quarter by "demand suppression" (load shedding or shifting).[12] To ensure net emissions benefits, it is important that DSR flexibility is increasingly provided by demand shifting and not fossil-fuel based generators. We will monitor this over time.
  - Ofgem is working to introduce elective half-hourly settlement for residential and small commercial consumers by mid-2017 (larger commercial and industrial consumers are already settled on a half-hourly basis). This will allow suppliers to introduce more cost reflective 'Time-of-Use' tariffs into the residential and commercial sectors. Ofgem plans to make this settlement mandatory as of 2018.
  - National Grid's 'Demand Turn Up' project, starting summer 2016, will reward consumers for absorbing excess generation at times of low demand and high renewables output.
- **Interconnection:** Interconnection to other electricity markets can help manage variability of demand and supply and reduce system costs by taking advantage of differences between connected electricity markets. The combination of current interconnection capacity and new capacity under development could bring total UK interconnection capacity to 11.3 GW by the early 2020s:
  - The UK currently has 4 GW of interconnection capacity with France, Holland and Ireland.
  - The 1 GW NEMO interconnector to Belgium, and 1 GW ElecLink interconnector to France are currently under development and expected to commission in 2019. Additionally, in 2015 Ofgem approved applications for an additional 5.3 GW of interconnection under its regulated Cap-and-Floor regime - to France, Ireland, Norway and Denmark - to come online by 2022.
  - In the 2016 Budget the Government announced its intention for an additional 9 GW of interconnection on today's levels, 1.7 GW beyond what is currently under development.
  - The impact of these interconnectors on UK imports, exports and emissions will depend on the characteristics of the interconnected electricity markets. We will return to this question in our 2017 *Progress Report to Parliament*.

[12] National Grid (2016) *DSBR 2015-16 Unit Composition Survey*. Available at: www2.nationalgrid.com

- **Electricity storage:** There is currently around 3 GW of pumped hydro storage in the UK. Further deployment of bulk and distributed energy storage (e.g. battery technologies) could reduce the need for additional back-up capacity and infrastructure, by storing electricity when demand is low and discharging when demand is high.
  - New electricity storage is beginning to deploy in UK electricity markets, e.g. via National Grid's Enhanced Frequency Response tender, which is contracting 200 MW of capacity. Further deployment of batteries could face barriers due to costs (and uncertain cost reduction pathways), choice of technology (several technologies are being developed and trialled) and a lack of clear regulatory frameworks.
  - In 2016 the National Infrastructure Commission recommended a deadline of spring 2017 for Ofgem to propose reforms which aim to reduce barriers to development of energy storage and aggregator services. In the 2016 Budget the Chancellor announced at least £50m of funding for innovation in energy storage, demand-side response and other smart technologies over the next five years.

In 2015, Ofgem conducted a review of electricity system flexibility - focusing on demand-side response, electricity storage and distributed generation - and identified regulatory and policy actions that may be taken to enable the transition to a more flexible electricity system.[13] Following this, Ofgem is working with DECC on managing the transition to a smarter energy system (see section 3).

We will develop a comprehensive set of system flexibility indicators, against which to monitor progress, for our 2017 *Progress Report to Parliament*.

Supporting infrastructure for low-carbon electricity generation

The transition to a low-carbon electricity system places new demands on electricity infrastructure, due to higher levels of renewables (often generating far from centres of demand), and to increased demand during peak periods as low-carbon electricity is extended to new markets (e.g. via the electrification of vehicles and heat in buildings).

Our indicators for transmission investment are based on the major network upgrades identified by the Electricity Network Strategy Group (ENSG) in 2009, updated to reflect a more recent assessment commissioned by the Committee on the upgrades to both transmission and distribution infrastructure required to accommodate low-carbon generation.[14]

Of the six 'Stage 1' new transmission assets identified by the ENSG in 2009, only one has been installed to date. However we do not consider that delivery is currently a barrier to deploying low-carbon generation:

- The West coast 'bootstrap' (a large transmission link off the West coast of the UK) is on track to be completed by 2017.
- Whilst completion dates for other stage 1 assets have been pushed back towards 2020 and beyond, this primarily reflects changes in the dates when generation assets are expected to come online.

[20] Ofgem (2015) *Making the electricity system more flexible and delivering the benefits for consumers*. Available at: www.ofgem.gov.uk

[14] Element Energy & Imperial College (2014): *Infrastructure in a low-carbon energy system to 2030: Transmission and distribution*. Available at: www.theccc.org.uk

- As projects wait for updated transmission infrastructure to be built, Transmission Operators are able to connect them to existing transmission infrastructure under Ofgem's 'Connect and Manage' scheme. However, generators are paid to curtail their generation at times of network congestion, and it will be important that the transmission infrastructure is developed to minimise the costs of curtailment.

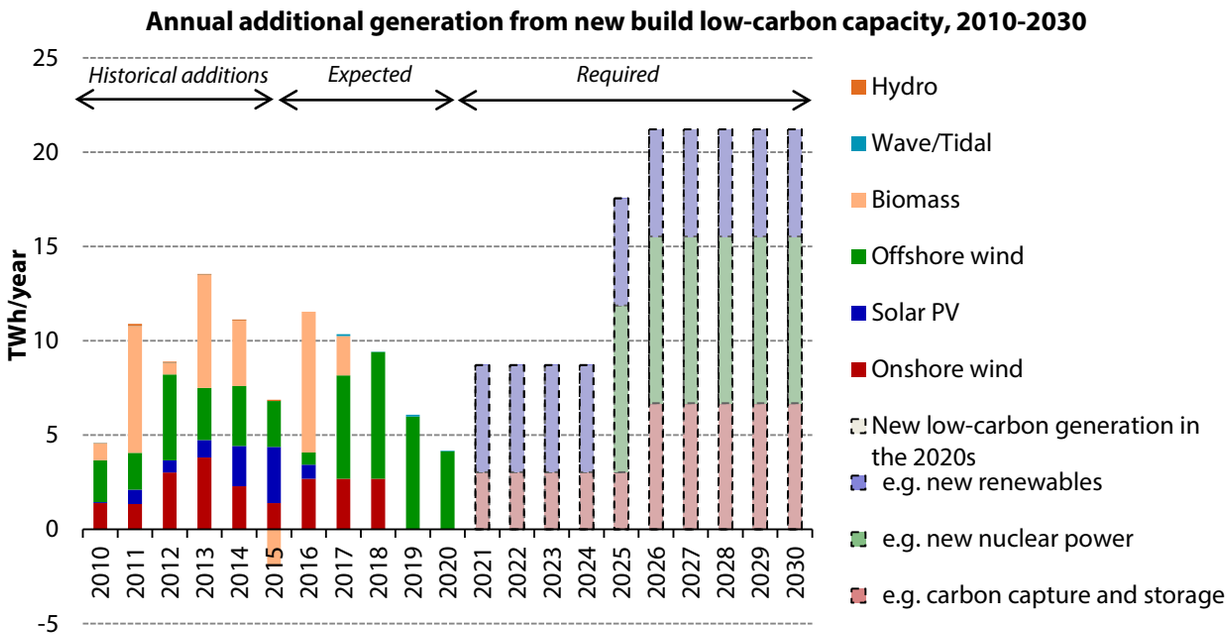
Given rapid developments in the electricity market it is important that transmission and distribution system operators are able to adapt their infrastructure to changing needs, and are incentivised appropriately for increasing flexibility in their networks. Ofgem regulates the business plans for transmission and distribution operators over a fixed period (to 2020 and 2022 respectively), which fixes the 'allowed revenue' these operators are allowed to recoup for their operations. Companies are also rewarded for network innovations, such as active network management, which can avoid unnecessary capital investment. Additional work outside of this framework needs to be approved by Ofgem on a case by case basis, though to date, as the price control periods are in their early stages, nothing has been requested.

3. Forward look and policy gap

Continuing decarbonisation of the power sector to 2030 is crucial to meeting the 2050 target at least-cost. As well as directly reducing emissions from UK electricity generation, it opens up decarbonisation opportunities for other sectors. Our 2015 report *Power sector scenarios for the fifth carbon budget* identified that the cost-effective path would be to continue low-carbon investment through the 2020s consistent with reaching an emissions intensity of below 100 gCO_2/kWh by 2030. Deployment of CCS and new nuclear, alongside expansion of renewables at recent rates could achieve this (Figure 2.6).

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 assess policies that are adequately funded and are based on proven delivery mechanisms as "low risk"; we assess policies that are unfunded (or inadequately funded) or are based on unproven delivery mechanisms as "at risk". 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).

Figure 2.6. Annual additional generation from new build low-carbon capacity, 2010-2030



Source: DECC (2016) *Energy Trends*, Low Carbon Contracts Company (2016) *CfD Register*, DECC (2016) *Renewable Energy Planning Database*, CCC (2015) *Power Sector Scenarios for the Fifth Carbon Budget*.
Notes: Generation estimates between 2010-2015 are based on average load factors of existing capacity. Estimates between 2016-2020 are based on our expectations of deployment under the Renewables Obligation and Contracts for Difference, and generation estimates beyond 2020 are net additions of new low-carbon capacity based on our Fifth Carbon Budget scenarios.

The policy gap in the power sector

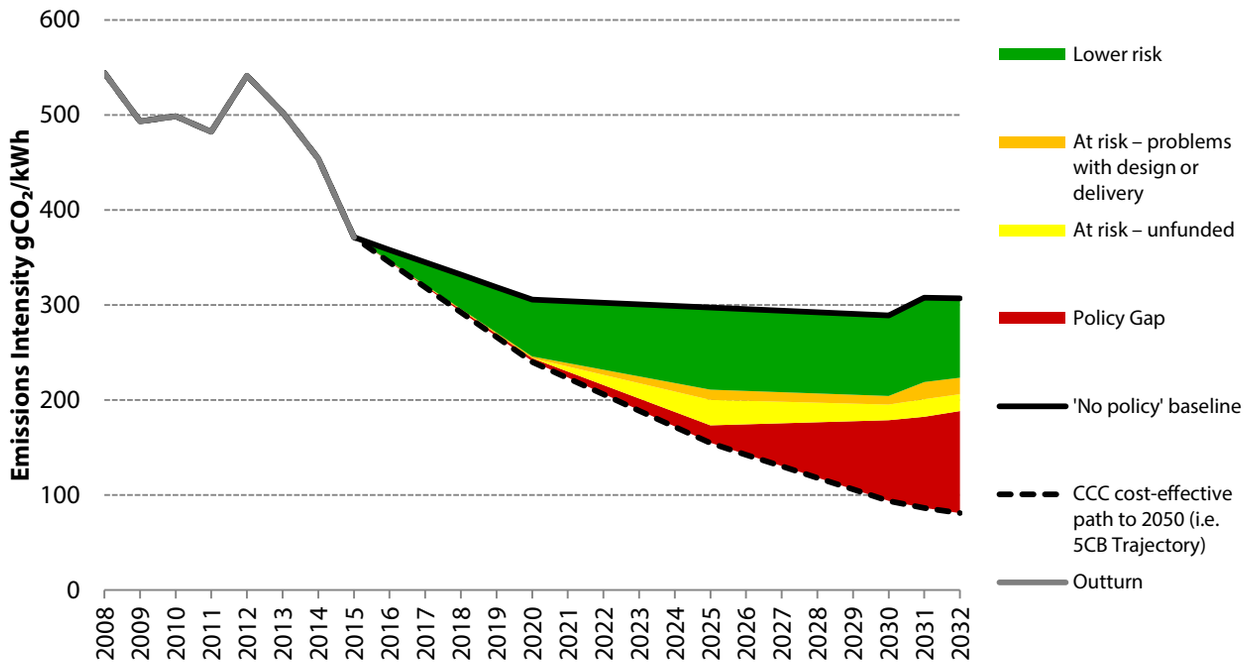
Last year we identified significant risks to sustained progress, particularly beyond 2020 and made several recommendations to address these. Policy has emerged that could bring forward offshore wind, but there has been a major step backwards on CCS and very limited progress in other areas (Table 2.3).

Given this lack of progress there remains a significant policy gap to address (Figure 2.7).

Table 2.3. Assessment of progress against previous year's recommendations

Recommendation in 2015	Assessment	Comment
Ensure the power sector can invest with a 10-year lead time: As soon as possible, set the Government's carbon objective for the power sector in the 2020s and extend funding under the Levy Control Framework to match project timelines (e.g. to 2025 with rolling annual updates).	No progress	Though the Government expressed its intention to set out the Levy Control Framework beyond 2020 in its response to our 2015 Progress Report, it is yet to do this, or provide a long-term carbon objective for the power sector.
Continue with auctions under Electricity Market Reform, maintaining momentum by adhering to the proposed timings and working with industry to learn lessons from the first auctions.	Low progress	No more auctions have been held, despite previous plans to do so. The Government has announced three more CfD auctions during this parliament, for 'Pot 2' technologies, but has not announced any further auctions for 'Pot 1' technologies.
Set out an approach to commercialise CCS through the planned clusters: including a strategic approach to transport and storage infrastructure, completing the two proposed projects and contracting for at least two further 'capture' projects this Parliament.	Backward steps	In November 2015 the Government cancelled the CCS commercialisation programme. This currently leaves no route forward for development of CCS in the UK.
Support offshore wind until subsidies can be removed in the 2020s: set out intention to contract 1-2 GW per year and wider innovation support provided costs fall with view to removing subsidies in the 2020s.	Partially met	In March 2016 the Government set out its intention to provide £730m per annum of funding for a range of technologies including offshore wind between 2021-26.
Be transparent over the full cost of technology choices: including the cost of alternatives if low-cost options are constrained, system integration costs and the full carbon cost of fossil-fired generation.	No progress	Support schemes for mature technologies (onshore wind and solar) have been closed early, without new routes to market being available. The Government has not identified the added cost this implies for the consumer.

Figure 2.7. Assessment of current and planned policies: power sector



Source: CCC analysis based on DECC (2015) *Energy and Emissions Projections.*
Notes: 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 updated our analysis since last year to reflect actual 2015 grid intensity, and the capacity mix changes in the latest DECC 'no policy' baseline. Emissions in the baseline increase beyond 2030 due to nuclear plant retiring from the electricity system.

Our assessment is that whilst near-term investments that are already underway may be considered low risk, others still have significant risk, especially in the absence of a timetable for future auctions, and there is a significant policy gap given the lack of funding and plans for the 2020s (see Technical Annex for more detail):

- Renewable deployment up to 2021 is considered lower risk, as contracts for difference have been signed for 28 TWh of generation to come online by 2021, and 11 TWh of projects under construction[15] are expected to commission under the Renewables Obligation grace periods.
- In November 2015 the Government announced that the UK would phase out coal-fired capacity by 2025, conditional on new build gas capacity being deployed to replace it. While no policy has yet been enacted to ensure no coal plant operate beyond this date, we consider phasing out of coal to be lower risk, particularly given the impacts of existing policy, such as the Carbon Price Floor, and air quality regulations.
- The newly announced Pot 2 CfD auctions for deployment post-2020 could deliver 3-6 GW of offshore wind by 2026, in line with the lower end of our indicators (5-10 GW); however, there is a risk that offshore wind could be crowded out by other eligible technologies or fail to deliver the stretching cost reductions that have been set. We have therefore assessed this deployment as "at risk".

[15] DECC (February 2016) *Renewable Energy Planning Database: Monthly Summary. Available at: www.gov.uk*

- Further delays to the final investment decision for Hinkley Point C sustain uncertainty over success of the new build nuclear programme.
- Following cancellation of the CCS Commercialisation Programme, previously assessed as "at risk", there is now no policy to develop CCS in the UK. No new CfD auctions have been announced or funding allocated for Pot 1 (onshore wind, large-scale solar PV) technologies. There is therefore a 'policy gap' for these opportunities.
- Given the importance of flexibility to reducing power sector emissions, it is important that incentives are sufficient to bring forward demand-side response, interconnection and electricity storage

Given this, our analysis suggests emissions intensity could be over 200 gCO_2/kWh in 2030 under current committed policy, whereas the aim should be to reduce emissions intensity to below 100 gCO_2/kWh.

We conclude that a significant gap remains between what current policies are on track to achieve and what should be achieved on the path to the 2050 target. Action is therefore needed in a number of areas: carbon capture and storage, subsidy-free route to market for cost-competitive renewables, CfD auction rounds for Pot 2 technologies, flexibility in the electricity market, and contingency plans for delays to nuclear deployment.

The following sections set out what is needed to close those gaps and Table 2.4 concludes by summarising how our assessment has changed since last year.

Closing the policy gap

Carbon capture and storage

Carbon capture and storage (CCS) is of critical importance in meeting the UK's carbon targets at least cost (see section 2). The cancellation of the CCS Commercialisation Programme in November 2015 leaves the UK without a strategy to develop CCS. Nevertheless, the Commercialisation Programme has provided valuable learning about the process of delivering CCS, and has resulted in the detailed characterisation of two storage sites, that may be built on in future.

A strategy should therefore be progressed immediately, beginning with a clear signal of renewed commitment to a UK CCS industry. A detailed review of ownership options and business models should be undertaken (by DECC or the National Infrastructure Commission), with the preferred approach and a new funding model for industry chosen as soon as possible. Funding should be allocated and the strategic locations chosen in the next 1-2 years, with the first capture contracts awarded during this Parliament.

Such a strategy should include:

- **Separate support for capture and for transport and storage infrastructure.** CO_2 pipes and stores are a separate shared infrastructure investment, whilst carbon capture is integrated to the power or industrial facility. Separate support ensures developers at each stage of the chain manage their own risks, without these being compounded by risks elsewhere, and reduces costs overall.
- **An initial focus on one or two strategic clusters:** clusters in areas of industrial activity around storage sites that have been identified and successfully characterised.

- **Suitable allocation of risks between the public and private sectors.** While the private sector is best placed to manage risks around construction and operation, Government is best-placed to manage policy-related risk (e.g. the volume of projects offered support and therefore the amount of CO_2 flowing to the transport and storage infrastructure). Government may also have to underwrite long-term storage liabilities.
- **Funding instruments for capture.** While contacts for difference fill this role for power plants, a new instrument, incorporating a similar competitive element, will be needed for industrial projects.
- **Sufficient scale of targeted roll-out:** a combination of industry and power plants is necessary to realise economies of scale and allow a build-up of skills, developer and financial interest. Our analysis suggests that an overall scale of 4-7 GW of power CCS and 3-5 Mt captured CO_2 from industrial plants by 2035 would be sufficient to commercialise CCS and facilitate subsequent wide-scale deployment.

Our assessment is underpinned by new analysis by Pöyry, and a report from our CCS Advisory Group.[16] These are summarised in the Technical Annex.

Subsidy-free route to market for cost-competitive renewables

Given their low and decreasing cost, onshore wind and solar are valuable low-carbon generation technologies. Constraints on their deployment will necessitate deployment of more costly technologies and increase the cost of decarbonising the power sector.

Costs for onshore wind and solar have decreased significantly with deployment. The levelised costs of electricity (LCOE) of some onshore wind and solar projects are already comparable to that of a new gas plant, accounting for the value of CO_2 emissions consistent with the UK's carbon targets (i.e. rising to £78/tCO_2 in 2030, as in the Government's target trajectory for the carbon price floor) and accounting for costs associated with the intermittency of renewable generation. Modelling conducted for our 2015 *Power Sector Scenarios* report suggested that intermittency costs associated with wind and solar generation in a decarbonised electricity system in 2030 would be about £10/MWh for each unit of intermittent generation. As with all new generating plant, price support would be required to cover the costs that cannot be recouped in the wholesale market, and should not be considered a subsidy.

To reduce emissions at lowest cost, policy should provide a route to market for onshore wind and solar, ensuring that cost-effective projects are able to compete fairly with other technologies and obtain long-term contracts at a price that implies no additional subsidy. For example, that could include:

- **Strike Prices:** capped at a level the Government considers to be 'subsidy-free', based on an assessment of the cost of alternative forms of generation (e.g. gas CCGT), including the full cost of CO_2 emissions (e.g. in line with the Government's published values, rising to £78/tCO_2 in 2030). The 'subsidy-free' strike price should take account of the intermittency costs not faced by generators.
- **Amount of generation to be contracted:** sufficient to bring total low-carbon generation in line with our indicators, and achieve a CO_2 intensity of 100 gCO_2/kWh by 2030.

[16] Pöyry (2016) *A Strategic Approach for Developing CCS in the UK*, and Gross (2016) *CCS in the UK: A New Strategy.* Available at: www.theccc.org.uk

- **Timing of auctions:** published with sufficient lead times to allow developers to plan a pipeline of projects, and maintain engagement of the financial sector to secure lower costs of capital.

To the extent that deployment of cost-effective projects that are locally acceptable is constrained, other options, which currently appear more expensive, will require increased support. The public should be clearly informed about the implications of this choice for the costs of decarbonising the power sector, and for their electricity bills.

CfD auction rounds for Pot 2 technologies

In our 2015 Progress Report to Parliament we noted that costs for offshore wind appear to be falling in line with industry goals and could continue to fall through the 2020s under a supportive policy environment. This would enable offshore wind to provide an additional option for low-carbon generation at costs that are comparable to those of nuclear and onshore wind. That would be a major step towards meeting the 2050 target in the Climate Change Act given the importance of providing low-cost, low-carbon electricity and the large potential offshore wind resource (i.e. over 400 TWh per year, more than total UK electricity demand in 2015). We suggested that a UK market of 1-2 GW per annum in the 2020s could support private sector innovation to bring costs down to competitive levels.

In the Budget 2016 the Government announced funding of £730m per annum by 2026 for Pot 2 technologies, including offshore wind. We estimate that this could potentially support between 3-6 GW of offshore wind deployment between 2021-26. This is towards the lower end of our assessment of what would be required to fully commercialise the technology. In order to deliver this level of capacity, it is important that other Pot 2 technologies do not crowd out deployment of offshore wind. The Government should consider applying maxima to other Pot 2 technologies in order to ensure sufficient scale in the offshore wind market beyond 2020 to support the technology to full commercialisation.

Flexibility in the electricity market

A significant conclusion from our 2015 *Power Sector Scenarios for the Fifth Carbon Budget* work was that a decarbonised power sector in 2030 will require a significant increase in the flexibility of the UK's electricity system.

DECC and Ofgem are currently conducting a review of system flexibility to identify and remove barriers to entry in the market for flexibility services such as electricity storage and demand side response. Additionally, as noted in section 2, plans are underway to connect smart meters in residential and small commercial properties by the end of 2020, alongside plans to significantly expand interconnection.

It will be important to build on this review and develop market rules to ensure flexibility options are incentivised and deployed as required. We will develop and set out indicators for electricity market flexibility in our 2017 Progress Report to Parliament, against which we will assess future progress.

Contingency plans for delays to planned projects

There are risks across the set of technologies that could provide increased low-carbon generation in the 2020s. In particular, given the long delays to the Hinkley Point C project, it is not clear that the UK's nuclear new build programme will progress smoothly through the 2020s.

It is important that Government consider alternative strategies to replacing the existing nuclear fleet, without increasing carbon emissions.

The Government should therefore develop a contingency plan for decarbonising the power sector if, planned projects, including new nuclear capacity, are not deployed. Any contingency plan should consider:

- Tidal lagoons or barrages could be a possible alternative, given their predictable output and long lifetimes, subject to cost and resolution of any environmental issues.
- If offshore wind reduces costs in line with the strike prices proposed by the Government to 2025, then it will have comparable costs to the Hinkley offer, allowing for intermittency costs. Whilst our previous analysis identified a risk that intermittency costs could increase for high penetration of wind (e.g. over 50 GW in 2030), this still leaves scope for a significant expansion of offshore wind in the 2020s beyond current Government plans, should new nuclear fail to deliver.
- Other renewables, to the extent these are locally acceptable, sustainable and can be accommodated on the system.
- Potential from CCS and small modular nuclear reactors in the longer-term (i.e. beyond the 2020s)

The challenge for the Government's emissions reduction plan is to demonstrate multiple plausible routes to keep the power sector on track to 2030 (i.e. to reduce carbon intensity below 100 gCO_2/kWh) and bring forward market instruments in which industry can be confident, so as to reveal the lowest cost route to power sector decarbonisation.

Table 2.4. Assessment of policies to drive abatement options in the power sector

Abatement option	2015 policy	Change in 2015/16	2016 policy
Renewables Obligation, FiTs, FIDER and the first CfD allocation round	Green: Delivery of over 100 TWh of generation per year by 2020	Although schemes are being closed early, projects have come through as planned	Green: Delivery of over 100 TWh of generation per year by 2020
CCS demonstration	Amber: Commercialisation programme to deliver up to two projects	Cancellation of commercialisation programme	Red
Fuel switching away from coal	Amber: IED, LCPD, EU ETS and carbon price floor	Announcement on coal closures	Green
Nuclear – first 2 reactors at Hinkley	Amber: Negotiations to reach FID	Ongoing delays	Amber
Support for offshore wind until cost-competitive in the mid-2020s	Red: No policy	Pot 2 auctions announced	Amber
A subsidy-free route to market for the cheapest low-carbon generation (e.g. onshore wind, large-scale solar PV)	Red: No policy	No planned auctions for Pot 1	Red
Flexibility	No formal plans	Joint (DECC and Ofgem) review of flexibility in the electricity market planned	Amber

Source: CCC analysis.
Notes: Key - Red: Policy gap, Amber: Policy at risk, Green: Effective policy in place.

Chapter 3: Buildings

Key messages and recommendations

Buildings emissions accounted for 18% of UK greenhouse gas emissions in 2015, mainly from use of fossil fuels for heating. Electricity consumption in buildings contributed a further 15% of UK emissions.

Progress on buildings emissions continued to stagnate in 2015 - the rate of uptake of insulation measures fell, there were continuing low levels of low-carbon heat uptake and rising emissions from public and commercial buildings. More effort is required on both heat decarbonisation and energy efficiency, which give significant scope for reducing emissions.

The vote to leave the EU may have an impact on how emission reduction is delivered in the buildings sector. A number of EU policies currently contribute to cost-effective emission reduction. To meet the UK's domestic emission reduction commitment, it will be necessary to agree new arrangements or adapt existing arrangements, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU agreements in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

The key messages of the chapter are:

- **Direct emissions from buildings have been broadly flat since 2012**. Building emissions increased 5% in 2015, but once adjusted for differences in winter temperatures were similar to those in 2014.
    - Emissions from non-residential buildings have shown little or no change in recent years and increased in 2015.
    - Progress in improving the energy performance of residential buildings has stalled since 2012, following good progress during the first carbon budget period, with the rate of uptake of insulation measures falling even further in 2015 despite plenty of potential remaining.
- **Uptake of low-carbon heat remains very low**, at around 2.5 % of heating supply. Planned policies to 2020 are insufficient to meet required contributions for future carbon budgets:
    - In 2015/16, the Government committed Renewable Heat Incentive (RHI) funding to 2021, but at a reduced level, together with £320m of capital funding for heat networks.
    - Current policy design and levels of funding will not deliver sufficient contributions to meeting future carbon budgets. This reflects both a wide range of barriers (e.g. upfront costs that deter investment, low awareness of low-carbon options, small supply chain) and inadequate policies to address them (e.g. 'light-touch' marketing strategy for RHI).
- **There have been significant setbacks in policy to deliver energy efficiency** measures during 2015. The failure of the Green Deal leaves a major gap for able-to-pay homes; private-rented sector regulations have been weakened; funding and targets for the successor to ECO reduced; and the zero-carbon homes regulations for new-build properties abandoned.
- **Government has made some progress on simplifying the non-residential policy landscape**, with the CRC scheme being replaced by increased CCL taxes from 2018/9. Government is developing a new reporting scheme that goes beyond current energy audits, which is critical to ensure incentives are not diminished and address the major information gap for commercial and public buildings.

Small incremental improvements, where they have been made, do not constitute a coherent plan for meeting carbon budgets. A more comprehensive approach is needed, addressing the behavioural barriers for different segments (i.e. new-build, private and social landlords, owner-occupiers, households and businesses) in a way that is attractive enough to deliver sustained uptake of energy efficiency, heat pumps and district heating at levels far above today's.

Key messages and recommendations

Table 3.1 sets out the areas that must be addressed for buildings to make the necessary contribution to economy-wide decarbonisation. In some areas, elements of the required policy are in place or planned, but require stronger implementation if they are to succeed. In other areas new policies are required.

We will assess the Government's emission reduction plan against this set of requirements. We will report more fully on future low-carbon heat and energy efficiency options in the Autumn.

On an earlier timescale, we further recommend that in designing the new Energy Company Obligation, priority is given to data availability to enable suppliers to effectively target the fuel poor; and that plans (for the next five-year phase) are set out to provide greater certainty to the supply chain.

Table 3.1. Buildings recommendations for the Government's emission reduction plan

Buildings emissions to fall by around 22% between 2015 and 2030, and create options to allow near-zero emissions by 2050. This will require:	**New policy**	**Stronger implementation**
Clear, consistent and credible policies to drive deployment of heat pumps and district heating, including: • Immediate action to address the upfront cost and information barriers that exist with the Renewable Heat Incentive. • A policy package for sustained low-carbon heat roll-out at higher rates, tackling key segments, addressing barriers and linking support with energy efficiency policy, fuel poverty policy and infrastructure decisions. This must make low-carbon heating visible, cost-competitive and attractive in a timely manner for households. • New policies to support SMEs in England to install cost-effective low-carbon heating.	✗	
Standards to ensure new-build properties are highly energy efficient and use low-carbon heating systems by default. On energy efficiency these should result in new buildings having low energy consumption without leading to overheating.	✗	
A stronger policy framework to drive residential energy efficiency improvement by addressing gaps and strengthening existing policies, including: • A comprehensive set of incentives to drive energy efficiency improvements in able-to-pay households. The policy package should address behavioural factors as well as financial barriers and provide a clear long-term signal to the supply chain. • Strong policy, backed by increased funding, to improve energy efficiency in fuel-poor households, contributing to meeting carbon budgets and fuel poverty targets. • Ensure the private-rented sector regulations are amended or have a new mechanism, in the absence of the Green Deal, to deliver required improvements in efficiency.	✗	✗

Key messages and recommendations		
More progress on improving the energy efficiency of non-residential buildings: • A consolidated reporting mechanism for commercial and public buildings. This must strengthen incentives without increasing administrative burden. • New emissions reduction targets in place for Central Government and additional support for the public estate, for example, through targets and information. • New policies to support SMEs in England to install cost-effective energy efficiency measures.	✘	✘
Notes: The emissions reduction to 2030 is based on temperature-adjusted emissions in 2015.		

We set out the analysis in the following sections:

1. Buildings emissions trends and drivers
2. Approach to tracking progress
3. Low-carbon heat
4. Energy efficiency of residential buildings
5. Energy efficiency of non-residential buildings
6. Forward look and policy gap

1. Buildings emissions trends and drivers

Direct emissions from buildings accounted for 18% of all UK GHG emissions in 2015 (Figure 3.1):

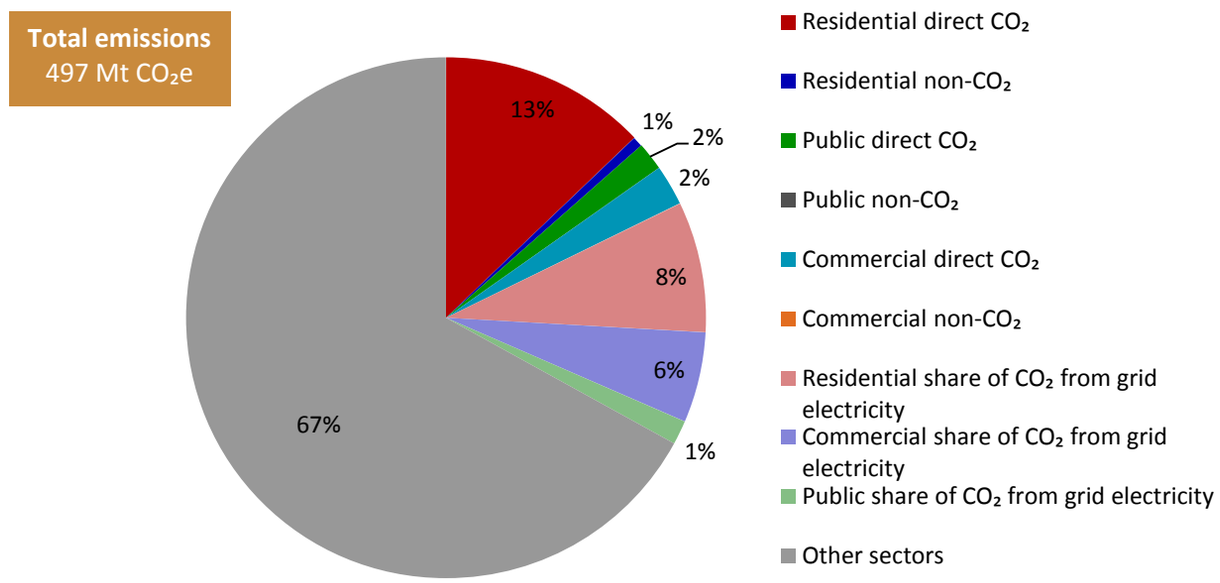
- Direct CO_2 building emissions are split between homes (75%), commercial buildings (15%) and the public sector (10%).
- Buildings are also the largest user of electricity. In 2015, electricity consumption in buildings increased 1% to 204 TWh, accounting for indirect emissions of 76 $MtCO_2e$.[1]
- There are also small quantities of non-CO_2 emissions from buildings. Estimates for 2015 are not yet available, so they are assumed to remain at 2014 levels.

Direct CO_2 emissions from buildings increased 5% in 2015 to 85 $MtCO_2e$. Adjusting for differences in temperature between 2014 and 2015, there was no overall change in emissions in 2015 (Table 3.2).

Progress across building types has stalled, compared to the average 1% annual reduction between 2009 and 2014 (Table 3.2). Progress is particularly poor for non-residential building emissions.

[1] Temperature variation mainly affects demand for heating, so we focus here on non-temperature adjusted electricity consumption.

Figure 3.1. GHG emissions from buildings in the context of total UK emissions (2015)



Source: NAEI (2016), DECC (2016) *Energy Trends, March 2016*, DECC (2015) *DUKES*; CCC calculations.
Notes: 2015 emissions are provisional. Non-CO_2 emissions are based on 2014 data as provisional estimates are not published.

Table 3.2. Summary of buildings emission trends

	2015 direct CO_2 emissions ($MtCO_2$)		**Trends (temperature-adjusted)**		**Change since 2007**
	Actual	Temperature-adjusted	% change 2014-15	annual average % change 2009-2014	% change 2007-2015
Residential	64	69	-1%	-2%	-16%
Non-residential	21	22	+3%	-1%	+6%
of which commercial	*13*	*13*	*+3%*	*-1%*	
of which public	*9*	*9*	*+4%*	*-2%*	
All buildings	85	91	0%	-1%	-12%

Source: GHG Inventory; CCC calculations.
Notes: Numbers may not sum due to rounding.

2. Approach to tracking progress

We track progress in buildings against a number of indicators. These are designed to show whether emissions are on track for meeting carbon budgets, and monitor roll-out of key measures for meeting carbon budgets:

- Along with the headline indicators on direct CO_2 emissions and electricity consumption, our indicators cover low-carbon heat deployment, the installation of energy efficiency measures (insulation, boilers, LED lighting and domestic appliances), and policies to deliver abatement.
- This means that they include measures which are cost-effective now (such as loft and cavity-wall insulation; heat pumps in off-gas homes and electrically-heated offices) along with other measures which are required to prepare for 2050 (such as solid wall insulation, other low-carbon heat).
- There are some measures (e.g. installation of insulation and heating controls in non-residential buildings, behavioural choices of households) for which data are not available, so while these can make important contributions to reducing emissions they are not included in our indicators.

Our central carbon budget scenario to 2030 is set out in Box 3.1, together with the rationale underpinning the scenario and the implications for prioritisation of buildings abatement measures.

We are updating our emissions indicators this year to include the low-carbon heat abatement factored in to the fourth and proposed fifth carbon budgets, and to extend them to 2032.[2]

The updated trajectories aim to set out a realistic pathway for buildings consistent with meeting future carbon budgets. Our starting point is temperature-adjusted emissions in 2014 (Figure 3.2). The respective trajectories for residential and non-residential buildings are set out in the Technical Annex.

[2] Our previous emissions trajectories for buildings were created in 2009, following the advice on the first three carbon budgets. They included savings from energy efficiency measures factored in to 2022. In our 2014 Progress Report, we updated the trajectories for buildings including energy efficiency measures and extended them to the end of the Fourth Carbon Budget in 2027.

Box 3.1. Abatement in our central fifth carbon budget scenario (2030)

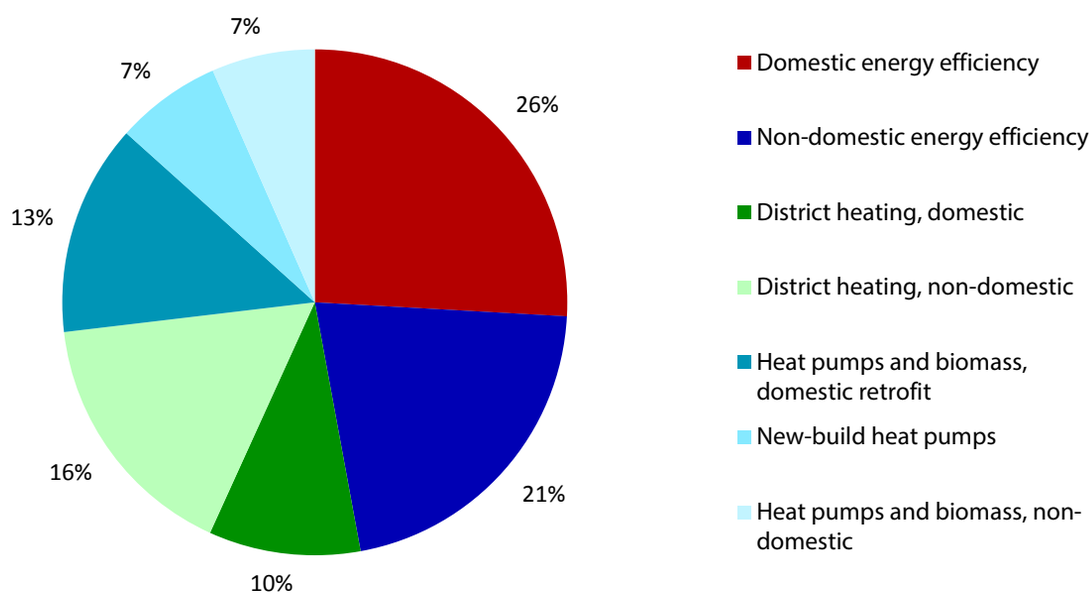
Our central scenario for our fifth carbon budget advice reflects the most recent evidence on cost-effectiveness.

Our primary focus is on abatement of emissions from fossil fuels ('direct' emissions) (Figure B3.1). Our priorities for policy reflect the balance of abatement between **residential and non-residential energy efficiency**, **heat pumps** and **heat networks** - each delivering around a quarter of abatement in 2030:

- Emission savings from **residential energy efficiency** are mainly fabric efficiency, with cavity wall insulation contributing the most savings. We assume the majority of remaining loft insulation is delivered in the 2020s and solid wall insulation is installed where cost-effective and in some cases to tackle fuel poverty. Other measures include turning down thermostats by one degree centigrade, other insulation and heating controls.
- For **non-residential** energy efficiency, we assume most of the savings are through energy management (e.g. heating controls) and mechanical ventilation heat recovery, with improvements in fabric efficiency also contributing.

The focus on direct emissions reflects the pressing need to make progress in reducing these emissions in order to meet future carbon budgets and the 2050 target (as progress on power sector emissions alone will not be sufficient). Nonetheless, electrical efficiency can save costs to consumers as well as power sector decarbonisation costs, and reduce emissions in the short-term. For this reason, we also track progress on electrical efficiency.

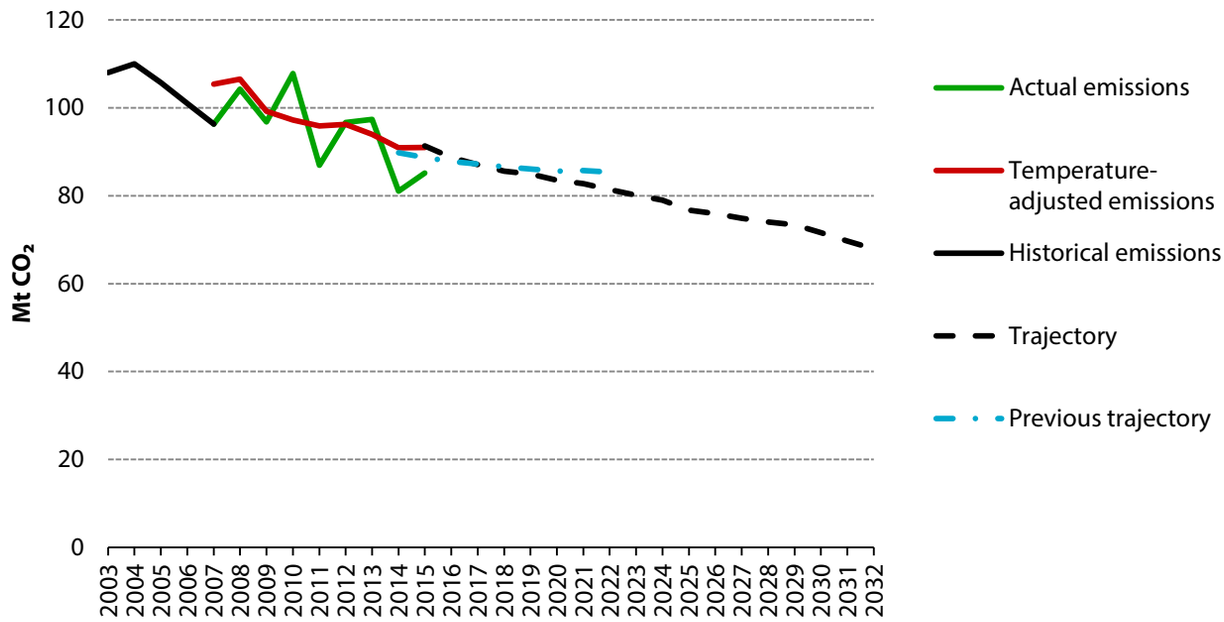
Figure B3.1. Direct abatement in 2030 in buildings, central scenario



Source: CCC analysis.

Source: CCC (2015) *Sectoral Scenarios for the Fifth Carbon Budget.*

Figure 3.2. All buildings direct emissions - updated indicator trajectory to 2032



Source: NAEI (2016), DECC (2016) *Energy Trends, March 2016*, DECC (2015) *DUKES*; CCC calculations.
Notes: 2015 emissions are provisional. Temperature-adjustment is based on CCC calculations.

We also update our indicators for low-carbon heat, residential heat pumps and insulation uptake, where new evidence means these have moved on in our fifth carbon budget analysis:

- Our fifth carbon budget central scenario includes a roll-out of low-carbon heat (primarily heat pumps and low-carbon heat networks, together with some biomass in large rural properties).[3] Uptake is equivalent to around 8% of space and water heating by 2020.
- The central scenario also includes uptake of 300,000 heat pumps in homes (around 1% of households) in order to be on course for a roll-out of around 2.5 million heat pumps in homes by 2030. We track the residential heat pump stock on the basis that heat pumps are an important low-carbon heat technology for meeting the 2050 target.
- The central scenario includes the insulation of 2 million solid wall homes to 2030, and insulation of the majority of remaining cavity walls and lofts in homes.
- We will consider updating the indicators for boilers and appliances for our 2017 Progress report.

All indicators are set out in the Technical Annex.

[3] Biomethane is included at an economy-wide level.

3. Low-carbon heat

Implementation of measures

In 2014, around 2.5% of heating came from low-carbon sources.[4] In our scenarios, this increases to around 8% of heating by 2020, which suggests a major ramp-up is needed to meet carbon budgets.

Whilst there is significant overlap between low-carbon heat and renewable heat, our approach is to track low-carbon heat uptake, as our focus is on meeting carbon budgets (rather than the 2020 EU renewables target). Effectively, this means we include abatement from using recoverable 'waste' heat and do not count wood burnt on open fires (as this is both supplementary rather than primary heating and low efficiency- and does not constitute progress towards heat decarbonisation).[5] It also means that we do not explicitly track progress towards the renewables target, although in practice progress is at a similar pace due to the overlap. The Government's main policy in this area, the Renewable Heat Incentive, is focused on renewable heat deployment rather than low-carbon heat (see below).

Residential heat pump sales tailed off in 2015, along with other domestic RHI measures (Figure 3.3). If delivery were to continue at this pace, then uptake in 2020 would reach around 200,000, below the uptake of 300,000 (around 1% of households) we have included under our fifth carbon budget central scenario (Section 2).

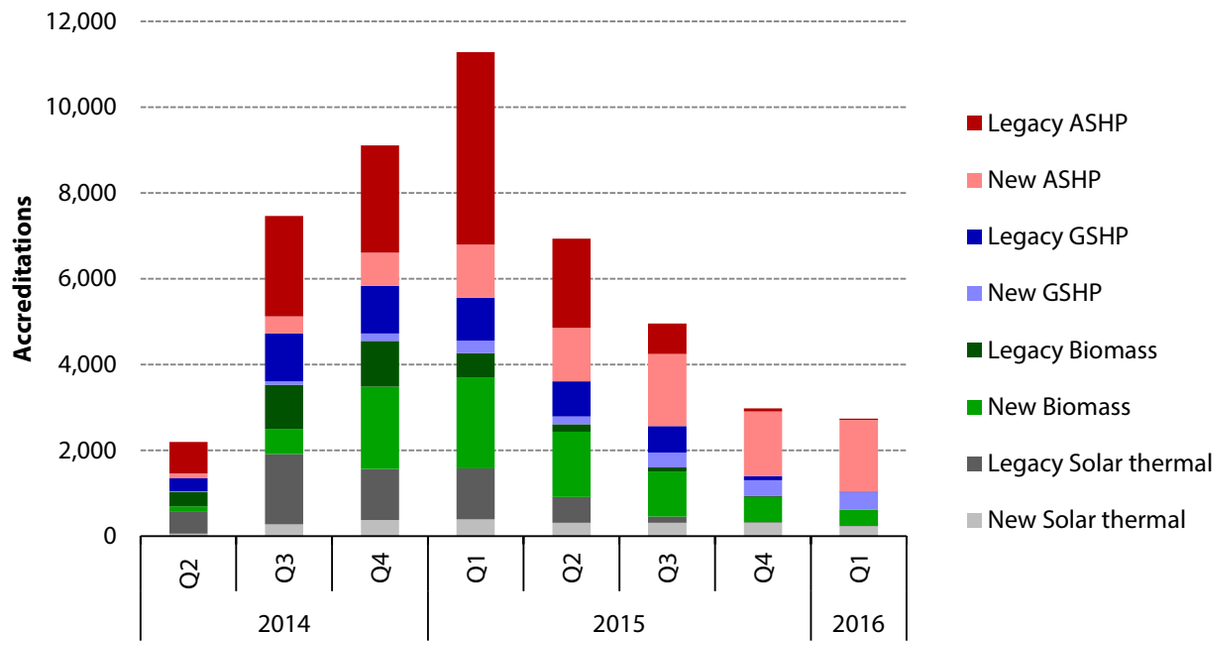
Uptake of low-carbon heat in existing public and commercial buildings in 2015 continued to be focused almost exclusively on biomass boilers, with an increase of around 400 MW of capacity. The number of biomethane production facilities in the UK doubled to 32 in total as of April 2016.

No good standardised data sources are available on heat networks deployment. There would be benefits from greater collection and reporting of deployment statistics.

[4] Or 2% if not including agricultural buildings, which have seen significant uptake of biomass boilers under Government subsidies. It is not clear whether these are new heat demand rather than any genuine emission reduction.

[5] We also include heat pumps on a heat output basis (not discounting a portion to reflect average EU grid emissions). According to DECC's assessment under the Renewable Energy directive, the proportion of heating and cooling from renewable sources in 2014 was 4.8%. The higher estimate reflects a significant increase in estimates of domestic wood combustion on open fires based on new survey data, together with other accounting differences (it includes industrial buildings, and is calculated on a net calorific basis in line with the Renewables directive guidance).

Figure 3.3. Accredited renewable heat installations under the domestic RHI



Source: Ofgem (2016) *Renewable Heat Incentive statistics.*
Notes: ASHP stands for air source heat pump; GSHP is ground source heat pump. Legacy installations refer to those installed between 2009 and 2014, which were eligible to apply for the subsidies once the scheme launched in 2014 during a window of the first year of scheme operation.

Policy

In this section, we focus on the uptake of heat pumps and low-carbon heat networks, which are the two key abatement measures in our fifth carbon scenarios, contributing around half of abatement in buildings in 2030 (Box 3.1). We also consider hydrogen for heat as an alternative route for decarbonising heat.

We will report more fully on future low-carbon heat policy options in the Autumn, ahead of the Government's emission reduction plan.

Building-scale low-carbon heat for existing buildings

Building-scale low-carbon heat is the cornerstone of long-term buildings abatement and fundamental for meeting the 2050 target. Our scenarios to 2030 focus on cost-effective uptake in off-gas buildings.

Low levels of low-carbon heat uptake are a result of a number of financial and non-financial barriers, which need to be addressed urgently:

- **Financial barriers**. These include the need to place a financial value on carbon savings, as well as the high upfront cost for technologies such as heat pumps. Consumers may also face additional costs from upgrading the energy efficiency of their home and changing radiators, particularly in the case of heat pumps which require efficient homes and large radiators (or underfloor heating) in order to work efficiently.
- **Non-financial barriers**. These are primarily to do with low awareness of the technologies and subsidies available, along with a risk premium attached to less familiar technologies.

Other barriers include a lack of the required skills in the supply-chain; and the need to coordinate with other energy efficiency and heating system improvements. Disamenity costs include loss of space and hassle factors.

- Other barriers stem from policy distortions (such as the fact that electricity is more heavily taxed than gas).

The Government Renewable Heat Incentive (RHI) is the main policy aimed at overcoming these barriers:

- It pays consumers and businesses to install renewable heat technologies through a set of technology tariffs. These are calculated based on the additional costs compared to conventional heating technologies.
- The tariffs are paid in the form of an ongoing subsidy per unit of heat generated. They include an uplift, which is aimed at overcoming the consumer risk premium, of around 16% for consumers and 12% for businesses and other organisations.

RHI deployment to date has been consistently under budget (Table 3.3) and concentrated on bioenergy (particularly in the case of the non-domestic scheme), while our indicators require heat pump uptake.

Table 3.3. RHI budget and spend

	2011	2012/13	2013/14	2014/15	2015/16
RHI budget (£ million)	56	133	251	424	430
RHI actual, est. (£ million)		27	52	159	377
Proportion of budget spent (%)		20%	21%	38%	88%
Proportion of total spend which is on bioenergy (%)		100%	100%	95%	90%

Source: Actual budget estimates based on estimates from DECC.
Notes: Nominal prices. Proportion of spend on bioenergy estimated based on DECC statistics and rounded to the nearest 5%. The proportion under the non-domestic RHI remains close to 100%.

The low uptake of technologies other than bioenergy is partly a result of mixed success in tackling barriers to uptake, together with the initial levels of the tariffs:[6]

- Whilst the tariff payments address the need for finance, they do not tackle upfront cost barriers.
  - The Government published a series of RHI evaluations in early 2016,[7] which show that most consumers taking up the domestic RHI are higher income and living in homes off the gas grid. The main means of financing is through savings (77%).

[6] The mixed performance of installations under the Renewable Heat Premium Payment grant scheme may also be contributing to low uptake, although the fact that only a few thousand installations were supported means this has probably had a limited impact.

  - Upfront costs are particularly likely to be a problem for segments of the market which are capital-constrained.

  The Scottish Government has set up a loans scheme for consumers and businesses to try and tackle this issue.

- Awareness of the scheme remains low, with little communication or promotion from national government and few examples of local initiatives.
- The current approach of paying to overcome the risk premium is expensive and may not be effective. The tariffs could be reduced through the provision of low-cost finance, and through a package of measures aimed at improving consumer confidence.

We previously recommended that Government should extend the funding of the RHI to 2020, and take additional steps to address barriers to uptake.

The Government announced an extension of the RHI to 2020/21 in the Autumn Statement, but with funding levels reduced by £700m relative to previously planned levels - equivalent to cumulative funding of £4,910 million to 2021 (Table 3.4). This is below the level required to fund roll-out consistent with our scenario to 2020, unless funds are retargeted towards heat pumps. An alternative approach would be to make subsidies go further with additional policy. Incentivising recovery of 'waste' heat (which can be low-carbon, if not renewable under EU definitions) also improves the overall cost-effectiveness.

Table 3.4. Committed RHI funding levels to 2021/22

	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Budget (£m)	430	640	780	900	1,010	1,150

Source: DECC (2016) *Consultation Stage IA: The Renewable Heat Incentive: A reformed and refocused scheme*.
Notes: 2015 prices.

Little progress has been made on addressing barriers. Government published a consultation on RHI reform earlier in 2016, focused on delivering greater value for money. The consultation also responded to issues of budget underspend and low take-up of technologies other than bioenergy, with a proposed increase in the tariff for domestic air source heat pumps (ASHPs), and assignment of rights to third parties. A number of other changes to the scheme are being consulted on, including an end of support for solar thermal (Box 3.2).

However, there is currently little provision for approaches to tackle non-financial barriers such as low awareness. The impact of third party assignment of rights is likely to be limited by the segments of the market with returns high enough to create the business case for third parties, which tend to be in larger properties rather than smaller lower income households. Finally, RHI funds cannot be used for other purposes than tariff payments. Consequently, there is a real risk that budget underspend on non-bioenergy will continue, particularly on the non-domestic scheme.

[7] DECC (2016). *Renewable Heat Incentive evaluation*. Available at: https://www.gov.uk/government/collections/renewable-heat-incentive-evaluation

Box 3.2. Proposed revisions to the Renewable Heat Incentive schemes

The recent 2016 consultation on RHI reform considers a number of proposals for creating better value for money and addressing shortfall in heat pump uptake:

- A number of new tariffs are being consulted on, including an increase for domestic ASHPs from 7.42p/kWh to up to 10.00p/kWh.
- It includes an assignment of rights to RHI payments to third parties to address the upfront cost barrier for low-income households, and consideration of whether to allow shared ground loop heat pump systems (multiple GSHPs running off the same ground loop) to apply to the domestic RHI, rather than remaining part of the non-domestic RHI.
- The consultation includes a proposed extension of the non-domestic scheme to reversible heat pumps, which could help boost sales in non-domestic buildings with heating and cooling loads. Given that these systems are low-cost compared to electric heating, there is a question of whether extending subsidies to these technologies is the best way to unlock this potential.

A number of other proposals are focused on budget management and improved scheme cost-effectiveness.

One such proposal is to remove support for solar thermal under both domestic and non-domestic schemes. Whilst small-scale solar thermal is relatively expensive to retrofit, larger schemes – particularly when integrated into heat networks – can be a cost-effective way to produce heat. Solar thermal can also work efficiently together with heat pump systems and is well suited to new-build, although these systems are not eligible for RHI subsidies. Current Government policy should aim to support cost-effective deployment of solar thermal in integrated schemes, along with continued innovation in this area.

Government is also consulting on new funding limits across all technologies to limit payments to large households. DECC's Impact Assessment shows the returns for GSHPs falling steeply above the cap, rather than remaining flat as in the case of the biomass boiler cap. Given that larger homes are the most economic section of the market, the proposed cap on payments may remove the sole section of the GSHP market which is currently viable.

Source: DECC (2016) *Consultation Stage IA: The Renewable Heat Incentive: A reformed and refocused scheme*.
Notes: 2015 prices.

Low-carbon heat in new-build

Installations in new-build properties are an important segment in our scenario roll-out to 2030 (Box 3.1). Currently however, there is no incentive for developers to fit heat pumps, as conventional boilers have lower capital costs.

The proposed Zero Carbon Homes policy, which could have been used to drive low-carbon heat in new homes, was cancelled in 2015 (Section 4).

Neither the current Part L building regulations, nor any proposed future regulations, are well designed to support low-carbon heat measures, because solar PV and low-carbon heat are treated as substitutes - and solar PV, together with fabric efficiency, is more cost-effective.[8] This is a problem because low-carbon heat is more important at a building-scale than solar PV: whilst there are other options for decarbonising electricity, heat decarbonisation must occur at the building- or local-scale.

[8] Sweet Group (2014) *Cost analysis: Meeting the zero carbon standard*. This is reinforced by the fact that solar feed in tariff is available to new homes, whereas the RHI is not.

New standards are needed to ensure new-build properties are not only highly energy efficient but use low-carbon heating systems by default.

Low-carbon heat networks

Our scenarios include 250,000 homes (fewer than 1% of domestic buildings) connected to low-carbon heat networks in 2020. They reflect the relative cost-effectiveness of uptake in non-domestic buildings, with over twice the uptake compared to domestic heat - equivalent to around 600,000 homes in total.

The Government committed £320 million in capital funding for heat networks in the 2015 Spending Review, aiming to support the equivalent heat from 400,000 new homes through to 2021. This suggests that funding is below the level required for our scenarios to 2020, although this may be subject to the scheme design and implementation.

We published a study in 2015 with a set of recommendations for addressing barriers to uptake of heat networks,[9] which we will review in the Heat and Energy Efficiency report later this year.

Some further progress has been made towards addressing barriers, with the launch in 2015 of the Heat Trust, an industry-led consumer standards body, together with an industry Code of Practice co-authored with the Chartered Institute for Buildings Services Engineers (CIBSE), which could be set as minimum standards for the industry. To date, the Heat Trust has signed up schemes which serve a total of around 20,000 consumers. Oversight of prices remains under the remit of the Competition and Markets Authority.

Additional measures that would enable the capital funding to go further include a review of the business rates charged to heat networks - from which other utilities are exempt - along with enabling measures include allowing district heating companies the same access rights as other utilities.[10]

Hydrogen

An alternative approach to decarbonising heat could be through gas networks converting over to hydrogen. There is a need for strategy to develop this option, supported by detailed technical studies to assess safety and costs. Long-term, carbon capture and storage (CCS) would be required to produce hydrogen for heat at both a sufficient scale and at reasonable cost.

We are currently undertaking research into the institutional and regulatory implications of a shift to hydrogen for heat, which we will publish in the Autumn together with our Heat and Energy Efficiency report (Box 3.7).

Devolved administrations

The devolved administrations have introduced some innovative policies that could drive greater take-up of low-carbon heat. These include loans to support RHI uptake, a requirement on Energy from Waste plant to capture heat in Scotland. These are set out in Chapter 9. Extension of these schemes across the UK should be considered if they prove successful.

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[9] Element Energy, Frontier Economics and Imperial College (2015) *Research on district heating and local approaches to heat decarbonisation*.

[10] These proposals are discussed in Association for Decentralised Energy (2016). *Levelling the playing field: Unlocking heat infrastructure investment.* Available at: http://www.theade.co.uk/medialibrary/2016/05/25/09552264/Levelling%20the%20playing%20field%20Unlocking%20heat%20infrastructure%20investment.pdf

4. Energy efficiency of residential buildings

Energy efficiency improvements in residential buildings contribute 26% of emissions savings in buildings in our scenario for meeting the proposed fifth carbon budget. The majority of these savings are assumed to come through insulation measures, with the largest of these being cavity wall insulation (Box 3.1).

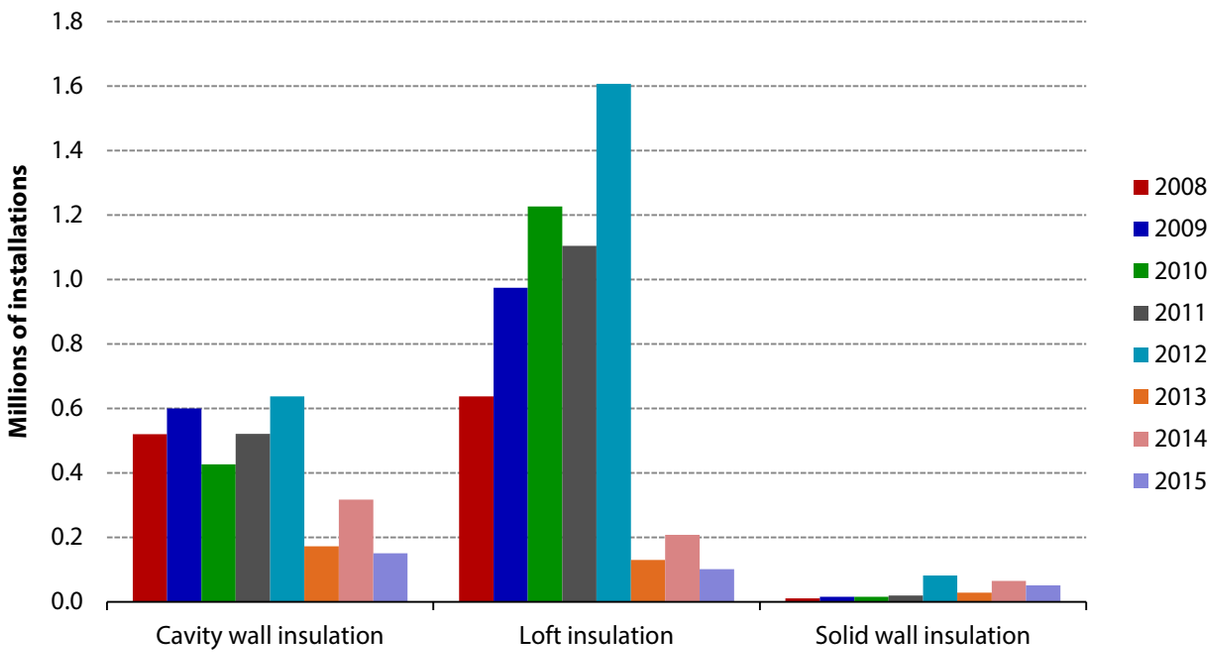
Implementation of measures

The total number of energy efficiency measures installed under government schemes in 2015 was down 49% on 2014 and 87% on 2012 (Figure 3.4) across cavity wall, loft and solid wall insulation. This was due to the reduction in installation under the Energy Company Obligation (ECO) during 2015, which was already delivering far less than previous policies in place to 2012. This lack of progress reflects the weakening of energy efficiency policy during this period:

- **Cavity wall insulation**: There were 151,000 installations in 2015, a 53% reduction on 2014. The majority were delivered through the ECO. The cumulative number of installations of cavity wall insulation is roughly on track for our updated indicator. The indicator has been revised downwards in line with our fifth carbon budget analysis which is more cautious on the uptake of hard-to-treat cavity wall insulation.
- **Loft insulation**: Just over 100,000 measures were installed in 2015. This is a halving of the level in 2014, which was itself already considerably lower than in the period 2008-2012 under previous policies (Box 3.3). This slow-down in uptake reflects the change in policy rather than market saturation. Our updated indicator is rebased to reflect cumulative uptake to 2014. Despite good progress in early years, the rate of uptake of loft insulation needs to increase multiple times to be on track.
- **Solid wall insulation**: There were around 51,000 installations during 2015, which represents a fall of over 10,000 from 2014. 63% of these installations were delivered through ECO, with the share coming through the Green Deal Home Improvement Fund (GDHIF) growing to 34%. We have revised down our indicator trajectory for solid wall insulation to reflect the latest evidence on cost-effectiveness and slow delivery to date (Figure 3.5).
- **Boiler replacement**: Around 1.4 million boilers were replaced with A-rated boilers in 2015. The uptake of efficient boilers has largely been driven by building regulations. Energy efficiency policy delivered only a small share of these, with ECO's Affordable Warmth sub-obligation subsidising around 74,000 boilers and the Green Deal financing a further 6,000. This puts the cumulative uptake of A-rated boilers at 10.6 million since 2008, which is 2.8 million above our existing indicator for 2015. However, there is evidence to suggest that a large proportion of A-rated condensing boilers are not operating efficiently, due to being set with flow temperatures above 55 degrees Celsius, at which point they do not condense properly. Ensuring boilers are condensing properly is more important for energy efficiency improvement than households' choice whether to purchase an A-rated boiler over a B-rated boiler, with the design efficiency of the former being a few percentage points higher, compared to over 10% difference between a boiler working in condensing mode or not. The largest gains come from replacing old inefficient boilers with new condensing boilers. DECC is currently developing new boiler regulations. It is important that the scope of these extend to consideration of system efficiency and flow temperatures as well as heating controls. We will consider how to update the boiler indicator for the 2017 Progress Report.

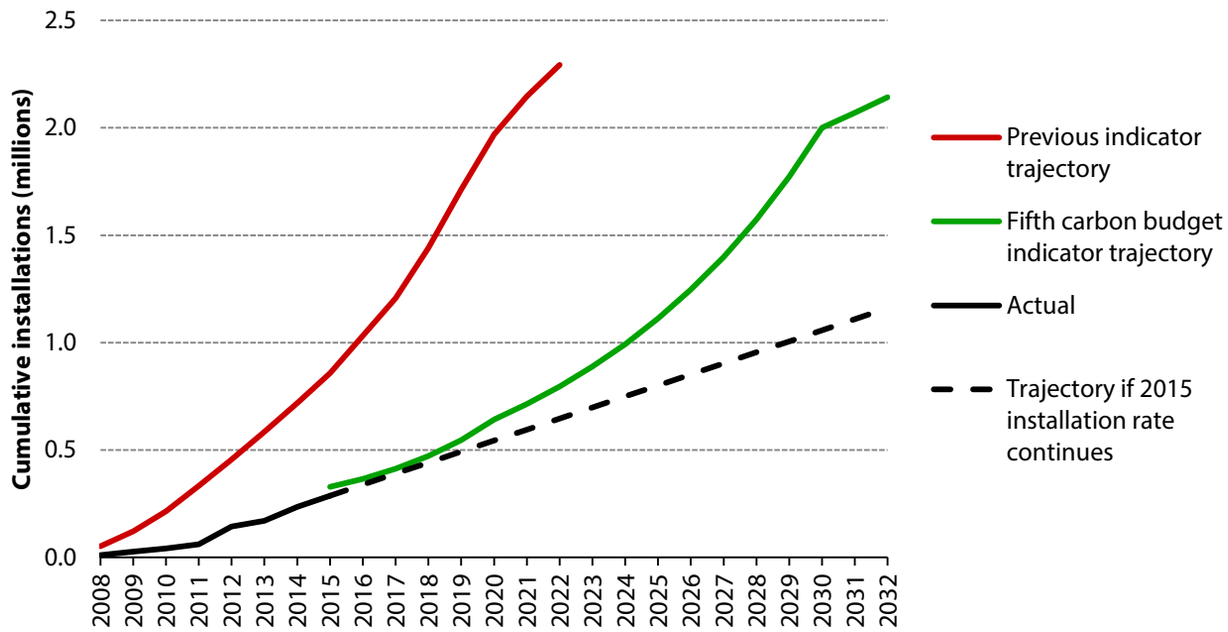
Further details on the indicators are provided in the Technical Annex.

Figure 3.4. Annual insulation installation rates (2008-2015)



Source: DECC (2016) *Household Energy Efficiency National Statistics*; DECC various sources for pre-2014; CCC calculations.

Figure 3.5. Solid wall insulation uptake and indicator trajectories (2008-2032)



Source: DECC (2016) *Household Energy Efficiency National Statistics*, CCC (2015) *Progress Report to Parliament*, CCC analysis based on CCC (2015) *Sectoral Scenarios for the Fifth Carbon Budget*.

More efficient appliances and lighting do not contribute to reducing direct emissions from buildings, but reduce electricity demand. In the near-term, before the power sector is decarbonised, this reduces emissions from power generation. In the longer-term, appliance and lighting efficiency improvements remain important in providing cost savings to households and reducing capacity requirements for power generation, particularly around the evening peak.

Total household electricity demand in 2015 was similar to 2014. There has been a longer-term trend for electricity demand to fall since 2005, with a general improvement in the energy efficiency of appliances contributing. However, the stock penetration of the most energy efficient appliances still remains low:

- Cold appliances (e.g. refrigerators): A++ or higher still only accounted for just over 1% of the stock in 2014, which is below our existing indicator of 9% for 2014.
- Wet appliances (e.g. washing machines): A+ or higher accounted for around 16% of the stock in 2014, a 2 percentage point increase on 2013. However, stock penetration remains below our existing indicator of 24% for 2014.
- LED lights: LED lights continue to represent just 0.6% of total household lighting appliances, with 4.7 million in place.

We will consider revisions to the indicators for appliances in the 2017 Progress Report.

Policy

Box 3.3 provides a summary of current and recent residential energy efficiency policy for context to the changes in policy described in this section.

Box 3.3. Current and recent residential energy efficiency policies

CERT - Carbon Emission Reduction Target (2009-2012): Delivered energy efficiency measures by placing an obligation on energy companies to achieve reductions in carbon emissions. The overall target of 293 $MtCO_2$ of lifetime savings was achieved.

CESP - Community Energy Saving Programme (2008-2012): Incentivised the installation of energy saving measures in low-income areas using a house-by-house approach, with a focus on hard-to-install measures (e.g. solid wall insulation). Overall the scheme achieved 85% of the carbon savings target.

ECO - Energy Company Obligation (2013-2017): GB-wide obligation on energy suppliers to improve energy efficiency, reduce fuel poverty and save carbon in homes. There are three sub-obligations: the Carbon Emissions Reduction Obligation (CERO), the Carbon Savings Community Obligation (CSCO) and the Home Heating Cost Reduction Obligation (HHCRO) also known as Affordable Warmth. The costs are recovered through the energy bills of all households. A new supplier obligation will replace ECO from April 2017.

Green Deal (2013-2015): Financial mechanism for energy efficiency measures in able-to-pay households recommended in a Green Deal assessment. Households choosing to take part did not face an upfront payment for measures, with the costs instead being recovered over time through their energy bill. Fixed interest rate finance was available through the Green Deal Finance Company. The Green Deal was cancelled in 2015.

GDHIF - Green Deal Home Improvement Fund (2014-2015): Provided a subsidy for installing insulation measures in England and Wales. The GDHIF was cancelled in 2015.

Energy Company Obligation (ECO)

324,000 households benefitted from measures under ECO in 2015. Low-cost measures such as cavity wall, loft insulation and boiler replacements have remained the most popular measures in 2015, after revisions were introduced in April 2014 to remove the emphasis for companies to focus on harder-to-treat measures.

The current ECO scheme is being extended to March 2017 with targets imposed pro-rata to March 2015 levels. The 2015 Autumn Statement announced ECO would be replaced by a "new cheaper energy efficiency supplier obligation" in April 2017 to run for five years:

- The new supplier obligation aims to upgrade the energy efficiency of over 200,000 homes per year. In 2015, 324,000 households in Great Britain received measures under ECO.
- The new supplier obligation will deliver measures costing an estimated £640 million per year, which is almost £200 million per year less than the estimated average delivery costs of ECO for 2015/16 and 2016/17 compliance years.[11]

[11] Based on DECC (2014) *The Future of the Energy Company Obligation: Final Impact Assessment.* Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/373650/ECO_IA_with_SoS_e-sigf_v2.pdf

- The lower cost and target number of households means the new policy risks being less ambitious than ECO, which was already delivering a fraction of the effort seen under the CERT and CESP.

The new obligation will primarily aim to improve energy efficiency for fuel-poor households. Our previous analysis has shown that there is potential for a focus of energy efficiency and low-carbon heat measures on fuel-poor households to significantly reduce fuel poverty levels. However, we estimated that annual funding of at least £1.2 billion a year would be needed to meet the government's target of an Energy Performance Certificate (EPC) C rating by 2030 for fuel-poor households in England.[12] Announced funding from ECO and the income redistribution of the Warm Homes Discount (£320 million per year to 2020/21)[13] will be inadequate for this objective. There is also a question over whether a supplier obligation is an efficient way to tackle fuel poverty, as energy suppliers lack appropriate data to be able to target fuel-poor households effectively.

With under a year until the new supplier obligation is introduced, providing information to the market and setting up transitional arrangements will be important to avoid stop-start investment. Ideally, information for the first five-year period should be made available to provide the market with some certainty on which to plan. Also, the design of the new system should give consideration to how to manage administrative costs and ensure the transfer of information to enable energy suppliers to effectively target the fuel poor.

Green Deal

DECC announced in July 2015 that the Green Deal Finance Company and the GDHIF were no longer being funded by government, due to low take-up and concerns over industry standards. Take-up of the Green Deal was well below DECC projections. Around 29,000 households benefited from Green Deal measures in 2015. DECC believes it is "unlikely to have provided any material additional energy and carbon savings over and above what would have been delivered by other policies."[14] We have previously highlighted that the 7% interest rate placed upon loans was too high to be attractive to households. The system was also complex and failed to understand household behaviour.[15]

The government have set up an independent review to consider consumer advice, protection, standards and enforcement for UK home energy efficiency and renewable energy measures. The National Audit Office have evaluated the value for money of the scheme and identified issues in its design and implementation including an untested design, lack of consistency and lower cost-effectiveness than previous policies. A summary of their findings and recommendations for future policy is provided in the Technical Annex.

The Green Deal was intended to provide finance to households to tackle barriers associated with the need for upfront capital investment in energy efficiency measures. The Green Deal's abolition and the refocusing of the new supplier obligation towards fuel-poor households leaves a significant policy gap for encouraging energy efficiency measures in able-to-pay households.

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[12] CCC (2014) *Fuel Poverty Strategy Consultation response.* Available at: https://www.theccc.org.uk/publication/letter-fuel-poverty-strategy-consultation-response/

[13] Rising with inflation.

[14] NAO (2015) *Green Deal and Energy Company Obligation.* Available at: https://www.nao.org.uk/report/green-deal-and-energy-company-obligation/

[15] Energy and Climate Change Committee (2015) *Home energy efficiency and demand reduction.* Available at: https://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/inquiries/parliament-2015/home-energy-efficiency/

The consideration of a new policy or package of measures to encourage energy efficiency in able-to-pay households is essential to achieve the necessary emission reductions from buildings. A new scheme will have to be simple, provide a stable and long-term framework, develop trusted intermediaries, help households to overcome financial barriers and the range of non-financial barriers (e.g. information, perceived risk, hassle, and social norms) and have effective delivery and communication. Differences in taxation between different fuels should also be considered. We will publish more detailed analysis of this policy area in the Autumn, ahead of the government's emission reduction plan.

Zero carbon homes

Under policy developed over the past decade, new homes in England from 2016 were to be built to zero carbon standards. The government has decided not to proceed with this policy due to concerns that the standards would impact on land availability for construction, and to give the industry more time to adjust to the 2013 regulations.

The Greater London Authority (GLA) has issued guidance that implements a similar zero carbon homes standard for construction in London, to apply from October 2016:

- This is expected to add 1-1.6% to the build cost of these homes,[16] which is offset by energy cost savings. Costs have fallen significantly in recent years, and are projected to fall further as a result of the standards implementation and falling solar PV costs.
- Research undertaken by the GLA suggested that the standards would have little impact on land values, and by extension the availability of land.[17]
- New-build in London is projected to be up to a fifth of the UK total to 2020.

A 2016 study by Energy Efficiency Watch reflected that many experts perceive the UK as lagging behind in its obligation to ensure that all new buildings were 'nearly zero-energy' by 2020, and unlikely to meet its wider energy efficiency targets.[18] The study placed the UK at 27th in 2015 out of EU Member States, ahead only of Spain - and down from 13th in 2012.

It is important that new measures are introduced, consistent with the previous requirements of zero-carbon homes, such that the market for low-carbon heat in new buildings is unlocked.

Private-rented sector regulations

Minimum energy efficiency standards for the private-rented sector no longer have a delivery mechanism following abolition of the Green Deal:

- In March 2015, minimum energy efficiency standards for the private-rented sector were legislated, requiring that from April 2016 - except in exceptional circumstances - residential private landlords agree to a tenant's request for energy efficiency improvements where Green Deal finance or subsidies are available to pay for them.
- From April 2018, landlords will need to ensure that their properties reach an EPC rating of at least E, or have installed those improvements that could be funded using available Green

[16] David Lock Associates with Hoare Lea and Gardiner and Theobald (2015) *Housing Standards Review - Viability Study*. Report for the Greater London Authority

[17] As above.

[18] Ecofys and the Wuppertal Institute for Energy Efficiency Watch (2016). *Survey report 2015. Progress in energy efficiency policies in the EU Member States - the experts' perspective*. Available at: http://www.energy-efficiency-watch.org/fileadmin/eew_documents/EEW3/Survey_Summary_EEW3/EEW3-Survey-Report-fin.pdf

Deal finance or subsidies available to pay for them, before granting a tenancy to new or existing tenants.

- These requirements will apply to all private-rented properties – including occupied properties – from April 2020 in the residential sector.
- The Green Deal mechanism underpinning these regulations has now been abolished.

A new delivery mechanism or amendment of the regulations is therefore required to ensure the intended energy efficiency improvements are delivered.

Policy in the devolved administrations

The Scottish Government announced that Scotland's Energy Efficiency Programme will be the cornerstone of the National Infrastructure Priority. This new programme will provide an offer of support to owners of all buildings in Scotland – residential and non-residential – to help them achieve a good energy efficiency rating over the next 15-20 years (Chapter 9).

The Welsh Government has announced a new strategy for energy efficiency and addressing fuel poverty to 2026 as part of The Well-being of Future Generations Act which was legislated in April 2015 (Chapter 9).

5. Energy efficiency of non-residential buildings

Energy efficiency improvements in non-residential buildings contribute 21% of emissions savings in buildings in our scenario for meeting the proposed fifth carbon budget (Box 3.1).

Tracking progress

Tracking progress in non-residential buildings is difficult due to the lack of data on energy efficiency uptake. Non-residential building emissions have fluctuated, but have failed to show a meaningful reduction over time. Non-residential building emissions dropped to a low in 2007 (likely associated with the recession), but have increased 6% since, leaving them not far below 2003 emission levels.[19]

With revisions to provisional data, a lack of information on underlying trends and a lack of progress in overall non-residential building emissions, it is difficult to assess what impact policy is making in this area. What is clear is that the current policy framework is not generating sustained emission reductions and that a transformational change is needed for non-residential buildings to make the necessary contribution to meeting future carbon budgets.

The provisional emission figures for non-residential buildings (described in Section 1) indicate emissions rose during 2015. Data is not yet available to explain this. Full data is available for 2014, so that is the focus of this section. In 2014, temperature-adjusted direct emissions in the sector fell 10%. This is a larger reduction than indicated in the provisional data presented in the last Progress Report:

- Energy intensity measured as energy consumption per unit of output fell during 2014 for both commercial and public buildings. This brought commercial energy intensity back to similar levels as in 2007 and marked a higher reduction for the public sector than in recent years (Figure 3.6). However, change in energy consumption per unit of floor-space is likely to

[19] See the Technical Annex for emission trends and the indicator for non-residential buildings.

be a better indicator. While information for the public sector is not available, Figure 3.6 shows only a marginal improvement since 2000 for commercial buildings on this basis. While data on public sector floor-space is not available, we anticipate that public sector floor-space has decreased over this period, meaning it too would have a lower energy intensity improvement if measured on a floor-space basis rather than by output.

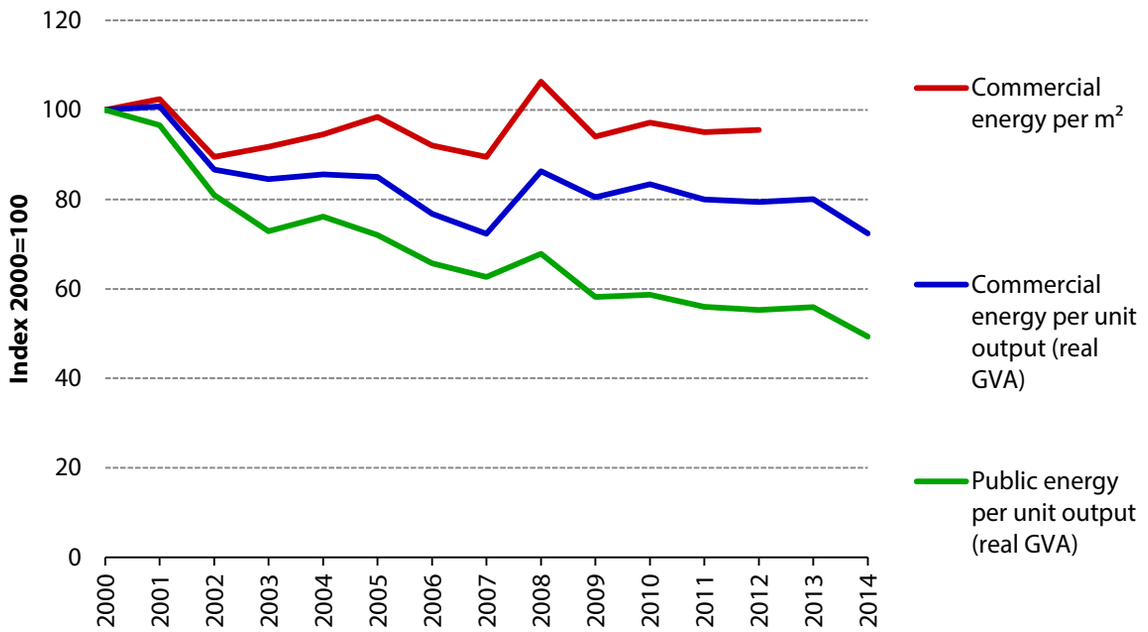
- The CRC Energy Efficiency Scheme covers 66% of electricity consumption and 39% of gas consumption in non-residential buildings, as well as large industrial and agricultural firms outside the EU ETS. Phase 2 of the scheme started in 2014/15 and introduced a number of changes in scope, which make it difficult to compare how the energy consumption of organisations within the CRC changed. The changes included:
  - Schools are now excluded from the CRC, which means that more than 50 public bodies who were previously in the CRC no longer meet the thresholds to be included and public bodies that continue to qualify now report on a smaller base of energy use.
  - The Phase 2 rules allow organisations to exclude any energy use covered under a Climate Change Agreement or the EU ETS from the qualifying supply to the CRC, which resulted in a number of organisations no longer being included in Phase 2.
  - Unmetered energy use is no longer used in checking qualification.
- The public sector represents around 10% of total direct building emissions. A number of schemes have set targets and actions to reduce emissions in parts of the public sector (Box 3.4). Good progress has been made under many of these sectoral schemes, but their continued progress is at risk with future plans for Greening the Government unclear and reorganisation and reduced funding potentially affecting the Higher Education Funding Council for England (HEFCE) and Climate Local.

Box 3.4. Public sector schemes

- The Greening the Government scheme sets a number of environmental targets including one to reduce GHG emissions from the government's estate and UK business-related transport by 25% by 2015 compared to a 2009/10 baseline. The government has made emission savings of 22% against this baseline, with 17 out of 22 departments meeting or exceeding the target. The government is considering future Greening Government arrangements, though it expects departments that have not yet met their targets to continue their effort to do so.
- The HEFCE scheme requires universities to report on emissions and set targets. The collective impact of higher educational institutional targets is a 38 per cent emissions reduction between 2005 and 2020. The Department for Business Innovation and Skills launched a consultation in November 2015 which sets out plans to merge the HEFCE with other organisations that have a publicly-funded regulatory role. It is important that the emission reduction targets, good monitoring and finance set up under the HEFCE remain.
- The Local Government Association (LGA)'s Climate Local scheme was launched in 2012 in partnership with the Environment Agency. It encourages local authorities to set action plans to reduce emissions and become more climate resilient. Nearly a third of councils in England have signed up to Climate Local. In March 2016, it was announced that there will be reduced Climate Local/ LGA support on this issue.

Source: Defra (2015) *Greening Government Commitments Annual report April 2014 to March 2015,* HEFCE website, *LGA* (2015) *Climate Local Annual report 2015/16.*

Figure 3.6. Energy intensity of public and commercial buildings



Source: DECC (2015) *Energy Consumption in the UK* , VOA (2012) *Business floorspace,* CCC analysis.

Policy

Box 3.5 provides a summary of current and recent policy for context to the changes in policy described in this section.

Box 3.5. Current and recent energy efficiency policy for non-residential buildings

CRC Energy Efficiency Scheme (2010-2019): Mandatory carbon reduction and energy efficiency scheme for large non-energy-intensive public and private organisations. It requires them to report on electricity and gas consumption and pay a carbon tax. It covers emissions not already covered by other schemes. The original CRC was modified in April 2014, including removal of the reputational lever of the performance league table.

CCL- Climate Change Levy (since 2001, ongoing): Tax on energy consumption which applies to all non-residential energy consumers.

ESOS - Energy Savings Opportunities Scheme (since 2014, ongoing): Compulsory energy audits have been required under the EU Energy Efficiency directive for all 'large' enterprises (over 250 employees and/or above turnover and balance sheet thresholds). The audits are to be carried out every four years, with the first deadline in December 2015.

An effective policy framework requires a clear carbon price signal, consistent information collection and reporting, regulation to set minimum standards and overcome split incentives in leased buildings, and available finance.

There have been some potentially positive developments in 2015 through proposed policy rationalisation, although a strong new reporting framework will be essential to ensure that incentives are strengthened.

However, given the lack of progress in emission reduction in the non-residential sector over the last decade, policies which lead to transformational change are urgently needed. There also remains a gap in support for SMEs to improve energy efficiency (especially in England), while SMEs make up around half of non-residential building energy consumption.

Carbon price instruments

DECC plans to close the CRC Energy Efficiency Scheme after the 2018/19 compliance year and increase and rebalance Climate Change Levy (CCL) energy tax rates in line with the relative carbon content of fuels. Provided this is combined with reporting requirements, this is a sensible rationalisation of the complex policy landscape for the commercial sector.[20]

Information

The first year of the Energy Savings Opportunity Scheme (ESOS) ended in December 2015 and had a poor compliance rate. Around 60% of organisations submitted notifications of compliance and a further 10% submitted notifications of intent to comply, leaving 30% unaccounted for by the extended deadline of 29th January 2016. Data submitted by the end of January revealed mixed progress overall:[21]

- Only 13% of organisations stated they had a quantitative energy efficiency target or benchmark.
- 72% of organisations without a target who responded to the relevant question said they would adopt measures from their ESOS assessment, although the response rate was low and may be weighted towards those more likely to be acting.
- Relatively few organisations indicated the results of the ESOS assessment would be discussed with senior management and hardly any have published any information from their audit.

With the removal of the CRC Energy Efficiency Scheme, the Government plans to consult on a new reporting framework later this year. The new framework should cover commercial, public and third sector organisations, maintain current incentives and fill the existing information gap.

Regulation

Commercial-rented premises will be subject to minimum standards (EPC E rating) from 2018 for new tenancies similar to privately-rented homes (Section 4), but have until April 2023 (rather than April 2020) before this applies to all private-rented premises, including those on an existing tenancy. A clear timetable for ratcheting up the standards over time would improve investor confidence and unlock additional potential for retrofit.

[20] CCC (2016) *Letter from Matthew Bell to Paul van Heyningen at DECC about the abolition of the CRC scheme.* Available at: https://www.theccc.org.uk/publication/letter-from-ccc-to-decc-on-crc-scheme/

[21] Environment Agency (2016) *Energy Savings Opportunity Scheme*. Available at: https://data.gov.uk/dataset/energy-savings-opportunity-scheme

Finance

There are a number of initiatives to provide finance for energy efficiency improvements, although there remain few finance sources that can provide zero or low interest loans to companies (Box 3.6). There is a particular gap for SMEs in England. The take up of finance in the commercial sector is limited by the short payback periods (e.g. 2-3 years) required on investments by companies.

Box 3.6. Finance for energy efficiency in public and commercial buildings

Commercial sector

The Green Investment Bank (GIB) continues to provide loans for large-scale energy efficiency projects such as street lighting. In June 2015, the government announced its intentions to sell-down its stake in the GIB, moving it into the private sector.

In April 2016, the Carbon Trust launched a Green Business Fund which is offering a capital contribution of 15% of project costs (up to a maximum of £10,000) to SMEs in England, Scotland and Wales installing energy saving equipment. There will also be support to businesses in identifying energy saving opportunities, producing business cases and procuring equipment. The overall funding to the Green Business Fund is £7 million.

Siemens, in partnership with the Carbon Trust, are continuing to provide Energy Efficiency Financing across the UK in the form of leases, loans and hire purchase, which are designed to be offset by energy cost savings.

Zero-interest loans for SMEs are available in Northern Ireland and Wales through the Carbon Trust and in Scotland through the Resource Efficient Scotland programme, which also provides advice and tools for companies. There remains a gap in support for SMEs in England.

Public sector

Salix Finance continues to provide interest free loans to public sector organisations to make energy efficiency improvements. In 2015/16, Salix committed £87 million in loans. Its continuation was secured in the Spending Review.

The Revolving Green Fund (RGF), run by the Higher Education Funding Council for England (HEFCE), provides recoverable grants to help higher education institutions in England undertake innovative projects to reduce energy use and emissions. The RGF has so far provided over £90 million of repayable grants to institutions.

6. Forward look and policy gap

The Government's progress in acting on our recommendations from last year's Progress Report has been limited, with no progress in some areas as well as some backwards steps (Table 3.5). In particular, removal of the Zero Carbon Homes standard, reduced ambition for ECO and the lack of a delivery mechanism for energy efficiency improvement in the private-rented sector following the cancellation of the Green Deal, mean that policy in this area has moved backwards overall in the last year.

In our Progress Report last year, we estimated the policy gap - defined as the portion of abatement which there is currently no policy in place to realise - to be 16 $MtCO_2e$ in 2025. A further 7 Mt of abatement was assessed as at risk due to policy design or implementation issues.

The projected policy gap is now around 6 Mt in 2025 (Figure 3.7). This is smaller than our previous assessment, due to the updates to our assessment of cost-effective roll-out to 2030:

- We have reset our indicators to align with progress to date, which in many cases is behind our previous indicator trajectory due to lack of deployment.
- The path going forward has also changed following the assessment in our advice on the fifth carbon budget, which has reduced ambition in some areas (e.g. solid wall insulation, heat pumps) to reflect evidence of lower cost-effectiveness, partially offset by increases in other areas (e.g. low-carbon heat networks).[22]

Our assessment of current policies which are at risk due to implementation or delivery issues has increased to 13 Mt, reflecting changes to smart meter roll-out plans and compliance issues with building regulations.

Our full assessment of current and planned policies is set out in Table 3.6. This illustrates the areas where there is a gap in existing policy that needs to be filled in the Government's emission reduction plan.

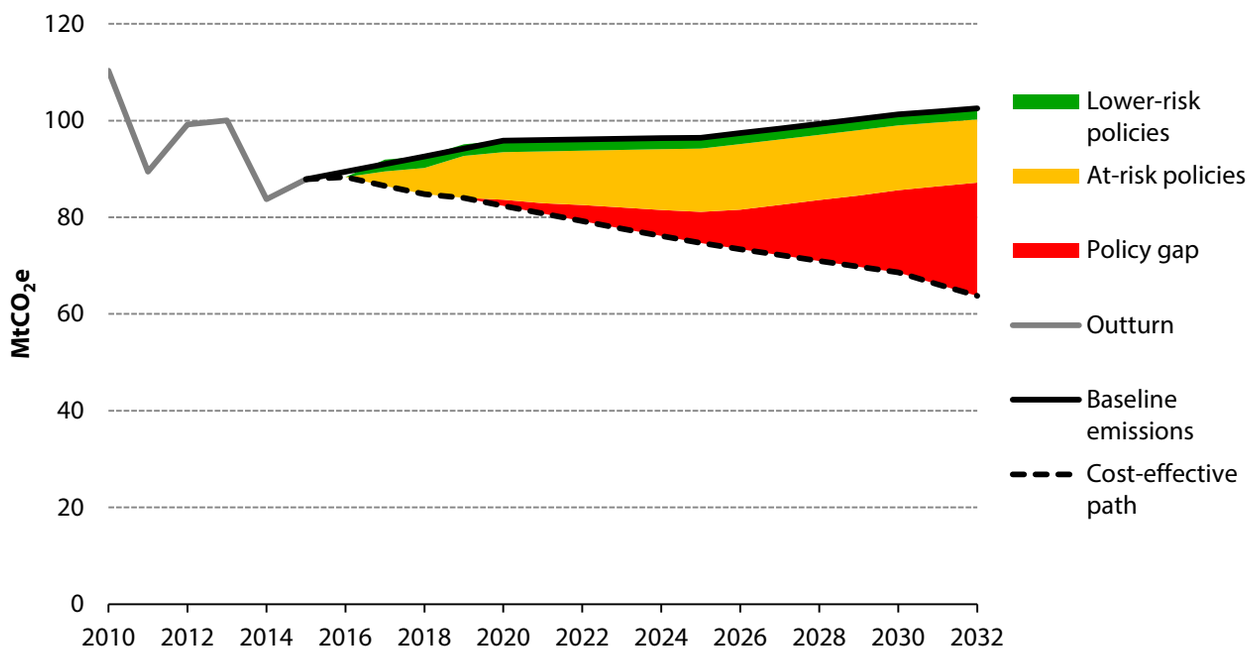
We will report more fully on future low-carbon heat options in the Autumn, ahead of the Government's emission reduction plan (Box 3.7).

[22] Other smaller changes include the Government's higher estimation of projected savings from biomethane injection under the RHI, along with the removal of Green Deal and Zero Carbon Homes policy savings.

Table 3.5. Progress against 2015 recommendations

Recommendation in 2015	Assessment	Commentary
Develop an action plan to address the significant shortfall in low-carbon heat. Short-term, this should commit to extend the Renewable Heat Incentive to 2020, or until a suitable replacement is found; long-term, it should link support for low-carbon heat with energy efficiency, support for heat networks and wider decisions about infrastructure for heat.	Not met	Government has extended the RHI to 2021, although forecast heat pump uptake remains below that required to meet our 2020 scenario uptake. It recently consulted on proposals for improving RHI delivery, including support for heat pumps. However, these do not sufficiently tackle the upfront cost barrier or low consumer awareness, so delivery to 2020 is at risk. Government has separately committed £320m of capital funding for heat networks, which is likely to be lower than required by our scenario roll-out to 2020. Additional effort is required to ensure roll-out of low-carbon heat to 2020, together with an action plan for meeting the fourth and proposed fifth carbon budgets.
Implement zero carbon standards without further weakening and ensure incentives are in places to encourage low-carbon heat sources.	Backwards step	The Zero Carbon Homes policy was cancelled in 2015.
Set out the future of the ECO beyond 2017, ensuring it delivers energy efficiency while also meeting fuel poverty targets.	Not met	Government set out in the Autumn Statement that the ECO will be replaced with a new cheaper supplier obligation from April 2017. This aims to treat 200,000 homes per year and will have a value of £640 million per year, which represents a reduction in targets and funding from the existing ECO. Government is expected to consult shortly on the design of the new obligation. The refocusing towards fuel poverty means fewer emission savings are likely to be delivered per £ spent and the new obligation is not likely to be sufficient to meet fuel poverty targets.
Commercial sector: Simplify and rationalise existing policies for energy efficiency improvement, with a view to strengthening incentives, by the end of 2016.	Partially met	Government plans to close the CRC Energy Efficiency Scheme after the 2018/19 compliance year and increase the CCL. Whilst this simplification is sensible, we will not know if it has weakened incentives until the new reporting framework is published in the coming months. It is important that the new reporting framework maintains incentives and fills information gaps.

Figure 3.7. Assessment of current and planned policies - all buildings



Source: DECC (2015) *Updated emissions projections*; CCC analysis.
Notes: The cost-effective pathway includes the 3Mt of abatement from biomethane in buildings in 2030, in order to be consistent with DECC's assessment of policy impacts.

Table 3.6. Assessment of policies to drive abatement options in the buildings sector

Abatement option	2015 policy	Change in 2015/16	2016 policy
Building-scale low-carbon heat in existing buildings to 2021	 Amber RHI	RHI funding committed to 2020/21 at reduced level and consultation	 Amber
Building-scale low-carbon heat in existing buildings from 2021	 Red No policy	No change	 Red
Building-scale low-carbon heat in new buildings	 Amber Zero Carbon Homes	Regulations cancelled	 Red
Residential energy efficiency, able-to-pay	 Red Green Deal	Green Deal cancelled mid-2015	 Red
Residential energy efficiency, low income	 Amber ECO	Decreased funding and targets from 2017	 Amber
Non-residential energy efficiency	 Amber CRC/CCL, ESOS	Simplification of CRC/CCL and reporting requirements consultation	 Amber
Heat networks	 Amber Feasibility studies	£320m capital funding announced	 Amber
Hydrogen	 Red No policy	Small-scale feasibility studies	 Amber Need for strategy

Notes: Key - Red: Policy gap; Amber: Policy at risk; Green: Effective policy in place.

Box 3.7. 2016 Heat and energy efficiency policy blueprint

We are currently undertaking an in-depth project on low-carbon heat and energy efficiency in buildings, looking ahead to the Government's emissions reduction plan at the end of this year. This work recognises the significant policy challenge in reducing emissions in buildings to the levels assumed necessary in meeting carbon budgets.

The advice is supported by several pieces of external research:

- Research into the institutional implications and impacts of future gas grid scenarios, undertaken by Frontier Economics and Aqua Consultants
- A 'What works' review of low-carbon heat policy, led by Imperial College
- A 'What works' review of non-residential energy efficiency policy, led by UCL.

This evidence will be combined with a review of barriers and current policy in light of a detailed segmentation of the building stock and the potential highlighted in our decarbonisation pathways, together with an internal 'What works' review of residential energy efficiency.

Working with an expert advisory group, we will assess the implications for policy priorities and decision points, and set out one view of a set of policies which could realise the carbon budget buildings scenario abatement.

As part of the future gas grid project, we are assessing the implications of four future gas scenarios, each consistent with meeting the 2050 target:

- Two natural gas scenarios. The first corresponds to our central fifth carbon budget gas scenario to 2050, alongside a second 'non-CCS' scenario which sees a greater fall in gas demand, with more regional coordination, switching and decommissioning of assets.
- Two hydrogen conversion scenarios. The first is equivalent to a near full conversion of the gas network to hydrogen. The second is a regional 'patchwork' scenario, with hydrogen roll-out in the north of England.

These scenarios suggest a wide range of possible outcomes in terms of throughput and decommissioning. The resulting uncertainty underlines the importance of managing the impacts for both consumers and investors. For each scenario, we consider the impacts on transmission and distribution prices and assess the strategic implications for DECC and Ofgem, including for the next price control review.

We intend to publish the report, along with the supporting research, in October 2016.

Chapter 4: Industry

Key messages and recommendations

Industrial activity directly accounts for almost a quarter of UK greenhouse gas emissions and includes manufacturing and construction, refining of petroleum products, plus extraction and production of oil, gas and solid fuels.

In this chapter we assess progress in decarbonising industrial activity to meet carbon budgets and the 2050 target, assess the delivery risks, and identify key areas for the Government to address in its emissions reduction plan to be published later this year.

As part of our assessment we consider the impact of low-carbon policies on industrial energy costs. Output and investment moving abroad is unlikely to have a positive impact on global emission reductions, and would not be desirable from a wider economic perspective.

The vote to leave the EU may have some impact on how emission reduction is achieved. A number of EU policies currently contribute to emissions reduction in industry, such as the EU Emissions Trading System, EU products policy and the Industrial Emissions Directive. To meet the UK's industry decarbonisation requirements it may be necessary to agree new arrangements or adapt existing arrangements, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU agreements in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

Our key messages are:

- **Emission trends.** Provisional CO_2 emissions have fallen in 2015 while industrial output grew around 1%. However, previous provisional energy and emission statistics have been readjusted significantly in following years and so need to be interpreted with care, with greater significance placed on the longer trend. Overall, industrial direct GHG emissions fell 2% per year on average over 2009-2014 and have halved since 1990.
- **Competitiveness risks to energy-intensive sectors from low-carbon policies are manageable.** There is no evidence that low-carbon policies have led to significant industry relocation to date. A number of measures are in place to protect energy-intensive sectors from competitiveness risks. The level and structure of these measures will need to be kept under review, depending on the development of low-carbon policies in the UK and other nations.
- **There has been limited progress developing the policy framework to drive industrial emissions reduction**. In our 2015 Progress Report, 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 heat-intensive industrial sectors. We also highlighted that there was an urgent need for a joined up approach with the power sector to the demonstration and commercialisation of carbon capture and storage (CCS).
- **Policy strengthening will be required to meet the fourth and recommended fifth carbon budgets**. Currently there is a gap between Government plans and our scenarios underpinning the recommended fifth carbon budget which include industry emission reductions of 13 $MtCO_2e$ in 2030. There are many areas of potential emissions reduction where policies are either missing (7 $MtCO_2e$) or have significant delivery risk (6 $MtCO_2e$).

Our recommendations reflect the need to for the emissions reduction plan due later this year to address the delivery gap to the fourth budget and recommended fifth carbon budget as set out in Table 4.1.

Key messages and recommendations

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

Industrial emissions to fall by around 20% between 2015 and 2030. This will require:	**New policy**	**Stronger implementation**
An overall approach to long-term industrial decarbonisation, developing existing 'Roadmaps' into specific actions and milestones and extending coverage to other industrial sectors.		✘
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.	✘	
A stronger policy framework for industrial energy efficiency, including reviewed Climate Change Agreements and an effective reporting mechanism.		✘

Source: CCC analysis.

We set out the analysis that underpins these conclusions in four sections.

1. Industrial competitiveness opportunities and challenges
2. Industry emission trends and drivers
3. Progress in reducing industrial emissions
4. Forward look and policy gap

1. Industrial competitiveness opportunities and challenges

Decarbonisation raises both challenges and opportunities for UK competitiveness.

We have previously considered how the transition to a low-carbon economy may create economic opportunities for new businesses, save existing businesses money through increased energy- and resource-efficiency and mitigate risks from fossil fuel prices. Investment in renewables and energy-efficient technologies will require new infrastructure and equipment for the power sector, households and commercial and industrial businesses. This will provide growth opportunities for UK manufacturing. The potential is not limited to supplying just the UK market. EU and other countries, from China to Mexico, are setting challenging emission targets and creating new markets.

In our 2013 *Managing competitiveness risks of low-carbon policies* report, we highlighted that the UK has a comparative advantage in some key low-carbon technologies.[1] Parts of heavy engineering and construction, as well some energy-intensive sectors such as parts of chemicals and plastics could contribute to low-carbon power and heat sector supply chains. Some energy-intensive industries have already developed new low-carbon technologies and processes which make them well placed to compete in new markets on the path to a low-carbon world (e.g. low-temperature detergents, low-resistance tyres and lightweight materials in aircraft and cars).

Our report also noted that there are potential competitiveness risks for electro-intensive industries that are subject to international competition and face higher relative energy costs if other countries are slower to act on climate change policies than the UK. These firms could see a squeeze on profits which could potentially drive output and jobs overseas.

While our 2013 assessment of competitiveness risks concluded that low-carbon policies by themselves have not caused any significant industry relocation to date, it is important to ensure that increased energy costs due to low-carbon policies do not result in offshoring of UK industry. Output and investment moving abroad is unlikely to have a positive impact on global emission reductions, and would not be desirable from a wider economic perspective.

Comparing UK industrial electricity and gas prices in 2015 against other countries that make up the EU 15 shows that the UK had one of the lowest gas prices, but one of the highest electricity prices (Figure 4.1).

The UK Government has recognised competiveness risks and has plans for, or has already put in place, support arrangements for electro-intensive sectors. In the 2015 Autumn Statement the Chancellor exempted at risk sectors from costs associated with action to tackle climate change.

These sectors currently receive:

- **Compensation for the EU ETS and Carbon Price Floor**[2] impact of rising electricity prices for electro-intense industries (e.g. iron/steel).
- **Exemption from Climate Change Levy for mineralogical and metallurgical sectors.**

At the beginning of 2016, these sectors have been able to submit claims for:

- **Compensation for the Renewables Obligation and small-scale Feed-in-Tariff** energy bill cost impacts, from the date of State Aid approval.

[1] Available at: http://www.theccc.org.uk/

[2] Carbon Price Floor (CPF) is minimum a carbon price for fuels, where the Carbon Support Price (CPS) tops up the carbon price from the EU ETS to the CPF.

In future, these sectors are expected to receive:

- **Exemption for the Renewables Obligation and small-scale Feed-in-Tariff** instead of compensation, which government is currently consulting on.
- **Exemption from the impact of Electricity Market Reform and Contracts for Difference (CfDs)** on electricity prices.

For the sectors that qualify, these plans should offset up to around 80% of the costs to support low-carbon electricity sector investment through to 2019-20.

Redcar steel works in the Teesside area closed in late 2015 and the impact of low-carbon policies on electricity prices was cited by some commentators as the cause. However, as we set out in a technical note late last year the closure of Redcar was mainly due to the depressed price of steel from global overcapacity and an appreciation in the pound, rather than specifically due to the cost of low-carbon polices.[3] Since the closure of Redcar, Tata steel announced the sale of its UK operations including its Port Talbot steel works (8 $MtCO_2e$ per year). The future of the Port Talbot site is not yet known and we will continue to monitor this situation.

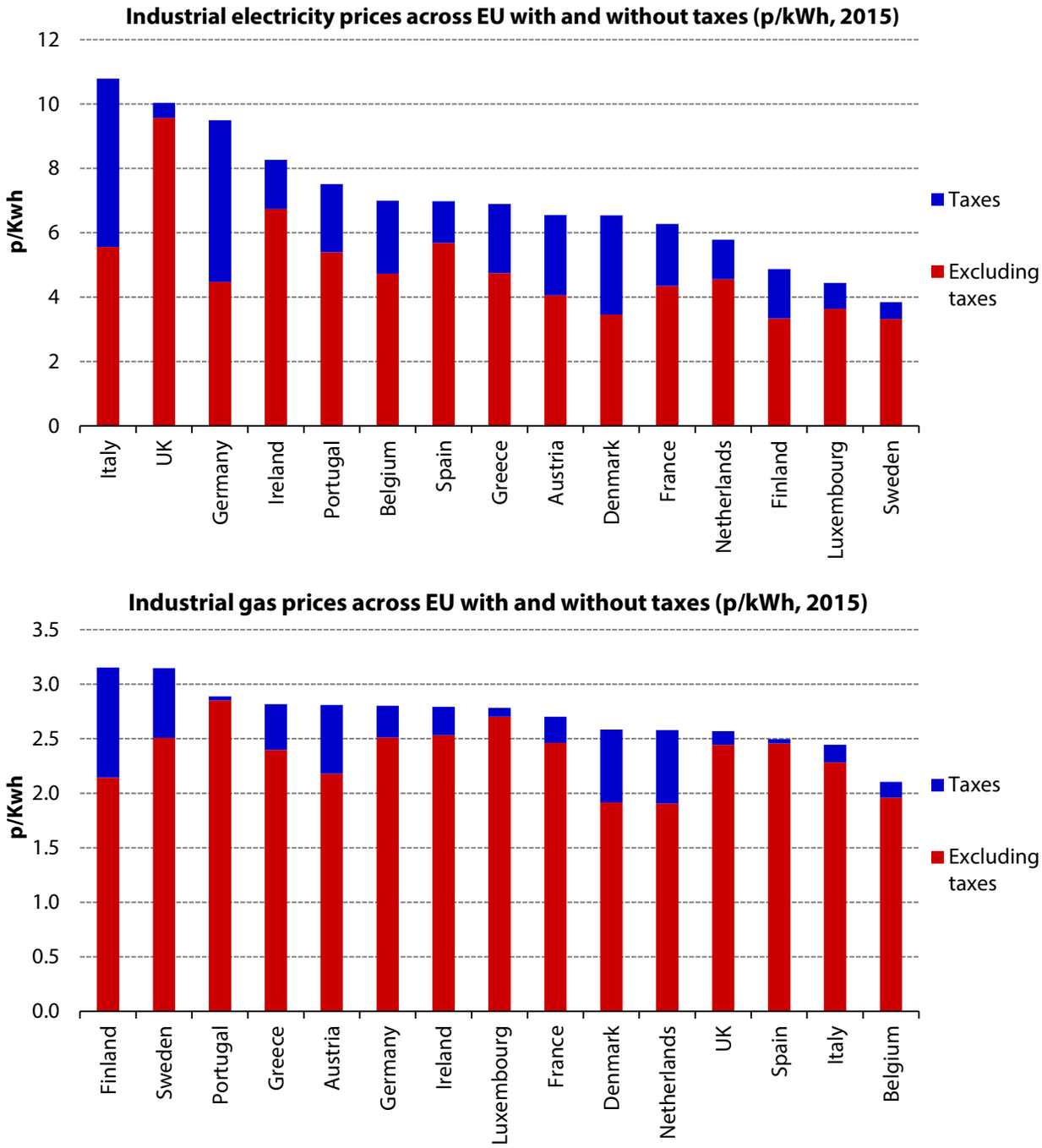
UK energy-intensive industries are included in the EU Emissions Trading System (ETS), requiring them to surrender allowances to cover carbon emissions associated with their energy consumption. Paying for such allowances would raise the costs of energy-intensive industries relative to competitors outside the EU that do not face carbon costs. In order to mitigate such risks, the EU has developed an approach whereby free allowances are granted to energy-intensive firms subject to international competition. Given the vote to leave the EU, the continuing role of the EU ETS for the UK is uncertain.

Overall, competitiveness risks to energy-intensive sectors from low-carbon policies are manageable. There are a number of measures are in place to protect energy-intensive sectors from competitiveness risks. The level and structure of these measures, whether the UK is included in the EU ETS or not, will need to be kept under review, depending on the development of low-carbon policies in the UK and other nations.

We will continue to monitor developments within the EU ETS. We will also review the current and future impact that the Government's climate change policy package has on industrial sector energy costs in an update to our *Energy prices and bills* publication, later in 2016.

[3] CCC Technical note: low-carbon policy costs and the competitiveness of UK steel production, available at: https://www.theccc.org.uk/publication/technical-note-low-carbon-policy-costs-and-the-competitiveness-of-uk-steel-production/

Figure 4.1. Industrial electricity and gas prices across EU with and without taxes (p/kWh, 2015)



Source: Eurostat (2016).
Notes: Prices converted to pounds sterling using annual average exchange rates. Prices include all taxes where not refundable on purchase. Prices excluding taxes have been estimated using a weighted average of general sales taxes and fuel taxes levied. Eurostat does not provide a breakdown of taxes and levies.

2. Industry emission trends and drivers

Overview

Industrial activity includes the manufacturing and construction sectors, refining of petroleum products and a range of activities linked to energy supply (extraction and production of oil, gas and solid fuels).[4]

Direct emissions from industry accounted for almost a quarter of UK greenhouse gas (GHG) emissions in 2015 (113 $MtCO_2e$), of which over 90% are CO_2 (Figure 4.2): [5]

- **Manufacturing** makes up almost two-thirds of industrial GHG emissions.
  - Combustion emissions, from burning fuel for the production of low-and high-grade heat, drying/separation, space heating and electricity generation for own use (Figure 4.3). Almost a third of combustion emissions are 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).
- **Refineries and other energy supply** are one-third of industrial GHG emissions. Other energy supply emissions (extraction and production of oil, gas and solid fuels) are two-thirds of this, over a quarter of which is non-CO_2.
- Industry consumes almost a third of UK grid-electricity, which is around 7% of UK GHG emissions.

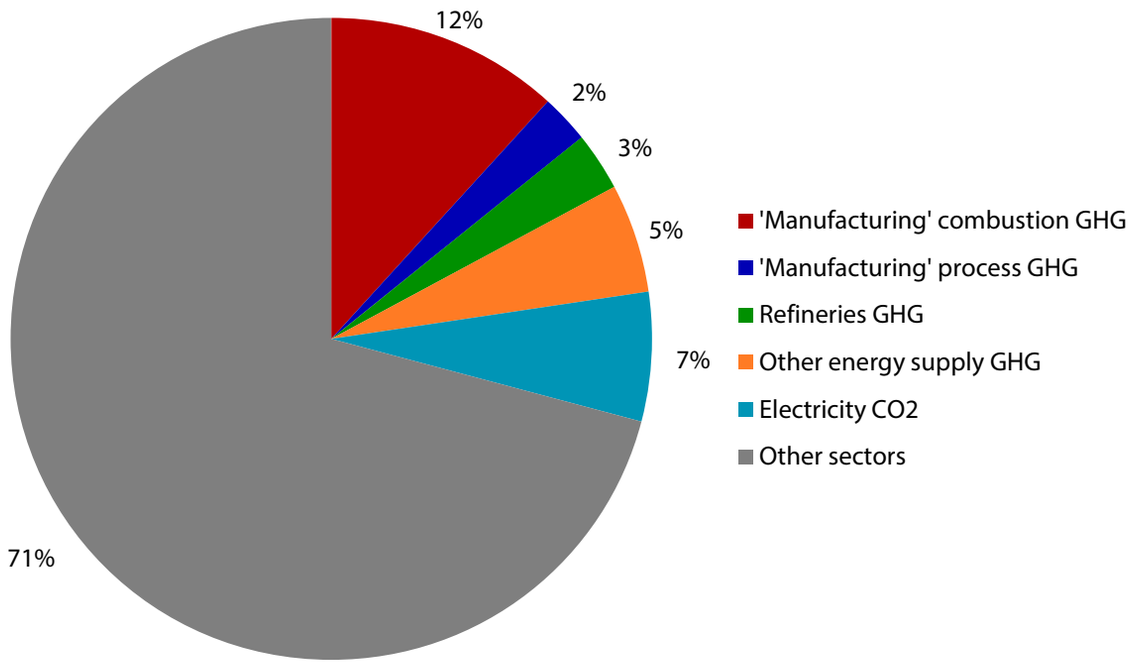
Within the manufacturing and refining sectors, around 70% of all GHG emissions are accounted for by the eight heat intensive sectors covered by the '2050 Roadmaps', which make up over 10% of UK GHG emissions (Figure 4.4).[6]

Industry production and emissions are not evenly spread across the UK. In our fifth carbon budget advice[7] we detailed the role of industry in the devolved administrations. For instance, in Wales, industry accounted for 34% of total emissions in 2014, with nearly half of these from Port Talbot steelworks.

Under the Infrastructure Act 2015, the Committee has a new duty to advise the Secretary of State about the impact of the exploitation of onshore petroleum on achieving the carbon budgets. We delivered this advice in March 2016.

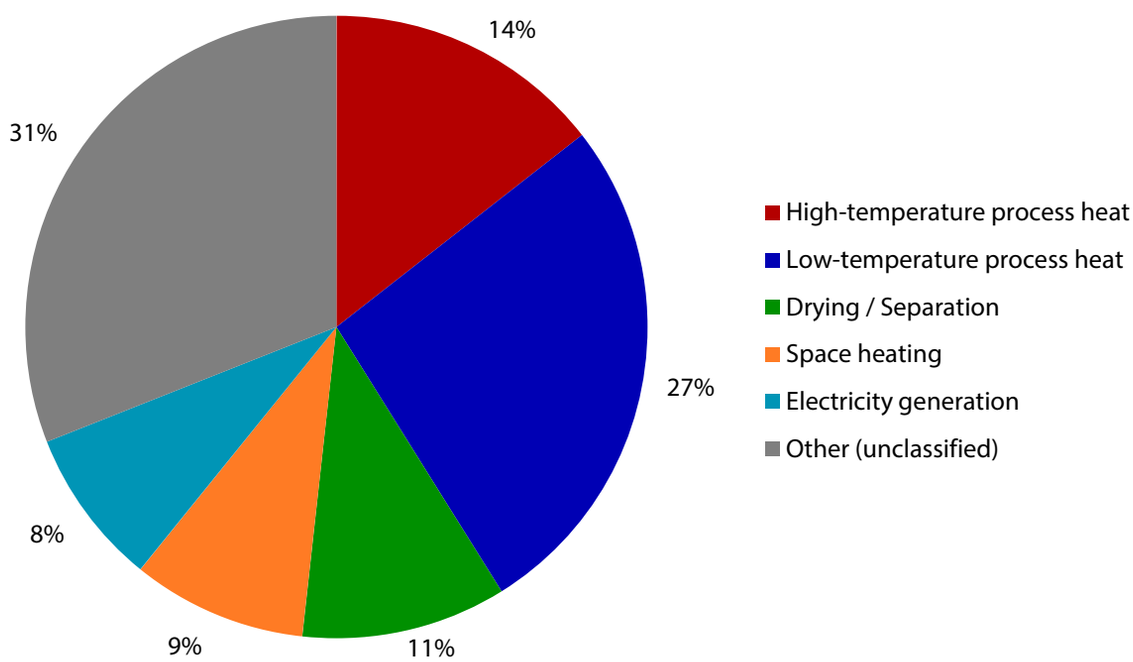
[4] From this point forward references to manufacturing will also include the construction sector.
[5] Direct excludes emissions from generation of electricity supplied through the grid, these are covered in the Chapter 2.
[6] The '2050 Roadmaps' established decarbonisation pathways to 2050 that could be possible while ensuring sectors remain competitive. The eight sectors covered were cement, ceramics, chemicals, food & drink, glass, iron & steel, oil refining, and paper & pulp. See section 3 for more details.
[7] CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget*, available at: www.theccc.org.uk

Figure 4.2. GHG emissions from industry in the context of total UK emissions (2015)



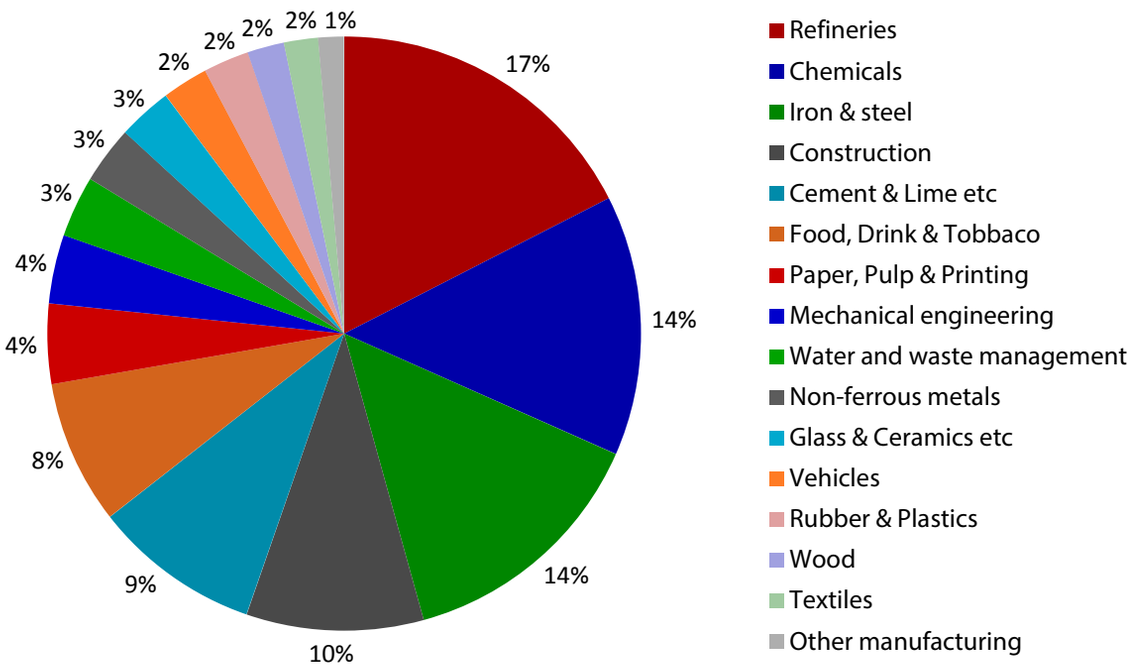
Source: DECC (2016) *Provisional UK GHG national statistics*, DECC (2016) *Energy Trends*, CCC analysis.
Notes: 2015 emission estimates are provisional. Percentage figures may not add up to 100% due to rounding.

Figure 4.3. Manufacturing and refining direct CO_2 from combustion by use (2014)



Source: DECC (2015) *Energy Consumption United Kingdom*; CCC analysis.
Notes: 'Electricity generation' refers to electricity generated and consumed on-site.

Figure 4.4. Manufacturing and refining GHG emissions by sector (2013)



Source: ONS *Environmental Accounts.*
Notes: Percentage figures may not add up to 100% due to rounding.

Emission trends

Provisional data suggests that CO_2 emissions fell in 2015 (Table 4.2) while industrial output grew around 1%. In our 2015 Progress Report we showed how previous provisional energy and emission statistics have been amended significantly in following years. Provisional figures need to be interpreted with care and greater significance should be placed on the longer trend. Overall, industrial direct GHG emissions fell 2% on average over 2009-2014 and have halved since 1990:

- Direct CO_2 industrial emissions fell by 1.6% in 2015, following an annual average 1.2% decrease over the period 2009-2014.
  - Manufacturing CO_2 emissions fell 5% in 2015, following a period 2009-2014 where emissions initially fell and then rose back up again towards their 2009 levels. Around two-thirds of the fall in 2015 can be explained by a reduction in steel production and the closure of Redcar steelworks in Teesside. The 2009-2014 trend can be largely attributed to the recession, which had a disproportionate impact on carbon-intensive sectors, specifically the mothballing and then reopening of Redcar steelworks.
  - Refineries and other energy supply CO_2 emissions rose 6% in 2015, following an annual average 3% decrease over the period 2009-2014. Half of this rise can be explained by an increase in indigenous gas and petroleum production. The 2009-2014 trend can be attributed to a fall in fuel production and closure of refineries.
- Non-CO_2 emissions in the published provisional 2015 statistics are assumed to be at the same level as they were in 2014. These emissions on average decreased 6% annually over the period 2009-2014. This reduction has 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 also fell by 1% in 2015, following an annual average 1% decrease over the period 2009-2014. The falls in grid electricity consumption suggest some potential energy intensity improvement.

The recession, which had a disproportionate impact on carbon-intensive sectors, changes in the fuel mix and technologies to abate N_2O emissions largely explain the fall in industrial direct GHG emissions over 2009-2014 (Box 4.1).

In our 2014 Progress Report, we set out an indicator framework for monitoring progress in industry towards meeting carbon budgets. From 2007 to 2014, industry direct CO_2 emissions declined in line with the indicator we set out (Figure 4.5). Provisional estimates for 2015 suggest direct emissions have fallen further than our indicator, but as discussed above provisional estimates are prone to revision.[8]

Falling investment in new plant and equipment suggests the continued use of older, less-efficient plant. Investment in new plant and equipment fell by 24% between 2007 and 2009. It is now rising slowly, but is still to reach its pre-recession level.[9] The rise is a positive effect of industry returning to growth after the recession, suggesting an increased replacement of older equipment with the latest more energy-efficient technology.

In our fifth carbon budget advice report we presented an assessment on UK industrial consumption emissions - these are emissions from the UK's consumption of industrial goods and services, both domestically produced and imported. The assessment shows that emissions from UK consumption exceed those of emissions from UK production, but that over 1997-2012 there has been a reduction in emissions from UK consumption of industrial goods. Consumption emissions should be monitored and the Government should regularly published updates to check whether these are falling in line with required global action, or whether further action is required.

[8] For analysis of other CCC indicators see Technical Annex 4.
[9] ONS Gross fixed capital formation statistics. Available at http://www.ons.gov.uk/ons/index.html

Table 4.2. Annual changes in industrial GHG emissions (2009-2015)

	2009-2014 annual % change	2015 % change
Manufacturing - combustion CO_2 emissions	-1%	-5%
Manufacturing - process CO_2 emissions	+4%	-5%
Manufacturing - total direct (non-electricity) CO_2 emissions	0%	-5%
Refineries and other energy supply direct CO_2 emissions	-3%	+6%
Total industrial direct CO_2 emissions	-1.2%	-1.6%
Total industrial direct non-CO_2 emissions	-6%	-
Total direct GHG emissions	-1.7%	-
Grid electricity energy consumption (TWh)	-1%	-1%

Source: DECC (2016) *Provisional UK GHG national statistics*, DECC (2016) *Digest of UK Energy statistics* (DUKES), DECC (2016) *Energy Trends*, CCC analysis.
Notes: DECCs 2015 provisional estimate for non-CO_2 emissions assumes no change from final 2014 emissions.

Box 4.1. Manufacturing and refining industries combustion emissions decomposition analysis

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 which could be caused by:

- **Output effects** (e.g. recession-related emission reductions).
- **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 or plant utilisation).

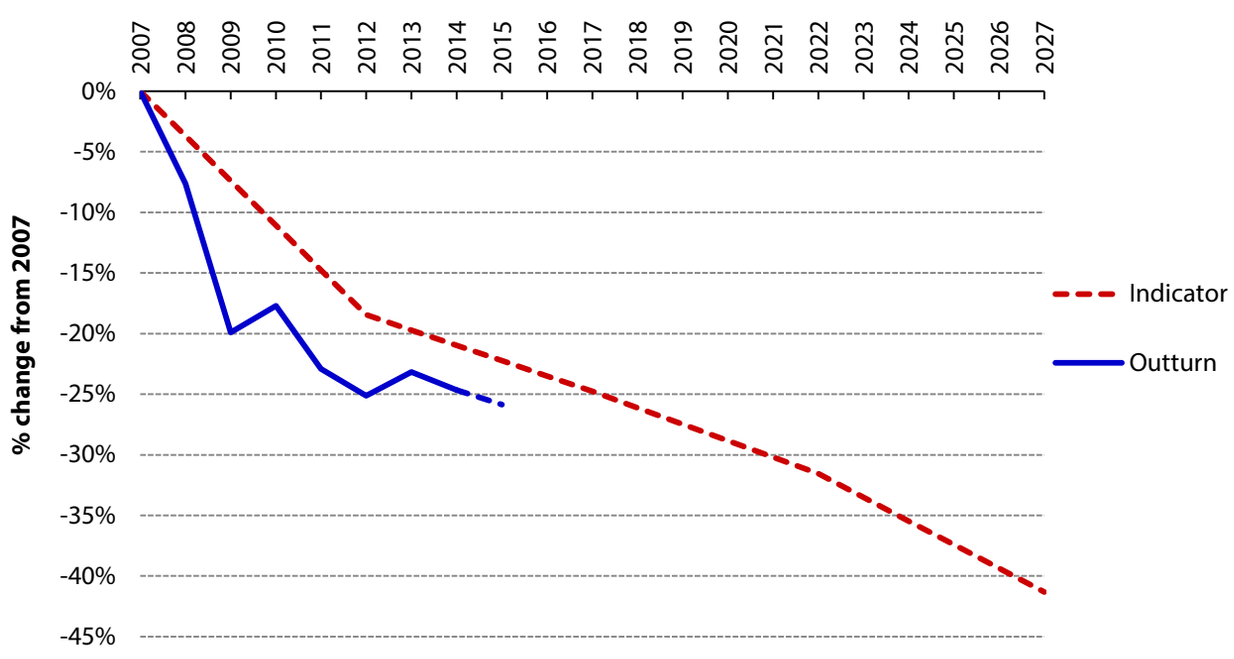
This analysis shows that between 1992 and 2007 improvements in energy intensity and switching to lower-carbon fuel were the largest contributors to the reduction in direct CO_2 emissions in the manufacturing and refining sectors. Improvements in energy intensity averaged around 1.6% per year over this period and switching to lower direct emission fuels saved 0.6% per year.

The updated analysis shows that over 2009- 2013, for which the latest data is available, saw a rise in industrial output and that the fall in direct CO_2 emissions can be attributed to a structural movement towards a less carbon-intensive mix of industrial output and changes in fuel mix.

This analysis can only give us some indication about whether and where industrial energy efficiency is improving. However, energy intensity is only a proxy for technical energy efficiency, and also includes the effects of changing product mix and utilisation of plant and equipment.

Source: CCC analysis.

Figure 4.5. Industrial direct CO_2 emissions and CCC indicator (% change from 2007)



Source: DECC (2016) *Provisional UK GHG national statistics,* CCC analysis.
Notes: The 2015 outturn estimate is provisional.

3. Progress in reducing industrial emissions

In this section we set out the opportunities and challenges in decarbonising industry, and assess progress in the Governments low-carbon policy framework.

Opportunities to reduce industrial emissions

The *'Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050'* reports were published in March 2015 for eight heat-intensive industrial sectors that make up 70% of manufacturing and refining direct CO_2 emissions.[10] The reports identified key abatement options in line with those considered below.[11]

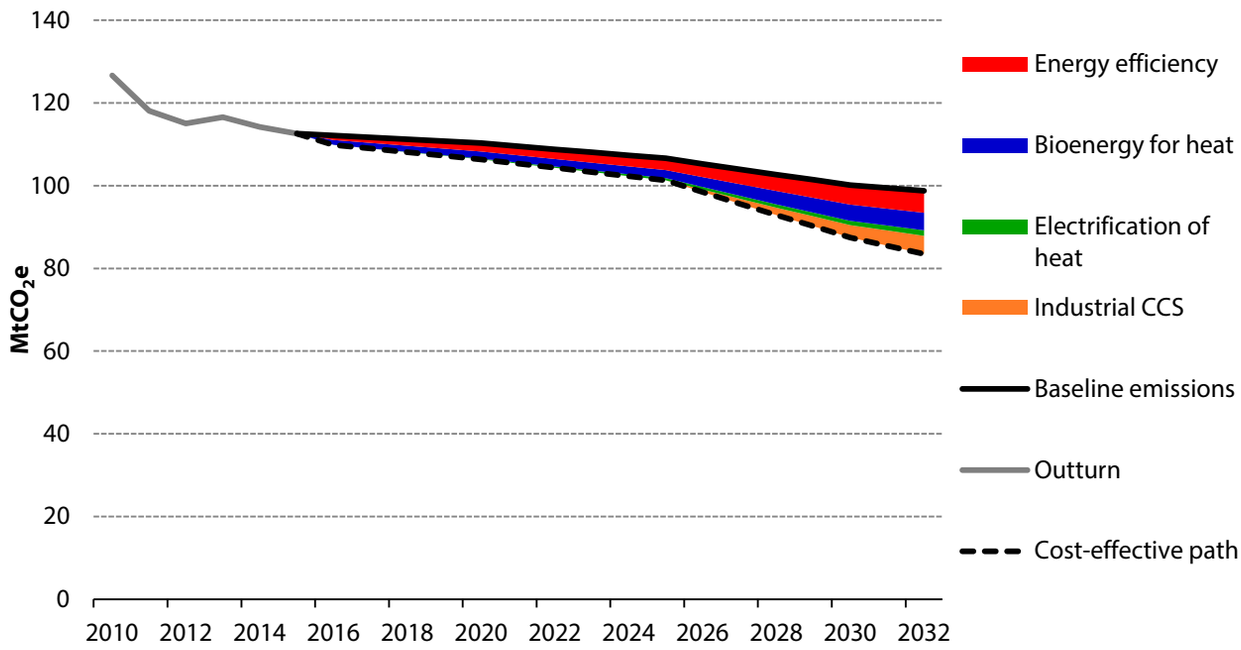
The fifth carbon budget advice published in December 2015 updated our view on the scope for reducing direct emissions in industry from around 155 $MtCO_2e$ in 2007 to around 87 $MtCO_2e$ in 2030 (Figure 4.6):

- **Energy efficiency improvement.** Improving the process of producing goods can save both emissions and energy, and thus reduce firm's 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 5 $MtCO_2$ 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. Biomass absorbs CO_2 during growth, so there is the potential to reduce emissions compared to fossil fuel sources. We have identified 4 $MtCO_2$ of cost-effective abatement potential by 2030.
- **Low-carbon electric 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. We have identified 1 $MtCO_2$ of cost-effective abatement potential by 2030.
- **Industrial carbon capture and storage and use (CCS/U).** Carbon Capture and Storage (CCS) technology is frequently considered in the context of power generation. However, the clearest case for its use lies in the application of CCS 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 3 $MtCO_2$ by 2030. It will require a new strategy for carbon capture and storage or utilisation to be developed immediately. That is discussed in detail in Chapter 2.

There is likely to be further abatement potential from resource efficiency in constructing buildings and infrastructure. A new publically available specification that aims to bring a joined up approach to the way industry evaluates and manages whole life carbon emissions and deliver reduced carbon, reduced cost solutions was published in early 2016 (Box 4.2).

[10] Cement, ceramics, chemicals, food and drink, glass, iron and steel, oil refining, and paper and pulp.
[11] 2050 Roadmap report is available at: https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

Figure 4.6. Fifth Carbon Budget industrial emission reduction cost-effective pathway ($MtCO_2e$)



Source: DECC (2015) *Updated energy and emission projections*, CCC analysis.

Box 4.2. Construction specification PAS 2080 and management of whole life carbon emissions

The HM Treasury Infrastructure Carbon Review of 2013 identified a causal link between carbon reduction and cost reduction in infrastructure delivery, and the creation of a new publically available specification (PAS) was one of the recommendations.

PAS 2080 developed by the Construction Leadership Council's Green Construction Board (GCB) was launched in 2016, and aims to establish a common understanding, approach and language for whole life carbon management in the provision of economic infrastructure (defined as water, energy, transport, communications and waste).

PAS 2080 aims to bring a joined up approach to the way industry evaluates and manages whole life carbon emissions and deliver reduced carbon, reduced cost solutions. It paves the way for consistency of methods and reporting which will make it easier to talk about carbon management and cost across the supply chain, and across the infrastructure sector.

The potential benefits of this specification include:

- **Defining good carbon management:** The PAS will provide clarity to asset managers and other value chain organisations on what constitutes good carbon management and on the key enablers to drive carbon reduction – leadership being key.
- **Consistency:** The PAS will ensure carbon is consistently and transparently quantified at key points in infrastructure delivery.
- **Increasing competitiveness in the UK:** Businesses which can demonstrate they are 'PAS 2080-ready' – and hence able to help asset managers/clients to manage and reduce carbon – might gain more work, while international clients which want to succeed in the UK infrastructure sector will favour companies with proven ability to cut cost by cutting carbon.
- **Gaining work overseas:** Experience of the carbon management principles of PAS 2080 – with its positive message of carbon and cost reduction – will be seen favourably when bidding for work overseas, especially in economies seeking to meet their international carbon reduction commitments but unsure of the best approach.

PAS 2080 will not guarantee low carbon success. But if applied intelligently with good business management then it could be a powerful enabler to cut emissions, drive down cost and unleash innovation in design and technology.

Notes: For more information see: http://www.greenconstructionboard.org/

Challenges to reduce industry emissions

We set out the main challenges in our 2015 Progress Report:

- **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 instance, to take full advantage of the potential abatement from industrial CCS, there needs to be adequate CO_2 transport and storage infrastructure.
- **Refurbishment 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.

Government policy has a role to support industry in meeting these challenges. The '2050 Roadmaps' focused in more depth on these barriers for the eight sectors covered. The next steps will be for government to work with industry on a series of actions, incentives and mechanisms to overcome these barriers.

Progress developing policies to reduce industrial emissions

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 heat-intensive sectors with a cross-sector report identifying conclusions that apply across multiple sectors and technology groups.[12] 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.[13] 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.

We recommended that the UK Government continue to work with industry to develop and publish a set of plans, setting out specific actions and clear milestones to move abatement efforts forward along the paths developed.

To encourage the level of private investment in the best equipment currently available and develop breakthrough technologies needed to implement the roadmaps, a stronger policy framework than currently exists is required:

- **EU ETS.** Total verified emissions have been consistently below the allocation of allowances, largely because of the recession, causing the market value of carbon to fall and remain at a low level. The limited carbon price signal means the incentives for energy-intensive industries to prepare for and make long-term investments in line with the fourth and recommended fifth carbon budgets are weak. Given the vote to leave the EU, the continuing role of the EU ETS for the UK is uncertain.
- **Energy efficiency.** A number of policies are in place or planned to encourage electricity and non-electricity energy efficiency.
  - **Business energy efficiency tax landscape review.** At the 2015 Summer Budget the government announced that it would review the business energy efficiency tax landscape and consider approaches to simplify and improve the effectiveness of the regime. At Budget 2016 the Government announced the changes it would make:
    - **CRC energy efficiency scheme.** Mandatory carbon reduction and energy efficiency scheme for large organisations covering emissions not already covered by the EU ETS and Climate Change Agreements. The Government intends to close the CRC scheme after the 2018/19 compliance year.
    - **Climate Change Levy (CCL).** A tax on energy consumption which applies to all non-domestic consumers. Following the closure of the CRC, the CCL will be

[12] 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.
[13] Available at: https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

increased, and by 2025, rebalanced in line with the relative carbon content of fuels.

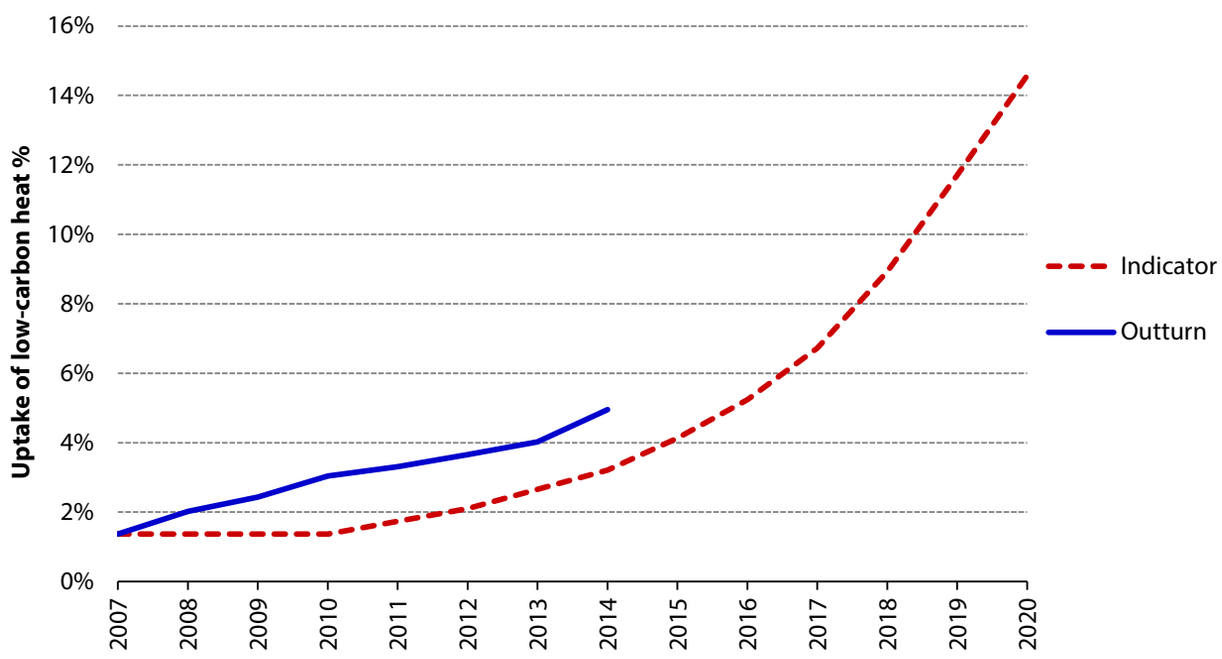
        - The Government is due to consult on a new reporting framework. It will be important that the new reporting framework maintains incentives, fills information gaps and raises the profile of energy efficiency (e.g. through board sign-off).

  - **Products Policy.** To improve the energy efficiency of machinery and equipment through EU regulated standards and labelling. The Government will need to consider product standards in the light of the vote to leave the EU, but manufacturers produce goods to sell across Europe, rather than solely for the UK market and the international nature of these markets will remain.
  - **Climate Change Agreements (CCAs).** Voluntary agreements that allow eligible energy-intensive sectors to receive up to 90% reduction in the CCL if they sign up to energy efficiency targets agreed with government. DECC estimate that the policy will not produce any additional savings beyond those attributed to 'products policy'. We have previously suggested that the current review of the 2020 targets should consider all possible cost-effective energy efficiency opportunities and tighten the CCAs accordingly.
  - **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. Policy therefore should encourage low-carbon CHP.
  - **Building regulations and Private Rented Sector regulations**. To improve the energy efficiency of buildings to a specified minimum standard. Industrial buildings are already covered to some degree by other policies (i.e. the CRC and CCAs). However, these policies do not cover the entire industrial building stock.
  - **Enhanced Capital Allowances (ECAs).** Companies can write off 100% of the cost of new energy saving plant or machinery against business taxable profits in the financial year the purchase was made.
  - **Energy Savings Opportunity Scheme (ESOS).** A requirement for all large businesses in the UK to undertake comprehensive assessments of energy use and energy efficiency opportunities at least once every four years. The extent to which they will lead to uptake of the most cost-effective measures identified remains uncertain. We have previously recommended that the Government should assess the case for enhancing the audits (e.g. through signposting to finance, follow-up support and benchmarking).

- **Low-carbon heat and use of bioenergy.** The Renewable Heat Incentive (RHI) encourages consumers to install renewable heating in place of fossil fuels.
  - Industrial uptake of low-carbon heat technologies has been in line with our indicators (Figure 4.7).
  - Funding of the RHI has now been agreed to 2021/22, and the government is proposing to include tariff guarantees to provide greater financial certainty on investment.
  - Over the next few years our indicator sets out an acceleration in low-carbon heat uptake which may 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.

We will report more fully on future low-carbon heat and energy efficiency options in industrial buildings in Autumn 2016, ahead of the Government's emission reduction plan (Chapter 3).

Figure 4.7. Industrial low-carbon heat uptake and trajectory (2007-2020)



Source: CCC analysis.

- **Industrial carbon capture and storage or use (CCS/U).** Industrial CCS is a key technology to meet the 2050 target:
  - A CCS commercialisation strategy would be an opportunity to coordinate a range of requirements including co-located industrial plant and power sector plant (Chapter 2).
  - Funding of £1m was awarded by the Government to the Teesside Collective, an industrial cluster, to develop a feasibility study on CO_2 capture, transport and storage from multiple sources in Teesside. This study suggested potential for an initial industrial cluster of four sites, including the Redcar steelworks, initially capturing 3 $MtCO_2$ per year.
  - Since publication of the feasibility study Redcar has closed. However, the report showed the feasibility of carbon capture, transport and storage from multiple sources within a cluster, and explored investment models and funding mechanisms.

There is a need for the Government to develop 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 (Chapter 2 for more discussion on CCS).

Based on the slow progress to date, the Government needs to closely monitor uptake of low-cost measures, commit to long-term funding of incentives (e.g. RHI), adapt the policy framework to overcome non-financial barriers and work with industry to strengthen incentives for measures with potential to significantly decarbonise industrial sectors to 2030.

4. Forward look and policy gap

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 assess policies that are adequately funded and are based on proven delivery mechanisms as "low risk"; we assess policies that are unfunded (or inadequately funded) or are based on unproven delivery mechanisms as "at risk". 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 fourth and fifth carbon budgets (to 2032).

The Government's progress in acting on our recommendations from last year's Progress Report has been limited, with no progress in some areas (Table 4.3).

Table 4.3. Progress against 2015 recommendations

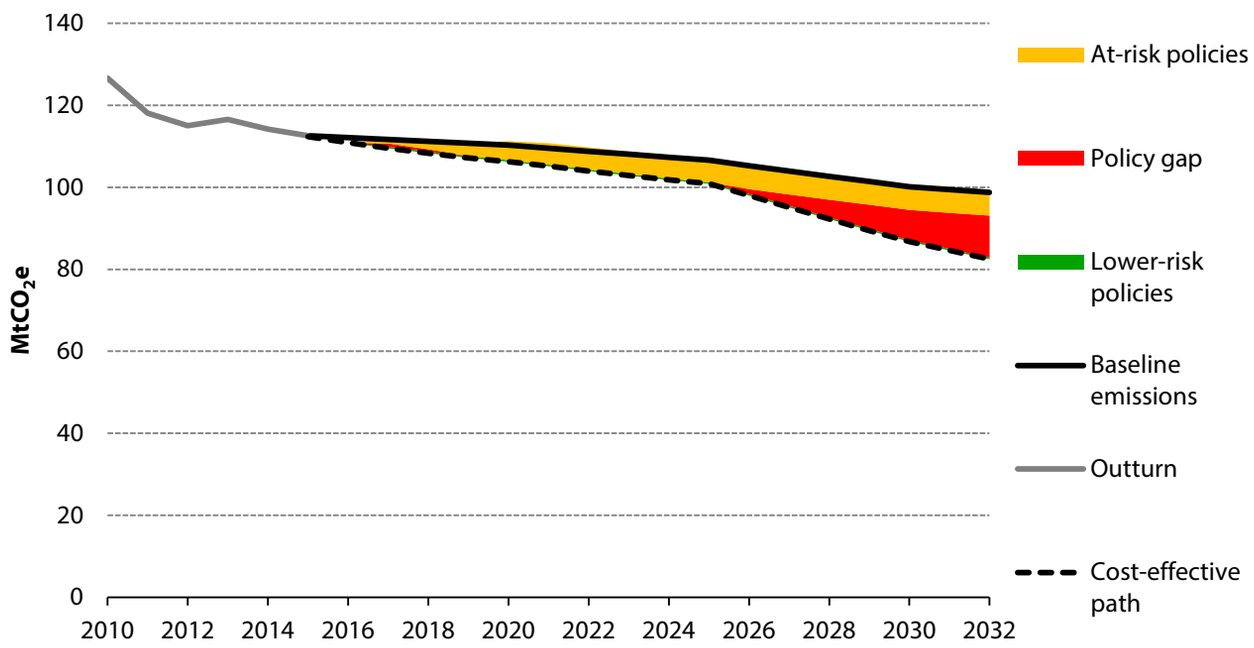
Recommendation in 2015	Assessment	Commentary
Develop joint work with industry into action plans: publish plans setting out specific actions and clear milestones to move abatement efforts forward along the paths developed with industry in the "Roadmaps".	No progress	Discussions with industry over action plans are still ongoing. These need to be completed, with short and long-term specific actions and clear milestones.
Complete roll-out of "Roadmaps" to other industrial sectors: taking account of lessons learned, roll-out roadmaps to industrial sectors not covered in first wave.	No progress	Government's response to this recommendation was that they are focussing on action plans for the first eight sectors.
Join-up industrial CCS with power sector projects: set an approach to commercialisation of industrial CCS alongside the approach adopted for the power sector, including ensuring industry can link into planned infrastructure.	Backward step	In November 2015 the Government cancelled the second CCS demonstration competition. No progress in developing an approach to power/industrial CCS.
Evaluate effectiveness of compensation to at-risk industries for low-carbon policies: independent evaluation of industries that are at-risk and effectiveness of the compensation framework.	No progress	No publication of evaluation of compensation scheme to date.

According to DECC's *Updated Energy and Emissions Projections*, industry direct emissions in the absence of policy would be 100 $MtCO_2e$ in 2030, falling to 94 $MtCO_2e$ when estimated savings of current and planned government policies are included. In our fifth carbon budget advice, we suggested that emissions could fall to 87 $MtCO_2e$ in 2030 to meet carbon budgets (Figure 4.8).

This leaves a gap of around 7 $MtCO_2e$ in 2030 which needs to be addressed to stay on the cost-effective path we have identified to meet carbon budgets. This gap comprises uptake of energy efficiency (4 $MtCO_2e$) and initial deployment of industrial CCS (3 $MtCO_2e$).

Not all policy savings are necessarily assured. We have assessed the risk associated with the policies in DECC's projections. While 0.4 $MtCO_2e$ is to be delivered by lower-risk policies, 6 $MtCO_2e$ savings are dependent on policies with design/delivery problems.

Figure 4.8. DECC industry emission projections risk assessment (2010-2032)



Source: DECC (2015) *Updated energy and emissions projections*; CCC analysis.
Notes: Cost-effective path includes an additional 1$MtCO_2e$ abatement in 2030 from biomethane injected into the natural gas grid.

We have identified three key areas where the policy framework is weak or there is no policy: larger energy efficiency projects, low-carbon heat (post-2020) and industrial CCS. The Government's industrial roadmaps project was an important first step towards identifying barriers to unlocking cost-effective abatement potential, but these now need to be translated into a delivery plan for an industrial low-carbon policy framework strong enough to support the level of investment required.

Our assessment of policies to drive abatement options in the industrial sector is shown in Table 4.4. This illustrates the areas where there is a gap in existing policy that needs to be filled in the Government's emission reduction plan. An effective plan will have addressed the gaps identified in the table as far as practically possible.

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

Abatement		2015 policy		Change	2016 policy
Energy efficiency		Red	Industrial roadmap action plans	Roadmap action plan discussions started	Red
		Amber	CRC, CCL, CCA, EU Products Policy tranche 1 & 2, ESOS, CHP, ECAs, Building regulations part L, Private rented sector regulations	Simplification - CRC to be replaced with higher CCL after 2018-19 with alternative reporting mechanism	Amber
Low-carbon heat and use of bioenergy	**To 2021**	Amber	RHI to 2015/16	RHI to 2021/22 & consultation on reforms	Amber
	After 2021	Red	No policy	-	Red
Industrial CCS		Red	Feasibility study at Teesside	Cancellation of commercialisation programme for power sector	Red

Source: CCC analysis.
Notes: Key - Red: Policy gap; Amber: Policy at risk; Green: Effective policy in place.

Chapter 5: Transport

Key messages and recommendations

Domestic transport is now the largest emitting sector, accounting for 24% of UK greenhouse gas emissions in 2015. Transport emissions increased in both 2014 and 2015. As demand for travel continues to grow, there is a need to decarbonise transport more rapidly to meet future carbon budgets. There is significant potential to reduce emissions through further efficiency improvements in conventional vehicles, switching to ultra-low emissions vehicles and changing travel behaviour.

The vote to leave the EU may impact on how emission reduction is delivered in the transport sector. A number of EU policies currently contribute to the cost-effective emissions trajectory. To meet the UK's domestic greenhouse gas target, it will be necessary to agree new arrangements or adapt existing ones, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU measures in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

The key messages of the chapter are:

- **Emissions trends**: Transport sector emissions increased by 1.4% in 2015. Emissions are increasing across all modes as demand increases outpace efficiency improvements and biofuel uptake.
- **New vehicle CO_2:** New car and van CO_2 emissions per kilometre have improved but more slowly than our indicator and there is evidence that the gap between real-world and test-cycle emissions has continued to grow. Little progress has been made in the key areas of agreeing targets for new cars and vans and developing CO_2 regulation for HGVs.
- **Electric vehicles**: Sales of electric vehicles (EVs) in the UK increased by 87% in 2015, continuing to outperform our indicator, although they made up only 0.9% of new car sales. The global outlook for EVs is increasingly positive, with battery costs falling more rapidly than previously anticipated and several governments and automotive manufacturers making public commitments to accelerate uptake.
- **Biofuels**: Uptake of biofuels decreased in 2015 to 2.5% by energy, from 3.2% in 2014, with average greenhouse gas savings broadly unchanged at 70%. This year the Government is expected to set policy to increase biofuel uptake to 2020. There is evidence of significant additional potential for uptake of sustainable, waste-derived biofuels.
- **Travel demand**: Whilst demand for car travel has increased it remains lower than the level predicted by Government models. Central funding for sustainable travel schemes has been extended to 2020 and the Government has published a walking and cycling strategy. More work is needed to assess the total funding and impact on emissions of public and active travel schemes across local authorities and the road and rail network.
- **Progress in developing policies**: Our recommendations for the transport sector in 2015 have been acted upon to a limited extent, with no progress in some areas. Emissions reductions from announced policies fall significantly short of our indicator by around 26 $MtCO_2$ in 2027.

Our key policy recommendations for the Government's emission reduction plan reflect the lack of progress in decarbonising the sector and the urgent need to develop a cohesive set of policies to reduce transport emissions (Table 5.1).

Key messages and recommendations

Table 5.1. Transport sector recommendations for the Government's emission reduction plan.

Domestic transport emissions should fall by around 43% between 2015 and 2030 and create options to allow near-zero emissions by 2050. This will require:	**New policy**	**Stronger implementation**
Stretching standards for new car and van CO_2 beyond 2020 that take account of the need for EVs (e.g. an average of 50 gCO_2/km for cars in 2030), are independently enforced and make use of real-world testing procedures. The tax regime should be aligned to these ambitions for efficiency improvement**.**	✖	
Policies to achieve a high uptake of EVs by 2030, of around 60% of new sales. This should include: support for upfront costs that drives innovation and declines over time until costs align with conventional vehicles; a national network of charge points; and roll out of local incentives such as preferential road access and free parking.		✖
Policy to deliver an increase in uptake of sustainable biofuels to around 8% by energy by 2020. This level should be maintained during the 2020s and increasingly derived from sustainable waste and advanced feedstocks with high lifecycle emissions savings.		✖
Policies to reduce emissions from HGVs, including vehicle efficiency improvements based on "real-world" testing, driver training, more efficient logistics and modal shift to rail. Ultra-low emission HGV technologies, such as electric and hydrogen options, should be developed for deployment to begin by around 2030.	✖	
National and local policies to reduce demand, sufficient to deliver car-km reductions of around 5% below the baseline trajectory, including through shifts to public transport, cycling and walking.	✖	✖
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.
Notes: In some areas there are elements of new policies needed and elements needing stronger implementation of existing policies – in these cases both columns are checked. In all cases policies will need to be strongly implemented, both new and existing.

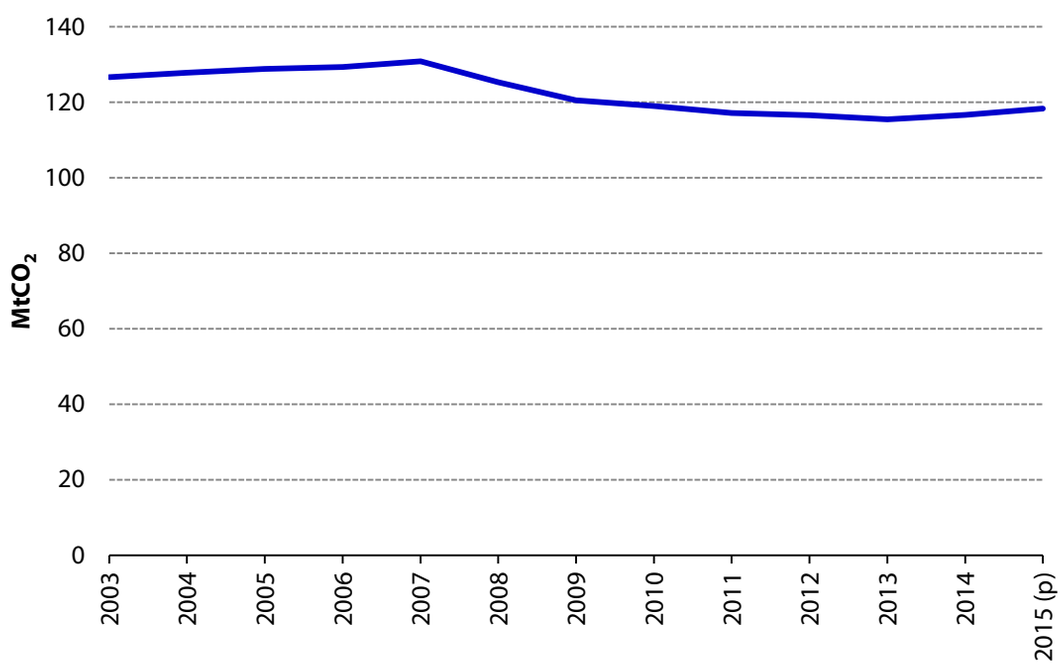
We set out the analysis in the following sections:

1. Trends in transport emissions
2. Progress in decarbonising surface transport
3. Progress in changing travel behaviour
4. Progress in reducing emissions from aviation and shipping
5. Forward look

1. Trends in transport emissions

Domestic transport CO_2 emissions for 2015 are provisionally estimated to be 118 $MtCO_2e$, accounting for 24% of total UK greenhouse gas (GHG) emissions. This is an increase of 1.4% relative to 2014, leaving emissions slightly above 2011 levels (Figure 5.1).

Figure 5.1. Domestic transport CO_2 emissions to 2015



Source: DECC (2016).

More detailed data on transport are available for 2014, providing a breakdown between emissions from different GHGs and different modes of transport[1]:

- In 2014, CO_2 emissions accounted for 99% of total transport GHG emissions.
- Surface transport CO_2 accounted for 95% of domestic transport emissions, with the remaining 5% being due to domestic aviation and shipping.

We now consider emissions from surface transport and from aviation and shipping.

[1] We use data from the National Atmospheric Emissions Inventory (NAEI), published by DECC, which is based on sales of different fuels allocated according to modelled estimates of activity for different modes of transport.

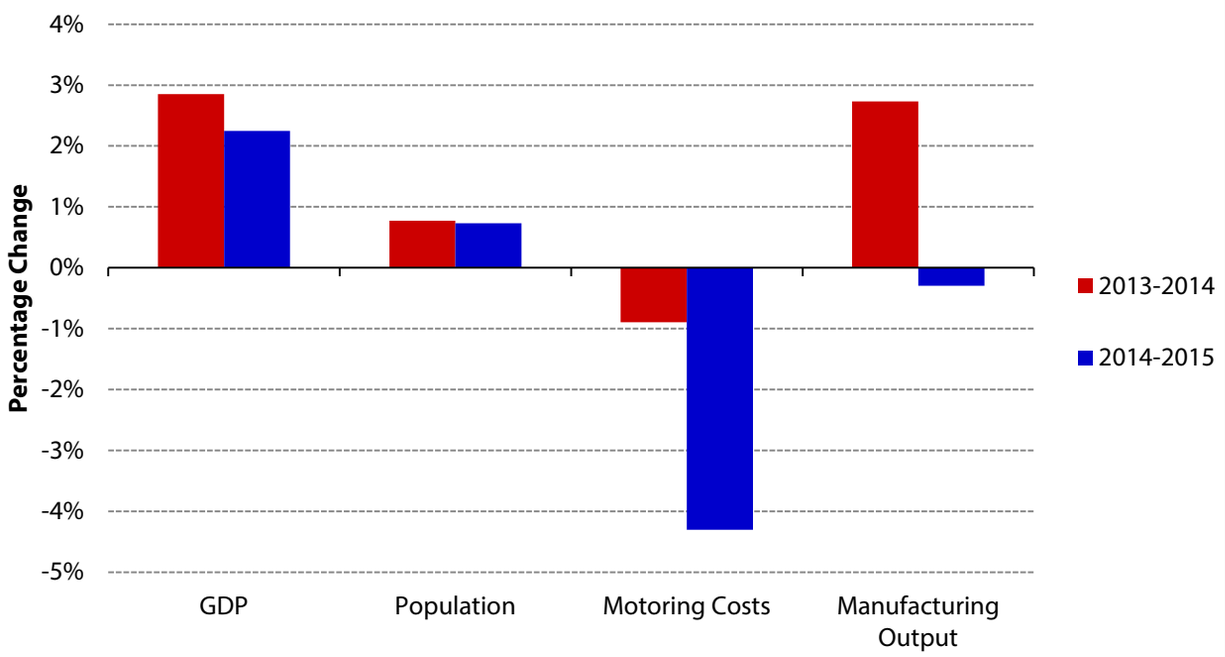
Surface transport emissions

Whilst some measures are in place to reduce the CO_2 intensity of surface transport, the reductions achieved in recent years have been smaller than anticipated and offset by rising demand for travel. Looking forward, the Government projects further increases in demand, though there is uncertainty over the level. There is also uncertainty over the extent to which existing polices will deliver real-world reductions in CO_2 intensity. The policies required to reduce emissions from transport are considered in section 2.

Economic context

Historically, changes in demand for road transport have largely been driven by factors such as income, population and motoring costs. In 2014 all of these economic drivers moved to increase demand for travel. GDP and population changes also supported increased demand in 2015, while manufacturing output fell slightly. The most significant change in 2015 was a sharp decline in motoring costs, primarily driven by a 13% fall in the cost of petroleum and oil (Figure 5.2).

Figure 5.2. Key economic indicators



Source: CCC calculation based on figures from the Office for National Statistics and DfT (2015) *Transport Statistics Great Britain.*

The Government's decision to freeze fuel duty since 2010/11 has contributed to a reduction in real motoring costs. We estimate that this freeze has increased annual traffic and associated

emissions by 1.5-2.5% compared to a scenario in which fuel duty was increased in line with pre-2010 plans.[2]

Whilst these economic drivers continue to play a role in determining demand for travel, there is evidence that the relationships have weakened in recent years, particularly for car travel. Understanding these drivers in more detail will help to improve the Government's forecasts of travel demand, which inform the required scale of future emissions reductions (Box 5.1).

Box 5.1. Forecasts of demand for travel

The National Transport Model (NTM) is one of the tools used by the Government to forecast demand for travel. These forecasts are also used to inform the Government's and the Committee's baseline emissions projections. Previous forecasts from the NTM have overestimated demand for car travel but the Department for Transport (DfT) has developed a new approach to forecasting, with more significant updates to the NTM planned in future:

- Previous forecasts from the NTM have tended to overestimate overall traffic in Great Britain. DfT has undertaken a programme of work to improve understanding of the changing trends in travel demand but the results are complex and difficult to factor into forecasts.
- DfT now uses a scenario-based approach to forecasting to reflect the uncertainty in future travel behaviour. In practice, DfT's 'Scenario 1', which has the highest demand of the three scenarios, is used as a central scenario for the Government emissions projections. We also take the conservative approach of using this higher demand projection for our central emissions scenario.
- Scenario 1 predicted an 11% increase in car travel demand between 2010 and 2015, against an outturn increase of 3%. This suggests that the underlying behavioural assumptions in this scenario do not accurately reflect current travel behaviour. Estimates of van and HGV travel demand perform better against outturn data.
- DfT is carrying out a review of the NTM performance and has an ongoing programme to improve its modelling capability and evidence base, which will feed into the next set of road traffic forecasts.

It is important that projections of demand reflect the latest evidence on travel behaviour. We welcome efforts to improve the NTM.

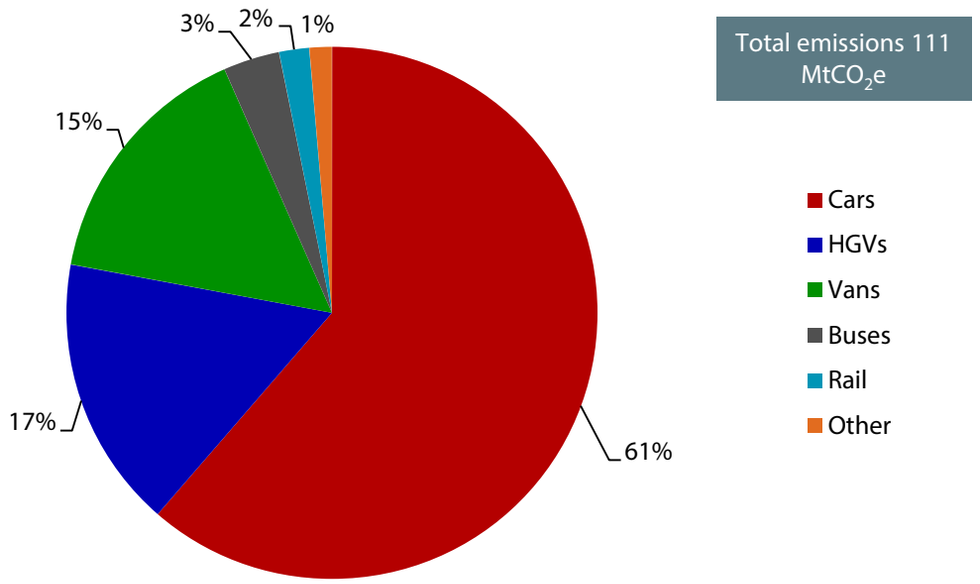
Source: Campaign for Better Transport (2015) *Small steps to better forecasts and transport models*; DfT (2015) *Understanding the drivers of road travel*; DfT for CCC (2015); DfT (2015) *Road Traffic Forecasts.*

[2] The Government estimates that this has saved motorists £75 per year compared to pre-2010 plans for fuel duty (Budget 2016) and we assume a travel demand elasticity of 0.2-0.3 for fuel costs. This does not include the impact of lower fuel costs on vehicle purchase decisions.

Surface transport emissions trends

Within surface transport 98% of emissions come from road transport with the remainder coming from rail and various other non-road transport vehicles (Figure 5.3).

Figure 5.3. Surface transport CO_2 emissions by mode in 2014

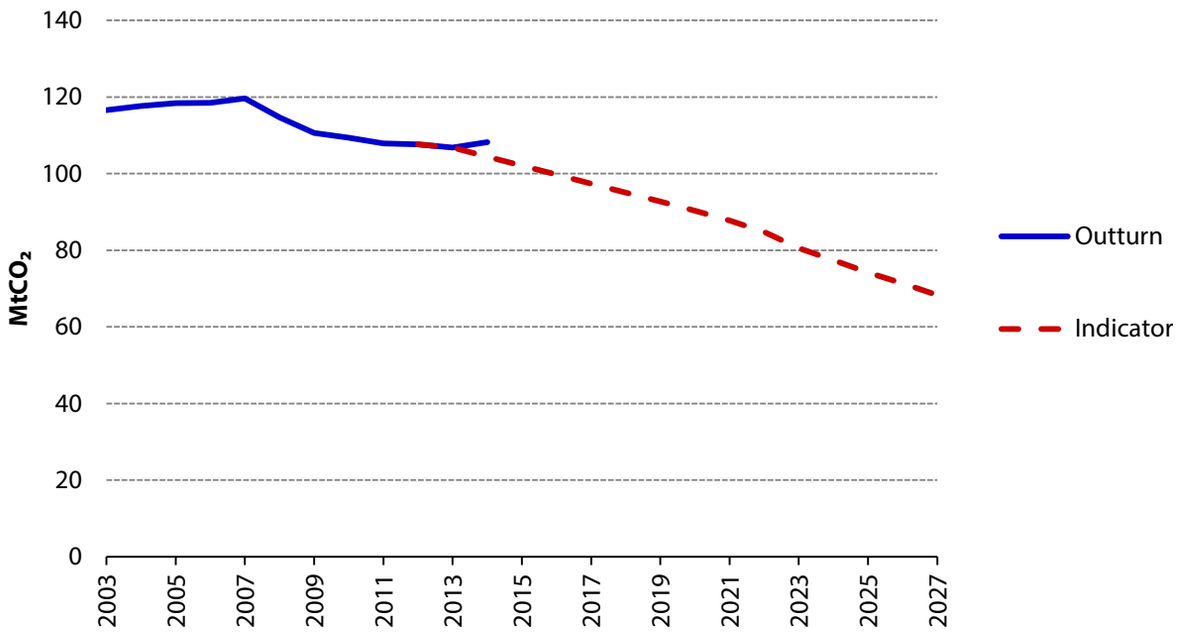


Source: DECC (2016).
Notes: 'Other' includes motorcycles, liquefied petroleum gas fuelled vehicles, aircraft support vehicles and other road vehicle engines.

In 2014, road transport emissions increased by 1.3% against a 2% decrease[3] in our indicator for road transport emissions based on our previous assessment of the cost-effective path to the 2050 target[4] (Figure 5.4).

[3] The average annual decrease in emissions to 2030 is about 4% under our cost-effective path.
[4] CCC (2013) *Fourth carbon budget review.*

Figure 5.4. Road transport CO_2 emissions against CCC indicator (2003-2027)



Source: DECC (2016); CCC analysis.

Official data are not yet available for road transport emissions in 2015, but it is possible to estimate emissions using data on sales of petrol and diesel. These data suggest that road transport emissions may have increased by around 2% in 2015. The continued growth in road transport emissions is a concern and highlights the urgent need for stronger policies to bring forward vehicles with lower real-world emissions and to moderate growth in demand for travel.

We now examine the three most significant sources of surface transport emissions; cars, vans and HGVs. The methodology for estimating emissions from these different modes has been updated in the latest official statistics[5] to allow for a greater gap between real-world and test-cycle emissions for cars and vans (Box 5.2), an issue that has been highlighted by the Committee in previous reports.[6] The implication of this revision is that car and van efficiency have not been improving as rapidly as previously assumed. The revision should re-focus efforts on urgent reform to car and van testing procedures and development of stretching post-2020 new vehicle CO_2 targets.

[5] Referred to hereafter as "2016 statistics".
[6] See, for example, CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget.*

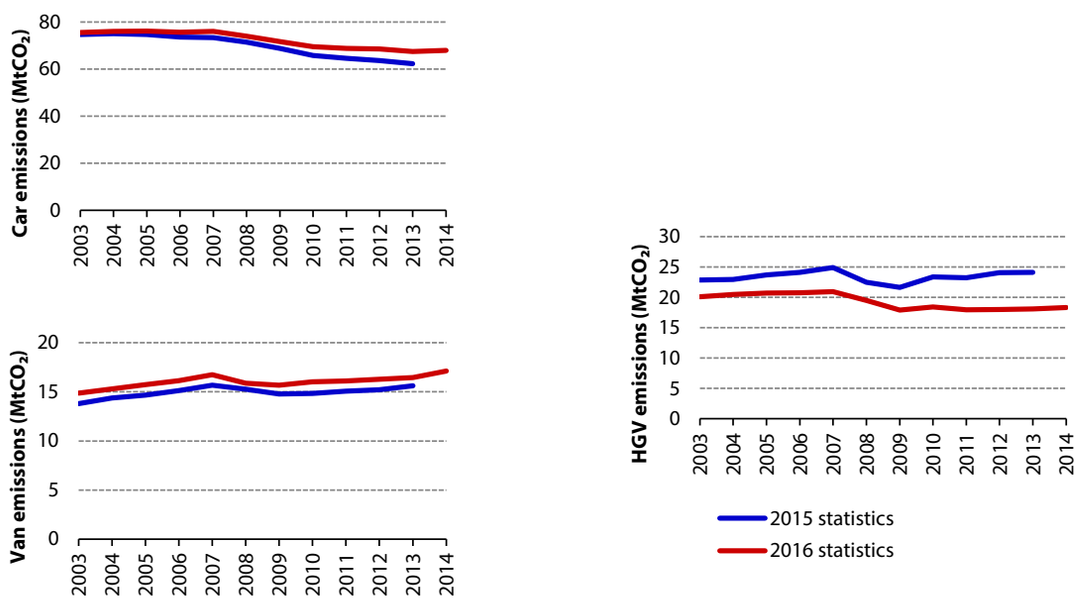
Box 5.2. Revisions to historical road transport emissions statistics

The methodology used to estimate emissions from the different road transport modes has been revised to better reflect the widening gap between real-world and test-cycle emissions for cars and vans:

- Estimates of overall road transport emissions are unchanged as they are based on total sales of petrol and diesel. However, the split between cars, vans and HGVs has been revised. Estimates of car and van emissions have been revised up and HGV emissions down (Figure B5.2).
- The updated methodology is based on the latest guidelines from the EU, which uses a CO_2 correction formula derived from analysis of a database of real-world fuel consumption.
- Our initial analysis suggests that this revision leaves the potential to reduce emissions from road transport by 2030 broadly unchanged, as increases in baseline car and van emissions are largely offset by lower HGV emissions. However, the revisions need to be properly factored into emissions projections in the National Transport Model in order to fully understand their impact.

The revisions have implications for policy. They demonstrate that car and van efficiency has not been improving as rapidly as previously assumed. This means that it is essential to re-focus efforts on reforming car and van testing procedures and developing stretching post-2020 new vehicle CO_2 targets.

Figure B5.2: Car, van and HGV emissions statistics from the 2015 and 2016 publications



Source: DECC (2015); DECC (2016)

Source: DECC (2015); DECC (2016); EEA (2013) *EMEP/EEA air pollutant emission inventory guidebook.*
Notes: Real-world fuel consumption based on analysis of data from Spritmonitor: http://www.spritmonitor.de/

Car emissions

Emissions from cars increased by 0.8% in 2014, compared to a 2% decrease in our indicator, as demand increased more rapidly than the decrease in CO_2 intensity (Figure 5.5):

- Car-km increased by 2.1% in 2014, with a further increase of 1.1% in 2015. The increases are nevertheless smaller than might have been expected given changes in the economic factors conventionally thought to influence travel demand (Box 5.1).
- Data on emissions and car-km imply that average car CO_2 intensity fell by 1.2% in 2014, compared to a 3.3% decrease in our indicator. Data on test-cycle CO_2 and biofuel uptake suggests the fleet average CO_2 intensity should have fallen by around 2.4% in 2014, indicating that test-cycle improvements are not being realised in the real-world.

Van emissions

Van emissions increased by 3.9% in 2014, against a decrease of 0.4% in our indicator. Demand is increasing very rapidly, with slow reductions in CO_2 intensity (Figure 5.6):

- In 2014, there was an increase of 5.7% in van-km. This has been part of a longer-term trend, which continued in 2015 with a further increase of 4.3%.
- The fleet average CO_2 intensity for vans fell by 1.7% in 2014, compared with a 3.1% decrease in our indicator.

HGV emissions

In 2014, HGV emissions increased by 1.3%, against a 4.4% decline for our indicator. There was a slight improvement in CO_2 intensity, offset by an increase in HGV-km (Figure 5.7):

- In 2014, there was an increase of 2.8% in HGV-km, with a further increase of 3.5% in 2015.
- Data on emissions and HGV-km imply that average HGV CO_2 intensity fell by 1.5% in 2014, as against a decrease of 4.7% in our indicator.

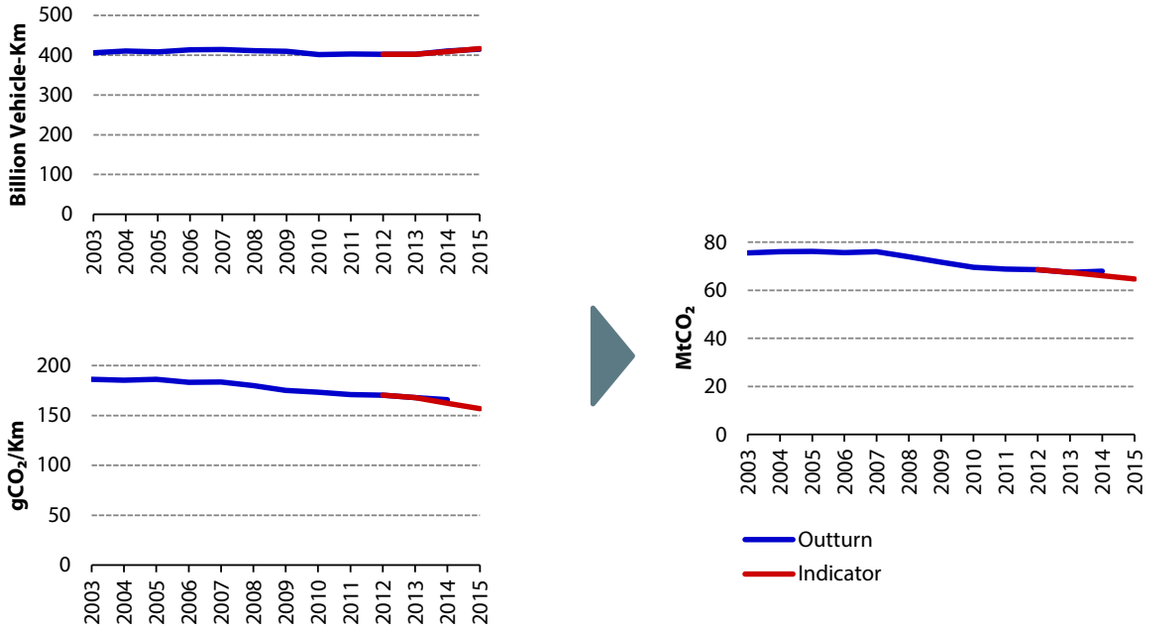
The fall in CO_2 intensity between 2013 and 2014 was primarily driven by improvements in vehicle efficiency, with the increase in biofuel uptake playing a secondary role (Table 5.2).

Table 5.2. Drivers of vehicle CO_2 intensity

Mode	Total change in CO_2 intensity in 2014	Change due to efficiency of the fleet	Change due to biofuels uptake
Cars	-1.2%	-0.9%	-0.3%
Vans	-1.7%	-1.1%	-0.5%
HGVs	-1.5%	-0.9%	-0.6%

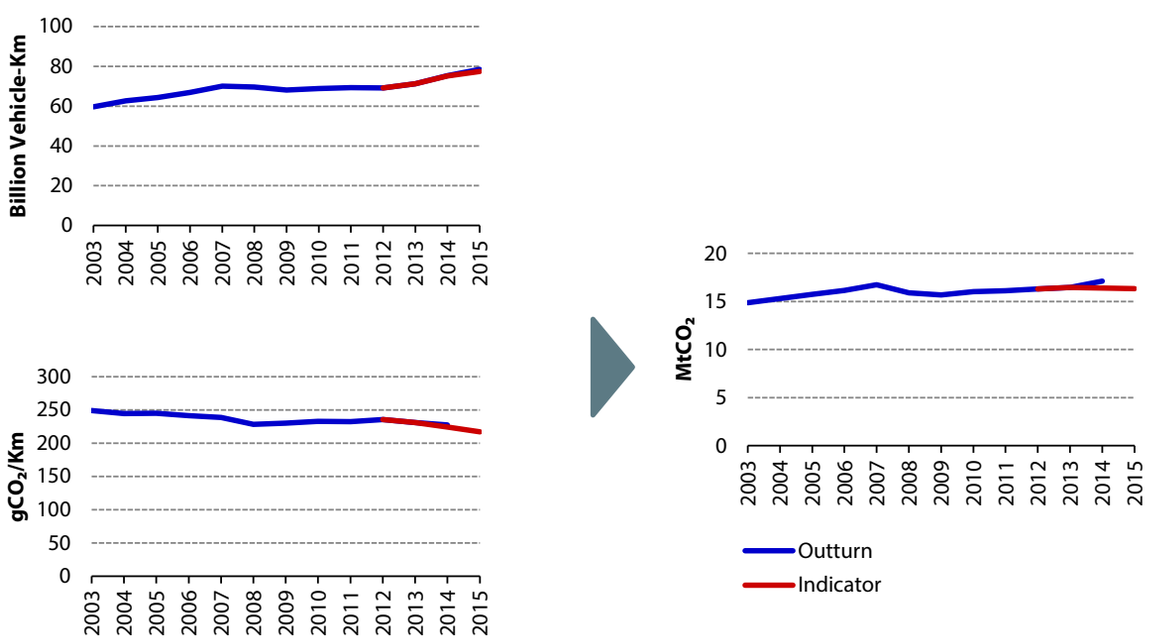
Source: CCC analysis.
Notes: CCC calculations based on data from DECC, the HMRC Hydrocarbon Oils Bulletin and SMMT.

Figure 5.5. Car emissions to 2014 / Car-km to 2015 / Car CO_2 intensity to 2014 against CCC Indicator



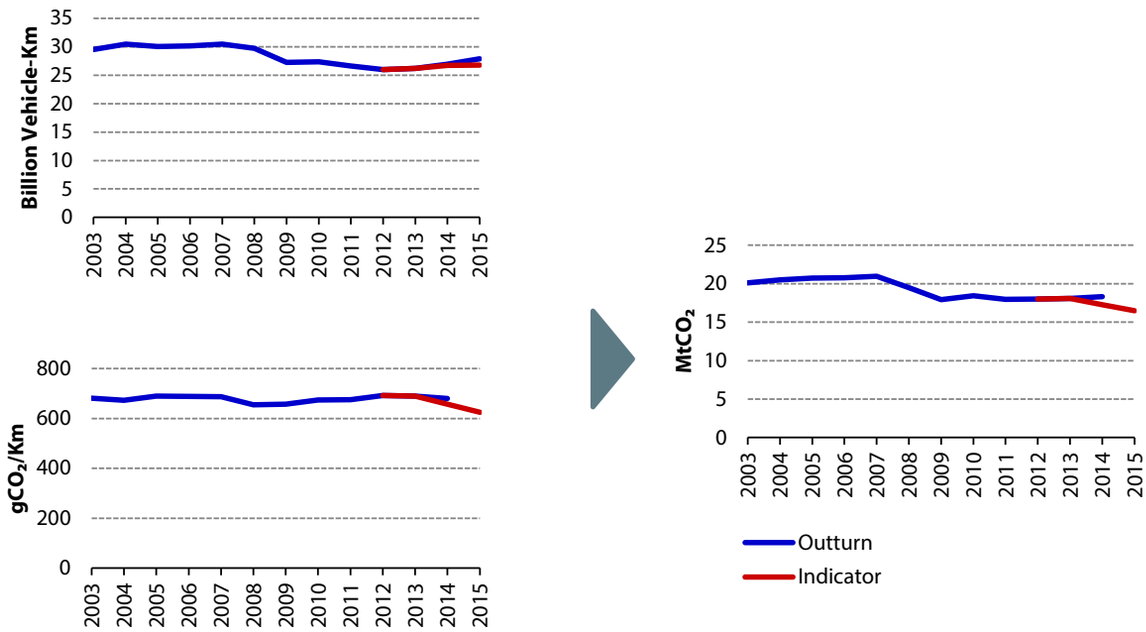
Source: DECC (2016); DfT (2016) *Road Traffic Statistics*; CCC analysis.

Figure 5.6. Van emissions to 2014 / Van-km to 2015 / Van CO_2 intensity to 2014 against CCC Indicator



Source: DECC (2016); DfT (2016) *Road Traffic Statistics*; CCC analysis.

Figure 5.7. HGV emissions to 2014 / HGV-km to 2015 / HGV CO_2 intensity to 2014 against CCC Indicator



Source: DECC (2016); DfT (2016*) Road Traffic Statistics*; CCC analysis.

Other surface transport modes

Emissions from buses and rail are covered in the Technical Annex.

Aviation and shipping emissions

Aviation

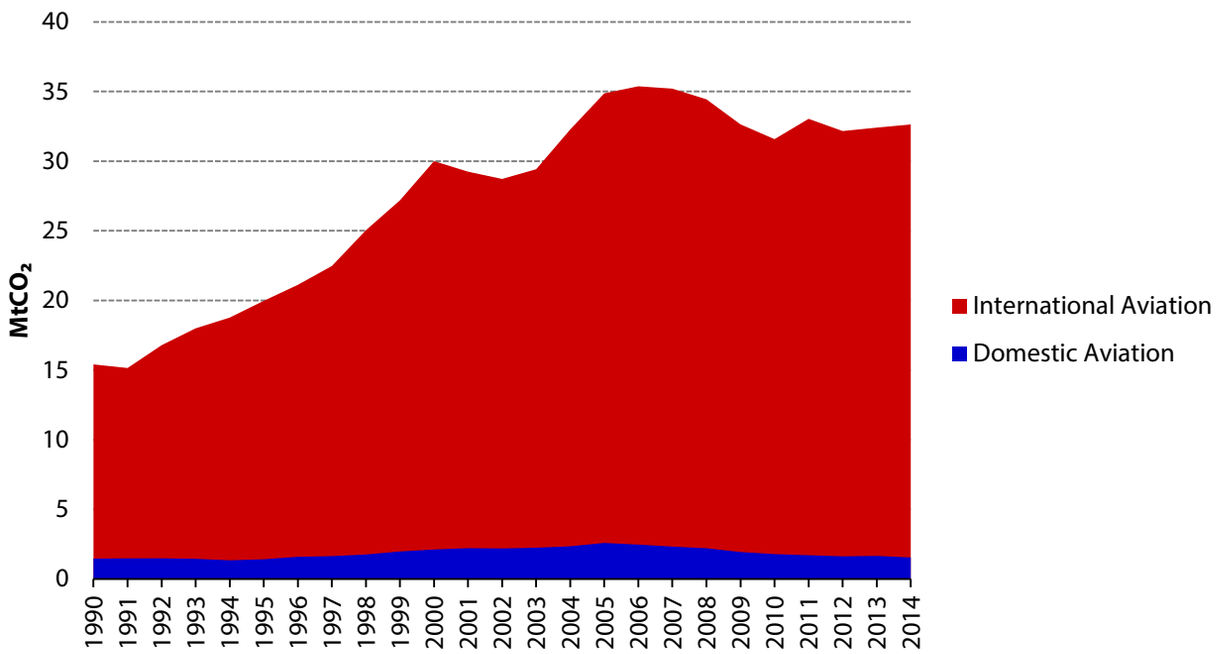
Total domestic and international aviation emissions remained broadly the same in 2014 compared to 2013 (34.2 MtCO2 compared to 34.0 Mt). Emissions have also been broadly flat in the period 2009 to 2014 (Figure 5.8).

- Domestic emissions decreased in 2014 by 7% to 1.5 $MtCO_2$.
- International emissions (which represent 95% of total aviation emissions and are not formally included in carbon budgets) increased in 2014 by 0.7% to 32.6 $MtCO_2$.

In 2014 passenger demand rose by 4.4% and the number of flights increased by 1.4%. The fact that emissions rose only 0.3% 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 plane increased by 3%), improved fuel efficiency of aircraft, and/or changes in the route mix towards closer destinations.

A further set of tracking and monitoring indicators for aviation can be found in the Technical Annex.

Figure 5.8. UK Aviation Emissions (1990-2014)



Source: DECC (2016).

Shipping

Total domestic and international shipping emissions decreased by 6.5% in 2014 to 9.9 $MtCO_2$, from 10.6 Mt in 2013. This is in line with the trend in recent years, where emissions fell 6% on an average annual basis between 2009 and 2014 (Figure 5.9).

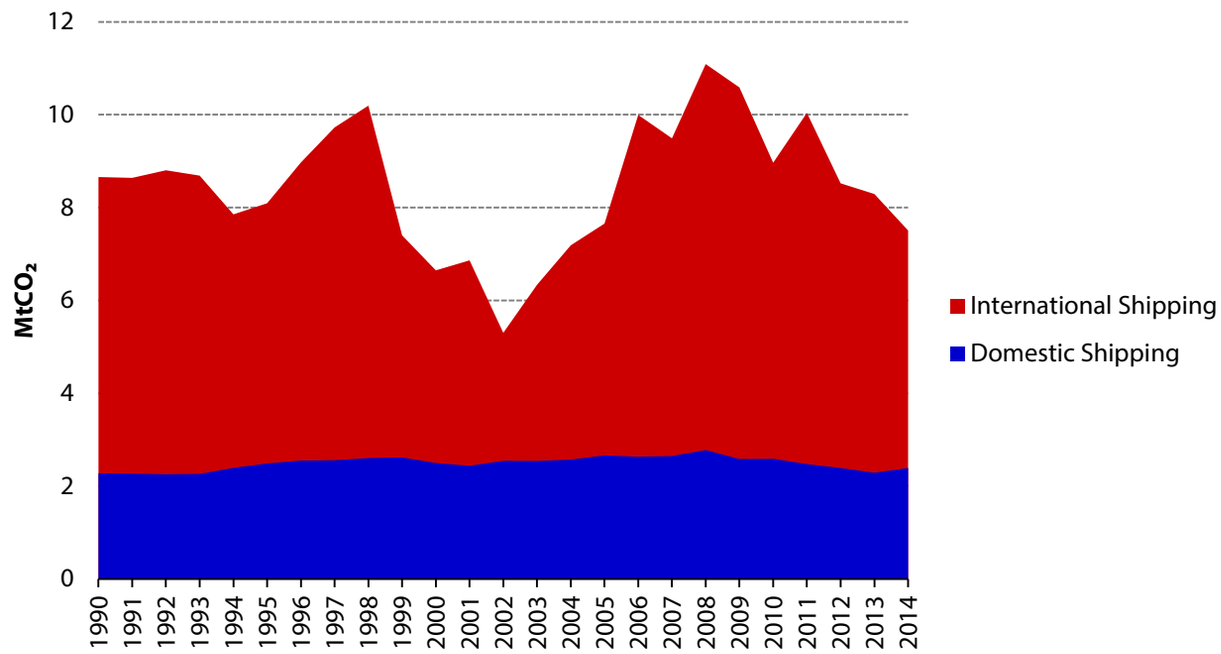
- Domestic emissions increased by 4.5% in 2014 to 2.4 $MtCO_2$.
- International emissions (not formally included in carbon budgets) fell by 9.5% in 2014 to 7.5 $MtCO_2$.

Total demand for UK shipping[7] remained broadly flat in 2014. However, the number of ship movements increased by 2% and average size of ships decreased by 2%, both of which would tend to suggest an increase in emissions. This therefore suggests other factors were responsible for the fall in emissions. For example these could include falling ship speeds, improvements in the fuel efficiency of ships, and changes in bunkering patterns (e.g. taking on more fuel at ports outside the UK, which therefore would not be recorded towards UK emissions).

A further set of tracking and monitoring indicators for shipping can be found in the Technical Annex.

[7] Measured as tonne-km of UK imports and domestic shipping.

Figure 5.9. UK Shipping Emissions (1990-2014)



Source: DECC (2016).

2. Progress in decarbonising surface transport

In this section we consider progress in developing options for decarbonising surface transport in the UK, which include conventional vehicle efficiency, ultra-low emission vehicles (ULEVs)[8], such as electric vehicles, and biofuels. Measures to change travel behaviour are considered in Section 3.

Many current policies to decarbonise surface transport in the UK, such as new vehicle standards and targets for renewable fuel uptake, are based on EU directives. The UK's vote to leave the EU will change the future impact of these policies in the UK. The extent of the change is highly uncertain at present. For example, whilst the UK may not be directly subject to future EU new vehicle standards, the market for vehicles is Europe-wide and vehicles sold in the UK may need to meet these standards. To meet the UK's domestic emission reduction commitment it will be necessary to agree new arrangements or adapt existing ones, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU measures in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

[8] Ultra-Low Emission Vehicles include battery electric vehicles, plug-in hybrid vehicles and fuel cell vehicles.

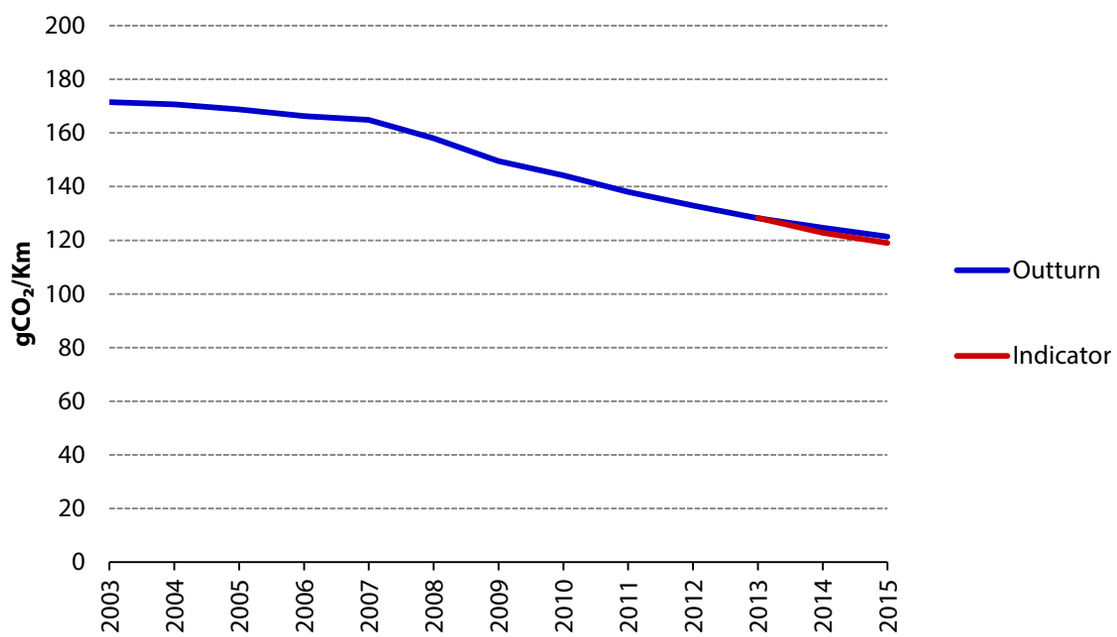
Progress in improving conventional vehicle efficiency

Cars and vans - Progress to date

EU regulations on average CO_2 intensity have been in place for new cars since 2009 and for new vans since 2011. For cars, there are targets in place for 2015 (130 gCO_2/km) and 2020/21 (95 gCO_2/km). For vans, the targets are for 2017 (175 gCO_2/km) and 2020 (147 gCO_2/km). The regulations apply to the average of a manufacturer's fleet of new cars and vans sold in the respective year.

New cars sold in the UK in 2015 had an average test-cycle CO_2 intensity of 121.4 gCO_2/km, a decrease of 2.6% since 2014 (Figure 5.10). The average CO_2 intensity of new vans was 179.3 gCO_2/km in 2015, a decrease of 1.4% since 2014.

Figure 5.10. Test-cycle new car CO_2



Source: SMMT (2016) *New car CO2 report 2016*; CCC analysis.

There were improvements in test-cycle CO_2 intensity across all car segments in 2015, although the most significant reductions were for dual-purpose cars, such as Sports-Utility Vehicles (SUVs), which have continued to grow in popularity. A more detailed analysis by segment can be found in the Technical Annex.

Whilst reductions in test-cycle emissions are positive, there is evidence of a growing gap between test-cycle emissions and those achieved in real-world driving conditions, implying smaller reductions in gCO_2/km on the road (Box 5.3). We cover our recommended approach to dealing with this problem in the next section.

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

Real-world emissions

Evidence has continued to emerge that there is a large and growing gap between test-cycle and real-world emissions for new cars:

- The latest evidence suggests that real-world emissions from new cars in the EU in 2014 were around 40% higher than emissions as measured on the official New European Driving Cycle (NEDC) test-cycle, up from 24% in 2010.
- Renault and Citroen published CO_2 intensity figures for a sample of their vehicles using a new protocol similar to the Real Driving Emissions (RDE) test procedure, in which a Portable Emissions Measurement system is attached to the vehicle exhaust while it is driven on real roads. The results were between 36% and 56% higher than the official NEDC values.

Reform of the test procedure

The NEDC is due to be replaced with the Worldwide harmonised Light vehicle Testing Procedure (WLTP) from September 2017. There is evidence that the WLTP alone will not fully close the gap, but there are options to further reform the testing procedure:

- In 2015 we commissioned a study to estimate the impact of introducing the WLTP. This found that introduction of the WLTP would narrow the gap to around 23%.
- The study also found that the gap could be reduced to around 5% if CO_2 was tested using the RDE procedure and enforced by an independent testing authority.
- In 2016, the European Commission published a proposal to increase independence of testing authorities.

Source: ICCT (2015) *Laboratory to road: A 2015 update* https://www.transportenvironment.org/news/first-real-world-car-co2-results-show-gap-56; Element Energy and the ICCT (2015) *Quantifying the impact of real-world driving on total CO2 emissions from UK cars and vans*; EC (2016) *Car industry: European Commission tightens rules for safer and cleaner cars.*

Cars and vans - Forward look

Regulation to 2020

New car CO_2 intensity will need to fall at an average annual rate of 4.8% between now and 2020 to reach an average of 95 gCO_2/km. To meet the 2020 target for vans, CO_2 intensity will need to fall at an average annual rate of 3.9%. Reductions at this level would be a step change in the rate of improvement, but evidence suggests that manufacturers could meet the targets:

- Progress to date is ahead of schedule, with both new car and new van CO_2 outperforming the 2015 and 2017 targets.
- There are stiff penalties for failure to comply with the targets.[9]
- There is evidence[10] that existing technology can be deployed to meet the target and that the capital costs of such measures would be lower than the lifetime fuel savings achieved through increased efficiency from a social perspective.[11]

[9] Penalties are currently €5 for exceeding the first g/km, €15 for the second g/km, €25 for the third g/km, and €95 for each subsequent g/km. From 2019, the cost will be €95 from the first gram onwards.

Post-2020 regulation

The European Commission is in the process of developing post-2020 targets for new car and van CO_2. Options will be set out in the Commission's 2030 transport strategy later this year. Given the vote to leave the EU, the extent to which the UK participates in this process is uncertain. However, UK domestic requirements to reduce emissions from transport will require measures that deliver similar outcomes - whether or not they are the same as the ones the EU will choose. Therefore, we consider here what the EU measures are likely to involve.

It is likely that emissions reductions to 2020 will be delivered mainly through continuing efficiency improvements in conventional vehicles. Beyond 2020, take-up of electric vehicles and other ULEVs will be increasingly important to reduce emissions:

- Our analysis has identified scope to reduce test-cycle CO_2 intensity to 86 gCO_2/km for conventional cars and 127 gCO_2/km for conventional vans by 2030.[12]
- These conventional efficiency improvements together with uptake of plug-in hybrid and battery electric vehicles could result in average test-cycle emissions in 2030 of around 50 gCO_2/km for new cars and 60 gCO_2/km for new vans.
- If it proved more challenging to achieve real-world efficiency improvements in conventional vehicles, similar emissions reductions could be achieved by a more rapid shift to electric vehicles.

The market for cars and vans is Europe-wide: manufacturers produce vehicles to sell across Europe, rather than develop models solely for the UK market. That is unlikely to change with the vole to leave because of the size of the economies of scale in car production. Therefore, the degree of EU ambition for new vehicles in 2030 is likely to affect the ability of the UK to achieve its domestic targets. That would suggest it continues to be important that the UK pushes for stretching EU targets for new car and van emissions in 2025 and 2030. Moreover, in deciding what level of target to support, it is important to recognise the need to achieve increasing uptake of electric vehicles and other ULEVs through the 2020s to be on track to a near-zero emission car and van fleet by 2050. If leaving the EU reduces the impact of these targets on emissions from UK cars and vans, the Government will need to develop additional domestic policies to achieve this level of abatement.

The recent historical revision to car and van emissions estimates (Box 5.2) has highlighted the lack of real-world progress in improving efficiency and the urgent need to reform testing procedures. The introduction of the new WLTP testing procedure provisionally agreed for 2017 should ensure a closer match between test-cycle and real-world emissions, but uncertainty over the size of the gap in future poses a risk to meeting longer term emissions reduction objectives. Given these risks, new car and van CO_2 targets should be tested with the more stringent Real Driving Emissions (RDE) procedure, alongside the introduction of more independent testing authorities across Europe:

- Data on new vehicle CO_2 emissions will be recorded as part of the RDE-based air pollution tests due to be launched in 2017. As a first step, this CO_2 data could be published alongside

[10] Ricardo Energy and Environment for the European Commission (Forthcoming) *Improving understanding of technology and costs for CO2 reductions from cars and LCVs in the period to 2030 and development of cost curves.*
[11] Using the social cost of fuel, which excludes fuel taxes.
[12] Tested using the WLTP test-cycle.

data on air pollutant emissions from 2017 at negligible additional cost in order to more effectively monitor real-world CO_2 emissions from new vehicles.[13]

- If these measurements prove to be reliable, the UK should consider setting 2025 and 2030 new car and van CO_2 targets using an RDE-based emissions limit to ensure that real-world emissions fall as intended. This should complement, rather than replace, more easily repeatable lab-based tests using the WLTP, which may still be needed to ensure comparability between vehicles.
- These targets should be enforced by independent testing authorities, with powers to conduct random in-use emissions tests and fine non-compliant manufacturers.

Notwithstanding the decision to exit the EU, the UK should push the European Commission to adopt this approach to new car and van testing as soon as possible. The UK may also have to decide whether it participates in this EU process or whether it sets up its own process given the vote to leave.

Fiscal measures

Countries with strong national policies complementing EU regulations have achieved greater improvements in average new vehicle CO_2. Fiscal measures could become increasingly important to help meet carbon budgets if future EU regulations are insufficient to deliver the real-world emissions reductions required in the UK or if needed as a substitute for grant funding to achieve higher uptake of ULEVs.

The UK has a number of fiscal measures in place alongside fuel duty aimed at encouraging purchase of more efficient vehicles:

- **Vehicle Excise Duty (VED)**: Since 2001 VED rates have been differentiated according to CO_2 intensity (gCO_2/km). In the 2015 Summer Budget, the Government announced a reform to VED starting in 2017, including new rates introduced below 100 gCO_2/km and higher first-year rates for higher emitting vehicles. However, CO_2 banding has been effectively removed for subsequent year rates, with a standard rate of £140 for all but zero-emission vehicles. The new system provides a relatively small incentive to purchase a ULEV and for buyers who consider the total cost of owning the vehicle over several years, incentives to purchase a lower-emitting vehicle could be lower than under the previous system (Box 5.4).
- **Company Car Tax (CCT)**: CCT has five differentiated rates below 100 gCO_2/km, including a band for zero emission vehicles. Rates have been announced out to 2020 and are set to gradually increase for lower emitting vehicles.
- **Enhanced Capital Allowance (ECA)**: In the 2016 Budget, the ECA scheme was extended to 2021. Currently, cars emitting less than 75 gCO_2/km are entitled to a 100% allowance and this threshold will fall to 50 gCO_2/km from 2018.

The Government has committed to review both VED and CCT rates to ensure they continue to incentivise the lowest emitting vehicles. The market for ULEVs is evolving rapidly and a more dynamic tax regime with stronger CO_2 banding could help to accelerate uptake, as it has in other countries (Box 5.4). We therefore recommend that the Government reviews VED and CCT rates immediately to ensure they are aligned to the UK's ambitions for higher ULEV uptake. The rates should be reviewed on an annual basis to ensure the tax regime keeps pace with technological change.

[13] Element Energy and the ICCT (2015) *Quantifying the impact of real-world driving on total CO_2 emissions from UK cars and vans.*

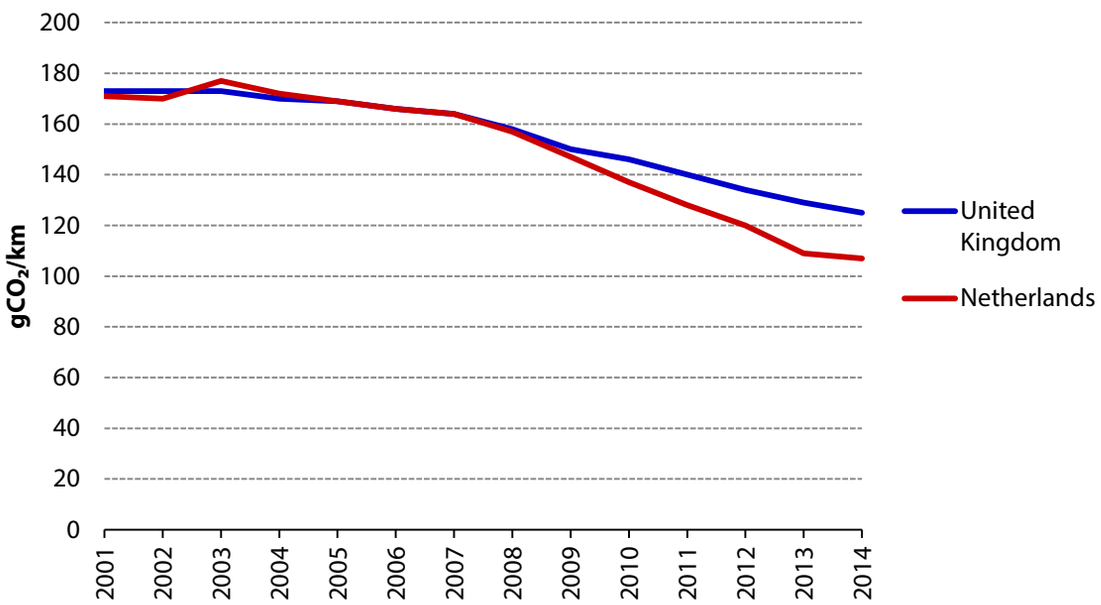
Box 5.4. Reforms to Vehicle Excise Duty

The Government announced a reform to VED in the 2015 Summer Budget. The overall CO_2 banding does not strongly differentiate between bands and when considered over a number of years the new system reduces incentives for low emission vehicles. Evidence from the Netherlands suggests stronger differentiation in CO_2 banding can have a significant impact on purchasing decisions:

- **The new VED system could provide lower incentives for ULEVs** compared to the previous system, depending on how much first year costs are weighted (Technical Annex). Some buyers consider cost of ownership over a longer period. This is particularly the case for fleet buyers, who make up around 60% of new car sales.
- **There is little differentiation of VED rates between lower emission bands. VEDs rates only increase significantly for CO_2 bands above 150 gCO_2/km.** Below 100 gCO_2/km, VED rates increase on average by £1 for every extra 1 gCO_2/km. Between 150 gCO_2/km and 200 gCO_2/km this differentiation increases to around £20 for every extra 1 gCO_2/km. However, in 2014, cars emitting more than 150 gCO_2/km made up only around 13% of new sales and this percentage is likely to decrease further over time.
- **Countries with stronger tax incentives have seen emissions fall more rapidly**. For example, registration tax in the Netherlands has been strongly differentiated according to CO_2 for several years. This has contributed to the Dutch achieving an average new car CO_2 around 14% below the UK level in 2014 despite starting from a similar level in 2007 (Figure B5.4). The CO_2 banding under the current Dutch system is much more differentiated than the new UK VED system, with an average increase of £16 for every extra 1 gCO_2/km below 100 gCO_2/km and an average increase of £274 for every extra 1 gCO_2/km between 150 gCO_2/km and 200 gCO_2/km.

Box 5.4. Reforms to Vehicle Excise Duty

Figure B5.4. Test-cycle new car CO_2 in the UK and the Netherlands (2001-2014)



Source: ICCT (2015) *European Vehicle Market Statistics Pocketbook.*

Source: CCC analysis.

HGVs - Progress to date

HGV CO_2 is not currently regulated by the EU. There is evidence[14] that CO_2 from new HGVs in the EU has been broadly flat over the last decade. This is reflected in the average CO_2 intensity of the UK HGV fleet, which has remained unchanged over the same period.

In addition to truck technology, emissions from HGVs can also be reduced by improving the efficiency of freight operations through measures such as driver training and reducing HGV-km through improved logistics (section 3).

HGVs - Forward look

Our cost-effective path suggests that there is potential for new HGV CO_2 intensity to fall by around 24% between 2010 and 2030, with further opportunities to reduce emissions from the existing HGV fleet by deploying retrofit technologies (Section 3). However, stronger policy is likely to be required to achieve this level of improvement. The European Commission is currently rolling out short-term measures to improve the monitoring and reporting of HGV emissions, with plans to publish a longer-term 2030 strategy this year. Other countries have already implemented new vehicle CO_2 standards for trucks:

- Direct measurement of whole-vehicle emissions is not appropriate for HGVs because of the diversity of vehicles and operations. As a solution, the European Commission has developed

[14] ICCT (2015) *Overview of the heavy-duty vehicle market and CO_2 emissions in the European Union.*

a software tool (VECTO) to simulate whole vehicles and calculate their emissions based on the performance of individual components. It is planned that VECTO will initially be used to certify the emissions performance of new HGVs to provide buyers with more accurate information and encourage competition between manufacturers to improve fuel economy.

- A 2030 strategy for the EU transport sector is expected later in 2016. This will consider options for policies to further reduce emissions from HGVs in the long term, such as mandatory new vehicle CO_2 targets.
- New vehicle CO_2 standards for trucks have already been introduced by Japan (2005), the US (2011) and China (2015), which suggests that it should be possible to implement similar standards in the EU. Whilst US trucks currently emit more than EU trucks on average, the US regulated emissions trajectory is more ambitious than the most optimistic trajectory proposed by the EU automotive industry and would result in US trucks being more efficient than EU trucks by 2027.[15]

We recommend that the Government closely monitors the work to develop an EU regulatory framework for CO_2 from HGVs and uses that as one source of evidence for what will be required at a UK level. The Government should consider how to engage with the EU if measures are not developed that are consistent with UK ambition in this area.

Progress in developing markets for electric vehicles

Whilst conventional efficiency improvements will play an important role in reducing emissions in the short to medium-term, an accelerating transition to electric vehicles (EVs) and other Ultra-low emission vehicle (ULEVs) during the 2020s and 2030s will be crucial to keep the UK on the cost-effective path to meeting the 2050 target. In recent years, a wide range of fully or partially electric vehicle models has become commercially available in the UK, with capabilities and costs that are approaching those of conventional cars. At present other ULEV types, such as hydrogen fuel cell vehicles, cannot be deployed at scale due to high costs and a lack of infrastructure. In future, such vehicles may make a significant contribution to decarbonising the fleet, but in this section we focus on the existing market for electric vehicles.

Whilst it is important for the UK to develop a market for EVs as part of the cost-effective path to meeting carbon budgets, the cost reductions needed to accelerate uptake will be driven by growth in the global market for EVs. The global outlook for EVs is looking increasingly positive, with battery costs falling more rapidly than previously anticipated and several governments and automotive manufacturers making public commitments to accelerate uptake (Box 5.5).

[15] Transport & Environment (2015) *Lorry CO_2 – why Europe needs standards.*

Box 5.5. Global EV outlook

The global outlook for EVs is looking increasingly positive, with battery costs falling more rapidly than previously anticipated and several governments and automotive manufacturers making public commitments to accelerate uptake:

Global sales

- Sales of electric cars increased by 70% in 2015, with over 550,000 vehicles being sold worldwide.
- China now has the biggest EV market in the world as sales overtook those in the EU and US in 2015.

Government commitments

- The Norwegian Government has published detailed proposals that aim to achieve 100% of new car, van and bus sales being zero-emission by 2025. Plug-in vehicles made up over 30% of new sales in Norway in March 2016.
- Dutch MPs recently proposed that 100% of new car sales should be zero-emission by 2025. The proposal received majority support in the Dutch Parliament, but details of how the target will be achieved are yet to be published.
- The Indian Government has announced an ambition that 100% of cars in the country should be electric by 2030. It is proposed that this will be achieved using a new scheme in which the capital cost of the vehicle is paid off over a number of years using the savings from lower fuel costs.
- China has announced a plan to increase EV sales by a factor of 10 between 2015 and 2020, equivalent to over 20% of projected sales.

Manufacturer commitments

- Automotive manufacturers including Ford, VW, Audi, Porsche and BMW have committed to increase the number of plug-in models available and/or announced billions of dollars of R&D spending on EVs to 2020.
- EV market leaders such as Nissan, Tesla and Chevrolet aim to bring "affordable", long-range (200-300 miles) EVs to market before 2020.

Optimistic battery cost projections

- Sources including Bloomberg and Goldman Sachs have suggested that EV battery pack costs are falling very rapidly and could fall below $200/kWh by 2020. EV battery pack costs are assumed to be over $300/kWh in our central scenario.
- Whilst lower costs will enable higher EV uptake, the Bloomberg analysis suggests that global EV sales would only reach 35% of new sales by 2040 in the absence of continued Government support for upfront costs and infrastructure. Our UK scenarios for higher EV uptake of 60% of sales by 2030 require continued Government support for EVs, in particular investment in infrastructure and continuation of fuel duty at currently planned levels.

Source: Full list of references provided in the Technical Annex.

Current market for EVs

Sales of EVs increased in 2015, a trend which has continued into 2016. EV sales are now above our indicator:

- EV sales were 28,342 in 2015 compared with 15,153 in 2014[16] and above our indicator trajectory of 10,425. This represented 0.9% of total new car and van sales in 2015.
- Sales have continued to increase in 2016, with EVs making up 1.4% of cars sold in the first quarter.[17] The high level of sales in this quarter partly reflects the fact that some buyers will have brought forward their EV purchase to take advantage of the higher plug-in car grant, which ended in March.

Manufacturers are continuing to provide consumers with a varied choice of EV models in the UK, at different prices and across different size segments. At present 36 models of electric car are available, up from 25 in 2015[18] (Technical Annex).

The Government has committed £600m to incentivise the uptake of EVs between 2015 and 2020. In 2015 there was continued roll-out of this package of policies, including upfront grants, recharging infrastructure and softer measures implemented at a local level:

- The plug-in car grant has been extended to 2018. The grant rate has been reduced from £5,000 for all EVs to £4,500 for fully electric cars and £2,500 for plug-in hybrids. The Office for Low Emission Vehicles (OLEV) estimates this will bring around 100,000 EVs into the fleet.
- The charging network continued to grow in 2015. There are now over 10,000 charge point connections in around 4,000 locations.[19] An evaluation of the existing Rapid Charge Network suggests that it has been important in increasing uptake and EV drivers would be willing to pay for it in future.[20]
- Five cities share £40m funding from OLEV to help them accelerate EV uptake. London, Milton Keynes, Bristol, Nottingham and Derby will use the funding to roll out charging infrastructure, low emission zones, free parking, access to bus and car pool lanes and try-before-you-buy schemes.
- Eight cities around the UK are taking part in feasibility studies for roll-out of ULEV taxis. Once the studies are complete £20m of funding from OLEV will be allocated across the cities.

As uptake of EVs grows, their impact on the electricity network will increase. If recharging demand occurs at peak times, additional investment will be required in power generation and distribution network infrastructure. New EV usage trials are beginning to demonstrate that smart recharging technology could partially mitigate this impact by shifting demand to off-peak times or even allowing for power to be transferred from vehicles back to the grid at peak times (Box 5.6).

[16] DfT (2016) *Vehicle licensing statistics.*
[17] Based on data from SMMT.
[18] Based on data from www.nextgreencar.com
[19] Retrieved from zap-map.com May 2016.
[20] Rapid Charge Network (2016) *Rapid Charge Network final study report.*

Box 5.6. The impact of EVs on the electricity network

Increasing uptake of plug-in vehicles will require investment in additional power generation and distribution network infrastructure, but this could be moderated by innovations in smart recharging technology. Small-scale trials using simple applications of this technology have demonstrated that it can work in real-world conditions and larger trials with more sophisticated technology are underway:

- In our Central emissions reduction scenario, demand for electricity from EVs increases to around 20TWh by 2030 (6% of UK electricity demand in 2030). This increase in demand and the associated investment in distribution networks are accounted for in our power sector scenarios. These scenarios assume that demand from EVs is flexible and can largely be shifted to off-peak times, which will require smart recharging to be rolled out alongside EVs during the 2020s.
- The 'My Electric Avenue' project tested technology to shift charging demand for 100 EVs away from peak demand to avoid excessive load on the distribution network. The project concluded in 2016, finding that the majority of participants were "comfortable" or "very comfortable" with external adjustment of their charging patterns.
- The Energy Technologies Institute recently launched a two year trial with 300 mass-market participants to better understand EV recharging behaviour and the market incentives that might be needed to encourage off-peak charging.
- Nissan recently launched a trial of vehicle-to-grid technology in partnership with National Grid. Under this trial EV owners will be able to sell power from their EV battery back to the grid at peak times.

Source: CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget*; MEA (2016) http://myelectricavenue.info/; ETI (2016) http://www.eti.co.uk/project/consumer-vehicles-and-energy-integration-cvei/; Nissan (2016) http://www.newsroom.nissan-europe.com/uk/en-gb/Media/Media.aspx?mediaid=145248

EV forward look

Our cost-effective path to meeting carbon budgets suggests that 9% of new car and van sales should be EVs by 2020 and 60% by 2030 (a mixture of battery-electric and plug-in hybrid electric vehicles). Reaching these levels of uptake will require an average annual growth rate of around 50% between now and 2020 and around 20% between 2020 and 2030.

Progress against our recommendations on how EV uptake should be promoted has been mixed. We re-iterate those recommendations below and provide more detail on what needs to be done:

- While EVs remain more expensive than their conventional alternatives from a consumer perspective, the Government should continue to provide support for their upfront purchase costs. In the long-term, upfront support does not necessarily have to be in the form of a grant and could be phased out as EV costs fall:
  - The EV market is developing rapidly. If costs fall in line with our central scenario then upfront support would need to be maintained to 2020 and beyond for uptake to stay on our cost-effective path. If costs fall more rapidly, as suggested by recent evidence (Box 5.5), then the amount of support required could fall at a faster rate. Given this uncertainty, it is important to continue support, but also sensible to adjust support as the market evolves.
  - An alternative to grant funding could be to increase VED rates for high emitting vehicles to provide much stronger incentives for both plug-in hybrids and battery electric

vehicles. Another approach would be to develop low-cost finance deals, with lower interest rates and longer payback periods. This could make EVs more competitive with conventional cars by spreading the upfront costs over a longer period and taking advantage of their lower running costs.

  - The Government should also consider announcing a staged phase-out of upfront support, contingent on specific levels of EV uptake, a stretching post-2020 target for new car CO_2 being in place and further infrastructure development. This would provide a strong signal to the automotive sector on the timescale over which cost reductions are required.

- Central and local Government should also continue to tackle non-financial barriers to EV uptake, such as roll-out of charging infrastructure and of softer measures to promote EVs:
  - Good progress has been made in rolling out a national rapid charging network on the road network. The number of rapid charging sites is around a third of the way to 2030 requirements for national coverage, while the total number of rapid charging posts installed is at around 10% of 2030 requirements. While there has been some progress in the installation of public charging infrastructure in towns and cities, more work is needed to develop a strategy for delivering on-street residential charging infrastructure so that drivers without off-street parking can choose an EV.
  - Progress has also been made in the development of softer measures to encourage EV uptake at a local level, with measures such as the City Scheme and ULEV Taxi Scheme. It is reasonable to trial these schemes in a limited number of cities, but we recommend that measures found to be successful are promoted at a national level as early as possible.

As well as reducing greenhouse gas emissions, roll-out of EVs will help to address the urgent need to improve air quality in UK cities. The Government recognises this, identifying EVs and other ULEVs as key to improving air quality in the UK in Defra's action plan to reduce emissions of nitrogen dioxide[21].

There is also a nascent market for electric buses and small HGVs, with emerging technology options for electrified long-distance freight:

- Transport for London (TfL) has been using fully electric buses for several years and plans that every single-decker bus operating in Central London will be zero-emission by 2020 in order to reduce air pollution in its Ultra-Low Emission Zone.[22] Recent announcements suggest this could be extended to double decker buses and beyond Central London in the near future.[23]
- A number of manufacturers[24] have developed partially or fully electric small HGVs, which could be suitable for urban delivery duty cycles. Depending on the degree of hybridisation, these electric trucks have batteries sized between 60 and 200kWh, providing an electric range of up to 240km.
- Whilst current battery technology does not have sufficient energy density to power long-distance HGVs, it is possible that they could be dynamically recharged whilst on the move:

[21] Defra (2015) *Improving air quality in the UK: Tackling nitrogen dioxide in our towns and cities.*
[22] TfL(2015) https://tfl.gov.uk/modes/driving/ultra-low-emission-zone.
[23] Mayor of London (2016) https://www.london.gov.uk/press-releases/mayoral/bold-plans-to-clean-up-londons-toxic-air
[24] See, for example, Tevva http://www.tevva.com/ and Magtec http://www.magtec.co.uk/

  - Sweden is trialling a 2 mile stretch of highway with overhead cables to electrically power hybrid trucks built by Scania.[25]
  - Highways England is planning a trial of a contactless, inductive recharging system for hybrid trucks in the UK over the next few years.[26]
  - Whilst both of these options would require upfront investment in infrastructure, a targeted approach could have a significant impact. Motorways and dual carriageways make up only 3% of the UK road network but carry over 70% of HGV traffic.
- An alternative option for long-distance freight is to combine batteries with low-emission range-extenders. New vehicle manufacturer Loop Energy has developed a zero-emission medium-sized electric HGV with a range extended to around 320 km using a hydrogen fuel cell.[27] Another new vehicle manufacturer, Nikola[28], has developed a large electric HGV with a range extended to nearly 2,000 km using a compressed natural gas turbine. The CO_2 intensity for this vehicle is estimated to be around 140 gCO_2/km, which is around 80% lower than the average HGV in the UK in 2014.

As ultra-low emission HGV technologies begin to be commercialised, the Government should consider extending existing incentives (e.g. the Plug-in Van Grant) to support the emerging market for these vehicles.

Progress in increasing uptake of sustainable biofuels

Biofuels can play an important role in decarbonising surface transport to 2030, but only if supply switches rapidly to sustainable waste-derived and advanced feedstocks that provide significant net GHG savings and do not compete with food crops for land.

Biofuels - Progress to date

Biofuel uptake fell in 2015 from 3.2% to 2.5% by energy according to HMRC fuel sales data. Despite this drop, all fuel suppliers met the Renewable Transport Fuel Obligation (RTFO) target:

- In 2014/15 waste-derived biofuels made up 50% of the total, up from 46% in 2013/14. The supply consisted of 48% bioethanol, 50% biodiesel and 1% biomethanol.
- The RTFO target was set at 4.75% for 2014/15. There are two factors that mean the total Renewable Transport Fuel Certificates (RTFCs) redeemed does not equal the litres of biofuel sold in that year:
  - Waste-derived biofuels are double counted. The percentage of double counted fuel increased from 50% in 2014/15 to 54% in 2015/16 (provisional).
  - Suppliers are allowed to carry forward up to 25% of the certificates from the previous year. Around 12% of certificates were carried forward to meet the target in 2014/15. If a high proportion were also carried over into 2015/16, this could partly explain the observed drop.

The Government's estimates of average GHG savings from biofuels increased slightly from 69% in 2013/14 to 70% in 2014/15, excluding emissions from Indirect Land Use Change (ILUC).

[25] Siemens (2015) http://www.siemens.com/press/en/feature/2015/mobility/2015-06-ehighway.php?content%5B%5D=MO
[26] TRL for Highways England (2015) *Feasibility study: Powering electric vehicles on England's major roads.*
[27] http://www.fleetsandfuels.com/fuels/hydrogen/2016/03/loop-energy-for-a-hydrogen-peterbilt/
[28] https://nikolamotor.com/one

Concerns over emissions from ILUC remain, with evidence that use of crop-based biofuels across Europe could be increasing emissions overall, but evidence suggests sustainability standards are helping to provide a net GHG saving for UK biofuels (Box 5.7).

Box 5.7. Risks to biofuel GHG savings from Indirect Land-Use Change

In previous reports we have stressed that biofuels should only be used where they can demonstrate genuine emissions savings, including land use impacts, as against fossil fuels.

In 2015 the EU mandated the reporting of indirect land use (ILUC) factors on suppliers and Member States before further decisions on their inclusion in biofuels sustainability criteria are taken. The Commission recently published a study on the land-use change (LUC) impacts (direct and indirect) of biofuels consumed in the EU. The main findings of the study are:

- Conventional biodiesel feedstocks have very high overall emissions when including LUC effects. For example palm oil emits 231 gCO_2e/MJ and soybean oil emits150 gCO_2e/MJ, with a fossil fuel comparator of around 90 gCO_2e/MJ.
- Conventional ethanol feedstocks such as sugar and starch have much lower LUC emission impacts, ranging from 14 to 38 gCO_2e/MJ.
- Advanced biofuels from short rotation crops and perennials have negative LUC emissions due to the increase in the carbon stock on the land that is converted to produce them.

Recent analysis by European campaign group Transport and Environment (T&E) suggests that including LUC emissions estimates leads to overall emissions from crop-based biodiesel of between 104% to over 300% higher than fossil diesel. Bioethanol impacts are lower, ranging from 51% to 121% compared with petrol. T&E estimates the overall impact of revised EU biofuel policy is to increase emissions in 2020 by 1.4%.

We estimate that LUC impacts would lead to a reduction in GHG savings of UK biofuels from 70% to just over 50% in 2014/15. The impact of taking account of ILUC is smaller than might be expected but is due to the large proportion of waste-derived feedstocks in UK biodiesel (94%) and LUC impacts of bioethanol are much lower than those from oil-based crops.

Source: Transport & Environment (2016) *Globiom: the basis for biofuel policy post-2020;* DfT (2016) *Biofuel statistics.*

Biofuels - Forward look

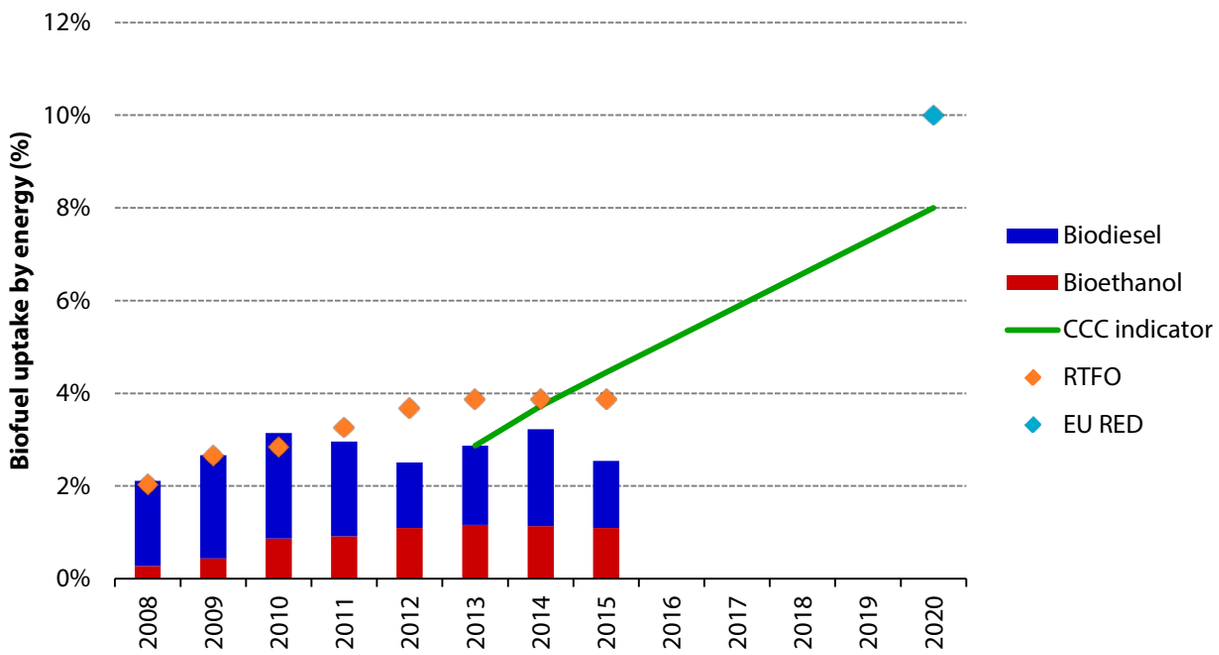
Biofuel uptake in the UK to-date has been largely driven by EU regulation, which may no longer be the case after the UK exit from the EU. Whilst the future cost-effectiveness of biofuels is highly uncertain, there remains a case for supporting biofuel production to help bring down the costs of sustainable advanced biofuels for potential future applications, such as in aviation or in HGVs if other low carbon options fail to develop. In the short term, the UK should continue to work towards meeting the objectives of the EU Renewable Energy Directive (RED). Alongside this, we will work with the Government to assess the appropriate longer-term contribution of biofuels to meeting carbon budgets.

The RTFO target is currently set at 4.75%. This will need to increase to 2020 to meet the RED.

- The RED target is for 10% of transport fuel to be from renewable sources by 2020.
- As waste-derived biofuels are double counted and renewable electricity is counted five times, the actual uptake is likely to be lower than this. Our previous analysis suggested sustainable biofuels could provide 8% of liquid fuel demand by energy by 2020 (Figure 5.11).

- The Government also assumes that biofuels will make up 8% of liquid fuel demand by 2020.

Figure 5.11. Biofuel uptake in the UK, target levels and CCC indicator by energy



Source: HMRC (2016) *Hydrocarbon Oils Bulletin*; CCC analysis.
Notes: The RTFO measures biofuels on a volume rather than energy basis.

There is significant potential for biofuels from waste across the EU, along with other sustainable feedstocks and lower levels of advanced biofuels:

- A recent study from the International Council on Clean Transportation (ICCT)[29] found that 4-5% of UK liquid fuel could be displaced by biofuels from sustainable waste-derived feedstocks, which typically have GHG savings of over 80%.
- A 2015 report from the Transport Energy Taskforce[30], a panel of Government and industry experts, suggested that a further 0.5% of biofuel supply could come from sustainable "advanced" feedstocks by 2020, with scope to increase this during the 2020s.

The Government is due to extend the RTFO trajectory to 2020 this year. The Government should set a trajectory that meets the RED target whilst maximising sustainability and total GHG savings. Depending on the level of waste-derived feedstocks available, the UK is likely to meet the RED with an actual uptake lower than our indicator in 2020. However, there may be scope to further increase uptake of sustainable biofuels beyond 2020 as the supply of advanced biofuels increases.

The Government also has an objective of increasing the use of biomethane in HGVs. As the supply of biomethane is limited, the Government should consider how emissions savings from use of biomethane in HGVs compare to savings from using it in other applications, such as heat

[29] ICCT (2016) *Waste and residue availability for advanced biofuel production in EU Member States.*
[30] LowCVP (2015) *Transport Energy Task Force: Options for transport energy policy to 2030.*

in buildings and industry. The risks of methane leakage must also be considered in this assessment. We have assessed the potential for using biomethane in transport out to 2050 (Annex - Long-term use of biomethane in surface transport). There is likely to be continued methane demand from buildings and industry in excess of the available biomethane resource, such that increased use in transport would displace biomethane from those sectors and not provide a net reduction in emissions.

3. Progress in changing travel behaviour

Whilst uptake of low-carbon vehicles and fuels is crucial to reducing emissions from transport, changing the travel behaviour of individuals and businesses can also help to reduce emissions through avoiding trips, using lower carbon modes of travel or altering driving styles. This section focuses on progress in encourage smarter modal choices and on more efficient freight operations. Measures to promote eco-driving and speed limiting are covered in the Technical Annex.

Smarter choices

Smarter choices - Progress to date

"Smarter choices" policy covers a range of measures designed to influence choice of transport mode, with the aim of reducing car travel, including:

- 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 and only make car trips when necessary.
- Better land-use planning that provides easy access to public transport infrastructure and reduces the need for car trips.

There is often a strong business case for implementing such schemes on the basis of reduced congestion, road safety, noise reduction and improved air quality, with carbon savings making up only a small fraction of the benefits.

The Government previously funded sustainable travel schemes through the Local Sustainable Transport Fund (LSTF), a £600 million programme that ran from 2011 to 2015. A recent interim evaluation of large LSTF-funded schemes suggests that they have helped to reduce car traffic. The Government has also announced a new "Access Fund" to replace the LSTF, running to 2020:

- An interim meta-analysis[31] of large schemes funded through the LSTF found that participating areas experienced greater reductions in traffic than comparable towns. However, the study avoids attributing this difference to the schemes without more detailed analysis. A final meta-analysis, including a more detailed bottom-up analysis to try and estimate the impact of specific interventions at a more local level, is planned.
- The new Access Fund will replace the LSTF from 2017/18, making £580 million available to 2020 for schemes to promote walking, cycling and use of public transport. DfT is also committing £20m of this fund to new sustainable travel projects in 2016/17.

[31] Sloman et al. (2015) *Meta-analysis of outcomes of investment in the 12 Local Sustainable Transport Fund Large Projects: Interim Report to Department for Transport.*

Guidance for the transition funding states that the scheme's two main objectives are local economic growth and cutting carbon emissions. It is unclear as to whether the Access Fund will have exactly the same objectives.

The Government has also launched a cycling and walking strategy. Meeting its objectives will result in a small decrease in emissions:

- The objectives of the strategy include doubling the number of cycle trips made each year by 2025 and reversing the decline in walking activity by 2020.
- The strategy proposes a series of measures to achieve these objectives, including improving the safety of cyclists and pedestrians, improving routes to schools and workplaces and promoting urban design policy that prioritises cyclists and pedestrians.
- If the objective to double cycle traffic is achieved and this traffic directly replaces car traffic, this would reduce car travel demand and emissions by around 1%.[32]

Smarter choices - Forward look

Our analysis based on the current mix of car trips in Great Britain suggests that through switching to other modes, car-km could be reduced by 3-10% below the baseline scenario, with a central estimate of 5%.

We do not prescribe the exact mechanisms by which the demand reduction in our scenarios is achieved, but it is likely to require a combination of investment in public transport, cycling and walking infrastructure, use of public information campaigns and/or better land-use planning. Such measures are delivered through a wide variety of schemes across central government and local authorities, which makes it difficult to track overall progress in reducing demand for car travel and to include the net impact of schemes in emissions projections:

- A variety of transport schemes include the benefit of a reduction in demand for car travel in their business case, including local authority improvements to public transport, rail electrification programmes and HS2.[33]
- As these schemes are delivered by a diverse range of public and private bodies, there is no central assessment of the net impact on total car traffic in the UK. This makes it very difficult to assess overall progress in reducing demand for car travel, other than the impact of schemes funded centrally through funds like the LSTF.
- The Government's emissions projections only include the impact of centrally funded sustainable travel schemes and do not reflect the current and potential future impact of measures that reduce car travel. This is partly because the Government's current modelling tools are not capable of assessing the impact on road traffic of cycling, walking, bus and rail schemes at a national level.

We recommend that the Government develops a set of indicators to track progress and assess the aggregate impacts on car travel of policies to promote cycling, walking and use of public transport, including rail schemes. This should then be used to improve the Government's capability to model the impact of modal shift and provide a more detailed assessment of the potential future contribution of such measures to reducing emissions.

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[32] In 2014, cycle traffic in the Great Britain totalled around 5 billion vehicle-km, compared to car traffic of 393 billion vehicle-km.

[33] See, for example; DfT (2015) *The economic case for HS2*; DfT (2016) *Value for money assessment for major bus-related schemes.*

Freight operations

In addition to improving the efficiency of new vehicles, emissions from road freight can be reduced by the actions of freight operators. These include retrofitting existing vehicles with fuel saving technologies, training drivers to drive more efficiently, reducing vehicle-km through more efficient logistics and shifting to less carbon intensive modes such as rail.

Freight operations - Progress to date

The overall efficiency of logistics did not improve significantly in 2014 according to Government statistics, with a slight increase in the percentage of freight carried by larger vehicles and the average vehicle fill staying broadly flat:

- Larger vehicles typically use less fuel to carry the same amount of freight. The percentage of freight carried by rigid trucks over 17 tonnes increased from 87% to 88% and for articulated trucks over 33 tonnes there was an increase from 96% to 97%.
- Measures of vehicle fill have not improved, with the percentage of empty vehicle running remaining flat at 29% and the average fill-factor of vehicles falling slightly from 0.63 to 0.62 in 2014.

Whilst progress across the sector as a whole is limited, voluntary industry-led schemes are helping some freight operators reduce their emissions through uptake of fuel-saving technology, lower-carbon fuels, improved logistics and driver training. The most notable of these schemes is the Freight Transport Association's (FTA) Logistics Carbon Reduction Scheme (LCRS). The membership of the LCRS remains relatively small at 120 members with combined ownership of around 67,000 HGVs (around 16% of UK HGVs), but it has grown, up from 109 members and 59,000 HGVs in April 2015. The LCRS had a target to reduce emissions intensity (gCO_2/km) by 8% between 2010 and 2015 and the FTA plans to set a new target later this year. Data from the most recent LCRS report suggests the scheme's members are on track to meet this 2015 target, with a reduction of 6.8% between 2010 and 2014. However, membership of the scheme will need to grow further before it can have a significant impact on total emissions from HGVs in the UK.

Freight operations - Forward look

The Government is undertaking a Freight Carbon Review, informed by a study we commissioned from the Centre for Sustainable Road Freight (CfSRF) for our advice on the fifth carbon budget.[34] The report identified cost-effective measures for freight operators to further reduce emissions, and a series of non-financial barriers that need to be overcome to do this:

- The CfSRF study suggested that there is significant potential for further rollout of freight demand-side measures that are cost-effective from both a social and commercial perspective. Our Central scenario for the fifth carbon budget[35] includes slightly lower levels of uptake than the CfSRF scenarios:
  - We include roll-out of such measures to improve average fleet efficiency by around 11% for small rigid HGVs and 18% for large articulated HGVs by 2030, with most of the savings from improved driver training.

[34] CfSRF (2015) *An assessment of the potential for demand-side fuel savings in the HGV sector.*
[35] CCC (2015) *Sectoral scenarios for the fifth carbon budget.*

  - Improved logistics and shifting freight to rail reduce emissions by 9% for small rigid HGVs and 11% for articulated HGVs by 2030. The majority of these savings are from improved logistics, with fuel savings of less than 1% from modal shift.

- This report identified three non-financial barriers that need to be overcome to improve the efficiency of freight logistics:
  - **Attitudes to collaboration**. Some logistics measures require collaboration between operators. Barriers include sharing commercially sensitive data, identification of potential partners and a lack of clarity around competition law.
  - **Regulation for longer, heavier vehicles**. Longer, heavier vehicles are currently only allowed to operate on UK roads as part of a Government trial to assess the circumstances in which they can be used safely.
  - **Land-use policies** do not always enable efficient freight solutions (e.g. use of Urban Consolidation Centres). This could be resolved by regional and local authorities incorporating freight strategies into their land-use policies.

The Freight Carbon Review should take this evidence into account and aim to develop a set of policies and schemes that the Government can roll-out to promote uptake of cost-effective measures that will reduce emissions and save freight operators and customers money.

4. Progress in reducing emissions from aviation and shipping

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).

The Kyoto Protocol gave specific responsibility for controlling IAS emissions to their respective UN regulatory bodies, the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO). While the Paris Agreement did not specifically mention IAS emissions, it did agree to aim to hold the increase in long-term temperature to well below 2°C and to pursue efforts to limit the rise to 1.5°C. Both these aims will require measures to control IAS emissions. Action at both ICAO and IMO therefore remains critical.

Progress agreeing policy at both ICAO and IMO has been slow and will need to urgently speed up. Recent developments include:

- **Aviation**. ICAO continues discussions to develop a global market-based measure to cap net emissions from international aviation. The aim is for this to be agreed at the ICAO General Assembly in Autumn 2016, and for it to enter into force from 2020. In a joint statement at Ise-Shima, G7 leaders expressed a strong commitment to work together to adopt this. If an agreement is reached then we will assess the implications for UK climate policy, including whether it is practical to include international aviation emissions in carbon budgets, or more sensible to continue the current approach (which is formally to exclude, whilst making allowance for, these emissions).
- **Shipping**. In April 2016 the International Maritime Organisation (IMO) approved mandatory requirements for large ships to record and report data on their fuel consumption, to apply from 2018. This broadly aligns the IMO with the EU's approach, which is also to introduce a monitoring and reporting system for CO_2 emissions from 2018. However, IMO discussions about reducing emissions from international shipping were postponed until later in 2016.

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.

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. There is particular scope for leadership in shipping given that the IMO is headquartered in London. In our fifth carbon budget advice we recommended that international shipping emissions should now be included in carbon budgets. There is no longer any reason to continue to formally exclude these emissions: uncertainties around their level are likely to be small relative to factors already accepted in carbon budgets, and there would be no additional costs or competitiveness risks of inclusion.

5. Forward look

The Government's progress in acting on our recommendations from last year's Progress Report has been relatively limited, with no progress in some areas (Table 5.3).

Table 5.3. Progress against 2015 recommendations

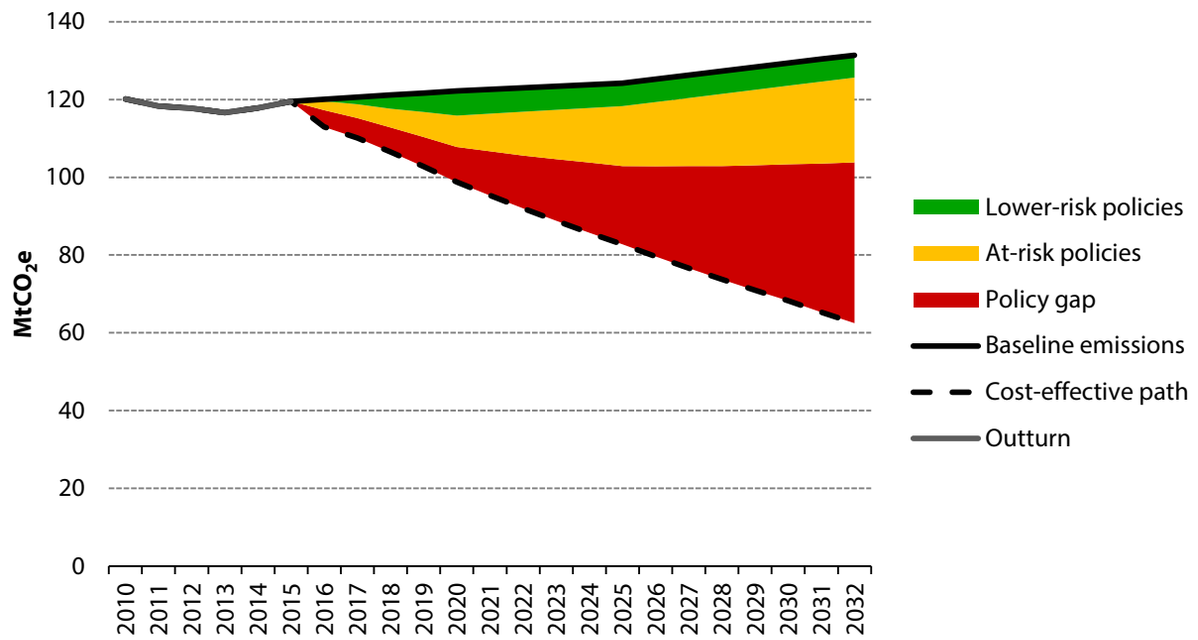
Recommendation in 2015	Assessment	Commentary
Provide motor industry with greater certainty to 2030: Push for clear, stretching 2030 EU targets for new cars and vans that take account of the need for ultra-low emission vehicles and use realistic testing procedures.	No progress	Post-2020 targets are not expected to be agreed until 2017 but the Government could do more to publicly support stretching targets. Limited progress has been made on improved testing and there is evidence that planned tests are vulnerable to divergence between real-world and test-cycle emissions.
Tackle barriers to EV uptake: Maintain support for upfront costs while they remain more expensive than conventional vehicles, provide a national network of charge points and roll out local incentives such as access to parking.	Partially met	Progress has been made in extending upfront support to 2018, but the Government should consider how to phase out the subsidy and the possibility of announcing this in advance. Development of infrastructure and local incentives has continued but this needs to be extended for full national coverage.
Ensure the tax regime keeps pace with technological change: Align existing fiscal levers (e.g. Vehicle Excise Duty) to ongoing improvements in new vehicle CO_2, including a greater differentiation between rates for high and low emission	Backward step	Reforms to Vehicle Excise Duty do not provide sufficient incentive to purchase low and ultra-low emission vehicles. Incentives worsened if more than just first year costs are considered. The Government should review VED and CCT rates immediately to

Table 5.3. Progress against 2015 recommendations		
Recommendation in 2015	**Assessment**	**Commentary**
vehicles.		ensure they are aligned to its ambitions for higher ULEV uptake.
Extend successful emissions-reduction schemes for freight operations: Larger freight operators have pioneered schemes to reduce fuel costs and emissions that should be rolled out across the industry, including small operators.	Partially met	We welcome the Government's ongoing Freight Carbon Review. We recommend that it is used to identify and put in place measures to deliver cost-effective emissions reduction measures across the freight sector.
Ensure lessons from schemes to reduce travel demand are applied: Sustainable travel schemes should be properly evaluated and extended if they provide cost-effective emissions reductions.	Partially met	The Government is evaluating schemes and has extended funding to 2020. As it is difficult to assess overall progress in this area we recommend that the Government develops a set of indicators to assess the impacts on car travel of policies to promote cycling, walking and use of public transport.
Publish an effective policy framework for aviation emissions: Plan for UK 2050 emissions at 2005 levels (implying around a 60% increase in demand) and push for strong international policies.	No progress	The Government has taken no action to address this recommendation.

The lack of action against our recommendations is reflected in the Government's emissions projections. Current policies are aiming to reduce emissions but have delivery risks and there remains a gap between anticipated emissions and our cost-effective path (Figure 5.12):

- Current and planned policies are aiming to reduce domestic transport emissions from 120 $MtCO_2$ in 2015 to 103 $MtCO_2$ in 2027. However, we identify risks to successful delivery of many of these policies, without which emissions would remain above 120 $MtCO_2$.
- Even with full delivery emissions reductions from announced policies would fall short of our cost-effective path by around 26 $MtCO_2$ in 2027, delivering less than 40% of the required abatement.

Figure 5.12. Assessment of emissions savings from current and planned policy against the cost-effective path in transport



Source: DECC (2015) *Updated energy and emissions projections*; CCC analysis.

Our assessment of policies to drive abatement options in the transport sector is shown in Table 5.4. This table illustrates the areas where there are gaps and weaknesses in existing policy that need to be addressed in the Government's emission reduction plan. An effective plan will strengthen the at-risk policies and fill the policy gaps identified in the table.

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

Abatement option		2015 policy		Change in 2015/16	2016 policy
New car/van efficiency	To 2020	Amber	EU targets and fiscal incentives in place but real-world improvements limited.	VED reformed but changes do not offer sufficient incentive for low emission vehicles.	Amber
	After 2020	Red	No EU targets beyond 2020.	No change.	Red
Electric vehicles	Financial incentives	Amber	Grant funding committed to 2016.	Grant funding extended to 2018, but no longer-term plan.	Amber
	Infrastructure	Amber	Rapid network on track but lack of strategy for on-street residential charging.	Rapid charging network continued to grow.	Amber
Biofuels increase to 8% by energy		Red	RTFO target at 4.75%. No policy to meet 2020 target.	No change, though consultation planned in 2016.	Red
Sustainable travel		Amber	Central Government funding for pilot schemes.	Funding extended to 2020 but unclear whether sufficient.	Amber
HGV and freight efficiency		Red	Industry-led schemes to reduce emissions.	Government carrying out a review of policy.	Red

Source: CCC analysis.
Notes: Key - Red: Policy gap; Amber: Policy at risk.

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

Key messages and recommendations

In this chapter we present the latest evidence on UK greenhouse gas (GHG) emissions in the agriculture and land use, land-use change and forestry (LULUCF) sectors. In 2014 agriculture accounted for 9.5% of UK GHG emissions, and the LULUCF sector continued to be a net carbon sink, sequestering 9 $MtCO_2e$ (equivalent to abating 2% of UK GHG emissions).

The vote to leave the EU may have an impact on how emissions reduction is delivered in the agriculture and LULUCF sectors. A number of EU policies, through regulation and the provision of funding, currently encourage the adoption of farming practices, afforestation and peatland restoration that impact on emissions. To meet the UK's domestic emission reduction commitments, it may be necessary to agree new arrangements, or adapt existing arrangements as appropriate. It is too early for the Committee to assess the precise impacts and balance of measures under new arrangements.

Our key messages are:

- **Agriculture emissions:** Having declined for much of the past two decades, emissions increased for the second successive year to reach 49 $MtCO_2e$ in 2014, up 2% up on the previous year. The sector now accounts for a larger share of UK economy wide emissions (9.5%) than at any time since 1990 (7.5%).
- **Emissions intensity:** Since 2003 emissions intensity has been broadly unchanged for crops but improved for livestock. Compared with 2013:
  - N_2O intensity of both crops and livestock improved in 2014 as the increase in output, associated with favourable weather, was larger than the overall increase in N_2O emissions.
  - Methane emissions intensity improved by 1.4% in 2014 as an overall increase in methane emissions was more than matched by higher livestock output and increased productivity.
- **Indicator framework:** Non-CO_2 emissions are above our indicator trajectory by gas and source in 2014. The sector is not on track to deliver savings of 4.5 $MtCO_2e$ by 2022 included in our trajectories for meeting carbon budgets.
- **Land use and forestry emissions:** Carbon sequestered by this sector increased by 0.3 $MtCO_2e$ in 2014 to 9 $MtCO_2e$, a 4% increase compared with the previous year. This is consistent with the long-term trend of an increasing carbon sink.
- **Progress in developing policies:** Our previous recommendations have been partially acted upon, but significant gaps remain:
  - Smart Inventory. On-going improvements to the methodology for calculating agricultural emissions have significantly reduced the level of uncertainty in emissions estimates. Further work is needed to deliver the Smart Inventory by 2017.
  - Measures to deliver emission reduction. The UK agriculture sector is not on track to deliver savings of 4.5 $MtCO_2e$ by 2022. The framework to assess the effectiveness of the GHG Action Plan has not developed sufficiently to assess fully progress in this area. The 2016 Government review of the GHG Action Plan setting out the future approach to emissions reduction in this sector is yet to be published.
  - Plans to deliver afforestation ambition. While England and the devolved administrations have announced plans to meet their respective targets for woodland creation, planting rates remain short of the ambition and continued efforts are required to address financial and non-financial barriers.

Our key recommendations for the Government's emission reduction plan reflect the need for a stronger policy framework to deliver GHG emissions reduction in agriculture, and firm measures to increase afforestation rates in line with our ambition. These are set out in Table 6.1.

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

Agriculture emissions to fall by around 15% between 2014 and 2030, and afforestation rates to increase to 15,000 hectares a year. This will require:	**New policy**	**Stronger implementation**
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 2017.		✗
New policies and measures required to deliver emissions reductions in agriculture to 2030 that moves beyond the current voluntary approach of providing information and advice.	✗	
Addressing financial and non-financial barriers to increase afforestation rates and agro-forestry schemes to deliver the level of abatement in the fifth carbon budget.		✗

Source: CCC analysis.
Note: In some areas there are elements of new policies needed and elements needing stronger implementation of existing policies - in these cases both columns are checked.

We set out our analysis that underpins these conclusions in the following sections:

1. Agriculture emissions trends and drivers
2. Progress against indicators
3. The policy framework
4. Forward look and policy gap
5. Land use, land-use change and forestry (LULUCF) emissions
6. LULUCF forward look and policy gap

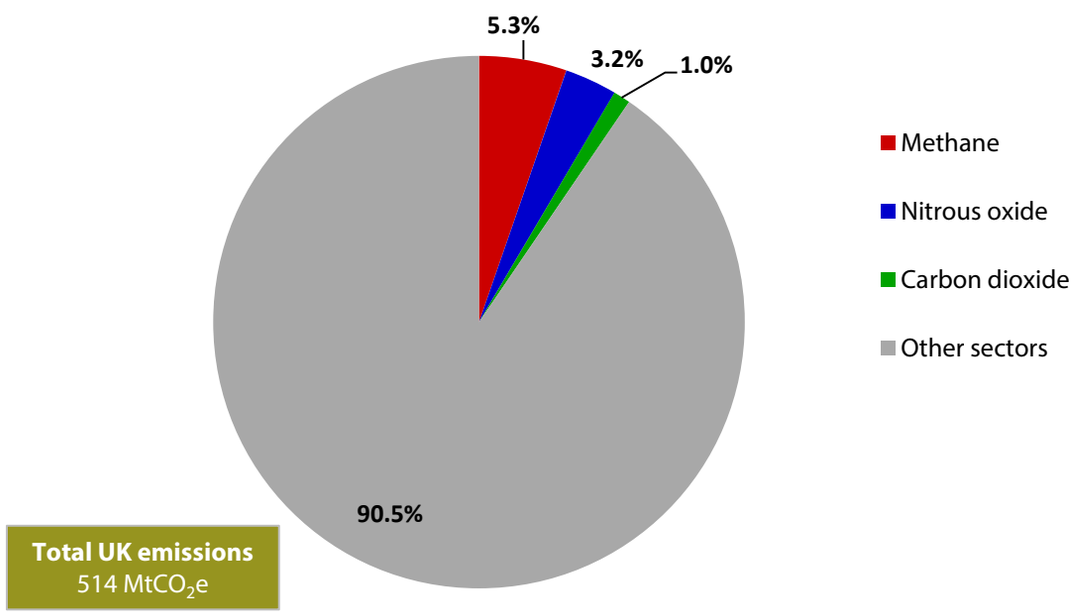
1. Agriculture emissions trends and drivers

The dominance of non-CO_2 emissions in agriculture means we are only able to report on 2014 emissions because of the lag in reporting non-CO_2 data. This section sets out the change in emissions from 2013 and in the recent past, and the drivers of change.

Emissions trends

Since 1990, agriculture emissions have fallen by 16%, an annual average decrease of 0.7%. In recent years, however, that trend has reversed, with emissions rising between 2009 and 2014 by an annual average of 0.4%. Agriculture emissions increased in 2014 for the second successive year, up 2% on 2013 to 49 $MtCO_2e$. The sector now accounts for a larger share of UK economy wide emissions (9.5%) than at any time since 1990 when the share stood at 7.5% (Figure 6.1). Going forward deeper cuts will be required in order to meet future carbon budgets.

Figure 6.1. GHG emissions from agriculture in the context of UK emissions (2014)



Source: DECC (2016).
Notes: Emissions from other sectors excludes international aviation and shipping sectors.

A breakdown of emissions by gas show increases for methane, nitrous oxide (N_2O), and carbon dioxide (CO_2) since 2009 (Table 6.2). This upward trend continued between 2013 and 2014 for methane and N_2O emissions, while the level of CO_2 emissions remained unchanged. In terms of the main sources of emissions, there have been increases from enteric fermentation, soils, wastes and manure management, and mobile and stationary machinery since 2009. This trend continued for most sources when comparing 2014 to 2013 levels, although stationary and mobile machinery emissions declined by 2%.

Table 6.2. Change in emissions by gas and source			
By GHG	**2014 emissions ($MtCO_2e$)**	**Change from 2013**	**Average annual change (2009-2014)**
Methane	27.4	1.5%	0.2%
Nitrous oxide	16.3	3.4%	0.8%
Carbon dioxide	5.3	0%	0.5%
Total	49.1	2%	0.4%
By source			
Enteric fermentation	23.8	1.5%	0.2%
Soils	14.4	3.8%	0.8%
Wastes & manure management	5.0	1.2%	0.1%
Mobile & stationary machinery	4.5	-2.2%	0.3%
Other	1.4	8.3%	1.8%
Source: DECC (2016) and CCC calculations.			

Inventory improvements

Inventory improvements have affected estimates of the absolute level of agricultural emissions, and the composition of emissions between gases and sources. The main inventory changes this year are due to improvements in estimating N_2O emissions (Box 6.1).

Box 6.1. Inventory improvements to estimates of N_2O emissions

Work by Defra on developing a Smart Inventory for agriculture emissions has led to a number of changes to the GHG inventory this year, resulting in a downward revision across the whole time-series. The changes largely relate to N_2O emissions from agricultural soils, which were revised down by 5.6 $MtCO_2e$ in 2013, with smaller changes to waste & manure management and liming and urea application.

The main elements of the changes in agricultural soils are the introduction of country-specific emissions factors for urine and dung deposition by grazing livestock. In addition, field scale measurements of N_2O emissions at a range of UK sites have been used to develop new country specific emission factors for several applications:

- Direct emissions from inorganic nitrogen fertiliser by type (e.g. urea and ammonium nitrate) and land-use.
- Direct N_2O from livestock manure application disaggregated by manure type (e.g. slurry and farm-yard manure).
- Indirect N_2O emissions from leaching and run-off from the application of inorganic fertiliser.

There have been minor changes in estimates of methane emissions arising from changes in sheep numbers, dairy cattle milk yields, cattle live weights and manure management practices. These have largely offset each other such that overall methane emissions have been revised by around 0.1 $MtCO_2e$ across the series.

Source: DECC (2016).

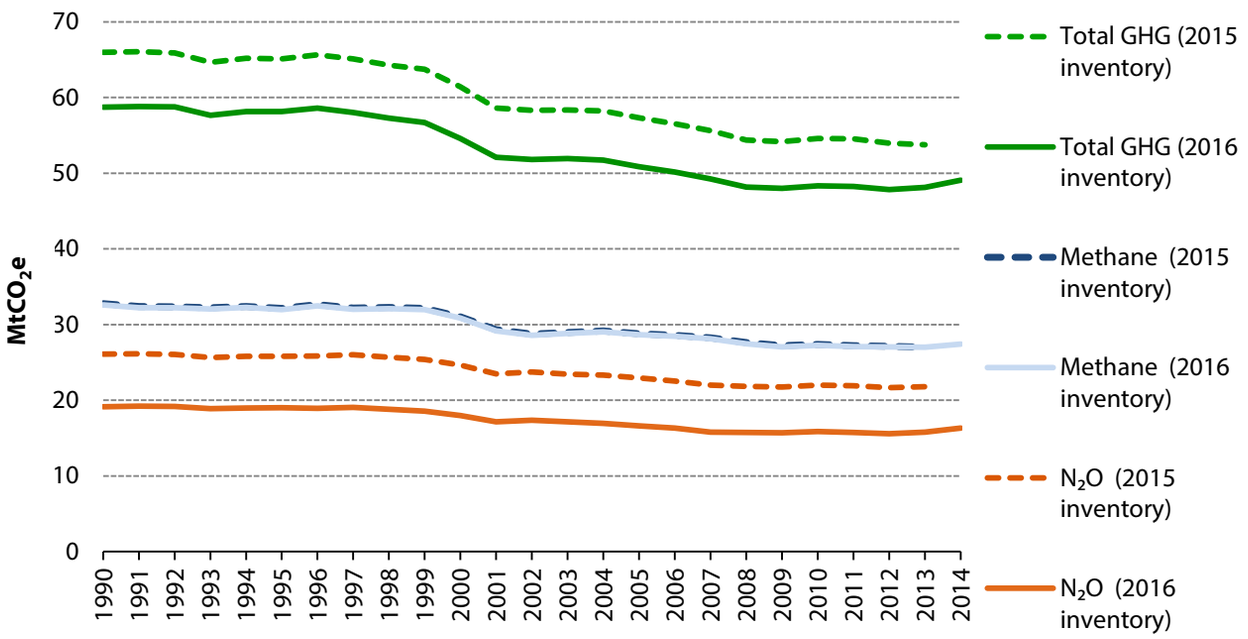
While these amendments have not changed the trend in emissions, they have reduced the absolute level of N_2O emissions across the time series since 1990, and its share of agricultural emissions. Compared with the estimates reported in last year's inventory:

- N_2O emissions for 2013 are 28% lower (15.8 $MtCO_2e$ vs 21.8 $MtCO_2e$).
- The share of N_2O in overall sector emissions has fallen to about a third compared with around 40% previously reported in 2013. Methane now accounts for 56%, up from 44% as reported in last year's inventory.

These changes have fed through to a downward revision in agricultural emissions which, on average, are 11% lower than previously reported across the time series since 1990 (Figure 6.2). These, and previous, inventory improvements have reduced the uncertainty in estimating emissions for the sector. The most recent inventory improvements have led to a reduction in the range of uncertainty in overall estimated agricultural emissions from 36% to 14% (Figure 6.3):

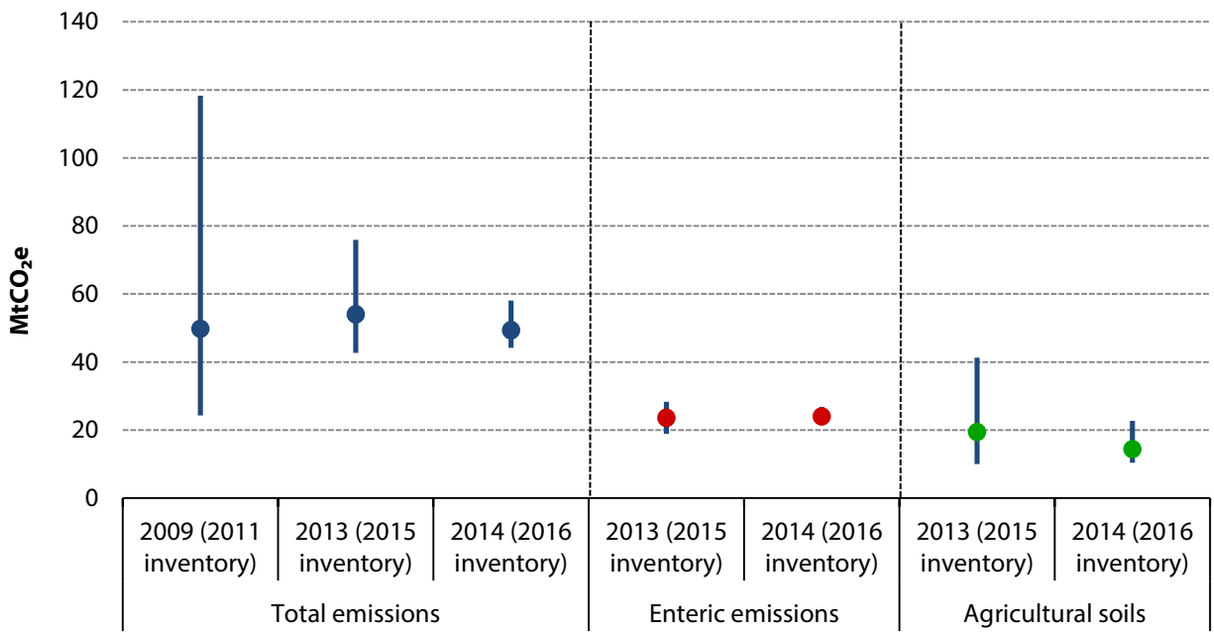
- Most of this is due to the improvements in estimating N_2O emissions, where the range of uncertainty in agricultural soils (comprising around 90% of N_2O emissions) nearly halved from 80% in 2013 to 43% in 2014.
- There is still considerable uncertainty around N_2O estimates due to the large range of emission factors applicable to different circumstances (e.g. soil type).
- Uncertainty in estimating methane emissions is generally lower because the default emissions factors are already based on models that are region and animal specific. In 2014 the reported range of uncertainty in estimates of enteric emissions was 11%.

Figure 6.2. Impact of methodology changes to the agriculture GHG inventory



Source: DECC (2015, 2016).

Figure 6.3. Changes in uncertainty ranges in estimating agricultural emissions



Source: DECC (2011, 2015, 2016).
Note: The analysis (at 95% confidence intervals) takes into account different known sources of uncertainty in activity and emissions factors. Monte Carlo analysis then generates distributions around these parameters.

Further inventory improvements are planned for next year. These include:

- Country-specific emissions factors for enteric fermentation and waste and manure management, which will impact methane emissions.
- Revision to the methodology to include emissions from anaerobic digestion for the first time, with digestate emissions to be allocated to the agriculture inventory.
- The inclusion of the impact of a wide range of farming practices on emissions.

These improvements will be delivered as part of the expected roll-out of the new Smart Inventory in 2017, which will provide a more robust evidence base to support our assessment of emission trends and the impact of abatement measures in this sector. It is important that this is delivered to the revised timelines, particularly given the recent increase in emissions.

We will provide a comprehensive account of the new Smart Inventory as part of next year's Progress Report.

Emissions drivers

Given the lack of progress in reducing emissions in the last few years, it is important to understand the cause of emissions changes to assess if the recent trend is due to short-term fluctuations (e.g. weather related) or indicative of structural changes in the sector. There is also a need to assess trends in emissions intensity, which relate emissions to levels of agricultural output and thereby provides an indication of production efficiency.

Nitrous oxide

Nearly half of all N_2O emissions come from organic and inorganic fertiliser use. The other key sources are manure management, grazing returns and the ploughing of crop residues. While there has been little change in the latter sources, emissions from fertiliser application have fallen substantially since 1990 and there has been an improvement in the soil nitrogen balance:

- Between 1990 and 2008 fertiliser emissions fell by over one third, due largely to the decrease in fertiliser applied to grassland associated with declining livestock numbers. Since 2008 emissions have risen slightly.
- While fertiliser application rates (kg/ha) have also decreased since 2003, emissions fell faster, implying an improvement in fertiliser use efficiency. This is consistent with a reduction in the overall nitrogen balance in agriculture, indicating a lower risk of nitrogen loss to the environment (Box 6.2).

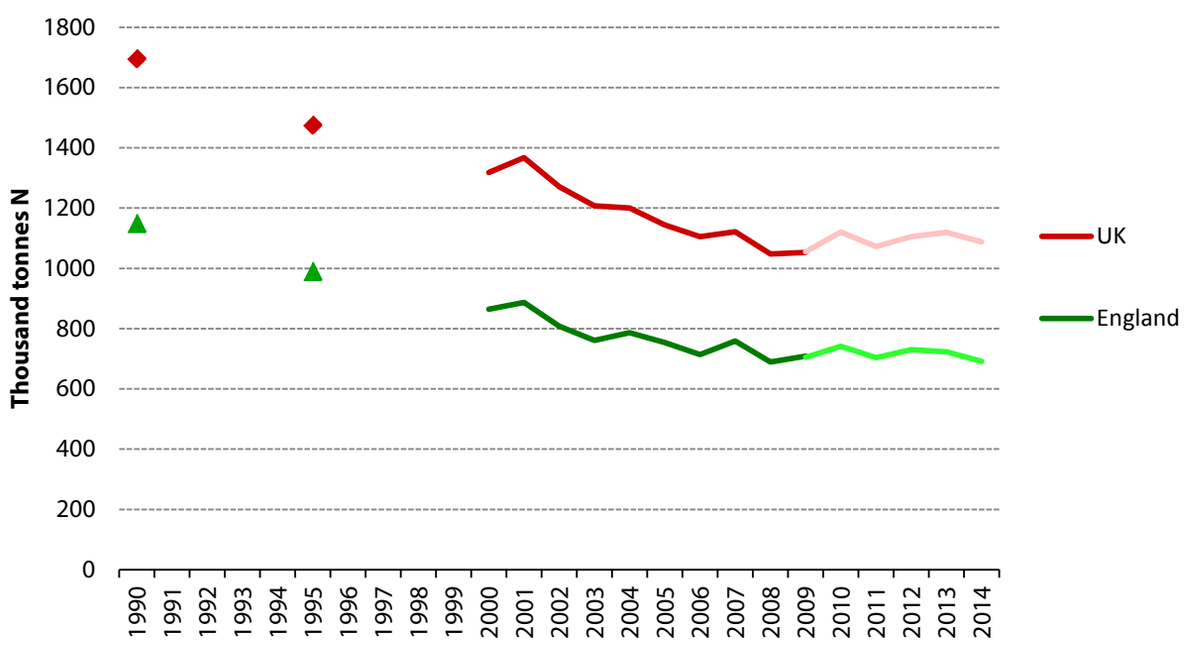
In the next section, we disaggregate the increase in N_2O between production related to crops and to livestock. We consider how changes in agricultural output alongside N_2O emissions have impacted the emissions intensity of both crop and livestock output.

Box 6.2. Nitrogen balance from agriculture

Soil nitrogen balance provides a measure of the total loading of nitrogen on agricultural soils. It provides a high level indicator of the potential risk of nitrogen loss to the environment. A more efficient use of manufactured and organic nitrogen fertilisers is generally associated with a declining nitrogen balance which will in turn lead to a reduced risk of N_2O emissions and other environmental pressures.

The overall trends in the nitrogen balance in the UK and England are shown in Figure B6.1. This indicates that between 1990 and 2009 the nitrogen balance decreased by 38% in the UK. In 2014 there has been a decrease in both England and the UK as a whole, which reflects more typical weather conditions and an increase in offtake by crops which offset the increase in fertiliser use.

Figure B6.1. Nitrogen balance from agriculture, UK and England



Source: Defra.
Notes: There was a break in the series in 2009 relating to farm type therefore the data are not strictly comparable after this point.

Source: *'Agriculture Statistics and Climate Change'*, (2015), Defra. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/476879/agriclimate-6edition-13nov15.pdf

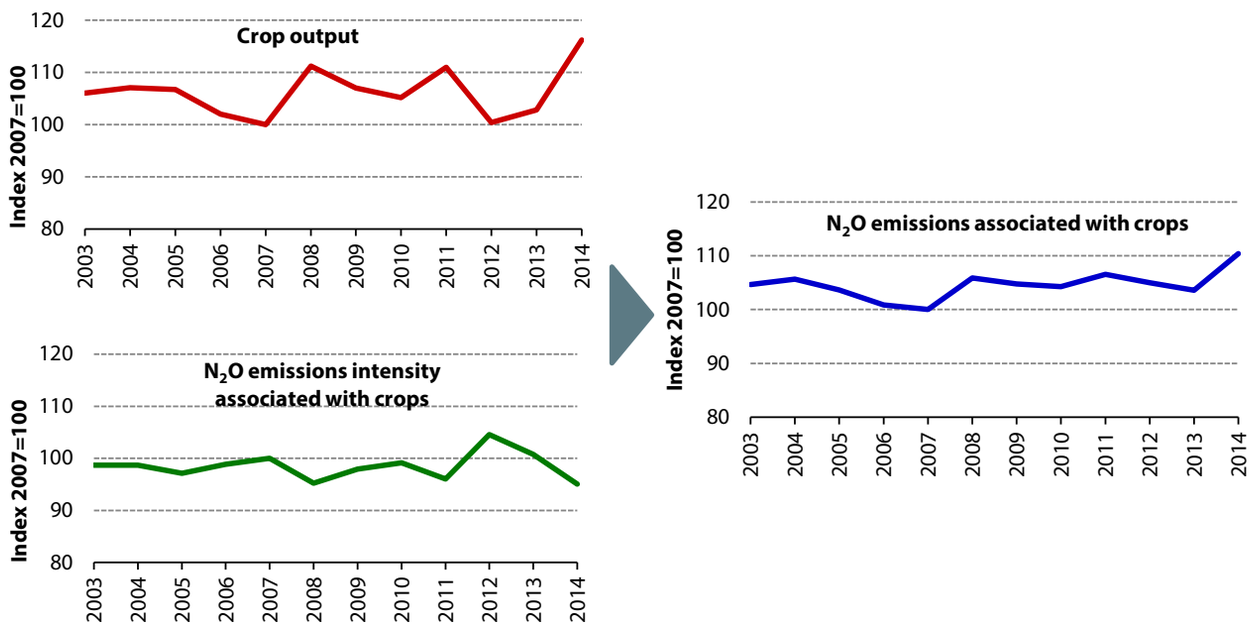
Crops

The change in N_2O emissions associated with growing crops can be disaggregated between changes due to output and those due to emissions intensity.

Since 2003 there has been no real change in crop-related N_2O emissions or in the emissions intensity of crops, with year-on-year variation due largely to weather. The impact of weather on emissions and output was mirrored in the most recent year (Figure 6.4):

- There was a 13% increase in crop output in 2014 (the highest recorded since 1996). Favourable weather conditions produced a return to the sowing of more winter crops, which typically deliver higher yields than spring sown crops.
- N_2O emissions associated with growing crops rose by 6.6%, mainly due to higher fertiliser use and more crop residues incorporated into soils (Box 6.3).
- These led to an overall improvement in N_2O emissions intensity in 2014 of 5.7%.

Figure 6.4. Crop output, N_2O emissions associated with crops and emissions intensity of output (2003-2014)



Source: DECC (2016), Defra (2014) *'Agriculture in the UK'* and CCC calculations.

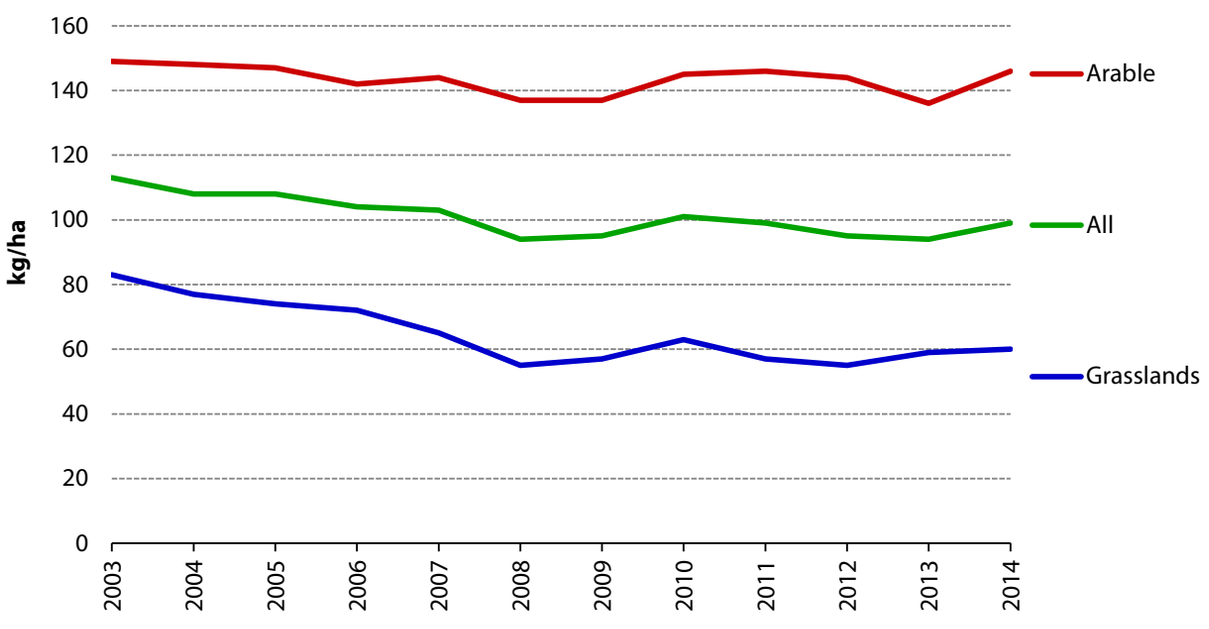
Box 6.3. Recent trends in farming practices and fertiliser use

Since 2003 the use of inorganic fertiliser on arable land has remained broadly constant, typically within the range of 142-149kg/ha. There were exceptions in 2008, 2009 and 2013 when levels fell to below 138kg/ha reflecting either record high fertiliser prices or more recently unfavourable weather.

Weather conditions were a key factor behind the increase in fertiliser use for both arable and grassland in 2014:

- Wet weather conditions in the autumn of 2012 resulted in a large shift to more spring sown crops in 2013, but farmers reverted back to the typical pattern of sowing more winter crops the following season.
- The balance of spring and winter sown crops is an important driver of emissions as it influences the amount of fertiliser used. As crops sown in the winter have a longer growing season, fertiliser use is higher. For all tillage crops, nitrogen fertiliser use increased by 7% to 146kg/ha in 2014, which marked a return to typical pre-2013 rates (Figure B6.2).
- Total grassland area remained unchanged in 2014 compared to 2013, but there was an increase in inorganic fertiliser use on grasslands, which led to a 2% increase in the application rate of nitrogen on grasslands to 60kg/ha (Figure B6.2). Manure application also increased in the year. Despite the increase in fertiliser use, a return to more favourable weather conditions in 2014 increased nutrient uptake by the grass (i.e. more nitrogen is taken up by grass so less is lost to the soil and air). This was reflected in the increased quantity and quality of harvested forage feed.

Figure B6.2. Inorganic fertiliser use (2003-2014)



Source: Defra (2014) *'British Survey of Fertiliser Practice'*.

Analysis for our fifth carbon budget report suggested that the scope for further improvements in nitrogen fertiliser use efficiency may be limited given that the bulk of arable farmers (around 95%) follow a nutrient management plan, although only half of these have professional advice. However, continuing improvements to the inventory should provide further evidence of the types of conditions and areas where further progress is possible. We will update this analysis for next year's Progress Report.

Livestock

Since 2003 there has been a 20% improvement in the N_2O emissions intensity of livestock output. This reflects a 16% reduction in N_2O emissions associated with livestock production, while output increased by 4% over the period.

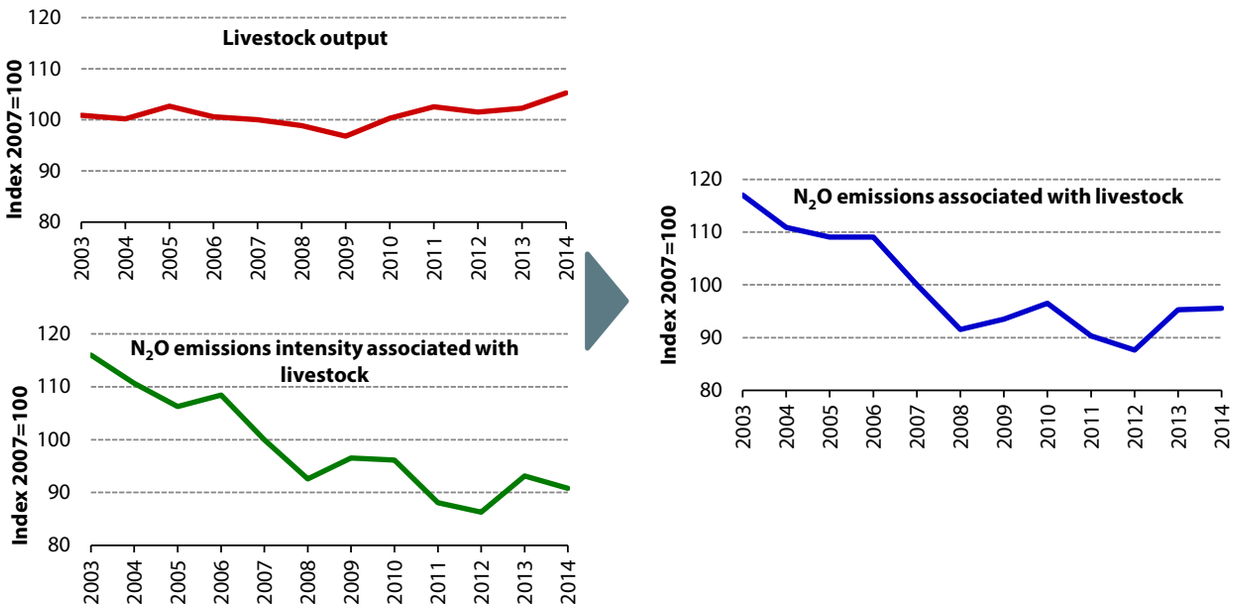
More recently, livestock output rose by 3% in 2014. With N_2O emissions associated with livestock production falling slightly, there was an improvement in the N_2O emissions intensity of livestock output over the year of 3.2% (Figure 6.5):

- N_2O emissions associated with livestock fell slightly in 2014 despite an increase in organic and inorganic fertiliser application. This is likely to be due to improved application practices and the return to more favourable weather in 2014, which increased nutrient uptake (Box 6.3).
- The rise in output was driven mainly by increases in non-meat products (e.g. milk and wool), while the output of meat products remained unchanged.

The more efficient use of fertiliser on grasslands is likely to reflect improvements in farming practices. However, our analysis for the fifth carbon budget suggests there is further scope to increase inorganic fertiliser use efficiency on grasslands. Around 50% of grasslands are being managed without a nutrient management plan, soil ph. testing and soil nutrient testing.

From the perspective of adapting to a changing climate, improving fertiliser efficiency can also deliver benefits beyond emissions abatement, such as reduced diffuse water pollution which can lead to greater biodiversity.

Figure 6.5. Livestock output, N_2O emissions associated with livestock and emissions intensity of output (2003-2014)



Source: DECC (2016), Defra (2014) *'Agriculture in the UK'* and CCC calculations.

Methane

The two main sources of methane emissions are enteric fermentation arising from the digestive process of ruminants (e.g. cattle and sheep), and the management of livestock waste and manures. Since 2003 the methane intensity of output has improved by 9% as higher output, particularly of cattle and sheep products, and better manure management practices have been accompanied by a decrease in emissions.

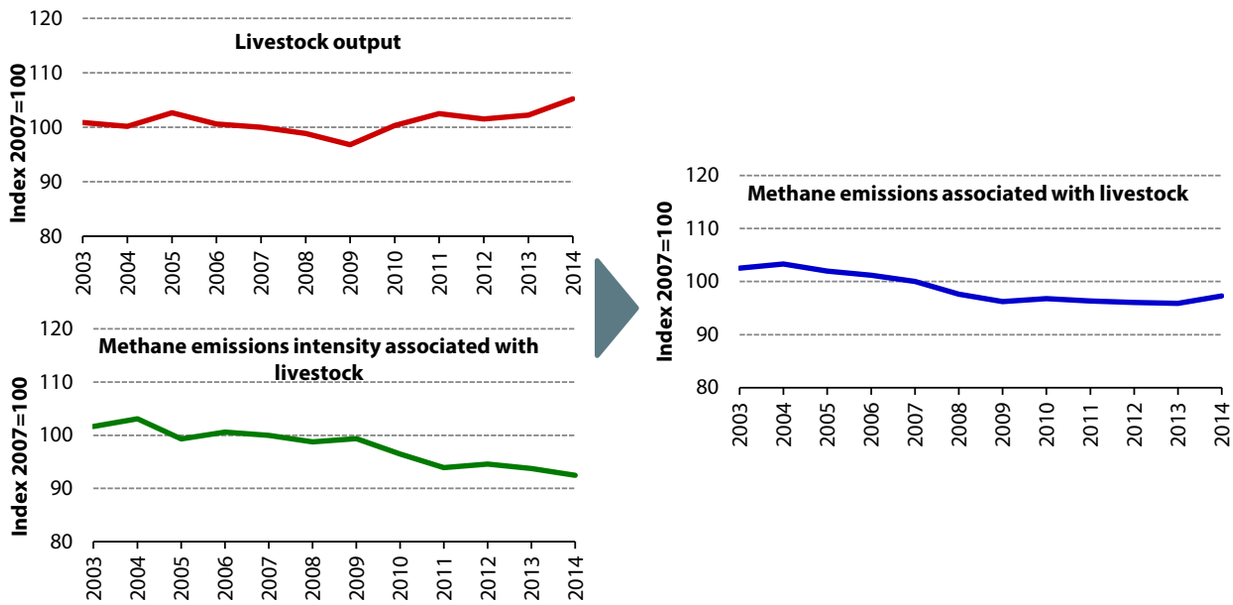
The 1.5% rise in methane emissions in 2014 can be largely attributed to an increase in the dairy herd and higher sheep numbers. These led to higher emissions from enteric fermentation. At the same time, the methane emissions intensity of livestock production improved by 1.4% (Figure 6.6), which can be partly explained by improving livestock productivity:

- While beef output declined slightly by 1%, there was an increase in productivity as measured by average dressed carcase weights, which increased by 3%. Yields also increased for clean pig meat and lamb, each by 2%.
- Higher yields are partly explained by the return to favourable weather conditions in 2014 which improved both the quality and quantity of forage feed for cattle and sheep. The feed conversion ratio[1] for pigs improved by 5%, which indicates that the increased yield was achieved through more efficient use of feed.
- Milk production increased by 8% to its highest level since 1990. This was due to a 5% increase in annual milk yields per animal to nearly 8,000 litres and a 3% increase in the size of the dairy herd.

The methane intensity improvement in 2014 continues a longer-term trend.

[1] The feed conversion ratio is a measure of the amount of feed required to produce one kg of pig live weight.

Figure 6.6. Livestock output, methane emissions associated with all livestock and emissions intensity of output (2003-2014)



Source: DECC (2016), Defra (2014) *'Agriculture in the UK'* and CCC calculations.

Looking ahead, the new agricultural inventory will make it easier to understand the drivers of methane emissions as it moves away from estimates largely based on the number of livestock animals. The inventory will look to include a variety of different factors that influence emissions such as feed type, quantity of dry matter intake and method for covering slurry storage tanks. We will provide a detailed account of the new inventory in next year's Progress Report.

2. Progress against indicators

In our 2010 Progress Report we set out our indicators to track progress in reducing non-CO_2 emissions in the agriculture sector, consistent with the Government's ambition to reduce emissions by 3 $MtCO_2e$ in England by 2022 (scaled up to 4.5 $MtCO_2e$ for the UK) compared to 2007.[2] The set of indicators comprise trajectories for reductions in emissions by gas and source (Figure 6.7).[3]

After two consecutive years of rising non-CO_2 emissions, emissions by gas and source are all above our indicator trajectories in 2014:

- Non-CO_2 emissions were 2 $MtCO_2e$ (5%) higher than our indicator in 2014, the second year running that emissions exceeded our indicator.
- Both methane and N_2O emissions were above their respective trajectories by 3% and 7%. N_2O emissions have been off track since 2008.
- By source, emissions from soils have been above our indicator since 2008 with the gap rising to a high of 9% in 2014. Enteric emissions had been on-track but were above the trajectory

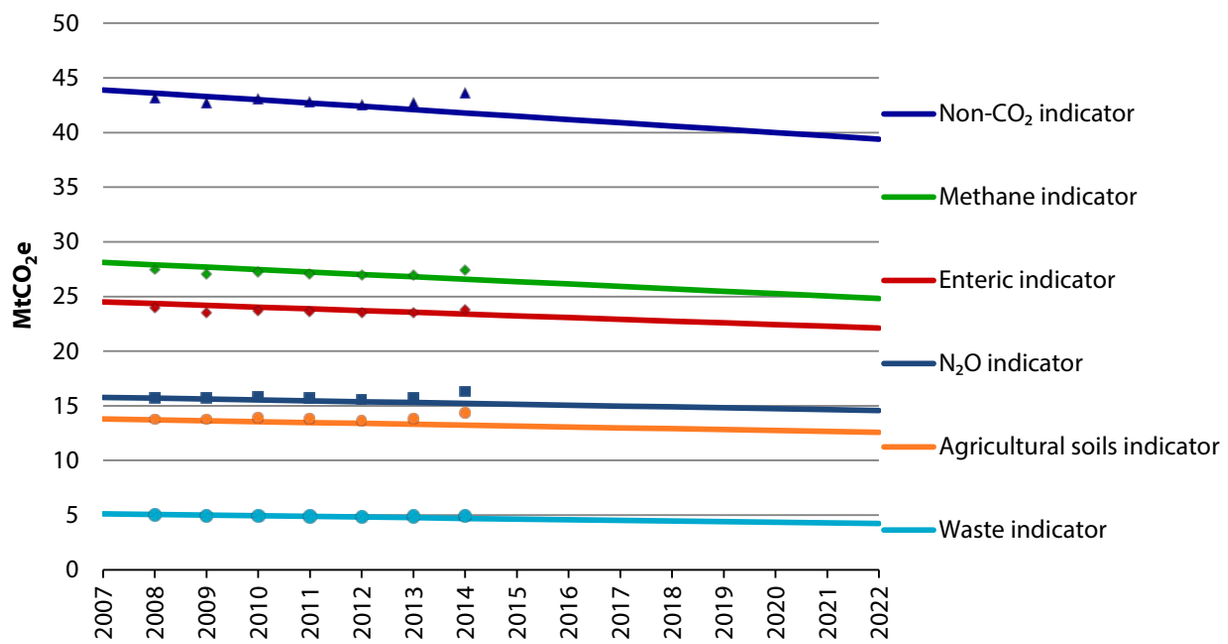
[2] The indicator table is set out in the Technical Annex on the CCC website, www.theccc.org.uk
[3] The indicator for N_2O has been scaled to take account of the revised inventory.

in 2014, while emissions from waste and manure management remained above the indicator for the third successive year.

Our assessment indicates that the sector is not on track to deliver saving of 4.5 $MtCO_2e$ in UK agriculture by 2022. For N_2O, soils and waste and manure management, emissions have not been consistent with the indicator trajectories for a number of years. To reach savings of 4.5 $MtCO_2e$ consistent with our trajectories to meet carbon budgets, future reductions of 1.3% per year will be required. Given the lack of progress it is important that appropriate action is taken to get back on track and an effective monitoring framework is put in place.

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



Source: DECC (2016), CCC calculations based on the England ambition scaled to the UK.
Note: Marker points indicate outturn data.

3. The policy framework

Industry-led approach (GHG Action Plan)

The Greenhouse Gas (GHG) Action Plan is the sole policy mechanism in place to deliver the Government's ambition for a 3 $MtCO_2e$ reduction in non-CO_2 emissions in England by 2022. UK agriculture emissions are not on track to deliver our trajectory for emissions reduction to 2022. As agriculture emissions have also risen in England (by 0.9 $MtCO_2e$ in the past two years), this implies the voluntary approach is not delivering the GHG Action Plan ambition. The current framework therefore needs to be strengthened, and Government should set out plans to achieve this in its 2016 review of the Action Plan to be published later this year.

The current Action Plan is being delivered through a voluntary industry-led approach over three phases. The second phase (2012-15) focused on the promotion of farming practices to reduce emissions in areas such as livestock feed, livestock health and soil and land management. Other work planned for the final phase, targeted at promoting measures that are cost-effective to reduce emissions, include roadmaps to deliver emissions reductions in the livestock sector and the promotion of information to help deliver healthy grasslands (Box 6.4).

Despite all the programmes and initiatives that the GHG Action Plan has established to date, it has been impossible to appraise its effectiveness with regards to reducing emissions given the lack of an effective monitoring and evaluation framework. We have therefore relied on a high-level assessment of trends and the comparison of emissions against our indicator framework in concluding that emissions are not on track with ambition in this sector.

Agricultural policy is a devolved matter, and as in England it is being delivered through a voluntary approach in the other nations. Our abatement scenario for the UK assumes a 4.5 $MtCO_2e$ reduction (based on scaling up the ambition of 3 $MtCO_2e$ in England to the UK) by the end of the third carbon budget period. Further details on progress in meeting targets by each DA are set out in Chapter 9.

Box 6.4. Developments under the second and third phases of the GHG Action Plan

A number of schemes were implemented as part of the second phase of the GHG Action Plan (2012-2015). These include the following to improve fertiliser use efficiency, animal nutrition and soil management:

- FACT's (fertiliser adviser certification) personnel providing nutrient management advice to farmers on such things as fertiliser use are now required to under-go training on emissions abatement in order to retain their professional status. The Plan found that all but 350 of the 2,500 plus advisors underwent the training.
- In the absence of any standard for advisors of animal feed nutrition, the Feed Adviser Register (FAR) was launched in 2013. Advisors wishing to be registered have to undertake core competencies on feed efficiencies and mitigation of GHG impacts. During the first two years, over 1,100 practicing advisors joined FAR across all livestock sectors, and on-going membership requires continual professional development.
- The GHG Action Plan has implemented a number of initiatives to fill the knowledge gap among farmers on management of soils. These include raising awareness on the benefits of conducting soil testing, particularly for livestock farms where uptake is less common than on arable farms; and the adoption of catch and cover crops, which can minimise the use of fertiliser and improve soil structure.

Work targeting cost-effective emissions reduction under the final phase include:

- Publication of an economic roadmap for feasible emissions reductions from manures and slurry in storage and animal housing. This will consider the costs of technologies and practices for different farm types, and policy mechanisms to incentivise take-up.
- The promotion of information on Healthy Grassland Soils to address soil structure, drainage and nutrients for the dairy, beef and lamb sectors. Information on uptake will be made available on-line and at industry run events.
- Assessing the impact of providing professionally tailored feed advice to 1,000 livestock farms by collecting and analysing case study information. The assumption is that better knowledge of energy and protein requirements of livestock will allow better planning and improved feed conversion efficiency.

The industry has stated a commitment to establish a set of robust indicators by which it can monitor progress for the final third phase of the scheme. As a first step it has identified indicators to track progress in reducing emissions for each of its seven key priority areas. It is important that this is completed as soon as practicable.

Source: GHG Action Plan (2016).

The Indicator Framework

The Government published a set of ten indicators in 2012, updated annually, to track progress in reducing GHG emissions in England. These were aligned with the Industry's GHG Action Plan and cover famer attitudes and knowledge, the uptake of mitigation methods and the GHG emissions intensity of production.

The latest assessment of these indicators[4] suggests that whilst there have been positive long-term trends in nitrogen use efficiency and soil nitrogen balance, there has been limited recent progress in other areas including: attitudes and knowledge of mitigation methods by farmers; livestock breeding regimes; feed conversion rates for some livestock; and uptake of slurry and manure management practices.

Other policies affecting agriculture

Anaerobic Digestion (AD)

The GHG Action Plan sets out an ambition to save 0.55 $MtCO_2e$ by 2022 through the use of manures and agricultural waste in AD plant. Recent Government changes to support for small-scale generation technologies, including AD, have led to a reduction of tariffs linked to deployment levels and new proposals to limit support for larger scale (over 500kW) plant (Box 6.5).

The proposals also aim to improve the environmental footprint of AD by introducing sustainability criteria for the Feed-in-Tariffs (FiTs). Key elements of this are:

- The introduction of minimum GHG emissions thresholds that reduce over time.
- Land criteria to ensure biomass is not sourced from land with high carbon stock or biodiversity value; and
- A restriction of payments for electricity generated from biogas derived from non-waste feedstocks.

AD should only be supported where it is delivering genuine emissions reduction, and the sustainability proposals aim to ensure this. A recent study commissioned by Defra[5] assessed the environmental impacts of growing maize for AD, the detail of which is provided in the Technical Annex.

Assessing the full GHG footprint of on-farm AD is complex. It is important that industry and Government continue to monitor this and work together to deliver best practice in this area. While FiT tariff levels should be adjusted as new evidence on costs emerges, the sector will need to monitor these developments closely to ensure that the emissions savings set out in the GHG Action Plan can be delivered, or alternative options pursued.

[4]Defra (2016) '*Agricultural Statistics and Climate Change*' available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/476879/agriclimate-6edition-13nov15.pdf

[5]ADAS and Ricardo Energy & Environment (2016) *'Impacts of agricultural maize cultivation on agricultural land rental prices and the environment'* available at: http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17806

Box 6.5. Recent changes to Government support for small-scale generation technologies

Following a consultation last year, Government set out changes to support for small-scale generation technologies, including AD. The key elements of this were:

- The introduction of quarterly deployment caps of 5.8 MW in the first quarter of 2016, falling to 5 MW thereafter.
- FiT rates linked to deployment, with a reduction of 10% if the cap is hit and a default reduction linked to technology costs and bill savings.
- The re-introduction of pre-accreditation of one year for AD plant. This gives developers some certainty over the level of support they will be eligible for, but they are still subject to the overall capacity limit.

Government issued another consultation on FiT tariff rates in May 2016. The main proposed change is to withdraw FiT payments for AD over 500kW plant, while they will still be eligible for export tariffs and RHI payments if they are a CHP plant.

These tariff reductions in recent years have impacted on deployment of these technologies, with small-scale (up to 500kW) installed capacity of AD falling from 35MW in 2014 to 10MW in 2015. The introduction of deployment caps will reduce deployment further, as the number of AD applications as of April 2016 has already reached the cap up to the first quarter of 2017.

Source: DECC.

Agri-tech strategy

In 2013 the Government published an Agri-Tech strategy which aims to improve innovation and productivity in the agriculture sector. The two main strands of this are:

- A £70 million Agri-Tech Catalyst Fund which funds projects designed to tackle challenges in the sector and boost growth. Projects range from crop and livestock production to food security and downstream food processing.
- Funding for centres for Agricultural Innovation, a collaboration between the agri-tech sector and Government. The first three centres are: Agri-metrics, launched in October 2015, aiming to connect Business with data integration and analysis; a Centre for Crop Health and Analysis and Centre for Innovation Excellence in Livestock.

Many of the projects are in the early stages of research and development and it is too early to evaluate their impact. The Government plans to undertake an interim evaluation in 2017/18. It is important that this covers impacts on agricultural productivity and sustainability.

The Common Agricultural Policy (CAP)

While the UK agriculture emissions reduction target to 2022 is based on a domestic voluntary approach that relies on the provision of information and advice to farmers, there are EU policies in place that can also influence emissions savings such as the CAP. However, as the CAP does not directly target the reduction of emissions we are unable to measure or attribute emission savings to this policy. Therefore, the impact of the UK's vote to leave the EU on emissions savings in agriculture is highly uncertain at present.

The main impact on emissions savings from possible CAP withdrawal is likely to result from the changes in funding from the agri-environmental schemes under what is now Pillar Two, which is currently funding schemes such as Countryside productivity:

- Launched last year, the scheme will invest £141 million during the course of the Rural Development Programme (RDP) (2014-2020) in both farming and woodland in England. The first tranche of capital funding worth £5 million was made available for specific equipment and innovative technology to improve productivity and sustainability in farming:
  - Slurry application systems, combined with flow monitors and GPS equipment to ensure accurate application so reducing emissions (e.g. ammonia and methane).
  - Tractor mounted remote crop sensing, which can vary the rate of fertiliser application to match crop needs. This enhances fertiliser use efficiency.
  - LED lighting and controls for livestock housing, reduce energy consumption and improves productivity. For example, increases in milk yield due to carefully controlled lighting times and levels.

Given the vital role that RDP funding can play with regards to emissions savings, Defra and the DAs should look to agree new arrangements or adapt existing arrangements, as appropriate.

Other developments

Defra is working on a 25-year Food and Farming Plan and a long-term Environmental Strategy. It is important that these take account of the need for the agriculture sector to reduce emissions in line with the advice in our fifth carbon budget report (i.e. by around 15% over 2014-2030).

4. Forward look and policy gap

Progress by Government in meeting our recommendations from last year's Progress Report has been relatively limited, with no progress in most areas (Table 6.3).

In last year's Progress Report, our assessment was that all the policy savings in our fourth carbon budget scenario, 8.4 $MtCO_2e$ by 2027, were at risk. We subsequently revised down our abatement potential based on updated evidence from our fifth carbon budget work, and methodology improvements to this year's inventory. The message however, remains the same that the bulk of abatement contributing to carbon budgets is at risk (Figure 6.8). This reflects:

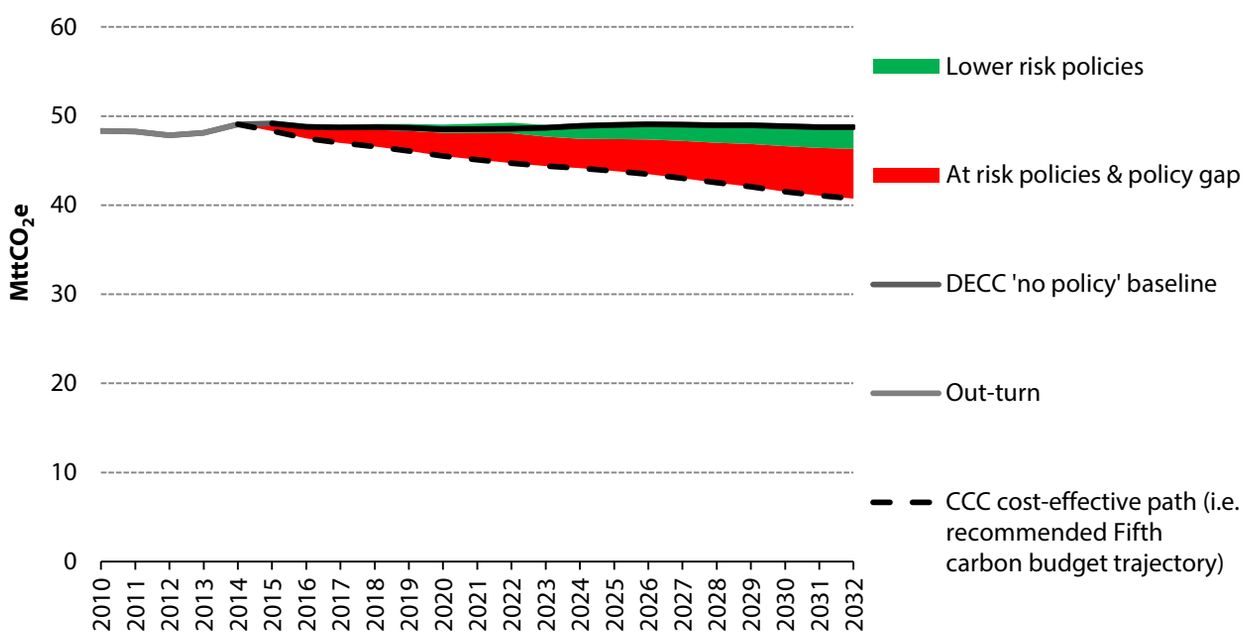
- The voluntary approach of the GHG Action Plan, and the difficulties in being able to monitor its effectiveness in reducing emissions. We assess some of these savings to be at lower risk as there is some evidence that farmers are implementing measures to reduce emissions, although it is difficult to attribute these directly to the GHG Action Plan.
- The absence of any policy instrument in place beyond 2022 to deliver additional emissions reductions to the end of the fifth carbon budget period.

Table 6.3. Assessment of 2015 recommendations

Recommendation in 2015	Assessment	Commentary
Deliver the Smart Inventory to the current timeline, without further delays.	Partially met.	There have been improvements to the inventory this year but this is yet to be completed. Expected to be delivered in 2017.
Strengthen the current voluntary approach to reduce agricultural emissions if the 2016 review cannot assess the effectiveness of the existing scheme.	No progress.	The 2016 Government review has not yet been published. Problems with monitoring the effectiveness of the GHG Action Plan remain.
Co-ordinate effort to reduce emissions from agriculture and forestry across all four nations.	No progress.	Government has not set out the ambition for the UK as a whole, taking into account ambition from all nations.

Source: CCC analysis.

Figure 6.8. Assessment of emissions savings from current and planned policy against the cost-effective path in agriculture



Source: DECC UEP projections (2015) and CCC calculations.
Notes: N_2O emissions projections and savings have been scaled to take account of the revised 2016 inventory. We will provide a more detailed assessment of the impact of inventory changes next year.

Our assessment of policies to deliver emissions savings in agriculture is set out in Table 6.4. This table illustrates the areas where there is a gap in existing policy and the need to set out a stronger approach to deliver our fifth carbon budget scenario. This needs to be addressed in the Government's emission reduction plan. An effective plan will have addressed the gaps identified in the table as far as practically possible.

Table 6.4. Assessment of policies to drive abatement options in agriculture

Abatement option	2015 policy	Change in 2015/16	2016 policy
GHG Action Plan – to 2022	Amber: Some measures being delivered but unable to fully assess.	Awaiting Government review of GHG Action Plan.	Red
Measures post 2022 aimed at reducing emissions through: • Crops and soil management • Livestock diet, health and breeding • Waste & manure management • Energy efficiency	Red: No policy.	No change.	Red

Source: CCC analysis.
Notes: Key - Red: Policy gap, Amber: Policy at risk.

5. Land use, land-use change and forestry emissions

The land use, land-use change and forestry (LULUCF) sector captures removals and sources of emissions arising from the use and change in use of different land types in the UK. The main land categories are cropland, forestry, grassland, wetlands and settlements. On a net emissions basis, the sector increased its sink by 4% to 9 $MtCO_2e$ in 2014 compared to the previous year. This is consistent with the annual average increase in net removals between 2009 and 2014.

Emissions trends

There have been a few amendments to the methodology for calculating emissions in this year's inventory. The most significant change occurred in the grassland category, where a correction in the emissions factor for the drainage of organic soils on grassland reduced emissions across the time series. This means that while grassland accounted for almost 4 $MtCO_2e$ of emissions released in 2013 based on the 2015 inventory, the revised estimate for the same year is closer to 0.4 $MtCO_2e$.

This, and other more minor amendments, combined to increase estimated total sequestration in the LULUCF sector across the time series:

- The net carbon sink for 2013 is now 64% higher than the estimate reported in last year's inventory (i.e. 9 $MtCO_2e$ versus 5.6 $MtCO_2e$).
- The sector became a net carbon sink ten years earlier (i.e. 1991) than previously reported.

There will be further amendments to the inventory. This is due to on-going work to provide better estimates of existing sources of emissions and sequestration captured in the inventory, in addition to quantifying new sources, which are not currently reported (Box 6.6).

Box 6.6. Planned improvements to the LULUCF inventory

Planned improvements to the LULUCF inventory cover a range of emissions and sequestration from peatland, other soil types and forestry:

- **Peatland.** The inventory does not report on emission losses from all peatlands and sequestration from restoration practices. However, DECC is currently in the process of incorporating the IPCC's Wetland Supplement into the UK's Inventory by 2018, which covers both upland and lowland peat. Defra funded projects are due to report later this year that will feed into the Wetland Supplement:
  - SP1202[6] is looking at how best to restore drained upland peatland to achieve the biggest emissions impact by maximising CO_2 sequestration and reducing methane loss. Field trials have been conducted over a four year period.
  - SP1210[7] will provide the first full carbon and GHG budgets for lowland peatland across England and Wales under different management and land uses (e.g. pristine bogs and lands that have been impacted by extraction, grazing and arable production). The results will be used to develop emission factors for each peat type under a range of management activities.
- **Forestry.** Forest Research is currently reviewing the Carbine model (which estimates the carbon accounts for UK woodlands for the inventory) to assess the soil carbon losses of forestry planted on organic soil. To date, the model assumes no carbon losses arise from trees planted on organic soils. Further changes in forestry will see the inclusion in the inventory of small woodland areas.
- **Soils.** Emissions factors are being developed for organo-mineral soils (i.e. organic soils that are not peat) in England, and coastal salt marshes so that both sources can be included in the inventory.
- **Land management practices on agricultural land.** The impact of cropland management practices on soil carbon stocks were introduced into this year's inventory. The results indicate that practices such as incorporating manure and crop residues have little impact on increasing carbon stocks. Management practices on grassland should still be included by 2021 in line with the EU timeframe for mandatory reporting of the impact of land management practices on soil carbon.

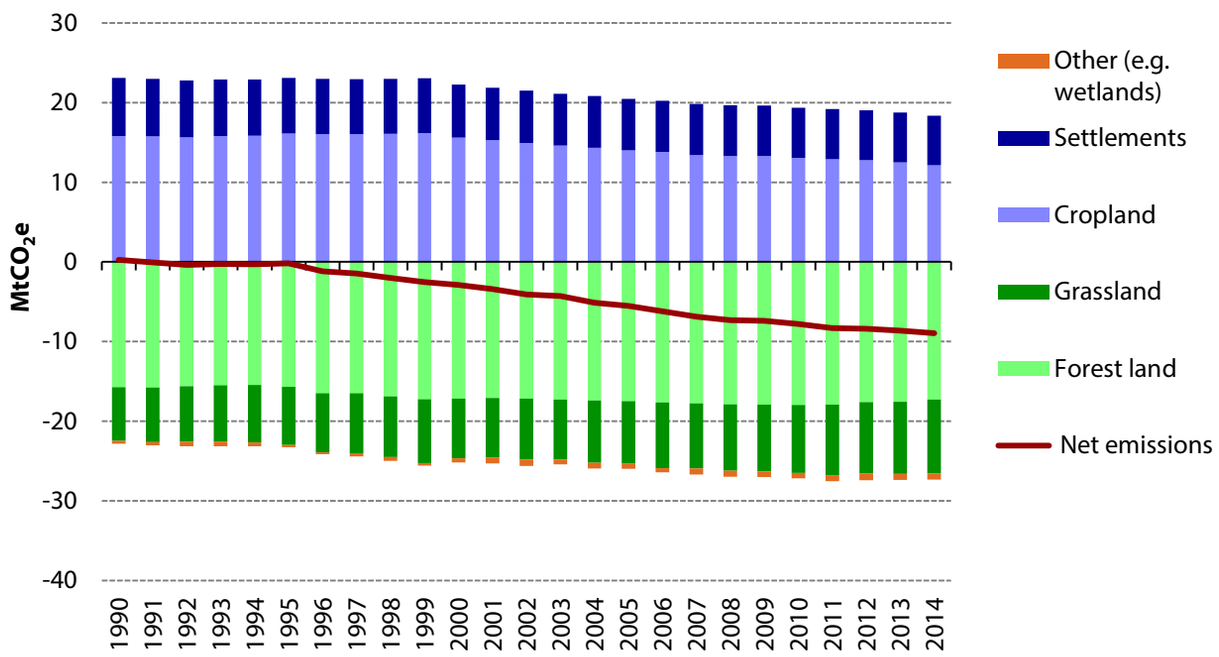
While peatland inclusion into the inventory is expected to lead to a big reduction in the estimated UK net carbon sink, we will have to await the results of all these projects to assess the overall impact.

The main changes in emissions and removals by land type in 2014 are (Figure 6.9):

[6] Defra, *'Investigation of peatland restoration (grip blocking) techniques to achieve best outcomes for methane and greenhouse gas emissions / balance - SP1202'.*
[7] Defra, *'Lowland peatland systems in England and Wales - evaluating greenhouse gas fluxes and carbon balances - SP1210'.*

- Forestry carbon sequestration reduced by 2% in 2014, though it remains the largest net carbon sink. This is mainly due to the declining strength of existing forestry to absorb carbon due to the ageing profile of the trees. Net removals from grassland increased by 2%.
- Cropland accounts for over 60% of emissions released in the sector, but emissions declined by 3% in 2014. Emissions from settlements remained unchanged between 2013 and 2014.

Figure 6.9. LULUCF emissions and removals (1990-2014)



Source: DECC (2016).

Opportunities to reduce LULUCF emissions

The main measures that could be deployed to increase the carbon sink and slow the release of emissions are planting trees and minimising carbon losses from degraded peatland and other soil types. In addition to the carbon benefits, there are synergies with efforts to adapt to climate change. For example, the restoration of peatland can improve water quality, while the creation of agro-forestry systems can improve soil structure and fertility, and enhance biodiversity.

Forestry

In our fifth carbon budget report we identified the planting of trees from both the creation of new woodland and the integration of trees and shrubs into existing arable and grassland systems (e.g. agro-forestry) as measures that could deliver 2.4 $MtCO_2e$ of savings by 2030. Our fifth carbon central scenario assumes:

- **Afforestation:** The planting of around 15,000 hectares a year between now and 2030. This would increase UK forestry land cover from the current level of 13% to around 14% over the period, and would deliver emissions saving of 1.8 $MtCO_2e$ by 2030.
- **Agro-forestry:** An increase in agro-forestry systems by an additional 0.6% to 1.6% of UK agricultural land area, could deliver abatement of 0.6 $MtCO_2e$ by 2030. These emissions

savings relate to the increase in carbon sequestration in soils and trees, but abatement could be higher once the savings from reduced fertiliser use for crops and grassland are taken into account.

The next section looks at the policy landscape for delivering these measures.

Afforestation

Plans for new woodland creation in the UK currently go beyond our recommended level of afforestation of around 15,000 hectares a year:

- England has an ambition to increase cover from 10% in 2015 to 12% by 2060, which is equivalent to an average annual rate of around 5,000 hectares. Work to identify and quantify 'low sensitive' areas suitable for planting, which would exclude specific areas such as national parks, sites of special scientific interest and high grade agricultural land is expected to be published later this year.
- Scotland has the most ambitious plan with a target to plant 10,000 hectares a year until the middle of the century, with a further 5,000 ha/year in Wales and 1,700 ha/year in Northern Ireland. However, in view of the low uptake achieved in Wales to date, the short-term target to 2020 has been lowered to 2,000 ha/year (see Chapter 9 for more details on the DAs).

Progress to date has been short of the ambition amongst all the counties with the combined level of new tree planting in the UK reaching just over 10,000 hectares in the year to end March 2015. To date plans have been largely funded by the Rural Development Programmes (RDP) under Pillar Two of the Common Agricultural Policy (see Chapter 9 for DA details). Given the vote to leave the EU, the extent to which the UK continues to participate in the CAP is uncertain. However, the UK domestic requirements to reduce emissions from afforestation will require measures that deliver similar outcomes.

A manifesto commitment was made last year to plant 11 million trees between 2014 and 2020 in England. This corresponds to around 14,000 hectares, and in the absence of future CAP funding will have to be delivered by alternative arrangements (Box 6.7).

Box 6.7. Public sources of funding for afforestation and woodland management in England

Public sources of funding are being made available in recognition of the 'market failure' for carbon sequestration. This will help contribute to the Government's ambition to increase woodland cover in England:

- **The Countryside Stewardship** of the RDP is providing £18 million annually for woodland creation. This equates to around 2,000 ha/year, totalling 14,000 hectares over the seven years of the RDP. Funds are awarded to applications that can demonstrate the biggest positive impact on biodiversity, water quality, flood alleviation and climate change. However, poor uptake of the scheme in the first year (2015/16) resulted in only 546 hectares of new woodland being approved. Defra should ensure that this does not represent more than a temporary slow start associated with running a new scheme, and that uptake in future years meets the intended target.
- The RDP will also provide a further £13 million annually over the period for **woodland management**. With around 42% of English woodlands in an unmanaged or under-managed state, active management can deliver carbon benefits by minimising the risk of carbon losses arising from wind, fire and pests, the incidence of which could increase with a changing climate. Furthermore, low intensity management can help young and better quality trees to thrive thereby aiding the sequestration of more carbon.
- An additional one million trees, all native species, are being made available to **schools in England** to 2020. The Government will fund 400,000 trees, with the remaining funded by the Woodland Trust's corporate-sponsorship programme.
- The Countryside Stewardship is being complemented by the **Woodland Creation Planning Grant (WCPG)**, which is a one-off payment for designing a woodland creation plan. The £200,000 grant is funded by Defra's Forestry Innovation Fund, which was launched last year to provide £1 million to support schemes to promote the growth of the forestry industry. The WCPG closed earlier this year with 11 applications, with plans to create over 1,000 hectares of new woodland.
- Separate to the RDP, the Spending Review in 2015 promised a further £19 million under the **Woodland Carbon Fund**. It is expected to provide capital funding for additional carbon reductions through further woodland creation in England.

The Government is expecting that these public sources of funding will leverage access to private finance. England is committed to attracting private investment in order to meet its aspiration through voluntary schemes such as the Woodland Carbon Code, while further work is on-going to reduce the financial and non-financial barriers for landowners (Box 6.8). However, it is unclear what the overall level of ambition in these schemes amounts to and whether it meets our fifth carbon budget central scenario.

Box 6.8. Enablers for private sector investment in woodland creation in England

In addition to public sources of funding such as the Rural Development Programme, England is committed to bringing forward private sources of investment to help deliver the ambition to increase woodland cover from 10% to 12% by 2060:

- **UK Woodland Carbon Code.** The scheme encourages companies to fund woodland creation as a means to offset their wider emissions with the carbon sequestered by trees. Since its launch in 2011, the scheme which is administered by the Forestry Commission has registered 220 projects by end 2015 covering almost 16,000 hectares of new woodland. It is estimated that these projects will sequester 5.7 $MtCO_2$ in their lifetime over the next 100 years.
- **Regulatory framework for woodland creation.** By May 2017, Defra will have decided how to meet the new requirements of the Environmental Impact Assessment Directive for forestry projects. This will enable them to decide whether and how to ease the current regulatory and consultation processes required to create new woodland in order to encourage more tree planting. At present, a full Environmental Statement may be required when planting more than five hectares of woodland, more than two hectares in protected landscapes, and in all cases when planting on protected sites such as Sites of Special Scientific Interest. Potential reform could allow an increase in the planting threshold, although developers would still be required to submit plans at the screening stage to ensure the planting would not create environmental harm. The Durham pilot which had been exploring the scope to improve the regulatory framework, has been extended to Cumbria and Northumberland, the results of which will help inform the approach to be taken nationally.
- **'Roots to prosperity'** is a pan north of England group initiated in 2014 comprising most large and medium timber processors, forestry sector advocates, a number of landowners, woodland initiatives, and the Forestry Commission. It aims to promote good forestry management, increase timber sales and promote economic growth. Its prospectus launched earlier this year identified the need to plant 2,000 hectares a year of productive woodland over the next ten years.

While we welcome the Government's provision of funding, it will be important to consider further policy incentives should the overall level of tree planting continue to remain below our scenario. Given the declining strength of existing forestry to absorb more carbon, meeting the targets for tree planting is critical to ensure that the LULUCF sector remains a net carbon sink going forward and that carbon budgets are met.

Going beyond 2030, the agriculture and LULUCF sectors combined will form a higher share of residual emissions as other sectors decarbonise more quickly. Deeper cuts and higher afforestation rates will be needed in these sectors to meet the current 2050 climate objective and the longer term ambition in the Paris agreement. We will be assessing the role of the land use sector in providing further emissions reduction and in particular the role of negative emissions (Bioenergy with Carbon Capture and Storage) in two further projects:

- The implications of the Paris agreement on the 2050 target and beyond; and
- The effective use of land to meet both mitigation and adaptation goals.

Agro-forestry

Take-up to date of agro-forestry in the UK has been extremely low, and no official estimates exist of the amount of land applying this type of system. For our fifth carbon budget work, we estimated that the 1% of agricultural land that contain trees and shrubs for buffer strips and shelter belts could act as a useful proxy for existing agro-forestry.

Our abatement scenario assumes a high level of policy support to overcome both financial and non-financial barriers. The lack of financial support remains a significant barrier given the up-front costs involved in buying and planting trees, and for arable farmers the loss of income before the trees can be harvested. In addition, lack of knowledge amongst farmers and Government on the multiple benefits that the system can deliver should also be addressed.

Peatlands

Our fifth carbon budget scenario does not include actions aimed at reducing carbon losses from peatland because of the need to better understand the impact of different emissions reduction measures, and the omission of some peat sources from the current inventory. However, UK peatlands are a large carbon store and degraded peatlands risk significant carbon emissions whether or not they are currently accounted for in the inventory.

It is therefore important that action is taken to improve the condition of degraded soils, and to limit damaging practices such as extraction for horticultural use and intensive rotational burning on upland moors (Box 6.9). The Environmental Audit Committee recently recommended the need for urgent action to increase carbon levels in all soils, including peat.[8] We support these recommendations and the need for Government to complete planned work to include peatland emissions and sequestration practices in the inventory by 2018.

Box 6.9. Developments to limit carbon losses from peatland

Steps are being taken by Government to restore peatland habitat by incentivising the private sector while making available public sources of funding:

- **Peat for horticultural purposes.** The extraction of lowland peat mainly for horticultural use is the only source of peat emissions captured in the inventory. It accounted for around 0.4 $MtCO_2e$ of emissions in 2014 as sales of domestically sourced peat in the UK increased by 13% to 850,000 m^3. England has an ambition to voluntarily phase out the use of all peat for horticultural use by 2030, and it will be reviewing this target later this year to assess whether it remains appropriate.
- **The UK Peatland Code.** Formally launched last November, the Code is a voluntary standard aiming to attract private investment to accredited restoration projects, with the emissions savings enabling investors to meet social corporate responsibilities. The next phase of work is focussed on developing governance for the Code alongside awareness-raising and marketing to potential sponsors, and identification of further potential sites for restoration.
- **Capital spend.** The Spending Review in 2015 announced £100 million of capital spend would be made available for a range of projects supporting the natural environment. While details have yet to be finalised, funds will be allocated to projects restoring important peatland habitats, with priority given to sites that deliver GHG benefits.

[8] Environmental Audit Committee (2016), *'Soil health'*.

6. LULUCF forward look and policy gap

In last year's Progress Report, we noted that plans by England and the DAs to increase woodland creation would, if achieved, be close to the 1 $MtCO_2e$ emissions reduction for 2030 set out in carbon budgets. Our updated scenarios for the fifth carbon budget suggested that this could be increased to 1.8 $MtCO_2e$, given the latest evidence on sequestration rates and tree planting ambition, with additional savings of 0.6 $MtCO_2e$ from agro-forestry. We consider both of these to be at risk:

- While the level of ambition to increase afforestation rates in the UK is close to the implied 15,000 ha/year by 2030 in our scenario, progress to date has been short of this.
- There are no measures currently in place to incentivise agro-forestry schemes, and no effective way to track up-take.

These imply savings at risk of 2.4 $MtCO_2e$ by 2030.

An effective plan needs to address these two areas and should include: measures to ensure the level of afforestation ambition in plans by all nations are delivered; and support for the take-up of agro-forestry consistent with the level of ambition set out in the fifth carbon budget (Table 6.5). Effective monitoring should be in place to ensure progress in this area can be tracked.

Table 6.5. Assessment of policies to drive abatement options in LULUCF

Abatement option	2015 policy		Change in 2015/16	2016 policy
Afforestation	Amber	Some funding available, not enough to deliver required tree planting rates.	Further public funding, but not clear on private investment being brought forward.	Amber
Agro-forestry	Red	No policy.	No change.	Red

Source: CCC analysis.
Notes: Key - Red: Policy gap, Amber: Policy at risk.

Chapter 7: Waste

Key messages and recommendations

Waste emissions account for almost 4% of total UK greenhouse gases and are predominantly methane emissions which arise due to the decomposition of biodegradable waste in landfill sites in the absence of oxygen.

Waste emission data lags other sectors by a year due to the longer time required to collate non-CO_2 emissions data. In this chapter, we assess waste emissions over the period 2009-2013, 2014 outturn data, as well as policy progress to unlock abatement potential.

The vote to leave the EU may have some impact on how emission reductions are delivered in the waste sector. A number of EU policies currently contribute to emissions reduction, such as the Landfill Directive, Waste Framework Directive and proposed Circular Economy Package. To meet the UK's domestic emission reduction commitments it will be necessary to agree new arrangements or adapt existing arrangements as appropriate. It is too early for the Committee to assess the precise balance. References to current EU agreements in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

Our key messages are:

- **Emission trends and drivers.** Waste emissions fell by 11% in 2014, following an annual average 12% decrease over the period 2009-2013. 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.
- Currently the GHG inventory estimates emissions from waste water treatment are 4 $MtCO_2e$. This is based on high default values due to limited available data on waste water emissions and could be an overestimate. There is need for accurate data for waste water emissions and the identification of further abatement potential.
- **Policy has been successful in making deep cuts in waste emissions to date, though there has been mixed progress in preparing for further cost-effective cuts in future.** Waste management is a devolved issue, with England and each of the devolved administrations developing waste strategies and legislating waste measures. For each UK nation we assess the policy progress to further reduce waste emissions.
    - England has put in place a waste prevention programme and anaerobic strategy, however there are no additional measures to minimise biodegradable waste going to landfill.
    - Scotland has put in place a waste prevention programme, set requirements for separate waste collections for businesses and a ban on biodegradable municipal waste going to landfill from 2021.
    - Wales has put in place a waste prevention programme and local authorities provide separate food waste collection to all households; however there are no additional measures to minimise biodegradable waste going to landfill.
    - Northern Ireland has put in place a waste prevention programme and food waste regulations, however there are no additional measures to minimise biodegradable waste going to landfill.
- **Further policy strengthening will be required to meet the fourth and recommended 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 should also be further progress in avoiding the release of methane emissions at landfill sites where possible (e.g. higher rates of capture).

Our recommendations reflect the need to address the delivery gap to the fourth budget and recommended fifth carbon budget. Specifically, the emissions reduction plan due later this year should

Key messages and recommendations

further develop measures to reduce waste emissions as set out in Table 7.1.

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

Waste emissions to fall by around 50% between 2014 and 2030. This will require:	**New policy required**	**Stronger implementation required**
Strengthened approaches through the waste chain, including waste prevention, separate collections (e.g. of food waste), diverting biodegradable waste from landfill and increased methane capture at landfill.	England N Ireland	Scotland Wales

Source: CCC analysis.

We set out the analysis that underpins these conclusions in three sections.

1. Waste emission trends and drivers
2. Policy progress in reducing waste emissions
3. Forward look and policy gap

1. Waste emission trends and drivers

Waste emission data lags other sectors by a year, due to the longer time required to collate non-CO_2 emissions data. In this chapter, we focus on the latest information which shows that waste emissions totalled 19 $MtCO_2e$ in 2014, almost 4% of total UK greenhouse gas (GHG) emissions.

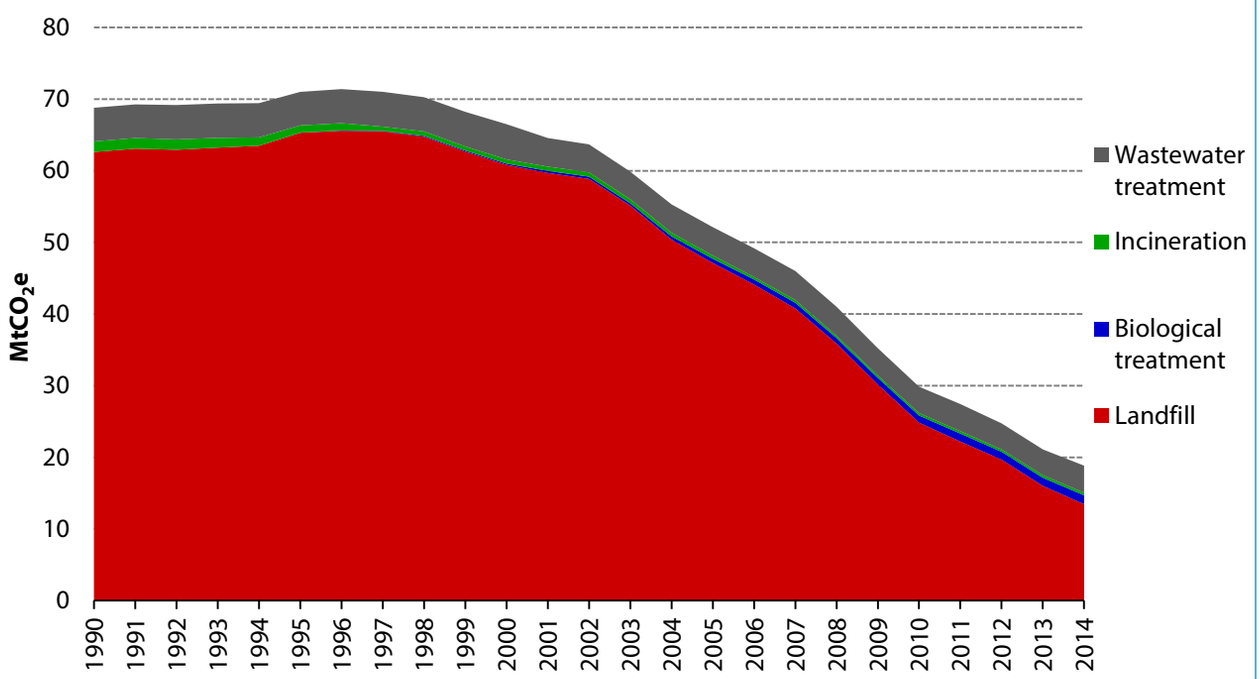
Waste emissions are predominantly methane emissions which arise due to the decomposition of biodegradable waste in landfill sites in the absence of oxygen. Emissions also arise due to wastewater treatment, biological treatment and incineration of wastes.

Waste emissions fell by 11% in 2014, following an annual average 12% decrease over the period 2009-2013. Since 1990 they have fallen by 73% (Figure 7.1). These reductions have almost entirely come from declining methane emissions from landfill:

- **Landfill emissions.** Account for 71% of waste emissions and entirely methane. Landfill emissions fell by 16% in 2014, following an annual average 15% decrease over the period 2009-2013. Since 1990 they have fallen by 79%. This fall has been due to reductions in biodegradable waste going to landfill, investment in methane capture technology and improved management at landfill sites (Figure 7.2).
- **Wastewater treatment emissions.** Account for 20% of waste emissions and mainly methane with some nitrous oxide (N_2O). Wastewater treatment emissions rose 5% in 2014, following an annual average 1% fall over 2009-2013. Since 1990 they have fallen by 19%.
- **Biological treatment emissions.** Account for 7% of waste emissions and a mixture of methane and nitrous oxide from composting and anaerobic digestion of waste. Biological treatment emissions increased by 10% in 2014, following an annual average 5% increase over the period 2009-2013.
- **Incineration (without energy recovery) emissions.** Account for 2% of waste emissions and mainly CO_2. Incineration emissions fell by 5% in 2014, following an annual average 3% increase over the period 2009-2013.

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

Figure 7.1. GHG emissions from waste by source (1990-2014, $MtCO_2e$)



Source: NAEI (2016) *UK Greenhouse Gas Inventory, 1990 to 2014.*

Waste emission drivers – methane from landfill

Landfill methane emissions are not directly measured, but are calculated based on: the quantity of biodegradable waste sent to landfill, assumptions on the properties of waste streams such as methane yield and decay rates[1], and the quantity of methane emissions avoided at landfill sites:

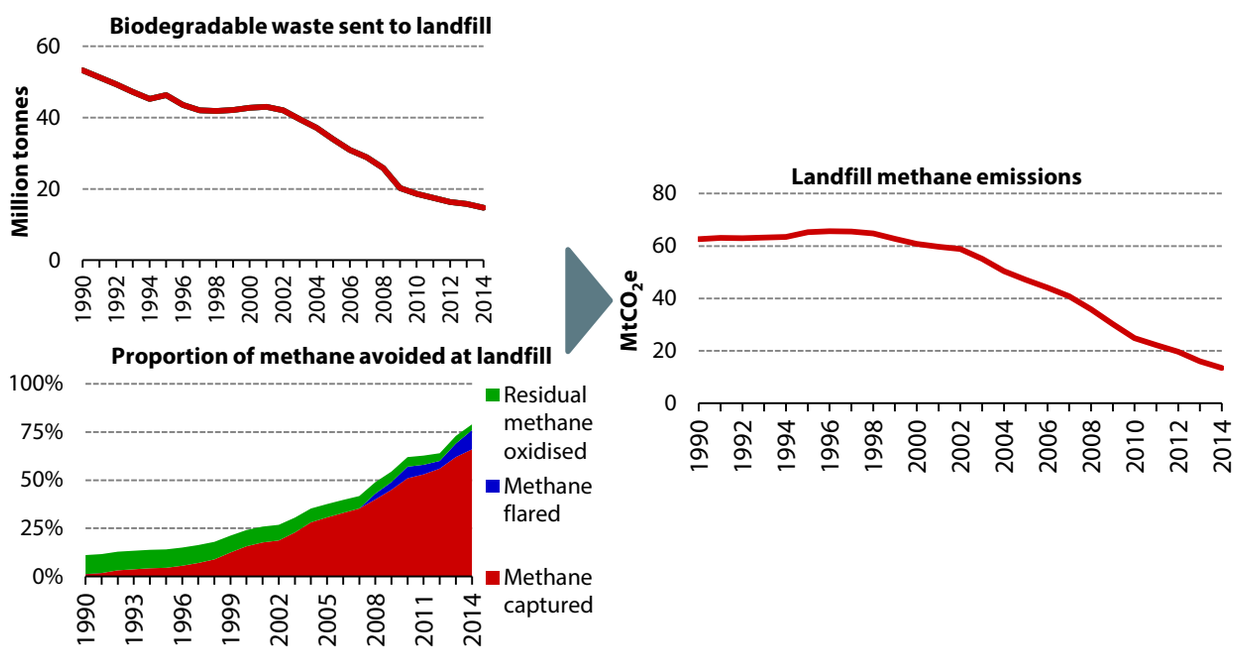
- **Biodegradable waste arising.** Waste Reduction Action Programme (WRAP) data suggests that avoidable household food and drink waste has fallen by 15% between 2007 and 2012, from 8.3 to 7 million tonnes.[2] Reductions in waste have been driven by waste prevention and resource efficiency campaigns at local level, voluntary responsibility deals and the recession.
- **Biodegradable waste sent to landfill.** Estimates suggest that the amount of landfilled biodegradable waste reduced by 6% in 2014, following an annual average 6% decrease over the period 2009-2013. Biodegradable waste sent to landfill in 2014 has fallen by 72% since 1990 (Figure 7.2).
- **Methane yield and decay rate.** 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. Uncertainties over methane yield and decay rates mean that methane emissions from landfill could be as much as 70% greater or lower than currently recorded in the inventory.

[1] Quantity of methane emitted and over how many years as the different types of waste degrade.
[2] *Household Food and Drink Waste in the United Kingdom 2012*. Available at: http://www.wrap.org.uk/

- **Methane emissions avoided at landfill sites.** Estimates suggest that 79% of methane emissions were avoided in 2014, rising from 54% in 2009 and 11% in 1990. Methane emissions can be avoided by capture, flaring to CO_2 and natural oxidisation.
  - The proportion of methane captured for use in energy generation rather than emitted is estimated to average 66% in 2014, rising from 45% in 2009.
  - Methane flared at landfill sites is estimated to average 10% in 2014, rising from 4% in 2009.
  - Residual methane that is oxidised at the landfill site is estimated to average 3% in 2014, falling from 5% in 2009.

Overall, since 1990 estimated landfill methane emissions have fallen by 79%.

Figure 7.2. Biodegradable waste, methane emissions avoided at landfill sites and methane emissions from landfill (1990-2014)



Source: NAEI (2016) *UK Greenhouse Gas Inventory, 1990 to 2014.*
Notes: Biodegradable waste and proportion landfill methane not avoided do not equal landfill methane emissions. Emissions also depend on methane yield from waste.

2. Policy progress in reducing waste emissions

In this section we set out the opportunities to further reduce waste emissions and progress developing policies to deliver these.

Opportunities to further reduce waste emissions

In our 2015 Progress Report we considered in detail the potential opportunities to reduce waste emissions. Due to their potent greenhouse gas impact, opportunities focus on reducing methane emissions from landfill:

- **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.

Since our 2012 Progress Report we have recommended specific strategies to minimise biodegradable waste going to landfill and widespread separate food waste collection. A report by Eunomia estimates that there are net benefits from banning sorted biodegradable waste from landfill, such as paper/card. The timing and sequencing of the bans is important in order to set up adequate supply chains and infrastructure.[3]

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 2025.[4] Methane emissions from waste is estimated to be ahead of our indicator, due to a higher percentage of methane being captured at landfill sites (Table 7.2).

[3] WRAP (2012) *Landfill Bans: Feasibility Research: The environmental, economic and practical impacts of landfill bans or restrictions: research to determine feasibility.* Available at http://www.wrap.org.uk/
[4] CCC (2015) *Sectoral scenarios for the Fifth Carbon Budget,* https://www.theccc.org.uk/

Table 7.2. Progress against the Committee's waste indicators

	Budget 2 (2013-2017)	Budget 3 (2018-2022)	Budget 4 (2023-2027)	Budget 5 (2027-2032)	2014 indicative	2014 outturn
Methane emissions from waste sent to landfill (% change from 2007)	-74%	-82%	-89%	-93%	-63%	-67%
Biodegradable waste sent to landfill (% change from 2007)	-64%	-77%	-93%	-93%	-50%	-49%
Methane captured at landfill	Increase from 61% in 2013 to 65% by 2016 and maintain at this level				62%	66%

Source: NAEI (2016) *UK Greenhouse Gas Inventory, 1990 to 2014*, CCC analysis.

Progress developing policies to reduce waste emissions

EU Directives have set targets to reduce biodegradable waste going to landfill and need for methane capture at landfill sites. The UK landfill tax has been the key driver of progress to date, in combination with waste prevention information and voluntary programmes, and regulations over landfill management. Policy has been successful in making deep cuts to waste emissions, and continued progress will need to address further actions throughout the waste chain (i.e. through waste prevention, separation, diversion from landfill and avoidance of methane released at landfill sites).

EU Directives

The 1999 EU Landfill Directive required a 50% reduction in biodegradable municipal waste (BMW) landfilled in the UK by 2013 relative to 1995 levels of BMW production, and requires a 65% reduction by 2020. Estimates for 2013 suggest that BMW sent to landfill has fallen by 74% against the baseline, and so is currently outperforming the targets set. There are a number of other waste-related EU Directive targets for which the UK also outperforming or in line to meet (Table 7.3).

In December 2015, the EU Commission proposed a new circular economy package with waste targets to 2030 (Box 7.1). The UK's vote to leave the EU may change the future impact of these directives in the UK. Meeting the UK's domestic emission reduction commitments will continue to require effective measures in the UK.

Table 7.3. EU Directive targets and UK performance to date

EU Directive	Target	UK progress
Biodegradable municipal waste landfilled	From 1995, 50% reduction by 2013 and 65% by 2020	74% (2013)
Recycling of waste from households	50% by 2020	45% (2014)
Recycling or recovery of packaging waste	60% by 2012	73% (2013)
Recovery of non-hazardous construction and demolition waste	70% by 2020	87% (2012)

Source: Defra (2015) *UK Statistics on Waste.*

Box 7.1. Closing the loop - An EU action plan for the Circular Economy

The circular economy is a generic term for an industrial economy that, by design or intention, is restorative and eliminates waste throughout the supply chain. It seeks to provide a model to decouple economic progress from resource constraints in a way that inspires innovation throughout the whole value chain, rather than relying solely on the waste recycling end of the market. The circular economy is restorative, with materials designed to circulate with their economic value preserved or enhanced.

The European Commission has proposed a Circular Economy Package, which includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy, boost competitiveness, foster sustainable economic growth and generate new jobs.

The Circular Economy Package consists of an EU Action Plan for the Circular Economy that establishes a concrete and ambitious programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials.

The UK Government will need to consider in light of the Leave vote, whether and how elements of the package might be delivered in the UK, to secure cost-effective emissions reduction.

Source: http://ec.europa.eu/environment/circular-economy/index_en.htm

National waste emission policies

Waste management is a devolved issue, with England and each of the devolved administrations developing waste strategies and legislating waste measures. We first consider progress in policies affecting the whole of the UK, then progress for the individual nations against the devolved targets, assessing each nation's policy framework with respect to meeting our cost-effective pathway to reducing emissions.

- **Landfill Tax.** Introduced in 1996, this imposes a charge on landfill operators for each tonne of waste landfilled, creating an incentive to reduce waste sent to landfill either through waste prevention or diverting waste to other treatments (recycling, recovery, and reuse). The tax has been increased from its initial rate of £7 per tonne in 1996 to £82.60/t in 2015/16. Scotland will be responsible for setting its own landfill tax from 2015, as will Wales in 2018.

- **Waste & Resources Action Programme (WRAP).** A registered charity that has developed a number of voluntary programmes aimed at reducing packaging and food waste through a number of targets to reduce waste in food production, groceries and household use. While not all targets have been met, there has been overall success in many of the programmes (Box 7.2).
- **Methane capture and flaring at landfill sites.** Capture of methane at landfill sites has significantly increased from an average rate of 1% in 1990 to 66% in 2014. This reflects investment driven by a combination of permit conditions and financial incentives for capturing methane from landfill and anaerobic digestion (e.g. under the Renewables Obligation, Feed-in-Tariffs, and Renewable Heat Incentive). There is further potential to increase average capture rates as highlighted in the recent ACUMEN study (Box 7.3).

Box 7.2. Waste & Resources Action Programme (WRAP)

WRAP is a charity working with businesses to deliver waste prevention and resource efficiency:

- **Love Food Hate Waste Programme.** Encourages voluntary reductions in food waste in households. The programme, introduced in 2007, has had good success on reducing avoidable household food waste by 21%, saving UK consumers almost £13 billion over the five years to 2012.
- **Courtauld Commitment.** Voluntary responsibility deals to 2015 and 2025 to improve resource efficiency in the grocery retail sector by preventing supply chain, packaging and food waste.
  - From 2005-2013, almost 3 Mt of waste has been prevented, with a monetary value of £5 billion and saving over 7 $MtCO_2e$. From 2013-2015, WRAP hopes to prevent an additional 1 Mt of waste, equating to 3 $MtCO_2e$.
  - WRAP has proposed a new set of targets to 2025 which include a 20% reduction in food & drink waste arising in the UK, a 20% reduction in the GHG intensity of food & drink consumed in the UK and a reduction in the impact from water use in the supply chain.
- **Hospitality and Food Service Agreement.** Launched in 2012 with the aim to:
  - Cut food and packaging waste by 5% by 2015. In 2014, there had been a cut of 3.6%.
  - Increase food and packaging waste that is being recycled, sent to AD, or composted to 70% by 2015. In 2014, this had increased by 12% points to 57%.

Source: WRAP, http://www.wrap.org.uk/

Box 7.3. Project ACUMEN

Assessing, Capturing and Utilising Methane from Expired and Non-operational landfills (ACUMEN) was a partnership project funded by the EU, Defra and other participating organisations, and staffed by the Environment Agency, local councils and technology companies. ACUMEN aimed to demonstrate new techniques and technologies to improve the capture and use of methane from closed landfill sites.

The project installed and operated a range of new techniques at demonstration landfills. The aim was to show technologies that can work on the full range of closed landfills. This includes innovative monitoring systems with an assessment of the costs and benefits of each demonstration project to see which options best suit certain categories of closed landfill.

The techniques demonstrated include small scale gas engines (8 - 150 kilowatts), a novel low-calorific gas flare and an active biological oxidation technique. The six demonstration sites ranged from 5 to 40 hectares in size, and between 20 and 50 years in age.

The project finished in late 2015 and provides a range of techniques to landfill owners to help them assess the options for managing methane at their sites and technical guidance in order to replicate the demonstrations at their own landfills.

Source: Project ACUMEN, https://www.gov.uk/government/groups/acumen-assessing-capturing-and-utilisingmethane-from-expired-and-non-operational-landfills

England

In addition to the policies above the Government has focused waste policy in England on prevention and developing alternative treatment of waste through anaerobic digestion:

- **Waste Prevention Programme (WPP)**. In our 2014 Progress Report we reported on the launch of the for England with a programme and funds to drive waste further up the waste hierarchy by helping businesses and households realise cost savings through waste prevention and resource efficiency.[5]
- **Anaerobic Digestion.** The Government's 2011 'Anaerobic Digestion (AD) Strategy and Action Plan for England' includes a £10 million loan fund to support new AD capacity, and an innovation fund to bring down costs of AD, identify potential sources of waste feedstock, and develop markets for digestate (an AD by-product). Since its launch in June 2011, the number of AD plants in England has increased from 54 to 253 plants by March 2016[6], with a further 454 projects under development across the UK.[7]

While these policies strengthen parts of the waste chain, there will need to be further reductions in emissions from all biodegradable waste going to landfill to meet the cost-effective path set out in our fifth carbon budget advice.

The Government has responded previously recommendations for separate waste collection and specific waste bans that priority should be placed on waste prevention to reduce biodegradable waste sent to landfill, that it did not believe landfill bans were the best way to achieve this goal, and it is for local authorities to decide on provision of separate collection of food waste.

We recommend that the Government in their emission reduction plan publish specific actions and clear milestones to strengthen approaches through the waste chain; including separate

[5] CCC (2014) *2014 Progress Report*, https://www.theccc.org.uk/
[6] http://www.biogas-info.co.uk/
[7] NNFCC (2016), *Anaerobic Digestion deployment in the UK*, http://www.nnfcc.co.uk/

waste collection, reducing biodegradable waste to landfill and improving methane capture rates at landfill sites where possible. We will review action on this in our 2017 Progress Report.

Scotland

The Scottish Government has launched Scotland's first *Zero Waste Plan* (2010)[8] and *Safeguarding Scotland's Resources* (2013).[9] This includes a number of targets to prevent waste and emissions from waste which Scotland is currently on track to meet (Table 7.4).

In the *Zero Waste Plan*, Scotland has set a plan to reduce the environmental impact of waste and move towards a circular economy. To help meet these long term targets:

- **Waste (Scotland) Regulations 2012** proposes a series of regulations in waste collection and disposal:
  - All businesses, public sector and not-for-profit organisations are required to present metal, plastic, glass, paper and card for separate collection from 1 January 2014.
  - Food businesses (except in rural areas) which produce over 5 kg of food waste per week are to present that food waste for separate collection from 1 January 2016.
  - Local authorities to provide a minimum recycling service to householders.
  - A ban on any metal, plastic, glass, paper, card and food collected separately for recycling from going to incineration or landfill from 1 January 2014.
  - A ban on biodegradable municipal waste going to landfill from 1 January 2021.
- **Landfill Tax (Scotland) Act 2014** means that the Scottish Parliament has new financial powers on disposals to landfill from 2015.
- **Scotland's Circular Economy Strategy** was launched in February 2016. The strategy sets out priorities to influence design, repair, reuse, remanufacture, recycling and, importantly, waste prevention. The strategy includes a target to achieve a 33% reduction in food waste by 2025, which will save £500 million.

Scotland has put in place detailed targets, an annual report detailing progress and programmes to help meet these, specifically with the ban on municipal waste going to landfill. There will need to be reductions in emissions from business waste to meet the cost-effective path set out in our fifth carbon budget advice.

To close this gap we recommend that Scotland publish specific actions to strengthen approaches through the waste chain; including separate waste collection for households, reducing business waste going to landfill and improving methane capture rates at landfill sites where possible. We will review action on this in our 2017 Progress Report.

[8] Scotland's Zero Waste Plan. Available at: http://www.gov.scot/

[9] Safeguarding Scotland resources: Blueprint for a more resource efficient and circular economy. Available at: http://www.gov.scot/Resource/0043/00435308.pdf

Table 7.4. Scotland's waste targets and progress		
Targets	**2014 Progress**	**On track**
Reduce the amount of waste produced by 7% by 2017 and 15% by 2025 against 2011 baseline	15%	Yes
Recycling/composting and preparing for re-use 70% of waste from all sources by 2025	55%	Yes
Reducing the proportion of total waste sent to landfill to a maximum of 5% of all waste by 2025	39%	Yes
Reduce biodegradable municipal waste to be sent to landfill to less than 1.8 Mt by 2013 and 1.26 Mt by 2020	1.06 Mt	Yes
Source: http://www.sepa.org.uk/		

Wales

The Welsh Government is aiming for a circular economy approach to waste, with the aspiration for no municipal waste sent to landfill from 2025 as an interim step to zero waste by 2050. In June 2010, Wales published *Towards Zero Waste*[10], an overarching waste strategy, which has included a number of detailed targets (Table 7.5):

- **Waste prevention.** Wales is exceeding their municipal waste target, but there has been no statistically significant change to reducing commercial/industrial waste. The Industrial and Commercial Waste Sector Plan (2013) will work to address this.
- **Waste reused, recycled or composted or reused.** There has been progress to waste reuse/recycling/composting targets, although greater progress needs to be made with respect to industrial waste.
- **Waste going to landfill.** Wales is currently making progress to reducing the proportion of waste sent to landfill. The proportion of waste is falling, but this will have to accelerate to meet the targets set.

Towards Zero Waste has set out a number of levers including a waste prevention programme, five sector plans, regulatory mechanisms and improvements in landfill management. In addition:

- **Landfill tax.** As of 2018, Wales will acquire responsibility for setting its own landfill tax.
- **Food waste collection.** Data collected from WRAP indicates that 99% of households in Wales now have a separate food waste collection service provided by their local authority, compared to a UK average of 49%.

Wales has put in place detailed targets and an annual report detailing progress against these. Wales has separate food waste collection for all households, but there will need to be further reductions in emissions from all biodegradable waste going to landfill to meet the cost-effective path set out in our fifth carbon budget advice.

[10] Wales' *Towards Zero Waste*. Available at: http://gov.wales/topics/environmentcountryside/epq/waste_recycling/zerowaste/?lang=en

We recommend that Wales publish specific actions to strengthen approaches through the waste chain; including reducing biodegradable waste to landfill and improving methane capture rates at landfill sites where possible. We will review action on this in our 2017 Progress Report.

Table 7.5. Wales' waste targets and progress

Target		Progress	On track
Waste Prevention (waste generated reduction per annum from 2006/07 to 2050)	Household – 1.2%	2% p.a (2013/14)	Yes
	Industrial – 1.4%	No statistical difference to 2012	No
	Commercial – 1.2%		
Reuse, recycling and composting (% amount of waste)	Municipal 2015/16 – 58% 2019/20 – 64% 2024/25 – 70%	2012/13 – 52% 2013/14 – 54%	Yes
	Industrial 2015/16 – 63% 2019/20 – 67% 2024/25 – 70%	2007 – 59% 2012 – 50%	No
	Commercial 2015/16 – 57% 2019/20 – 67% 2024/25 – 70%	2007 – 37% 2012 – 68%	Yes
Landfill (% of waste sent)	Municipal 2019/20 – 10% 2024/25 – 5%	2012/13 – 41% 2013/14 – 38%	Yes
	Industrial 2019/20 – 10%	2007 – 29% 2012 – 27%	Yes
	Commercial 2019/20 – 10%	2007 – 51% 2012 – 26%	Yes

Source: *Towards Zero Waste 2010–2050 Progress Report July 2015*, available at www.gov.wales

Northern Ireland

A revised *Northern Ireland Waste Management Strategy,* published in December 2013. That led to a waste prevention programme alongside Waste Regulations (Northern Ireland) 2011.

Food waste regulations came into force in February 2015, banning landfilling of food waste once collected. The regulations provide for the separate collection and subsequent treatment of food waste and require district councils to provide food waste bins for households. It also places a duty on food businesses to present food waste separately if producing in excess of 5kg per week.

There will need to be further reductions in emissions from all biodegradable waste going to landfill to meet the cost-effective path set out in our fifth carbon budget advice.

We recommend that Northern Ireland 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. We will review action on this in our 2017 Progress Report.

3. Forward look and policy gap

In this section we evaluate the "policy gap", where the set of current and planned policies are not sufficient to meet the cost-effective path through the fifth carbon budget (to 2032).

Progress on our recommendations from last year's Progress Report has been relatively limited, with no progress in some areas (Table 7.6).

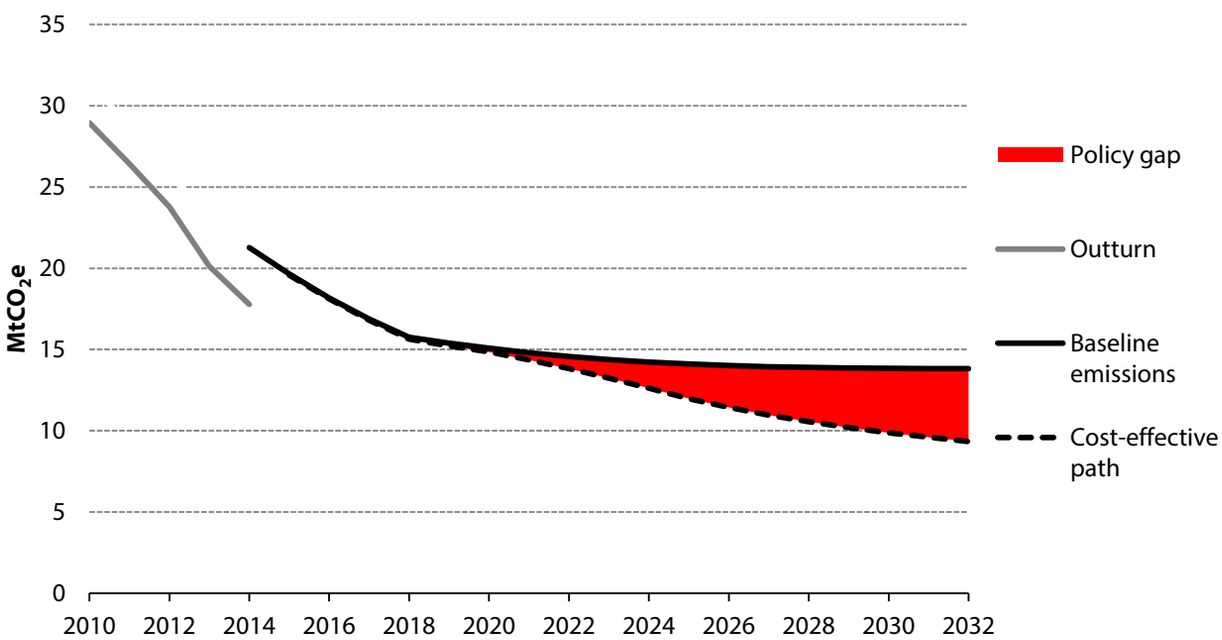
Table 7.6. Progress against 2015 recommendations

Recommendation in 2015	Assessment	Commentary
Scotland, England, Wales and Northern Ireland to set out approaches to increase methane capture rates: as a devolved matter, each nation should set out specific actions and clear milestones.	Not met	Results from Project ACUMEN have been published but no actions or milestones have been published
Reduce biodegradable waste to landfill: each nation should set out specific actions and clear milestones – including England – to further reduce biodegradable waste to landfill.	Partially met	Scotland has a landfill ban from 2021, Wales has a number of targets to restrict waste to landfill. England and Northern Ireland have not brought forward regulations or targets to ensure minimal landfill of biodegradable waste.

In our fifth carbon budget advice, we suggested that waste emissions could fall to 10 $MtCO_2e$ in 2030 to meet carbon budgets (Figure 7.3). According to DECC's projections; waste emissions in the absence of further policy would be 14 $MtCO_2e$ in 2030. This leaves a gap of around 4 $MtCO_2e$ in 2030 which needs to be addressed to stay on the cost-effective path we have identified to meet carbon budgets.

Meeting our cost-effective path will require delivery mechanisms through the waste chain to succeed. These should be included in the Governments emission reduction plan later this year.

Figure 7.3. DECC waste emission projections (2010-2032)



Source: NAEI (2016) *UK Greenhouse Gas Inventory, 1990 to 2014*, DECC (2015) *Updated energy and emission projections*, CCC analysis.
Notes: Outturn emissions and emission projections do not meet as has been a change to the GHG inventory since DECC published its projections.

Chapter 8: F-gases

Key messages and recommendations

Fluorinated gases accounted for around 3% of total UK emissions in 2014. While F-gas emissions come from various applications, they are mainly used as refrigerants in air conditioning and refrigeration products and 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. We review current policy progress and indicate a future emission path based on our latest understanding of the sector.

The vote to leave the EU may have an impact on the delivery of F-gas emission reduction. Several EU policies are driving cost-effective emission reduction. It will be necessary to agree new arrangements, or adapt the existing ones, to meet the UK's domestic emission reduction commitments. It is too early for the Committee to review the precise balance under the new arrangements. References to current EU agreements should be read to indicate areas that future arrangements will need to cover so as to achieve objectives.

Our key messages are:

- F-gas emissions rose by around 1% in 2014, in line with the annual average growth of 1% over the period 2009-2013.
- The F-gases regulation, which was legislated in the UK in 2015 together with enforcement measures, aims to cut hydrofluorocarbons (HFCs), the main source of emissions, by 79% by 2030. It also introduces a series of new bans on the use of certain F-gases and strengthens checks on leaks.
- Under the Montreal Protocol, all countries have agreed to work together on a pathway for controlling the production and consumption of HFCs with the aim to agree on an HFC amendment in 2016.
- Although existing regulation is expected to substantially reduce F-gas emissions, there may be potential to go further. Last year, we recommended the Government should review cost-effective opportunities to exceed regulatory minimums on F-gas abatement. We have not seen any action from Government.

Our recommendation for the Government's emission reduction plan to address opportunities to further reduce F-gas emissions are provided below (Table 8.1). This sets out the criteria against which we will evaluate the plan.

Table 8.1. Policy requirements for the emission reduction plan

F-gases emissions to fall by around 70% between 2014 and 2030. This will require:	New policy	Stronger implementation
Monitoring and updating progress on the implementation and enforcement of the EU 2015 F-gases regulation.		✖
Opportunities to go beyond regulatory minimums on F-gases abatement, including assessing and addressing barriers where evidence suggests cost-effective abatement above minimum standards exists	✖	

Source: CCC analysis.

In this chapter we review progress in F-gas emissions at domestic and international level as well as existing evidence on opportunities to reduce F-gas emissions further and the expected level of reduction by 2030. The chapter is structured in 3 sections:

1. F-gas emissions trends and drivers

2. Progress in reducing F-gas emissions

3. Forward look

1. F-gas emissions trends and drivers

F-gas emissions were slightly above 17 $MtCO_2e$ in 2014, accounting for around 3% of total UK GHG emissions. This share of total emissions has been relatively stable since 2009.

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 gases. Other F-gases 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 very efficient at trapping heat and some of them remain in the air for many centuries after release. As a result, despite being released in small amounts, they have a relatively high impact on global warming. The four reported F-gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3):

- **HFCs** emissions (96% 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 (2%) 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 halocarbons 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 fitting 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 8.1).

In 2014, F-gas emissions rose by 1%, which is in line with the average annual growth of 1% between 2009 and 2013. The change in demand for F-gases in refrigeration and air conditioning as well as the introduction of the 2006 EU F-gas regulation and the EU Mobile Air Conditioning (MAC) Directive are the main drivers behind this trend:

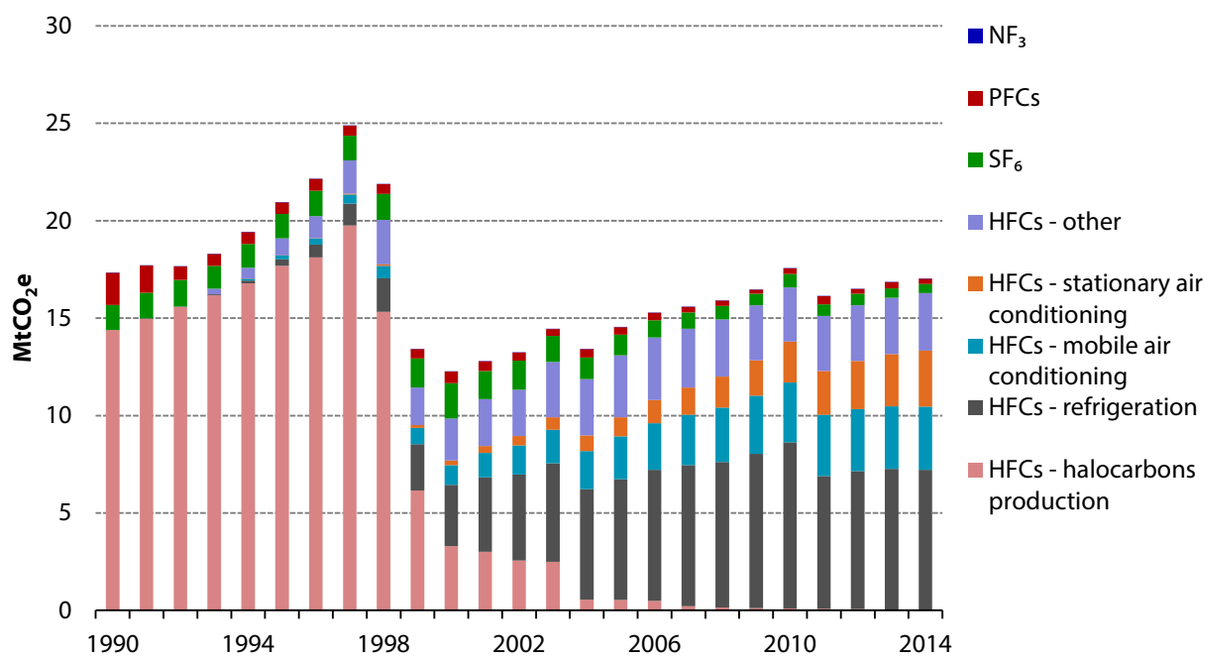
- **Refrigeration.** The main source of F-gases (42% of the total) stayed flat between 2013 and 2014 at around 7.2 $MtCO_2e$. They reached a peak of 8.5 $MtCO_2e$ in 2010 and showed an average 2% reduction in the period 2009-2013. The decline after 2009 is likely to be the result of the 2006 EU F-gas regulation that aimed to replace high GWP F-gases with lower GWP refrigerants.
- **Mobile air conditioning.** Accounting for around 19% of total F-gases emissions, these increased by around 1% in 2014, following a 2% average increase between the years 2009-

2013. The slower growth in emissions is likely to be due to the impacts of the EU MAC Directive which restricts the use of F-gases in new cars.

- **Stationary air conditioning.** While these currently represent around 17% of total F-gas emissions, they have been growing strongly recently: a 7% increase in 2014 following 10% annual average growth over the period 2009-2013.
- **Aerosols and metered dose inhalers (MDIs).** These represent 13% of total F-gas emissions in 2014. They increased by around 1.5% in 2014 due to a slight rise in emissions from MDIs, but they were broadly flat over the period 2009-2013.
- **Firefighting, foams, electrical insulation and other.** Accounting for the remaining 9% of F-gas emissions, these fell by around 3% in 2014 following a 1% average increase over the period 2009-2013.

In summary, while emissions from some sources (i.e. mobile and stationary air conditioning) increased in 2014 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.

Figure 8.1. GHG emissions from F-gases by source and type of gas (1990-2014)



Source: UK National Atmospheric Emissions Inventory.

2. Progress in reducing F-gas emissions

Opportunities to reduce F-gas emissions

In our fifth carbon budget advice to Government, we reviewed evidence of further potential for reduction in remaining F-gases.[1] Many sectors have cost-effective alternatives 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 alternatives available (e.g. existing hydrocarbons or CO_2) which could reach 100% of the relevant market in or before 2030.
- **Mobile air conditioning** can in many cases replace current F-gases with lower GWP alternatives, although they are expected to be higher cost.
- **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 like 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.

Policies to encourage these alternatives are being strengthened at the EU level and the Government will have to consider how this might be achieved for the UK.

Policy progress to reduce F-gas emissions

This section reviews the progress on policies recently introduced in the EU and the UK. We also consider current international negotiations to reduce global use of HFCs.

Progress in the UK

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

- The MAC regulation 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 from 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, with a 7% cut from the initial cap in 2016, 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.

[1] See CCC (2015) *Sectoral scenarios for the fifth carbon budget* at https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/

- The regulation introduces bans for some new equipment. These bans cover various areas, including domestic and imported refrigerators and freezers or air conditioning systems. For example, domestic refrigerators and freezers are not allowed to use refrigerants with GWP above 150 from 2015.
- 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.
- 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.[2] 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.

The UK is currently participating in international negotiations, looking for ways of controlling HFCs through the Montreal Protocol. The UN countries have agreed to work together on a pathway for controlling the production and consumption of HFCs with the aim to present an HFC amendment to the Montreal Protocol in 2016 (Box 8.1).

[2] See *Sectoral scenarios for the Fifth Carbon Budget* at www.theccc.org.uk

Box 8.1. International negotiations on F-gas emission reductions

The UK is currently taking part in international negotiations over the ways of reducing HFC emissions through the UN Montreal Protocol which was originally adopted in 1987 to reduce the production and consumption of ozone depleting substances (ODS).

The first proposal to control HFCs through the Protocol was introduced by Mauritius and the Federated States of Micronesia in 2009, followed by a proposal from Canada, Mexico and the USA. However, the progress on the amendment proposals was initially slowed down by some countries arguing that the United Nations Framework Convention on Climate Change is the most appropriate framework to discuss the phase down. Since 2013 the EU, the USA, China and Japan all committed to more ambitious HFCs reduction targets at the national level. A growing consensus has been built as India, Brazil and the Africa Group have joined the countries to use the Montreal Protocol for the HFCs phasedown.

In November 2015, all 197 parties of the Montreal Protocol approved a 'Dubai Pathway' for controlling HFCs. The parties agreed to work together on challenges (e.g. concerns of countries with very hot climates where HFCs alternatives are not always available) and solutions on the ways of managing HFCs through the Protocol with an ambition to produce the HFC amendment in 2016.

For non-Article 5 Parties (i.e. developed countries), the EU has proposed to control the production and consumption of HFCs in a similar manner to that introduced in the EU by the 2015 F-gas regulation:

- The initial level of total HFCs available (in CO_2e) would be set as the average of the total production/consumption in the years 2009 to 2012.
- The total amount of HFCs available would then be reduced consecutively: 85% of the initial level in 2019; 60% in 2023; 30% in 2028 and 15% in 2034.

Article 5 parties (i.e. developing countries) would follow a similar approach with 100% of emissions allowed in 2019, and then reduced to 15% by 2040.

These numbers indicate that, were the EU proposal agreed as the final HFC amendment by all parties, then UK F-gas emissions would be likely to fall in line with the 2015 EU regulation, which is at least as stringent as the EU international proposal.

Source: CCC analysis.

The 2015 F-gas regulation has been in force in the UK since January 2015. The UK Government also introduced further regulation in March 2015, setting:

- Powers for custom officers to impound unlawfully imported material.
- Powers for the Environment Agency to issue notices for failure to comply with the requirements of the EU regulation.
- Appointment of the bodies that certify companies and train individuals handling F-gases.

We will review the impacts and effectiveness of the regulation in future Progress Reports.

As reported in our 2015 Progress Report, 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. Further measures should also be considered in the UK, where deeper reductions in F-gas emissions could offer a cost-effective way to reduce UK emissions.

3. Forward look

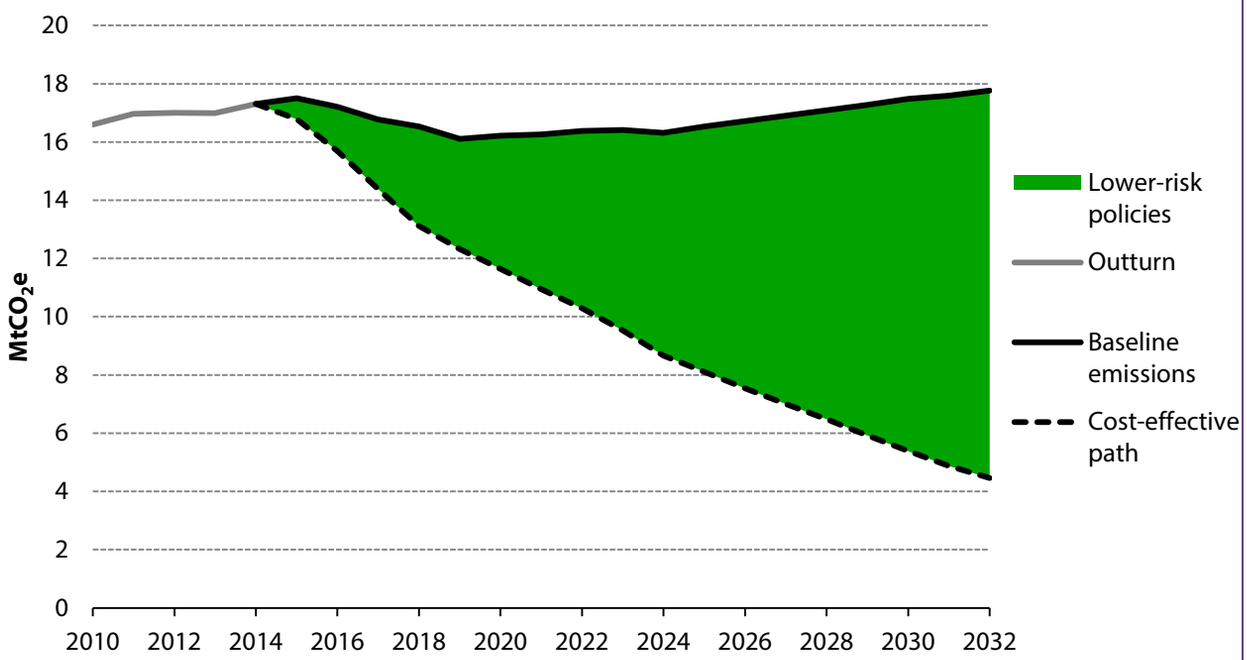
Last year, we recommended the UK Government should seek opportunities to exceed EU regulatory minimums on F-gas abatement, where evidence suggests cost-effective and comparable alternatives exist. While F-gases are a relatively small sector for GHG emissions, emissions reduction from remaining sources may be easier and more cost-effective than in some other sectors. There has not been any new action from the UK Government over the last year on this (Table 8.2).

Table 8.2. Progress against our recommendation

Recommendation in 2015	Assessment	Commentary
Government should seek opportunities to go beyond regulatory minimums on F-gas abatement.	No progress	Government's response to our recommendation did not suggest any new action on looking for further abatement opportunities for F-gases.

Our current emission trajectory is based on our understanding of the impacts of the 2015 F-gas regulation, and is in line with DECC's reference scenario. By 2030, F-gas emissions fall by 69% when compared to current 2014 total emissions (Figure 8.2). This is as a result of the HFCs phasedown, introduction of new bans, and improved leak checking. We currently regard this policy to be at lower-risk of delivering the expected emission savings since the 2015 F-gas regulation has already been implemented, together with enforcement measures.

Figure 8.2. Cost-effective emissions path for F-gases to 2032 ($MtCO_2e$)



Source: UK National Atmospheric Emissions Inventory; DECC (2015): Updated emissions projections; CCC analysis.
Notes: See Chapter 1 on the criteria to evaluate level of risk in current policies.

The UK Government is to set out its emission reduction plan to meet the fourth and fifth carbon budgets by the end of the year. There are gaps in current policy (Table 8.3):

- While we consider the 2015 F-gas regulation as a lower-risk policy Government should monitor the progress on its implementation and enforcement and update on the progress.
- The emission reduction plan should also seek opportunities to go beyond the regulatory minimums on F-gases, including assessing and addressing barriers where evidence suggests that further cost-effective abatement exists.

Table 8.3. Assessment of policies to drive abatement options in F-gases

Abatement option	2015 policy	Change in 2015/16	2016 policy
Phasedown in the use of HFCs in refrigeration, mobile and stationary air conditioning.	Green 2015 F-gas regulation	No change	Green 2015 F-gas regulation
Cost-effective emissions reduction in F-gases not covered by regulation.	Red No evidence review on further potentially cost-effective options	No change	Red No evidence review on further potentially cost-effective options

Source: CCC analysis.
Notes: Key - Red: Policy gap, Amber: Policy at risk, Green: Effective policy in place.

An effective plan will address the gaps identified in Table 8.3 as far as practically possible. We will evaluate the plan against these criteria in our next Progress Report.

Chapter 9:
Devolved administrations

Key messages and recommendations

The devolved administrations have an important role to play in meeting the UK's carbon budgets. Scotland, Wales and Northern Ireland together account for 22% of UK emissions (9%, 9%, and 4% respectively in 2014, the latest year for which data are available), while they account for 16% of the UK's population and 13% of GDP.

They have each adopted their own ambitious targets for reducing emissions. Scotland has passed its own Climate Change Act and has legislated annual targets, while in Wales and Northern Ireland targets have been set by the devolved governments. The Welsh Government will legislate emission reduction targets and are due to set carbon budgets, required by their new 2016 Environment (Wales) Act.

Powers are (fully or partially) devolved in a number of areas relevant to carbon reductions, with some variation by nation. Key areas of devolved powers include transport demand-side measures, energy efficiency, waste, agriculture and land use. It is expected more powers will be devolved in line with recommendations of the Smith Commission and Silk Commission. There are also important roles implementing UK policy (such as renewable energy deployment), through the provision of additional incentives and approaches adopted in areas such as planning consents.

The vote to leave the EU may have an impact on how emissions reductions are delivered in the devolved administrations. A number of EU policies currently contribute to cost-effective emission reduction. To meet domestic emission reduction commitments it will be necessary to agree new arrangements or adapt existing arrangements, as appropriate. It is too early for the Committee to assess the precise balance under the new arrangements. References to current EU agreements in this chapter should be read to indicate areas that future arrangements will need to cover so as to achieve similar objectives.

In this chapter, we highlight progress towards emission reductions in each main sector and highlight a number of areas of good practice.

Our key messages are:

- **Emissions and targets:**
  - In 2014, emissions fell in Scotland by 9%, in Wales by 8% and in Northern Ireland by 3%, compared to a reduction of 8% across the UK. This reflected continuing decarbonisation of the power sector and a much warmer than average year. In all nations emissions fell in power, residential buildings and waste. In Scotland and Wales emissions also reduced in non-residential buildings.
  - Scotland is leading the UK in emission reductions with a 41% reduction from 1990 to 2014, compared to 18% in Wales, 17% in Northern Ireland and 36% at the UK level.
  - The devolved administrations have their own targets to reduce emissions. Scotland has met its fifth statutory annual target in 2014 after failing to meet its first four, which have been set separately to the UK carbon budgets. Scotland has also met its 2020 target for a 42% emissions reduction six years early with a reduction of 46% in 2014 (including international aviation and shipping and trading in the EU ETS). However, this was in large part due to one-off contributions related to very mild winter temperatures and emissions accounting around the EU ETS. Wales's progress to meeting a 40% reduction by 2020 and Northern Ireland's progress to meeting a 35% by 2025 are currently falling short of the actions required.
- **There has been mixed progress in renewable deployment across the devolved administrations.** Renewable generation in Scotland, Wales and Northern Ireland accounted for 23% of the UK's total generation in 2015. Progress in renewable heat deployment is slow and targets are not being met.
- **The devolved administrations lead the UK in some policy areas with stronger targets and**

Key messages and recommendations

delivery mechanisms backed with additional allocated funding. This is particularly notable in residential energy efficiency and programmes to reduce emissions from waste.

  - Energy efficiency and fuel poverty: the devolved administrations operate taxpayer-funded schemes to tackle fuel poverty in addition to the supplier obligations. These often focus on area-based delivery, working with local authorities.
  - Waste: Ambitious household waste recycling targets have been set in Wales and Scotland. Scotland has banned biodegradable municipal waste going to landfill from 2021, while Wales has the highest rate of separate food waste collection. Northern Ireland has no additional targets beyond those in the EU Directives to minimise biodegradable waste going to landfill.

- **Stronger action will be required in key areas in order to meet future targets.** Polices and action at a devolved administration level should be included in the UK-wide Emission Reduction Plan. Table 9.1 sets out the full set of areas that must be addressed to keep the UK on the lowest-cost path to meeting its statutory targets. In some areas elements of the required policy are in place or planned but require stronger implementation if they are to succeed. In other areas new policies are required from the devolved governments.

Table 9.1. Recommendations for Emission Reduction Plan

Reductions in devolved administration emissions by 2030 to meet their own targets and contribute to UK-wide carbon budgets will require:	New policy	Stronger implementation
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: 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, following the closure of the Northern Ireland Renewable Heat Incentive and Renewable Heat Premium Payment Scheme.	✘	

The Committee produces a stand-alone annual progress report for the Scottish Government based on extensive analysis of progress in Scotland against its own climate targets. The Committee's next report will be published September 2016 and will include a number of recommendations to the Scottish Government.

The analysis in the chapter is presented in nine sections:

1. Devolved administrations overview
2. Emission trends and progress towards targets
3. Power sector
4. Buildings
5. Industry
6. Transport
7. Agriculture and land use
8. Waste
9. Forward look

1. Devolved administrations overview

The devolved administrations have an important role to play in meeting the UK's carbon budgets. They have (fully or partially) devolved powers in a number of areas relevant to emissions reduction. These vary by nation, and will become increasingly important as powers are devolved further. Key areas of devolved responsibilities 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.[1]

As part of their contribution to the UK's long-term emission reduction goal, the governments of the devolved administrations have adopted a range of emission reduction legislation, policies and strategies for monitoring progress:

- **Scotland** has passed its own Climate Change Act (2009) which sets a long-term target to reduce emissions of greenhouse gases (GHGs)[2] 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 2027. The Committee provided advice[3] to the Scottish Government in March 2016 on the appropriate level of annual targets for 2028-2032 as well as advice on re-aligning current targets set through the 2020s to the most cost-effective path for the Scottish economy. The Scottish Government is required to legislate targets by October 2016, alongside publishing their third report on policies and proposals detailing where emission savings will occur.
- **Wales** passed an Environment Act in 2016 which has tackling climate change as a key component. The Act provides for the setting of emission reduction targets to 2050, including an 80% reduction from 1990 levels in 2050, and five-year carbon budgets. The Committee will provide advice to the Welsh Government on the levels of carbon budgets later in 2016.

[1] Energy policy is fully devolved to the Northern Ireland Executive.
[2] Including emissions from international aviation and shipping.
[3] Available at: https://www.theccc.org.uk/publication/scottish-emissions-targets-2028-2032-the-high-ambition-pathway-towards-a-low-carbon-economy/

- **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.[4]

In the following sections we assess progress in key policy areas since our previous report in 2015. We also assess progress in existing key policy areas where matters are largely or completely devolved, providing a rating. Where matters are reserved we have not provided a rating.

2. Emission trends and progress towards targets

The latest UK emissions data are for 2015, but the latest data available for the devolved administrations are for 2014. We focus in this section on analysis of the change in emissions from 2013 to 2014 and the longer-term trend between 2009 and 2014.[5]

Scotland, Wales and Northern Ireland account for 22% of UK emissions (9%, 9% and 4% respectively) in 2014 while they account for 16% of the UK's population and 13% of GDP.

UK-wide, greenhouse gas emissions decreased 8% between 2013 and 2014, with an average annual fall of 2.2% between 2009 and 2014 (Table 9.2). In the devolved administrations (Figure 9.1), Scottish emissions fell further in 2014 (9%), with an average decrease of 3% per year between 2009 and 2014, while Wales' emissions fell (8%),with an average increase of 0.9% per year between 2009 and 2014, and Northern Ireland emissions decreased (3%) with an average decrease of 0.4% per year between 2009 and 2014.

- In **Scotland**, total emissions fell to 44.4 $MtCO_2e$ as a result of reduced electricity demand and a switch to low-carbon fuels in power generation and warmer than average temperatures reducing the need for heating in buildings. Emissions since 1990 have fallen 41%, the largest reduction in the UK. In 2014:
  - There were strong falls in emissions from power (14%), residential buildings (16%), non-residential buildings (14%) and waste (13%).
  - There was little change to emissions in transport (0.5% increase) and from agriculture (0.6% decrease).
  - Scotland's targets are set on a net basis, taking gross emissions (including international aviation and shipping) and then adjusting to take account of trading in the EU ETS. For 2014, the Scottish target was just under 47 $MtCO_2e$ compared to a Net Scottish Emissions Account of 41.9 $MtCO_2e$. As a result, Scotland met its legislated annual target. This has largely been due to the impact of backloading in the EU ETS,[6] which has reduced Scotland's share of the EU ETS cap, and the very mild temperatures in the winter months of 2014.
  - Scotland's net emissions in 2014 were below the level required to meet the target for a 42% reduction by 2020 relative to 1990 levels. In 2014, emissions (including international

[4] Available at: https://www.theccc.org.uk/publication/the-appropriateness-of-a-northern-ireland-climate-change-act/

[5] Unless stated emissions data do not account for trading in the EU ETS and do not include emissions from international aviation and shipping.

[6] Backloading is an EU-wide initiative that involves temporarily withholding allowances from auctioning (400m in 2014, 300m in 2015 and 200m in 2016) in order to more accurately balance supply and demand. The Scottish share of EU-wide auctioned allowances is around 1%, implying that backloading was responsible for around 3-4 $MtCO_2e$ of the reduction in Scottish net emissions in 2014.

aviation and shipping and adjusting for trading in EU ETS) had reduced by 45.8% compared to 1990. However, given the one-off factors affecting emissions in 2014, those in future years may not be below this target.

  - The latest revisions to the emissions inventory have reduced estimated emissions for 2013 by 1.8 $MtCO_2e$, which has offset previous additions to the inventory by around a third. These revisions can cause problems because the annual targets are absolute and fixed in legislation.

- In **Wales**, total emissions fell to 46.4 $MtCO_2e$ due to a switch to low-carbon fuels in power generation and warmer than average temperatures reducing the need for heating in buildings. Wales currently has a 2020 target and annual emissions reduction targets, which are challenging to achieve:
  - Wales has a target to reduce greenhouse gas emissions by 40% from 1990 levels by 2020. In 2014, emissions were 18% lower than in 1990 (compared to 36% for the UK). On the basis of progress to date, the 40% target by 2020 is likely to be missed.
  - There has been significant progress across a number of sectors (e.g. power, buildings and waste), but emissions from agriculture have increased and the size of the land-use sink decreased. Between 2009 and 2014 emissions from power and industry have risen each year (average 2.5 and 2.6% per year respectively). This partly reflects the importance of individual power and industry installations at a devolved level (e.g. changes in production at sites such as Tata Steelworks in Port Talbot can have a large impact).
  - 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. By 2013 (the third target year), emissions had fallen by 14.7% against the 2010 baseline. The reduction was 2.5% between 2012 and 2013, but overall the target for 2013 was met. Due to the outperformance of the target so far it is likely to also be met in 2014. The Welsh Government will publish its assessment of performance in 2014 later in 2016.
- In **Northern Ireland**, emissions in 2014 fell to 20.3 $MtCO_2e$. Northern Ireland's target requires less emissions reduction than the Scottish and Welsh targets, reflecting the larger share of its emissions from difficult to reduce sectors (in particular agriculture).
  - Emissions in 2014 fell in power, residential buildings and waste.
  - Emissions in 2014 rose in non-residential buildings, industry and transport.
  - Northern Ireland has a target to reduce emissions in 2025 by at least 35% compared to 1990 levels. In 2014, emissions in Northern Ireland were 17% 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 29% below 1990 levels in 2014. The differences across the countries in part reflect the relative importance of different sectors at the devolved level (Figure 9.2).

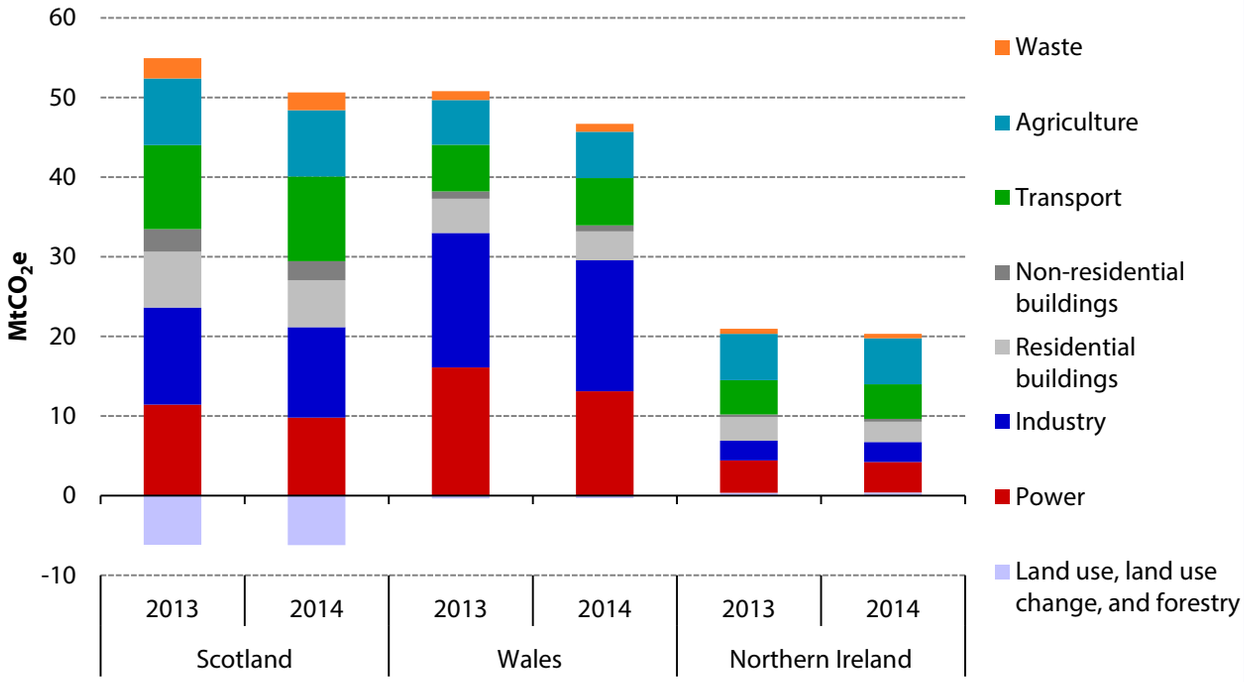
Table 9.2. Devolved administration's emission targets and progress

	Targets/milestones – reductions from 1990 baseline	On track	Emissions change 1990-2014	Average annual emission change 2009-2014
UK	35% by 2020	Yes	-36%	-2.2%
Scotland	42% by 2020[7]	Yes	-46% -41% without IA&S	-3.3%
Wales	40% by 2020	No	-18%	0.9%
Northern Ireland	30% by 2020[8]	No	-17%	-0.4%
Total DA target	39% by 2020	Yes	-29%	-1%

Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014*
Notes: The latest UK emissions data considered elsewhere in this report are for 2015, but the latest data available for the devolved administrations are for 2014. These data (unless stated) do not account for trading in the EU ETS and do not include international aviation and shipping (IA&S).

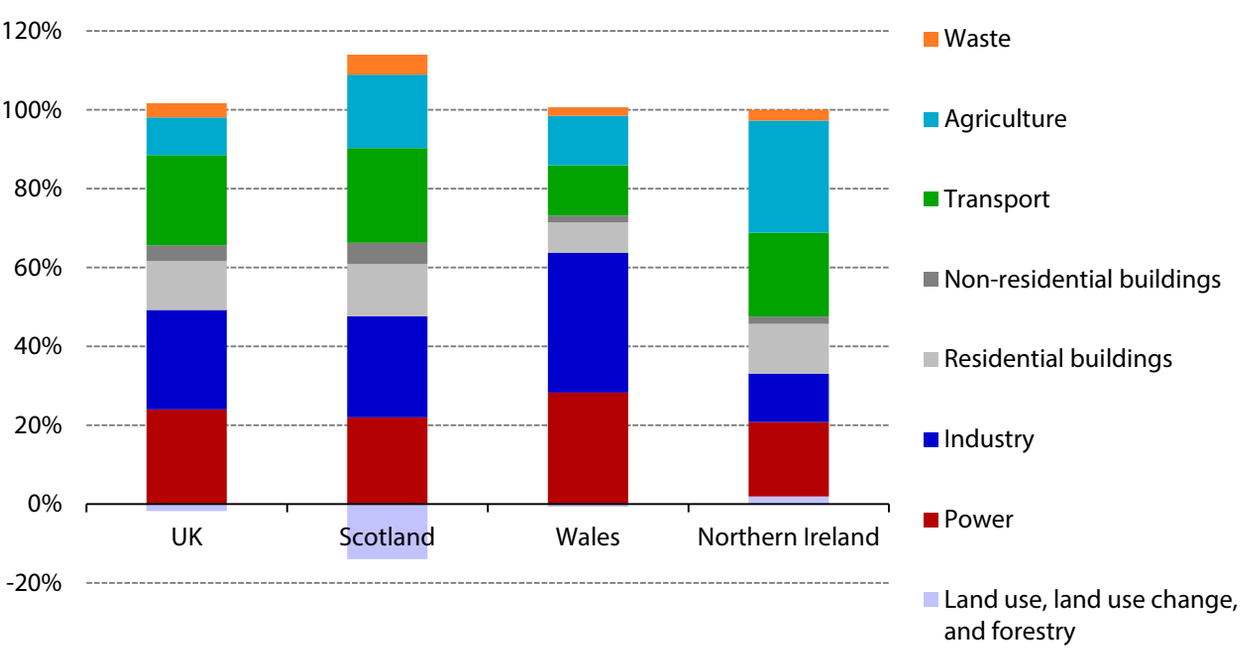
[7] Including international aviation and shipping.
[8] The target is 35% by 2025; on a straight-line basis this implies 30% by 2020.

Figure 9.1. Greenhouse gas emissions in the devolved administrations by sector (2013 and 2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014*
Notes: Emissions not adjusted for trading in the EU ETS, and excluding international aviation and shipping.

Figure 9.2. Proportion of greenhouse gas emissions in the devolved administrations by sector (2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014*

3. Power Sector

Overview

Table 9.3 provides an overview of emissions and the current policy framework.

Table 9.3. Power sector dashboard

Emission reductions (average annual change 2009 - 2014)		**Policy framework**	**Progress**
UK	3%	Chapter 2 : Renewables Obligation, FiTs and Contracts for Difference (CfD)	-
Scotland	5% accounting for 13% share of UK reduction	Renewable Energy Infrastructure and Innovation Fund - awarded 40 projects to date across Scotland to help with areas such as barriers to grid capacity and connection.	 Green
		Highlands and Islands Enterprise investment fund (£18.8m funding for 2014-2016) including the Renewable Energy Investment Fund, which will run until March 2017.	
Wales	2.5% increase	Welsh Government Local Energy programme - launched in 2016	 Amber
Northern Ireland	0.7% increase	Northern Ireland Renewables Obligation, which has worked the same as the GB-wide RO. However, DETI have not announced a support scheme to replace the RO when it closes in 2017.	 Amber

Notes: Key – Red: Policy gap, Amber: Policy at risk, Green: Effective policy in place.

Emissions, drivers and electricity generation trends

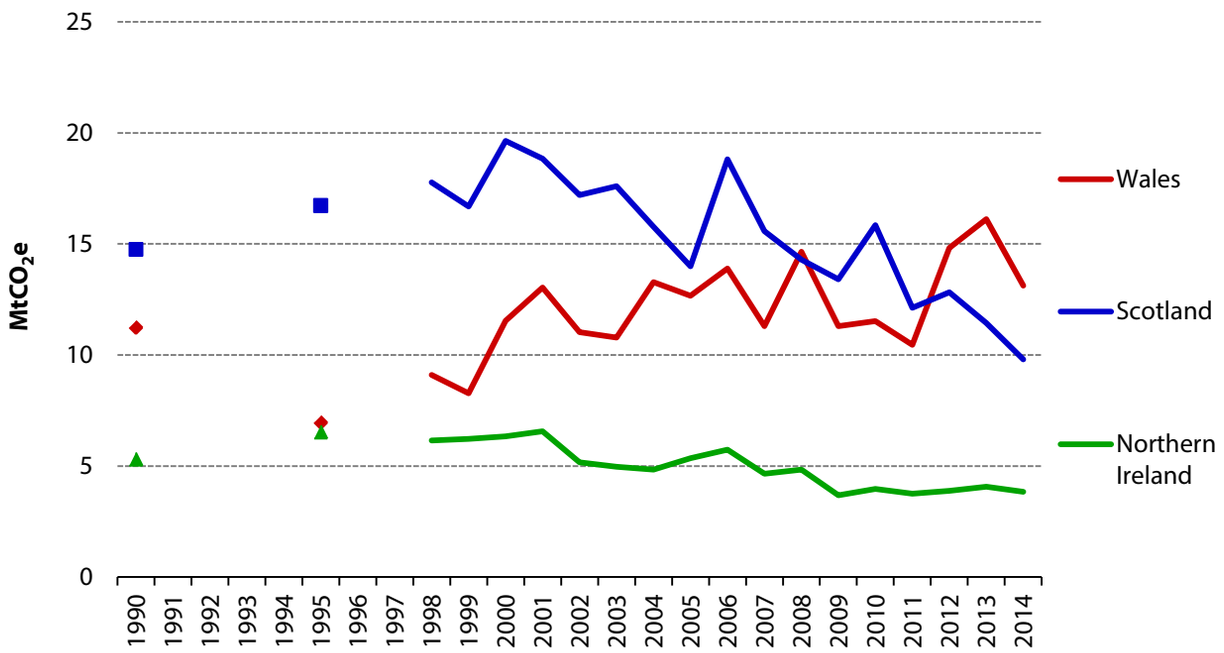
Power sector emissions fell across the devolved administrations in 2014 (Figure 9.3) due to a fall in demand and changes in the fuel mix (Figure 9.4):

- In Scotland, emissions fell 14% in 2014 with an average annual decrease of 5.1% between 2009 and 2014.[9] Power sector emissions account for 22% of total Scottish emissions. They have fallen 34% since 1990 levels.
- In Wales, emissions fell 19%, as against an annual average increase of 2.5% between 2009 and 2014. Power sector emissions account for 28% of total Welsh emissions, and are 17% higher than 1990 levels.

[9] More recently, 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 Northern Ireland, emissions fell 6%, with an annual average increase of 0.7% between 2009 and 2014. Emissions are 28% lower than 1990 levels. The sector accounts for 19% of total Northern Irish emissions.

Figure 9.3. Power sector emissions in Scotland, Wales and Northern Ireland (1990-2014)



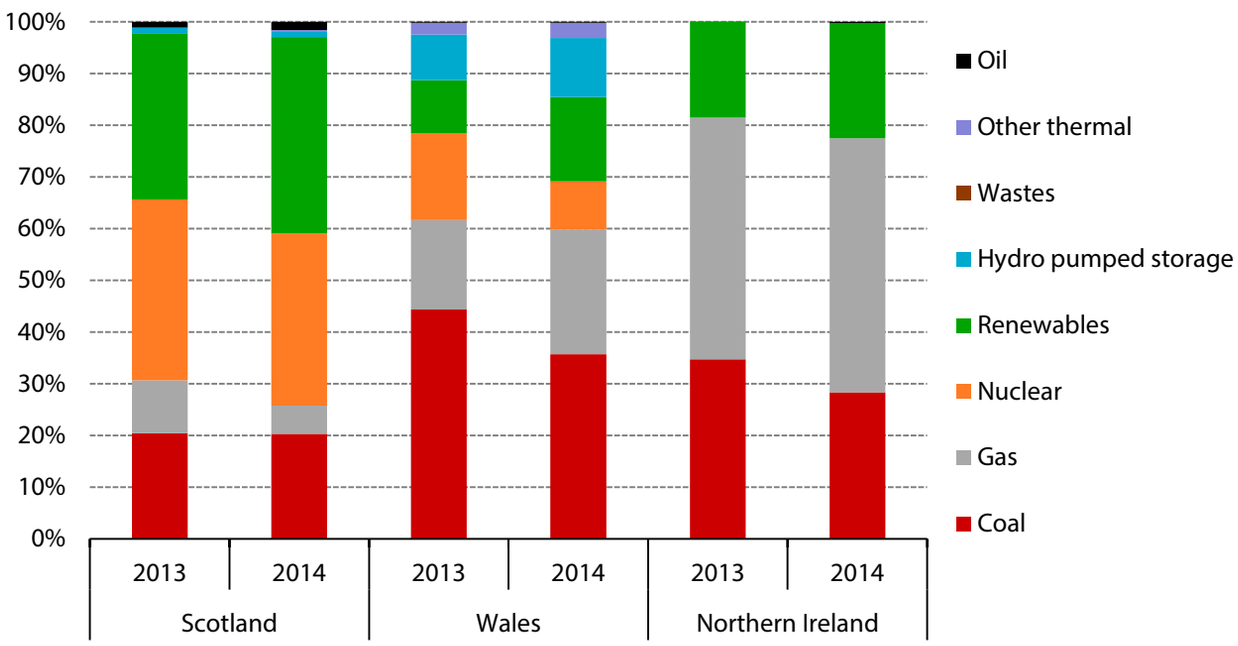
Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

The reduction in power sector emissions in **Scotland** reflects reduced generation (down 6%), as well as a reduction in carbon-intensive fuels for generation such as coal (6% fall), and gas (50% fall due to outages at Peterhead in 2014), alongside a rise in renewables (12%). Renewables in Scotland made up 38% of all generation, up from 32% in 2013.

In **Wales**, there was a large decrease in coal generation (35%) due to the closure of Uskmouth in April 2014, as well as a reduction in generation at other plants due to market conditions. There was a 28% increase in renewable generation, but nuclear generation fell 55% due to both planned and unplanned outages.

In **Northern Ireland**, there was also a decrease in coal generation (18%) and a rise in renewable generation (12%). However, there was also a small increase in gas generation (5%), which already makes up the largest share (49%) of total generation.

Figure 9.4. Proportion of generation by fuel type in Scotland, Wales and Northern Ireland (2013 and 2014)



Source: DECC (2015) *Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2014.*

At the UK level, emissions fell 16% in the power sector between 2013 and 2014 with an average annual decrease of 3% per year between 2009 and 2014. While Scotland saw stronger falls in emissions than at the UK level, the annual increase of emissions from the power sector in Wales and Northern Ireland was in contrast to overall UK trends. This highlights the larger impacts of individual installations at the devolved level with closure or changes in production at particular plants having significant impact on the overall picture.

For the first time in 2014 Wales was a net importer of electricity from England.

Progress and policy on renewable electricity

There has been continuing progress in the deployment of renewable electricity across the devolved administrations (Figure 9.5), which in 2015 together accounted for 36% of UK renewables capacity. The devolved administrations each have targets or milestones for renewables:

- **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 54%, up from 50% in 2014 - renewable sources grew due to an increase in onshore wind, hydro and solar generation. Changes to UK government support for renewables have caused some hold-ups in the consenting process for offshore wind, with 4.1 GW awaiting construction. However, if the projects which are currently under construction or consented (8.9 GW) are built by 2020, then this would be sufficient to meet the target.

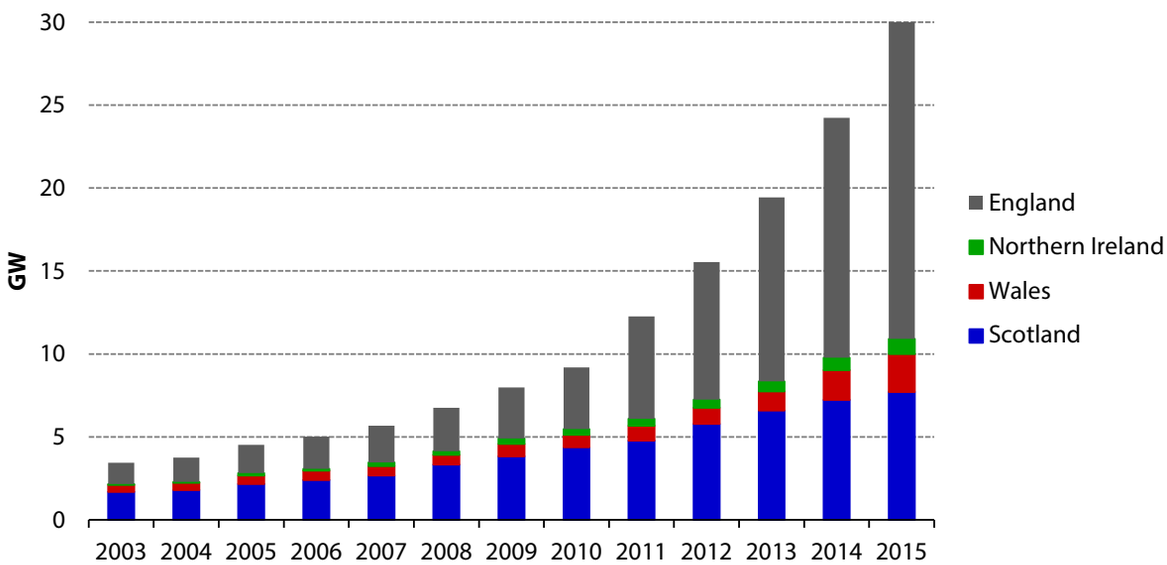
- In **Wales**, large infrastructure planning is a reserved matter, so decisions over projects greater than 50 MW are decided by the UK Planning Inspectorate.[10] Small-scale developments can be decided upon locally, with funding provided through the GB Feed in Tariff (FiT).
  - A target[11] to produce 7,000 GWh from renewables by 2020 is likely to be met. A further 0.8 GW of capacity will be required by 2020. As of March 2016, there are 2.3 GW of projects in the pipeline, either consented or under construction.
  - The world's second largest wind farm (Gwynt y Mor, providing nearly 600 MW of capacity) opened in 2015 off the coast of Wales.
- In **Northern Ireland**, the success of renewable electricity development has, according to Department of Enterprise, Trade and Investment (DETI),[12] been due to the support provided by the Northern Ireland Renewables Obligation which operates in the same way as the GB-wide scheme. DETI has a target to produce 40% of electricity consumption from renewables by 2020. In 2015 consumption was 25.4% from 0.9 GW of capacity:
  - Onshore wind dominates renewable energy capacity; there are no offshore wind farms. In 2015, 79% of renewable electricity generated was from onshore wind. Solar PV capacity increased by 69% and generation from plant biomass increased 303% as the ERE biomass power plant in Derry/Londonderry became operational.
  - Power producer AES completed the construction of a 10 MW energy storage system at its Kilroot power station, the UK largest. The Kilroot Advancion array consists of around 53,000 batteries and is the first step in the company's plan to diversify its supply by building as much as 100 MW of energy storage at this location.
  - Northern Ireland Renewables Obligation (NIRO) is being closed in 2017 and there is a proposal to introduce a similar Feed in Tariff (FiT) with some Contracts for Difference (CfD) in 2016/17, which will take over from the NIRO as the main incentive mechanism for Northern Ireland.

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.

The devolved administrations should continue to make use of the powers and capacities available for promoting and demonstrating renewable energy, signifying commitment to investments and undertaking a mediating role between stakeholders.

[10] 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.
[11] Welsh Government (2005) *Technical Advice Note 8: Planning for Renewable Energy.*
[12] DETI (2010) *Energy A Strategic Framework for Northern Ireland* available at: http://www.detini.gov.uk/strategic_energy_framework__sef_2010_-3.pdf

Figure 9.5. Renewable deployment in the UK (2003-2015)



Source: DECC (2016) *Energy Trends 6.1 Renewable electricity capacity and generation.*

4. Buildings

Overview

Table 9.4 provides an overview of emissions and the policy framework.

Table 9.4. Buildings dashboard

Emission reductions (average annual change 2009 - 2014)		**Policy framework**	**Progress**
UK	Residential: 3% Non-residential: 3%	Chapter 3 : includes Energy Company Obligation (ECO), RHI, buildings regulation	-
Scotland	Residential: 3% accounting for 9% share of UK reduction	Renewable Heat Incentive alongside Home Energy Scotland renewables loan scheme and Resource Efficient Scotland - Scotland has performed well compared to its share of GVA and GB-housing stock with further uptake from Scottish Government funding.	Green
	Non-residential: 1.6% accounting for 13% share of UK reduction	District Heating Loan Fund and Warm Homes Fund - between 2011 and 2015 all projects funded produced annual savings of nearly 9,000 tCO_2 a year with 12 MW_{th} installed capacity supplying low carbon heat to 850 homes.[13] Wider marketing of opportunities of schemes to housing associations or facilities management companies might further increase the potential for uptake for larger projects.	Amber
		Scottish Government Fuel Poverty and Energy Efficiency Programmes. HEEPS provided £199m funding for 2015/16 and has provided continuity and certainty in face of UK government changes to ECO in 2014. However, funding timescales have been challenging and eligibility for the programme means households cannot also make use of ECO.	
Wales	Residential: 3% accounting for 6% share of UK reduction	Renewable Heat Incentive - increase in renewable heat (255 MW_{th} in 2014 from 59 MW_{th} in 2012[14]) reflects increase in non-residential biomass from RHI. Wales has performed well compared to its share of GVA and GB housing stock, although further uptake from Welsh Government policies	Amber

[13] Energy Saving Trust (2015) *District Heating Loan Fund Evaluation*, available at www.energysavingtrust.org.uk
[14] Welsh Government (2015) *Low Carbon Energy Generation in Wales*. Available at: http://gov.wales/docs/desh/publications/151120-updated-study-of-low-carbon-energy-en.pdf

Table 9.4. Buildings dashboard

Emission reductions (average annual change 2009 - 2014)		Policy framework	Progress
	Non-residential: 2% accounting for 4% share of UK reduction	has not occurred.	
		Nest - targets buildings with an energy efficiency rating of F or G. Improvements are estimated to have delivered average annual bill savings of over £470 per household, (over £2m overall) on annual household energy bills.[15] The total number of homes improved is over 17,000.	Amber
		Arbed - area-based scheme, which has improved the energy efficiency of nearly 30,000 homes. It has demonstrated up to £2 return into the local communities for every £1 of investment.	
Northern Ireland	Residential: 1.9% accounting for 2% share of UK reduction	Northern Ireland Renewable Heat Incentive - run by DETI. Closed to new applications in March 2016 due to budgets being exhausted. It is estimated that there is an overspend of £30m. No other scheme has been announced.	Red
	Non-residential: 3% accounting for 4% share of UK reduction	Sustainable Energy Programme - Northern Ireland's equivalent of ECO has funding for residential and non-residential buildings. Affordable Warmth - area-based scheme aimed at reaching more of those in severe fuel poverty. Local councils run the scheme; as of end-2015 £9m of grants have been issued. The Housing Executive is carrying out a review of the scheme to speed up process and examine performance to date.	

Notes: The RHI is a GB-wide scheme, but we have assessed progress in Scotland and Wales.

Emissions from residential buildings

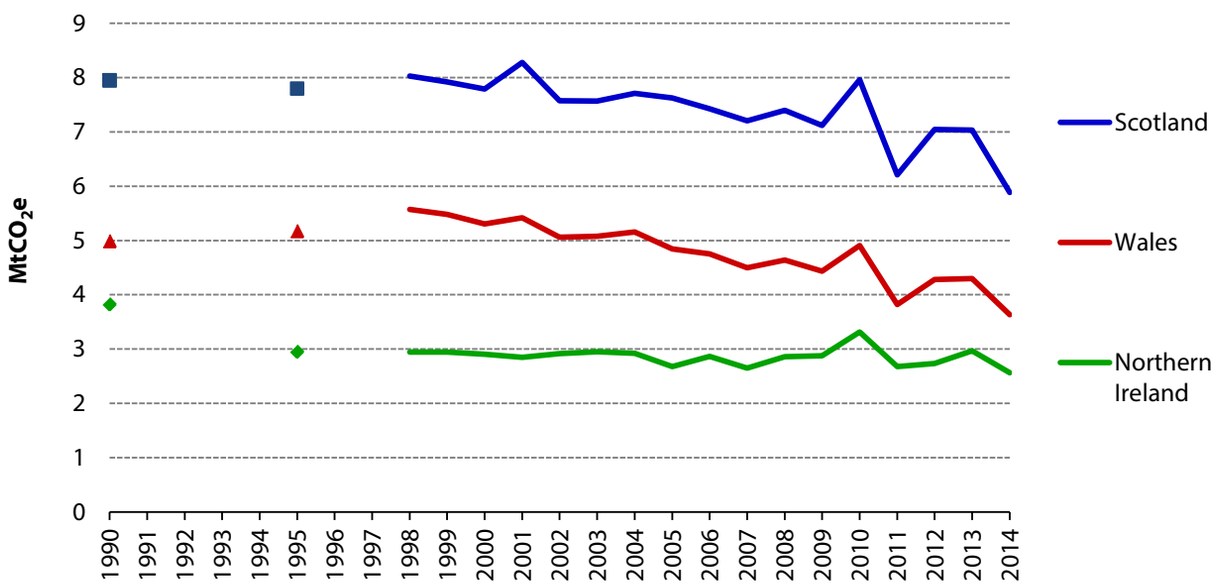
Direct residential emissions fell across the devolved administrations in 2014 compared to 2013 (Figure 9.6). This was similar to the UK (17% decrease in 2014) and reflects a decrease in the demand for heating during 2014 due to higher than average temperatures in winter months:

- In Scotland, emissions from residential buildings fell 16%, following a period of little change between 2009 and 2013. Emissions were 13% of the total and 27% lower than 1990 levels.
- In Wales, emissions from residential buildings fell 16%, following a period of little change between 2009 and 2013. Emissions were 8% of total Welsh emissions and 28% lower than 1990 levels.

[15] Nest (2015) *Annual Report*. Available at: http://www.nestwales.org.uk/sites/default/files/Nest%20Annual%20Report%202014-15_2.pdf

- Emissions from residential buildings in Northern Ireland fell 14% in 2014, following a period of little change between 2009 and 2013. The sector accounted for 13% of total emissions in 2014, and emissions were 33% lower than in 1990.

Figure 9.6. Residential emissions in Scotland, Wales and Northern Ireland (1990 - 2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990-2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Low-carbon heat

Scotland and Northern Ireland each have targets for renewable heat (Table 9.5); Wales currently has no heat strategy or heat targets.

Table 9.5. Low-carbon heat targets and progress

	Target	Progress in 2014	On track
Scotland	Source 11% of heat demand from renewable sources by 2020, and a largely decarbonised heat sector by 2050. Interim target of 3.5% in 2012.	In 2014 just over 1 GW_{th} operational with an output of over 3.0 TWh (42% increase in capacity and a 36% in generation since 2013). The Scottish Government has estimated that 3.7-3.8% of heat demand was from renewable sources in 2014 up from 2.7% in 2013.[16]	No
Wales	-	-	-
Northern Ireland	4% of total heat consumption to be provided by renewable sources by 2015 and 10% by 2020.	DETI have estimated that in 2015 6% of heating needs were provided through renewable technologies.	Yes, although future is uncertain.

Source: DECC (2015), Scottish Government (2016), Welsh Government (2016), DETI (2016).

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, with: 19% of non-residential capacity installed in Scotland and 9% in Wales (greater proportions than would be expected based on GVA shares of 8% and 3% respectively), and 20% of residential accreditations in Scotland, 7% in Wales compared to housing shares of 9% and 5% respectively. 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% GB overall). In Scotland Home Energy Scotland renewables loan scheme also supplements funding from RHI.

Scotland also has further policies to encourage the uptake of renewable heat. We recommended, in our 2015 UK Progress Report, that further action to facilitate heat networks should be considered. Good progress has been made:

- The Scottish Government published a Heat Policy Statement (HPS) in June 2015, setting out its approach to working towards decarbonising the heat system by firstly reducing the need to heat. Energy efficiency has been designated as a National Infrastructure Priority, with Scotland's Energy Efficiency Programme (SEEP) providing support to all building types. The statement also includes a target for district heating, to have 1.5 TWh of heat by 2020 and

[16] Scottish Government (2016, *Energy in Scotland.* Available at: http://www.gov.scot/Resource/0050/00501041.pdf

40,000 homes connected by 2020. We will examine the implementation of the Heat Statement commitments in our next Scottish Progress Reportin September 2016.

- Publication of the Scotland Heat Map,[17] increased funding for the District Heating Loan Scheme, and setting up of the Scottish Heat Networks Partnership Practitioner Group.

For **Wales**, although heat generation from biomass boilers, heat pumps and biogas is increasing, this is largely due to the non-domestic RHI for farm and commercial activities. We recommended in 2015 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.

To support the development of low-carbon heat in **Northern Ireland**, the Executive introduced its own RHI and Renewable Heat Premium Payment (RHPP) schemes. These operated in the same way as the GB schemes. However the Department for Enterprise, Trade and Investment closed the schemes to new applications in early 2016, due to the budgets for both being exhausted. We recommend that a support mechanism for low-carbon heat is developed.

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 continue to use the 10% definition,[18] rather than the Low Income High Cost (LIHC) measure used in England. Fuel poverty in Scotland in 2014 was 35%. For Wales and Northern Ireland the latest available data are for 2012 when fuel poverty was 30% and 42% respectively (compared to 35% in Scotland and 12% in England in 2012).

For a number of reasons, reducing fuel poverty is more of a challenge in the devolved administrations: lower average incomes; higher average energy costs due to housing stock characteristics with more houses off the gas grid; a greater proportion of energy-inefficient properties.

Energy efficiency policy is more comprehensive in the devolved administrations than in England. The main energy efficiency schemes, the Green Deal (now ended) and Energy Company Obligation (ECO) are GB-wide (Chapter 2), but Scotland and Wales have devolved powers to develop their own schemes. Scotland and Wales have been successful in leveraging funding from the ECO, taking a higher share of the measures than their housing stock. In Northern Ireland, energy efficiency is fully devolved and the Executive has developed similar supplier schemes to the GB ones, as well as their own additional policies.

New schemes and funding available include:

In Scotland:

- In April 2015 the Scottish Government announced a £224m scheme (over seven years, opened in September 2015 under the Warmer Homes Scotland initiative), aiming to target funds at installing insulation, heating and low-carbon or renewable measures in up to 238,000 fuel-poor households.

[17] Available at: http://www.gov.scot/heatmap

[18] 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.

- An integrated approach to energy efficiency in buildings, SEEPS, will begin in 2018. The £14m fund will allow councils across Scotland to make homes, public buildings and businesses more energy efficient. In the next two years councils will test pilot projects to evaluate the impact of innovative approaches to funding and delivery and test the market for investments in the commercial sector. A full delivery phase will start in 2018, once further devolution of energy efficient powers takes place under the Scotland Bill.
- We previously recommended that the Scottish Government carry out an evaluation of current energy efficiency programmes (especially the area-based schemes) to help determine the best way to implement supplier obligations as they become devolved. The Energy Agency in Scotland, is currently conducting an evaluation project to investigate the success of the Scottish Government funded insulation schemes in alleviating fuel poverty. Households receiving insulation in 2016 under the Area Based Schemes will be monitored. A report will be available early 2017.[19]

In Wales:

- The Well-being of Future Generations Act (legislated 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[20] for energy efficiency and addressing fuel poverty to 2026 as part of the Act. The strategy includes prioritising actions such as overcoming barriers, skills and education and innovation.

In Northern Ireland:

- The Northern Ireland Energy Bill will include provisions on energy efficiency.
- Boiler Replacement Scheme closed to new applications in March 2016.

As previously recommended, Wales and Northern Ireland would benefit from up-to-date housing condition surveys[21] in order to provide a basis for effective monitoring of the uptake of energy efficiency measures.

Fuel poverty targets are not being met and fuel poverty remains high in the devolved administrations compared to numbers in England. However, the Scottish Government has recently made energy efficiency an infrastructure priority and is taking an integrated approach, allowing local authorities to pilot new and innovative methods. The other nations would benefit from learning more from each other about what works.

Non-residential buildings

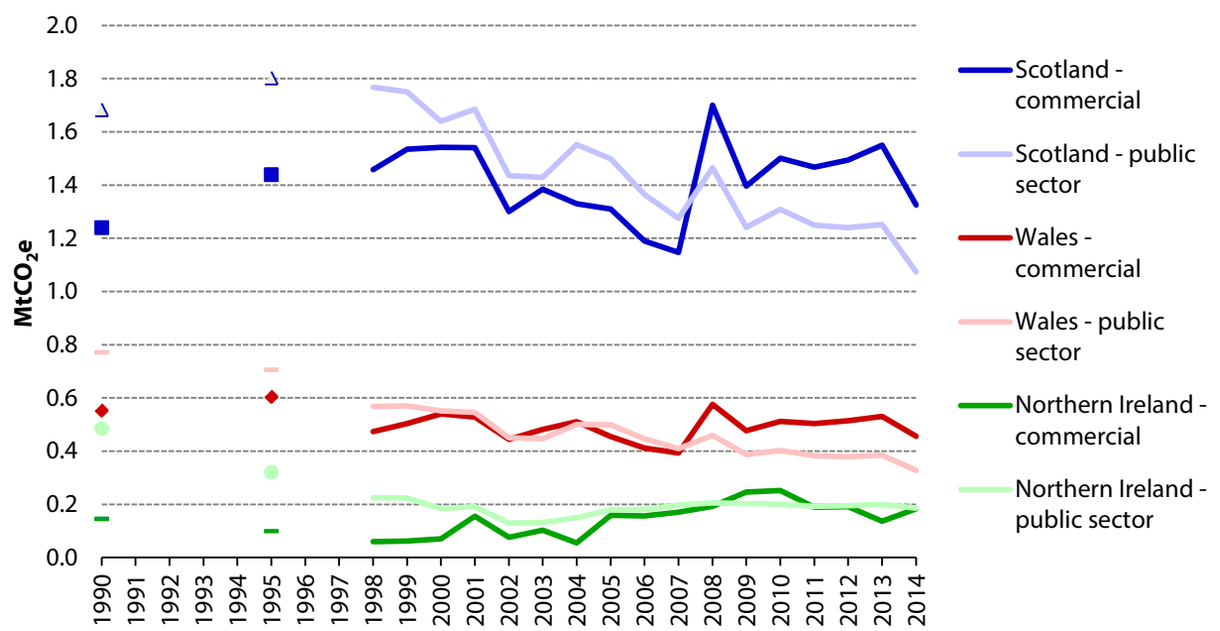
Emissions from non-residential buildings fell in Scotland and Wales but rose in Northern Ireland in 2014 (Figure 9.7):

- In Scotland, emissions from non-residential buildings fell by 14%, with emissions from commercial buildings falling 15% and those from the public sector 14%. The non-residential buildings sector accounted for 5% of total Scottish emissions in 2014.

[19] Available at: http://www.energyagency.org.uk/en/free-insulation-scheme-case-studies_46663/
[20] Welsh Government (2016) *Energy Efficiency in Wales – A strategy for the next 10 years 2016–2026*. Available at: http://gov.wales/docs/desh/publications/160223-energy-efficiency-in-wales-en.pdf
[21] The most recent housing condition surveys were in 2008 for Wales and 2011 for Northern Ireland.

- In Wales, emissions from non-residential buildings fell by 14%, although it is a very small sector, accounting for 2% of total emissions in 2014. Emissions from commercial buildings fell 14% and those from the public sector fell 15%.
- In Northern Ireland, emissions from non-residential buildings rose 10%. This was due to a rise in emissions from the commercial sector of 35%, while those from the public sector fell 7%. The non-residential buildings sector accounted for 2% of Northern Ireland emissions in 2014.

Figure 9.7. Emissions from non-residential buildings in Scotland, Wales and Northern Ireland (1990-2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

Since our 2015 Progress Reportthe Scottish Government has introduced reporting requirements for all public bodies from September 2015. Annual reporting of emissions, savings from emission reduction projects, as well as renewable energy generation and consumption is now required. This provides information essential to understanding and curbing waste. The Scottish Government's Energy Efficiency Programme (SEEP) includes funding and programmes for public buildings and businesses to make them more energy efficient.

A new scheme aimed at helping public bodies in Wales to make savings and reduce their carbon impact has been launched by the Welsh Government in March 2016. The Re:fit Cymru programme is being supported by £1.5m funding from the EU's Intelligent Energy Europe Programme.

5. Industry

Table 9.6 provides an overview of emissions and the policy framework.

Table 9.6. Industry dashboard

Emission reductions (average annual change 2009 - 2014)		**Policy framework**	**Progress**
UK	1%	Chapter 4: EU ETS, Climate Change Levy, Renewable Heat Incentive	-
Scotland	2% accounting for 19% share of UK reduction	Policy is a reserved matter	-
Wales	3% increase		
Northern Ireland	1% increase	Northern Ireland Renewable Heat Incentive	 Amber

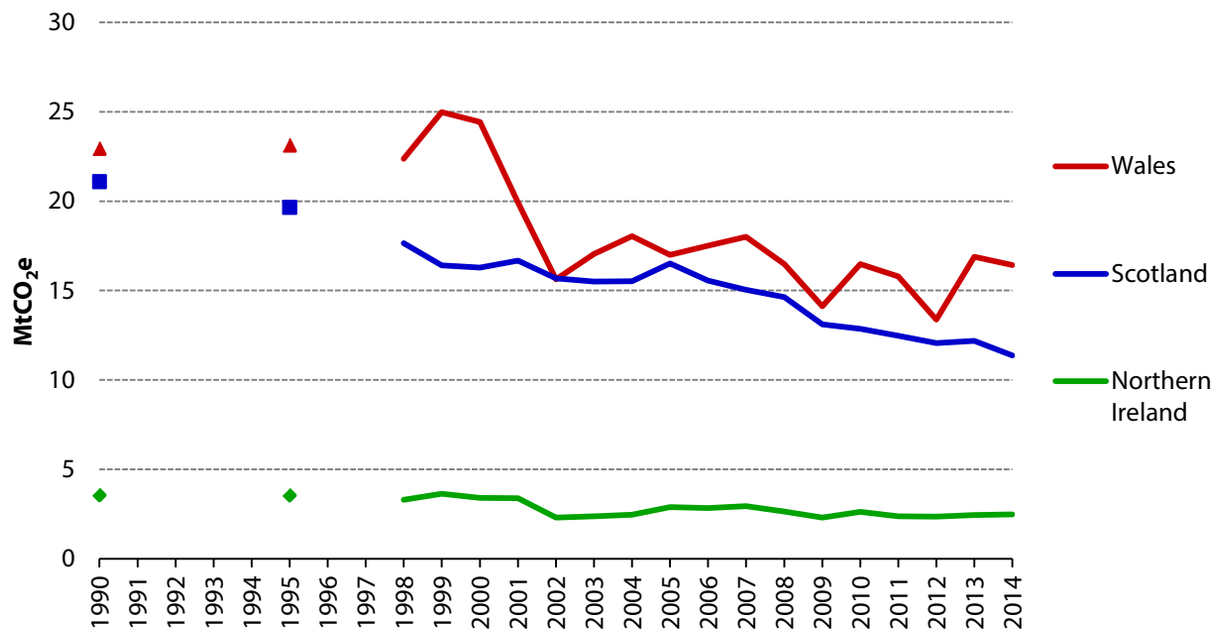
At the UK level, direct emissions from industry fell 2% from 2013 to 2014. Emissions fell in Scotland and Wales, but rose slightly in Northern Ireland (Figure 9.8):

- In Scotland, emissions from industry fell 7% in 2014, with an annual average decrease of 2% between 2009 and 2014. Emissions from the sector accounted for 26% of total Scottish emissions and have decreased 46% since 1990.
- In Wales, emissions from industry fell 3% in 2014 to 16.4 $MtCO_2e$, but had an annual average increase of nearly 3% between 2009 and 2014. However, emissions are still 28% lower than 1990 levels. In 2014, industry emissions were 35% of total Welsh emissions, accounting for the largest share.
- Emissions from industry in Northern Ireland accounted for 12% of total emissions in 2014 and rose by 1.5%, with an annual average increase of around 1% between 2009 and 2014. They are 30% lower than in 1990.

Industry makes up a particularly large share of total emissions in Wales, with 60% of industrial emissions coming from the iron and steel sector in 2014. These are largely from Port Talbot steelworks. In 2014, EU ETS verified emissions for Port Talbot steelworks were 6% higher than in 2013, although emissions fell again in 2015 by 10% to just under 2013 levels.

In March 2016, Tata steel announced the sale of its UK operations including its Port Talbot steel works. The future of the Port Talbot site is not yet known and in light of the final decision, the Welsh Government should consider implications and actions needed for emission reductions.

Figure 9.8. Industry emissions in Scotland, Wales and Northern Ireland (1990-2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

The devolved administrations have little control over industrial policies for emission reductions which are largely reserved and operate at the UK/EU level (Chapter 3). Policies include the EU ETS, Climate Change Levy (CCL) and Climate Change Agreements (CCAs), and the Renewable Heat Incentive (RHI). The Green Investment Bank also operates across the UK focusing on technologies that reduce energy consumption and emissions in industrial processes.

The devolved administrations all offer interest-free loans for small and medium-sized enterprises (SMEs) for energy efficiency or resource efficiency projects, through Resource Efficient Scotland in Scotland and Carbon Trust in Wales and Northern Ireland.

6. Transport

Overview

Policy for road transport is mostly reserved in all the devolved administrations, though demand-side provisions such as road maintenance, cycling, bus policies and provisions are devolved. As part of the devolution settlement, air passenger duty will be devolved to the Scottish Government which plans to reduce APD by 50% from April 2018.

Table 9.7 provides an overview of emissions and the policy framework.

Table 9.7. Transport dashboard

Emission reductions (average annual change 2009 - 2014)		**Policy and scheme framework**	**Progress**
UK	0.5%	Chapter 5: Decarbonising vehicles	-
Scotland	0.6% accounting for 11% share of UK reduction	Electric Vehicle Loan Scheme and Low Carbon Transport Loan Fund	 Amber
		Smarter Choices, Smarter Places - In 2015/16, a wider roll-out of behaviour change initiatives was undertaken, supporting 160 projects, in partnership with local authorities and with Paths for All administering the programme.	
Wales	0.6% accounting for 6% share of UK reduction	The Active Travel (Wales) Act 2013 makes it a legal requirement for local authorities in Wales to map and plan for suitable routes for active travel and to build and improve their infrastructure for walking and cycling every year. It has included high design standards and continuous improvements but has been hampered by lack of funding to date.	 Amber
Northern Ireland	0.9% accounting for 7% share of UK reduction	The Executive published an active travel strategy in 2013 developed to reflect how government departments, local authorities and voluntary bodies can help to deliver the recommendations of the Active Travel Strategy over the period 2012-2015.	 Amber

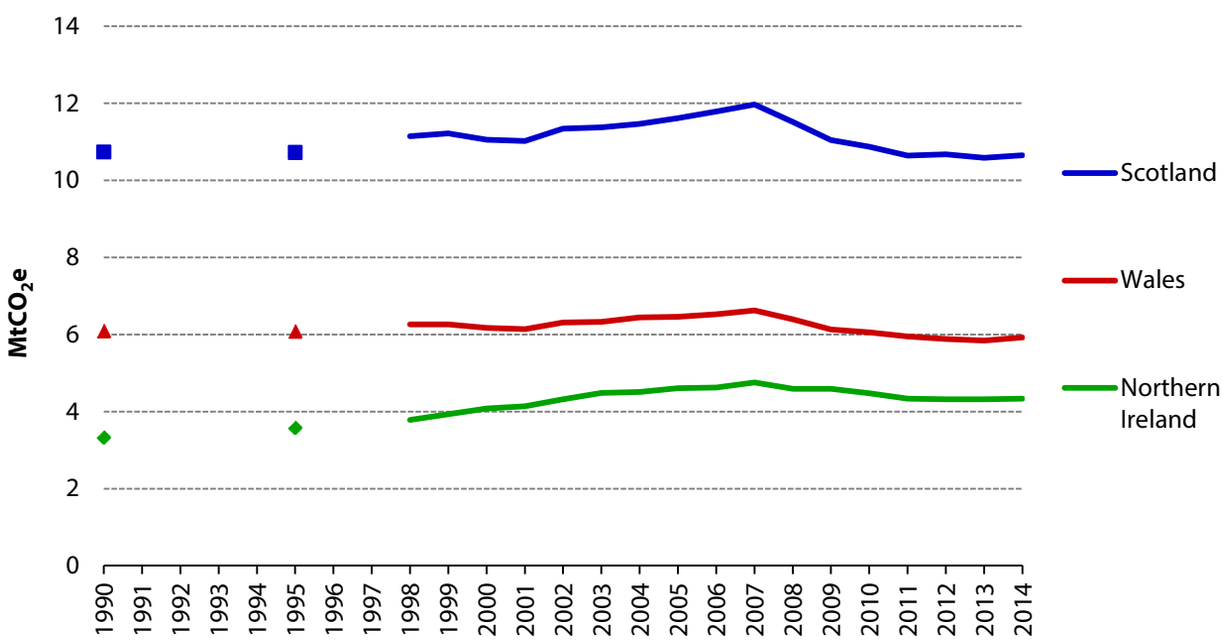
Emissions trends and drivers

Emissions from transport rose across the devolved administration from 2013 to 2014 (Figure 9.9):

- In **Scotland**, transport emissions rose by 0.5%, although they were broadly unchanged from 1990 levels, with annual average reductions of 0.6% between 2009 and 2014. Transport emissions account for 24% of total emissions in Scotland in 2014, in line with the UK.

- In **Wales**, the transport sector accounts for a smaller share (13%) of overall emissions. Emissions from transport also rose in 2014 by 1.3%, with an annual average decrease of 0.6% between 2009 and 2014, and are 3% lower than in 1990.
- In **Northern Ireland**, transport emissions rose by 0.5% in 2014, with an annual average decrease of 0.9% between 2009 and 2014, but were 30% higher than in 1990. Emissions from the sector were 21% of overall Northern Irish emissions in 2014. 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. Northern Ireland has the highest share of road emissions from rural driving at 61%, compared with 55% in Wales, 49% in Scotland and 39% across the UK as a whole in 2014.

Figure 9.9. Transport emissions in Scotland, Wales and Northern Ireland (1990-2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

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 9.8). The efficiency of new cars has been driven by EU legislation; however, there has been some variation in progress towards achieving the EU's 2020 target of 95 gCO_2/km in 2020.

Evidence has continued to emerge that there is a large and growing gap between test-cycle and real-world emissions for new cars (Chapter 5).

Table 9.8. Change in vehicle-kms in 2014 and new-car efficiency 2015					
	Road traffic	**Heavy Goods Vehicles**	**Cars**	**New car test-cycle efficiency 2015**	**Target for 95 gCO_2/km by 2020 on track?**
Scotland	2.2% increase	0.6% decrease	1.7% increase	121.5 gCO_2/km (2% decrease from 2014)	Yes – although behind Wales and Northern Ireland, Scotland is in line with UK average
Wales	3.1% increase	0.1% decrease	2.9% increase	120.7 gCO_2/km (2% decrease from 2014)	Yes
Northern Ireland	Not available	Not available	Not available	120.0 gCO_2/km (2% decrease from 2014)	Yes – best efficiency in UK

Source: Scottish Government (2015) *Scottish Transport Statistics No 34*, Welsh Government (2015) *Road Traffic in Wales 2014*, Department for transport (2016), The Society of Motoring Manufacturing and Traders Limited (2016)
Notes: Northern Ireland vehicle-km data for 2014 are not available until the end of June 2016.

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 91% of the total UK market in 2015. Sales of electric vehicles in Scotland accounted for 5% of UK sales in 2015, with Wales taking 2% and Northern Ireland 1%. These shares were lower than the proportion of overall vehicle sales (8% Scotland, 4% Wales and 2% Northern Ireland 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 end of January 2016, there were 1,670 public charging points across Scotland[22] (15% of total UK points). In June 2016 £7.8m was made available for interest-free loans to help businesses and consumers purchase EVs through the Low Carbon Transport Loan Fund.
- In Wales, there has been less of a push for EVs; it has 3% of UK charging points (around 300).
- The eCar project in Northern Ireland has installed electric vehicle charging infrastructure and offers grants to electric vehicle owners to install charging points in their homes or workplaces. There are 460 charging points available at 174 different locations. In 2013/2014 the usage of these increased by 790%.

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. In our 2015 Progress Reportwe recommended that Wales and Northern Ireland address the non-

[22] Available at: https://www.zap-map.com/statistics/

financial barriers for electric vehicles. Progress appears to have been made in Northern Ireland, but more could be done within Wales.

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.

In 2015 in Scotland:

- Transport Scotland has agreed a further £5m funding in 2016/17 for Smarter Choices, Smarter Places. Paths for All will continue to administer the programme. However there is a desire to continue the programme beyond March 2017.
- Scottish Government's National Transport Strategy 2016 sets out the future of Scotland's transport infrastructure and services. The provision of walking and cycling is included as a high-level objective contributing to improved health and the protection of the environment.

In 2015 in Wales:

- The new National Transport Plan 2015 sets out in more detail how the Welsh Government proposes to deliver in those areas of transport for which it is responsible, to achieve the outcomes set out in the Wales Transport Strategy from 2015 and beyond.
- 'Active journeys' is a new three year project to promote active travel in schools, which started in August 2015. It will work closely with a large number of primary and secondary schools across Wales, and develop resources which will be available for all schools to encourage walking and cycling among pupils, staff and parents.
- An independent review of travel strategies in Wales[23] highlighted that funding is a key barrier to schemes progressing. The review suggests that Wales currently spends less per person on active travel than other parts of the UK (an estimated £5 per head, total £15m; as against £10 per head in other parts of the UK). The review suggested that a longer-term (three-year) investment would be beneficial.

In 2015 in Northern Ireland:

- The Travel survey Northern Ireland (2012 – 2014)[24] compares results from 2007-2009 to 2012-2014 and found that there has been no significant modal shift (change from one mode of travel to another).
- Northern Ireland Changing Gear – A Bicycle Strategy for Northern Ireland[25] was published in August 2015 to set out a 25-year approach to cycling. Belfast's first bicycle route, encompassing new engineering measures to create a safer space for those using the bicycle, was officially opened in March 2016.
- TravelwiseNI is an initiative to encourage the use of sustainable transport options such as walking, cycling, public transport or car sharing.

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[23] Cole (2015) *Active Travel Independent Ministerial Report.* Available at: http://gov.wales/docs/det/publications/transport/150916-professor-cole-active-travel-report-en.pdf

[24] DRDNI (2015) *Travel Survey for Northern Ireland.* Available at: https://www.drdni.gov.uk/sites/default/files/publications/drd/travel-survey-for-northern-ireland-in-depth-report-2012-2014.pdf

[25] DRDNI (2015) Changing Gear – *A Bicycle Strategy for Northern Ireland.* available at: https://www.drdni.gov.uk/sites/default/files/publications/drd/a-bicycle-strategy-for-northern-ireland.pdf

The devolved administrations are often at the forefront of behaviour change programmes. Nevertheless, emissions are increasing and measures to tackle this are a priority.

7. Agriculture and land use

Overview

Table 9.9 provides an overview of emissions and the policy framework.

Table 9.9. Agriculture and land use dashboard

Emission reductions (average annual change 2009 - 2014)		**Policy framework**	**Progress**
UK	0.4% increase	Chapter 6: Policy is mostly devolved	-
Scotland	0.1% increase	Farming for a Better Climate initiative (FFBC) - Scottish Government announced that the initiative would receive £0.8m funding for 2014/2015 and 2015/2016.	Red
		Increase afforestation rate to 10,000 hectares per year. A number of schemes, such as The Forestry Grant Scheme, support new woodland creation and sustainable management of existing woodlands. This is through eight category grants from the Scottish Rural Development Plan.	Red
Wales	1% increase	Glastir and Rural Development Plan - provide direct funding and the Welsh Government is encouraging co-operation between land owners in the public and private sectors to deliver additional tree planting.	Red
Northern Ireland	0.4% increase	Greenhouse Gas Implementation Partnership	Amber
		Rural Development Programme	

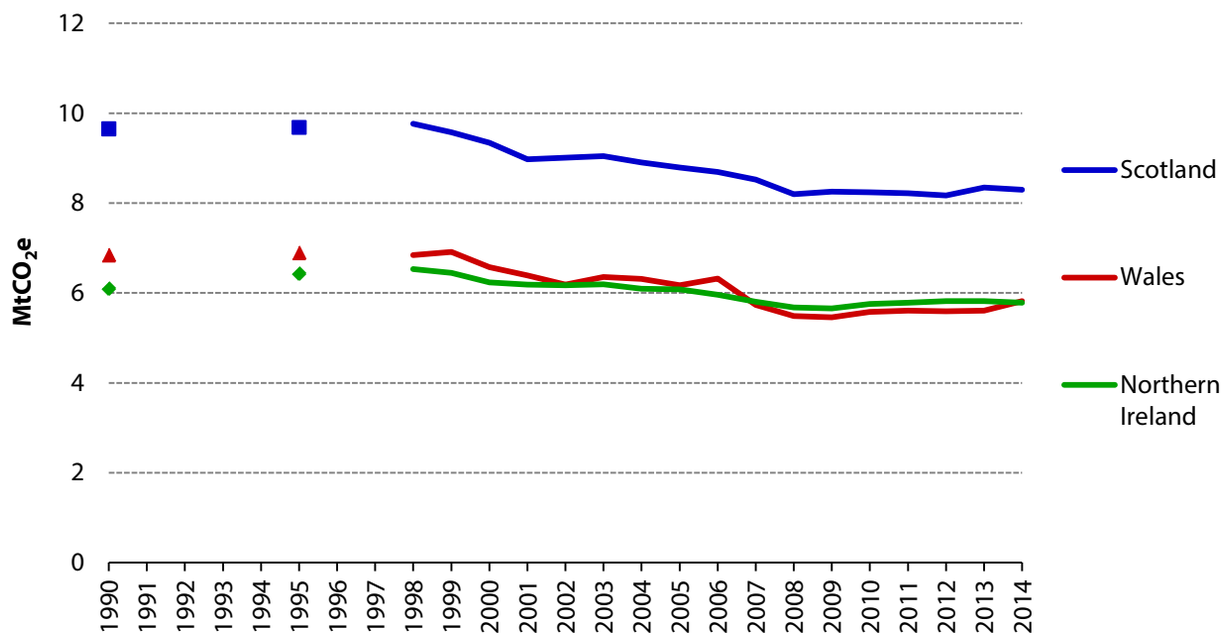
Agriculture emissions and drivers

Emissions from agriculture fell in Scotland and Northern Ireland in 2014, although they rose in Wales (Figure 9.10). 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.

Agriculture in the devolved administrations is relatively more important for emissions and the economy than for the UK as a whole. This is especially the case for Northern Ireland where 2014 emissions were 28% of the total compared to 19% in Scotland, 13% in Wales and 10% at a UK level. In 2014:

- In Scotland, agricultural emissions fell slightly (0.6%), with little change on average each year between 2009 and 2014, although they have reduced 14% since 1990.
- Emissions from agriculture in Wales rose nearly 4%, with annual average increases of 1% between 2009 and 2014, and were 15% below 1990 levels.
- In Northern Ireland, emissions from agriculture fell slightly (0.6%), with annual average increases of 0.4% between 2009 and 2014, and are just 5% lower than they were in 1990.

Figure 9.10. Agriculture emissions in Scotland, Wales and Northern Ireland (1990-2013)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

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, though 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 to help towards a 42% reduction by 2020 in all emissions. In 2014 emissions had reduced 0.4 $MtCO_2e$ since 2006. However, assessment of progress is difficult due to changes in the methodology used to measure agricultural emissions since the target was set. We recommend that the Scottish Government carry out a survey to establish whether there has been uptake of their voluntary Farming for a Better Climate initiative.
- **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. In 2014, emissions were 0.1 $MtCO_2e$ higher than in 2008. 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. Since our 2015 Progress Report:

  - It opened five different schemes offering grants to farming businesses for sustainability projects and land management, animal welfare improvements, food enterprises and also support grants for rural communities.
  - The Welsh Government has commissioned a range of modelling and monitoring activities in order to gauge actual quantification of scheme impacts – the Glastir Monitoring and Evaluation Programme (GMEP) will be available late 2016.

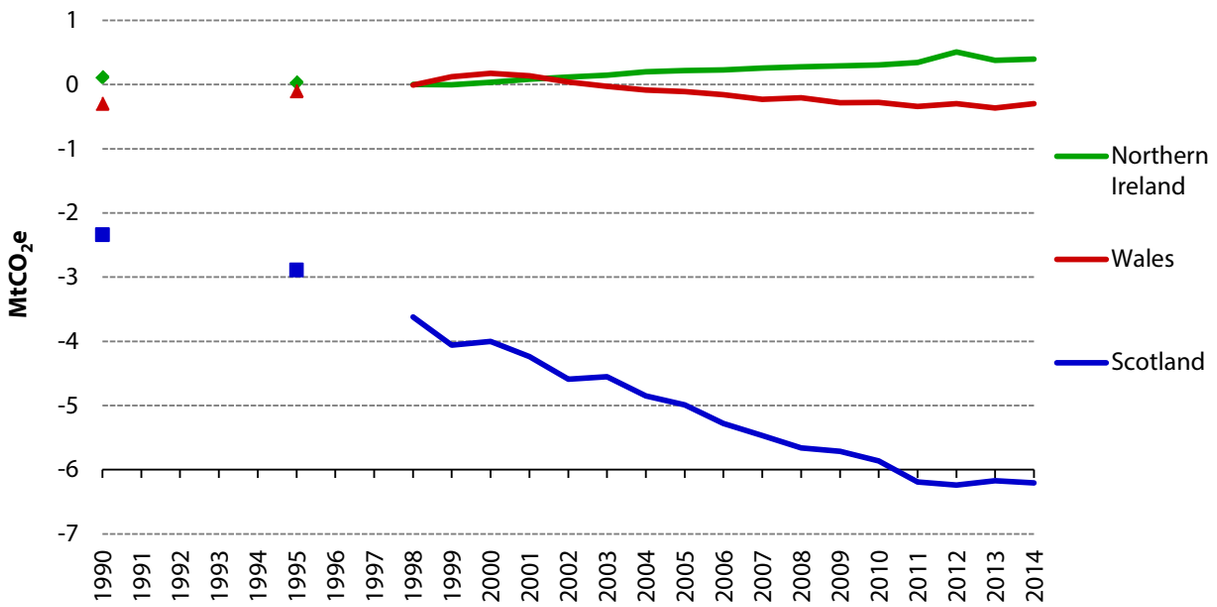
- In **Northern Ireland**, in 2015 the Greenhouse Gas Implementation Partnership (GHGIP), a collaborative strategy between stakeholders and the Executive, is working towards the launch of phase two of the scheme to implement on-farm efficiency measures to reduce the carbon intensity of local food production. The approach allows the agri-food sector, which is a large contributor to the economy in Northern Ireland, to address its carbon footprint whilst contributing to economic growth by meeting the growing global demand for food.

Forestry and land use emissions

The size of the carbon sink from the land use, land-use change and forestry (LULUCF) sector increased in Scotland in 2014, although it reduced in Wales (Figure 9.11). In Northern Ireland, the sector was a net emitter with emissions increasing since 2013:

- In Scotland, the size of the carbon sink increased 0.5% and reached 6.2 $MtCO_2e$ in 2014, with an annual average increase of 1.4% between 2009 and 2014. This is an increase from 1990, when the sector was removing 2.3 $MtCO_2e$. It reflects increased planting rates and the changing age profile of the trees and their ability to sequester carbon. The carbon sink in Scotland represents 69% of the UK's total LULUCF sink.
- In Wales, the sink reduced in 2014, to 0.3 $MtCO_2e$, although between 2009 and 2014 there has been an annual average increase of 0.6%. The reduction was largely due to land being converted to settlements.
- In Northern Ireland, the sector was a net emitter in 2014, emitting 0.4 $MtCO_2e$, with an annual average increase of 5% between 2009 and 2014. This was mostly due to land being converted to settlements. The sector accounts for 2% of total emissions.

Figure 9.11. Emissions from land use, land-use change and forestry in Scotland, Wales and Northern Ireland (1990 - 2013)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014.*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

For the forestry sector, the devolved administrations have ambitious targets to increase the rates of forest planting (Table 9.10):

- In **Scotland**, planting rates have failed to meet their target, with an 8% reduction for 2014 compared to 2013. This was in line with reductions across each nation, although 73% of new planting in the UK was in Scotland. The shortfall of 11m trees relative to the target of 100m to be planted between 2010 and 2015 was due to difficulties negotiating with landowners and farmers. Since our 2015 Progress Report, the Scottish Government has published an updated land use strategy. The strategy retains the long-term vision; the three objectives relating to the economy, environment and communities; and the principles for sustainable land use to guide policy and decision making by Government and across the public sector to 2021.
- The planting rate in **Wales** decreased in 2015 by 89% to 1,000 hectares (ha). This is off-track for the Wales 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 view of low planting rates to date, the Welsh Government has established a short-term target of 2,000 ha/year between 2015 and 2020, while retaining the 2030 aspiration of 100,000 ha. In the past year:
  - The Welsh Government has said that the statutory changes made by the Well-being of future Generations (Wales) Act 2015 and Environment Act 2016, including carbon budgeting, will help to further encourage tree planting.
  - Glastir launched five schemes in February 2016 - one of those allowed about £2m, available under the Timber Business Investment Scheme, to support proposals to encourage both active woodland management and increased value of outputs.

- In **Northern Ireland**, the Rural Development Programme 2014-2020 is worth over £500m and aims to improve competitiveness in agriculture and forestry, improve the environment and the quality of life in rural areas and diversification of the rural economy. The woodland investment scheme and forest expansion scheme have £800,000 available for 2014-2020.

Table 9.10. Afforestation targets and progress

DA	Forestry targets/policy	Progress 2015	On track
Scotland	Plant 10,000 hectares per year, creating 100,000 hectares by 2020 Plant 100m trees between 2010 and 2015	7,600 hectares planted, an 8% reduction on 2014 89m trees planted by 2015 since 2010	No
Wales	Plant 100,000 hectares of new woodland over a 20-year period, equivalent to 5,000 hectares per year	1,000 hectares planted an 89% reduction on 2014	No
Northern Ireland	Double the area of forest from 6% in 2012 to 12% in 2056, equivalent to planting 1,700 hectares per year	800 hectares planted, a 33% reduction on 2014	No

Source: Forestry Commission (2015), *Forestry Statistics 2015.*

The devolved administrations should consider what further action is needed to ensure tree planting targets are met. These could include introducing additional measures to incentivise planting. Any plan or strategies introduced should be developed and delivered jointly with key stakeholders and other nations. Future planting should also include a diverse range of species.

The LULUCF inventory currently only includes emissions from lowland peat, mainly related to extraction for horticultural use. DECC is currently in the process of incorporating the IPCC's Wetland Supplement into the UK's Inventory by 2018, which will capture emissions from all upland and lowland peat, and sequestration from restoration practices:

- 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 the land area in Northern Ireland but store 42% of the country's 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.

Peatlands in the devolved administrations account for large areas of land. 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.

8. Waste

Table 9.11 provides an overview of emissions and the policy framework.

Table 9.11. Waste dashboard

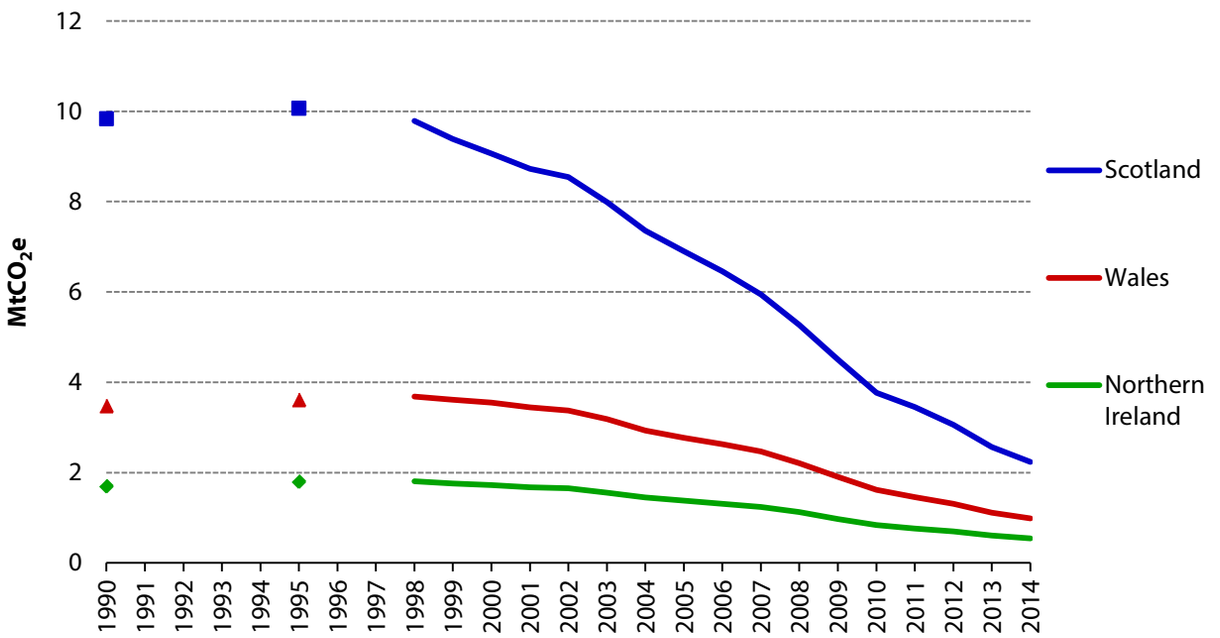
Emission reductions (average annual change 2009 - 2014)		**Policy and scheme framework**	**Progress**
UK	10%	Chapter 7: Policy is devolved.	-
Scotland	11% accounting for 14% share of UK reduction	Zero Waste Plan - 2013 interim municipal recycling target was missed, although the introduction of the Household Recycling Charter should help rates.	Amber
Wales	10% accounting for 6% share of UK reduction	Towards Zero Waste - municipal waste reduction and recycling targets are being exceeded with progress to reduce the proportion of all waste going to landfill.	Green
Northern Ireland	9% accounting for 3% share of UK reduction	Delivering Resource Efficiency - recycling targets missed in 2015; however there has been success with a ban on food waste going to landfill and a successful first year of the carrier bag levy.	Amber

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 (5%, 2% and 3% respectively). In 2014, emissions from waste declined across all the devolved administrations (Figure 9.12). They fell 13% in Scotland, 11% in Wales, and 10% in Northern Ireland, compared to 10% in England.

Recycling rates have been improving in recent years (Figure 9.13), with more than 55% of municipal waste reused, composted or sent for recycling in Wales in 2014/15,[26] the highest in the UK. Scotland has rates of 43%, Northern Ireland 41% and England 45%.

[26] Available at: https://statswales.wales.gov.uk/Catalogue/Environment-and-Countryside/Waste-Management/Local-Authority-Municipal-Waste/Annual/wastegenerated-by-source-year

Figure 9.12. Waste emissions in Scotland, Wales and Northern Ireland (1990 - 2014)



Source: NAEI (2016), *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 -2014*
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

We consider progress in the implementation of devolved waste policies in detail in Chapter 7. Key findings are:

In Scotland:

- Scotland missed its Zero Waste Plan 2013 interim target of 50% for municipal waste recycled, with around 40% recycled in 2013. It was expected that this would improve in 2014/2015 following new measures introduced under the under the Waste (Scotland) Regulations 2013. However, this does not seem to be the case with latest data showing 43% recycled or composted in 2014. The Household Recycling Charter agreed by the Scottish Government in October 2015 should help address the gap. The charter aims to bring in consistent practices across Scotland's local authorities and should make it easier and less confusing for people to recycle potentially valuable materials including paper, card, glass, plastics and food waste.
- Overall waste sent to landfill decreased by 9% in 2013 (33% of total waste) despite overall waste increasing 12%. From 2015 landfill tax has been devolved to Scotland and is set 10% higher than the UK rate for the first three years.
- A Circular Economy Strategy, the first of its kind in Europe, was launched in February 2016, along with the Scottish Food Waste Reduction Target.

In Wales:

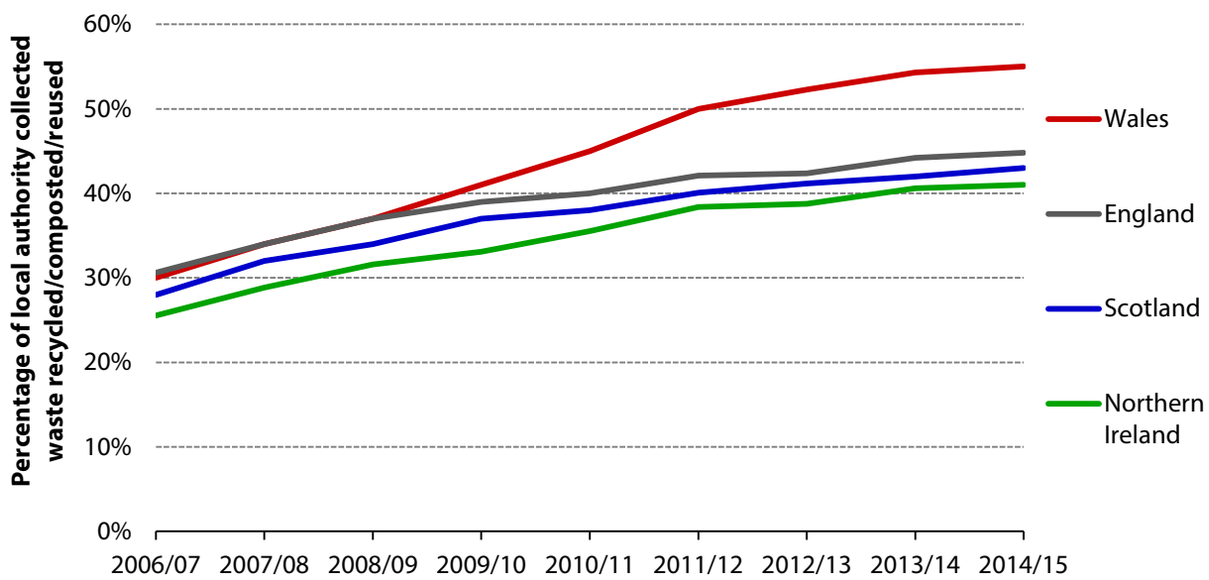
- Reductions in emissions are due to a number of regulatory targets for municipal recycling and waste going to landfill under the Towards Zero Waste Strategy. In 2014 household recycling rose to 55% - leading the UK. Between 2010 and 2013 waste sent to landfill has reduced by 37%.

- Landfill tax is likely to be become devolved to Wales in 2018. The Government has also moved to a circular economy approach with regards to waste.

In Northern Ireland:

- Progress has been made with a ban on food waste going to landfill, targets for waste material recycling and recovery across the economy and a successful first year of the carrier bag levy. However, the 2015 target for 45% of municipal waste to be recycled was missed, with 41% being achieved.

Figure 9.13. Recycling rates in Scotland, Wales, Northern Ireland and England (2006/07-2014/15)



Source: Defra, SEPA, Environment Agency Wales, and the Northern Ireland Executive (2016).

9. Forward look

Tables 9.12 to 9.14 assess progress towards meeting our recommendations made last year in each devolved administration.

Table 9.12. Progress towards 2015 recommendations for Scotland

Recommendation in 2015	Assessment	Commentary
Consider further action to facilitate heat networks: for example, obliging local authorities to connect to existing local networks and requiring consideration of network heat in new developments	Met	A number of actions have taken place including publishing a Heat policy statement in 2015; 19 out of 23 actions from the District Heating Action Plans have been completed, including work with Local Authorities to develop support and knowledge sharing.
Evaluate current energy efficiency schemes: focus particularly on area-based schemes to better understand the most effective way to implement supplier obligations once they become devolved	Partially met	The Energy Agency in Scotland is currently conducting an evaluation project to investigate the success of households receiving insulation under area based schemes.
Improve evidence on agricultural abatement: to include what has worked under "Farming for a Better Climate" and whether its measures have been taken-up beyond the focus farms	No progress	No information on progress to assess uptake of measures outside of the focus farms.

Table 9.13. Progress towards 2015 recommendations for Wales

Recommendation in 2015	Assessment	Commentary
Develop a heat strategy: build on UK evidence and approach to develop clear heat strategy for Wales including a renewable heat target	No progress	There is no evidence of progress to develop low-carbon heat in Wales above measures installed through the Renewable Heat Incentive.
Prepare for higher ambition required of industry: plan ways to reduce industry emissions, including consideration of voluntary partnership agreements with industry and encouraging innovative solutions	No progress	There is no evidence of significant progress to plan for higher ambition to reduce industrial emissions.
Address non-financial barriers for electric vehicles: including further measures which	No progress	Little evidence of barriers being addressed or a push for an EV market in

Table 9.13. Progress towards 2015 recommendations for Wales		
Recommendation in 2015	**Assessment**	**Commentary**
could be implemented such as parking, use of priority lanes, raising awareness and public procurement		Wales.
Meet tree planting targets: consider whether further measures are needed to ensure tree planting targets are met, and develop approach jointly with stakeholders and other DAs	No progress	In 2015 89% fewer trees were planted than in 2014, a total of 1,000 ha; a review has revised the short-term target from 5,000 to 2,000 ha per annum to 2020. There remains potential to achieve higher rates than this if issues relating to poor uptake to date can be resolved.

Table 9.14. Progress towards 2015 recommendations for Northern Ireland		
Recommendation in 2015	**Assessment**	**Commentary**
Consider further action to facilitate heat networks: for example, obliging local authorities to connect to existing local networks and requiring consideration of network heat in new developments	No progress	Lack of funding has closed the NI RHI early and no other scheme to replace it has been announced. We recommend that a support mechanism for low-carbon heat is developed.
Improve monitoring of agricultural emissions: following Defra's delivery of the Smart Inventory, put in place local monitoring and process for acting on its findings	No progress	Smart Inventory is not being implemented until 2017, therefore we will assess this recommendation in more detail in a future report.
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	Partially met	The eCar project has offered grants and installed charging points. Usage of these has increased 790%. However sales of EVs in 2015 are below share of overall car sales.

The devolved administrations each have emission reduction targets that if met would contribute greatly towards the UK's ability to meet the next set of carbon budgets.

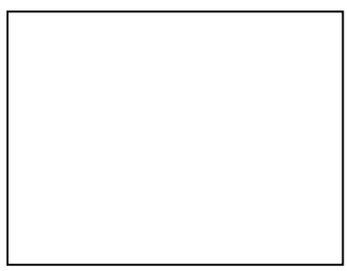
By 2020, if emissions in the devolved administrations fall in line with their targets, there would be a combined reduction of 39% (96 $MtCO_2e$) on 1990 emissions levels.

Our fifth carbon budget analysis included abatement potential from all the devolved administrations in key sectors. There is a similar pattern of abatement though the 2020s with the following key differences highlighted:

- There is potential for Scotland to contribute a greater share of low-carbon power, given the size of its renewable resources, although UK Government financial and other support will be required if renewable electricity resource potential is to continue to be exploited.
- The high share of energy-intensive industry in Wales is reflected in a relatively lower amount of abatement and a lesser overall projected fall in emissions compared to UK as a whole.
- Agriculture abatement is more pronounced, given the higher share of agriculture emissions in devolved nations. This is especially the case in Northern Ireland where the sector is relatively more important for emissions and the economy.

Devolved levers and policies are important to delivering the scenarios for reducing emissions in future carbon budgets. In areas where the devolved administrations are so far progressing further than England or the UK as a whole, there is scope to reduce emissions further. There is also potential for greater learning across the UK from experience at each devolved administration.

Key policy gaps which should be covered in the Emission Reduction Plan are policies to address non-financial barriers to electric vehicles, action to encourage tree planting and prioritised actions to reducing agricultural emissions across all of the devolved administrations, as well as targets and policy to drive low-carbon heat in Wales and a mechanism for low-carbon heat projects in Northern Ireland.



Committee on Climate Change
7 Holbein Place
London
SW1W 8NR

www.theccc.org.uk

@theCCCuk