Meeting Carbon Budgets – 2014 Progress Report to Parliament

Committee on Climate Change
July 2014

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Presented to Parliament
pursuant to section 36(1) and 36(2)
of the Climate Change Act 2008

Preface

The Committee on Climate Change (the Committee) is an independent statutory body which was established under the Climate Change Act (2008) to advise UK and devolved administration governments on setting and meeting carbon budgets, and preparing for climate change.

Setting carbon budgets

In December 2008 we published our first report, 'Building a low-carbon economy – the UK's contribution to tackling climate change', containing our advice on the level of the first three carbon budgets and the 2050 target. This advice was accepted by the Government and legislated by Parliament in May 2009. In December 2010, we set out our advice on the fourth carbon budget, covering the period 2023-27, as required under Section 4 of the Climate Change Act. The fourth carbon budget was legislated in June 2011 at the level that we recommended. In April 2013 we published advice on reducing the UK's carbon footprint and managing competitiveness risks. In November and December 2013 we published, in two parts, our review of the fourth carbon budget, as required under Section 22 of the Climate Change Act, as an input to the Government's decision in 2014.

Progress meeting carbon budgets

The Climate Change Act requires that we report annually to Parliament on progress meeting carbon budgets. We have published five progress reports in October 2009, June 2010, June 2011, June 2012 and June 2013.

Advice requested by Government

We provide ad-hoc advice in response to requests by the Government and the devolved administrations. Under a process set out in the Climate Change Act, we have advised on reducing UK aviation emissions, Scottish emissions reduction targets, UK support for low-carbon technology innovation, design of the Carbon Reduction Commitment, renewable energy ambition, bioenergy, and the role of local authorities. In September 2010, July 2011, July 2012, July 2013 and July 2014, we published advice on adaptation, assessing how well prepared the UK is to deal with the impacts of climate change.

Acknowledgements

The Committee would like to thank:

The team that prepared the analysis for the report: This was led by Adrian Gault and Mike Thompson and included: Andrew Beacom, Owen Bellamy, Ute Collier, Taro Hallworth, Mike Hemsley, Jenny Hill, Verity Howell, David Joffe, Alex Kazaglis, Ewa Kmietowicz, Sarah Leck, Eric Ling, Nina Meddings, Stephen Smith and Indra Thillainathan.

Other members of the Secretariat that contributed to the report: Kris Davies, Joanna Higgins, Nisha Pawar, Joanna Ptak and Hannah Witty.

A number of organisations for their support, including DECC, Defra, Department for Transport, Energy UK, Northern Ireland Executive, Office for Low Emission Vehicles, Scottish Government, Society of Motor Manufacturers and Traders, and the Welsh Government.

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

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Foreword

This is our sixth annual report to Parliament on progress towards meeting carbon budgets. Regular monitoring and reporting of progress is an important part of the framework set up by the Climate Change Act and an important part of driving the transition to a low-carbon economy. Circumstances change, new opportunities appear and challenges take shape; an effective strategy must identify these and respond.

In this report, which is our first with complete data for a full carbon budget period, we identify the changes since carbon budgets began in 2008 and look forward to assess what is required to stay on track to future carbon budgets, stretching to 2027.

It is no surprise that the first budget (2008-12) was met relatively comfortably. As much as anything this reflects the impact of the economic downturn, which significantly dampened energy demand and consequently the burning of fossil fuels and resulting emissions of carbon dioxide.

Looking back there is encouragement in some areas – the scale-up in deployment of wind generation, both onshore and offshore, and the major improvements in the efficiency of new cars show what can be achieved by effective policies.

However, in some areas we have done little more than find our way to the starting line. This applies in a number of emerging areas likely to be important in the future – carbon capture and storage, electric vehicles, and heat pumps. It is vital that we position these technologies to make a major contribution to decarbonisation by the mid-2020s. That requires technology and market development now.

More generally, we should avoid complacency on policy. In residential buildings we have seen new programmes introduced (the Green Deal and the Energy Company Obligation) and progress that had been strong has slowed dramatically.

Looking forward, there are promising policy initiatives with potential to drive progress in many areas. However, the package is not yet complete and there are significant delivery risks across the programme. We identify a gap between likely delivery and what is needed to meet the legislated fourth carbon budget (2023-27).

The fourth carbon budget is our best estimate of the lowest cost path for the UK to contribute to global efforts to tackle dangerous climate change. It can be achieved using currently identified technologies and offers significant cost savings compared with delay. It could also improve the UK's energy sovereignty while offering wider health and environmental benefits, such as improved air quality.

This report therefore includes recommendations designed to close this gap. It will be for the Government to decide on exactly how policies are developed, but design changes are needed, commitments must be extended further in time and it is vital that these are suitably funded or otherwise supported.

As ever, I am grateful to the Committee and secretariat for their excellent guidance and hard work. I would particularly like to thank David Kennedy, who recently left his role as Chief Executive after seven years, and Adrian Gault for ably taking the reins since his departure. David created the team here and established our reputation for scientific rigour and accuracy. He has laid the firmest foundations for our continued success and I am tremendously grateful for his contribution.

Lord Deben

Chairman, Committee on Climate Change

The Committee

The Rt. Hon John Gummer, Lord Deben, Chairman

The Rt. Hon John Gummer, Lord Deben established and chairs Sancroft, a Corporate Responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues. He was the longest serving Secretary of State for the Environment the UK has ever had. His experience as an international negotiator has earned him worldwide respect both in the business community and among environmentalists. He has consistently championed an identity between environmental concerns and business sense.

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.

Sir Brian Hoskins

Professor Sir Brian Hoskins, CBE, FRS is the Chair of the Grantham Institute for Climate Change at Imperial College 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. He has worked on the economics of public policy throughout his career. Paul has been chief economist at the Department for Education and director of public spending in HM Treasury, where he had particular responsibility for environment (including climate change), transport and public sector pay and pensions. Between 2004 and 2007 Paul was deputy head of the Government Economic Service. He has also served on the council of the Economic and Social Research Council.

Professor Dame Julia King

Professor Dame Julia King DBE FREng is Vice-Chancellor of Aston University. She led the 'King Review' for HM Treasury in 2007-8 on decarbonising road transport. She was formerly Director of Advanced Engineering for the Rolls-Royce industrial businesses, as well as holding senior posts in the marine and aerospace businesses. Julia is one of the UK's Business Ambassadors, supporting UK companies and inward investment in low-carbon technologies. She is an NED of the Green Investment Bank, and a member of the Airports Commission.

Lord John Krebs

Professor Lord Krebs Kt FRS is currently Principal of Jesus College Oxford. Previously, he held posts at the University of British Columbia, the University of Wales, and 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, Chairman of the Food Standards Agency. He is a member of the U.S. National Academy of Sciences. He was chairman of the House of Lords Science & Technology Select Committee from 2010 to 2014 and President of the British Science Association in 2012.

Lord Robert May

Professor Lord May of Oxford, OM AC FRS holds a Professorship at Oxford University. He is a Fellow of Merton College, Oxford. He was until recently President of The Royal Society, and before that Chief Scientific Adviser to the UK Government and Head of its Office of Science & Technology.

Professor Jim Skea

Professor Jim Skea, CBE, is Research Councils UK Energy Strategy Fellow and Professor of Sustainable Energy at Imperial College London. He was previously Research Director at the UK Energy Research Centre (UKERC) and Director of the Policy Studies Institute (PSI). He is Vice-Chair of Working Group III (Mitigation) of the Intergovernmental Panel on Climate Change.

Executive Summary

This is our sixth annual report to Parliament on progress reducing emissions.

Under the Climate Change Act (section 36), the Committee's progress reports are required to set out:

(a) the progress that has been made towards meeting the carbon budgets… and… the target for 2050

(b) the further progress that is needed to meet those budgets and that target, and

(c) whether those budgets and that target are likely to be met.

This report is published two years after the end of the first budget period (2008-12). It is therefore also required to address an additional provision in the Act to set out the Committee's general views on:

(a) the way in which the budget for the period was or was not met, and

(b) action taken during the period to reduce net UK emissions of targeted greenhouse gases.

Whether the first carbon budget was met/action taken during the period

The first carbon budget (2008-12) was met through a combination of the impact of the recession and low-carbon policies.

The net carbon account was 2,982 $MtCO_2e$ compared to the legislated budget of 3,018 $MtCO_2e$. Emissions in 2013 were 12% lower than 2007 and 28% below their 1990 level.

There was good progress implementing some policies, in particular to support improved fuel efficiency of new cars and investment in wind generation. There was also good progress developing new policies, most notably Electricity Market Reform. However, there was limited progress in other areas including energy efficiency improvement in the commercial and industrial sectors, uptake of electric vehicles and heat pumps, and demonstration of carbon capture and storage.

More generally, the underlying pace of emissions reduction – allowing for the impacts of the recession – through the first carbon budget period and in 2013 was insufficient to meet future carbon budgets.

Further progress needed/whether future budgets are likely to be met

The legislated fourth carbon budget (2023-27) commits the UK to reduce emissions by 31% from 2013 to 2025 (50% from 1990).

Our recent *Fourth Carbon Budget Review* assessed the cost-effective path to meeting the UK's statutory 2050 emissions target (i.e. to reduce emissions by at least 80% on 1990 levels) and showed the clear economic benefit of cutting emissions as required to meet the budget. This offers significant cost savings relative to delaying action (over £100 billion under central assumptions for fossil fuel and carbon prices), and will build a resilient energy system that is less reliant on imported fossil fuels. Its potential impacts on energy affordability and competitiveness are important, but manageable with appropriate policies in place.

The fourth carbon budget is consistent with the target proposed recently by the European Commission (EC) to cut EU emissions by 40% in 2030 on 1990 levels. More generally, there is action internationally across all major emitters, and the UK is far from acting alone in cutting emissions.

Current policies have been designed to deliver emissions reductions to 2020, so it would not necessarily be expected that they would deliver the emissions cuts required in the 2020s. This is confirmed by the analysis in the report, which projects emissions in 2025 up to 60 $MtCO_2e$/year above the level of the fourth budget.

The cost of closing this gap is affordable, through a combination of changes on the demand and supply sides for electricity, transport and heat, based on low-carbon technologies that are currently available, supported by some behaviour change.

However, achieving this will require further strengthening of policies – including those for residential and commercial energy efficiency, electrification of heat and transport, and power sector decarbonisation. This policy strengthening will entail significant design improvements and increased ambition, extended further in time. There is also a need to extend funding in some cases, with opportunities for reduction in others.

- **Residential energy efficiency.** More low-cost insulation could and should be delivered by existing policies in the near term, supported by extended fiscal incentives. Beyond 2017, there is a fundamental choice about what the focus of policy should be and whether to continue with the current approach.
  - **Near-term ambition and incentives.** The focus of the redesigned Energy Company Obligation (ECO) on low-cost opportunities (i.e. loft and cavity wall insulation) is appropriate. However, the ambition for carbon reduction for this policy has been cut significantly and is low relative to underlying potential and funding; ambition should therefore be increased. Fiscal incentives should be maintained and developed in the light of take-up to 2017.
  - **Medium-term policy.** Beyond 2017, as low-cost potential is increasingly exhausted, there is an open question of whether ECO should focus on delivering more difficult options (e.g. solid wall insulation) across the housing stock or only for the fuel poor, or whether an alternative approach would better address fuel poverty. This should be considered in light of evidence on solid wall insulation costs, projected carbon prices, and whether an alternative and better delivery mechanism for addressing fuel poverty exists.

- **Commercial sector energy efficiency.** Given limited progress to date, there is a need to strengthen incentives to improve commercial sector energy efficiency. At the same time there is scope to rationalise the number of policy instruments, leading to lower administrative costs as well as better delivery. A new approach should embody one instrument for each of information provision, financial incentives and regulation.
  - **Information.** It is essential that businesses and organisations have good information about their energy performance and scope to improve this; only one policy instrument is necessary here in place of the current complex landscape. For example, this could be based on a strengthening of current energy audits required under EU legislation.
  - **Financial incentives.** The carbon price signal should be consistent across firms and fuels. Therefore, the carbon price aspect of the Carbon Reduction Commitment should be abolished, and the Climate Change Levy increased, unless there is compelling evidence to suggest that this would undermine incentives.
  - **Regulation.** The Energy Act 2011 provides for the setting of minimum standards in the private rented sector from 2018, which can help to address the landlord-tenant split. This is particularly important in the commercial sector, where around 60% of space is rented and unexploited potential is likely to remain even if information is improved and financial incentives are strengthened. Given long refurbishment cycles, the Government should set the minimum standards for 2018 now, and a clear timetable for tightening these over time.
- **Low-carbon heat.** Increasing uptake of low-carbon heat (i.e. renewable heat and district heating from low-carbon sources) is a priority. Despite the fact that the current instrument to incentivise this – the Renewable Heat Incentive (RHI) – is very generous, take-up to date has been low. The appropriate response is not to increase the subsidy. Rather it is to overcome financial and non-financial barriers to uptake. There may also be an opportunity to support action on fuel poverty by targeting RHI payments at the fuel poor, many of whom live in homes without access to the gas grid.
  - **Committing to the RHI.** While it is possible that alternative delivery mechanisms could be found in the future, the RHI is the only realistic support mechanism for investment in low-carbon heat for the foreseeable future. Given the need to increase low-carbon heat uptake, funding for the RHI should be committed to 2020, and a commitment should be made to its continued existence beyond 2020. This would resolve current uncertainty, where funding has been committed only until 2016, and the policy is due to end in 2020.

- **Limiting RHI funding costs: addressing financial barriers.** The RHI is a subsidy paid quarterly to consumers and businesses, based on the additional upfront cost of low-carbon heat installations, along with their operational costs or savings, compared to the conventional heating technology. In the case of the domestic scheme, the net upfront cost is annuitised across a 7-year period. The tariff is calculated so as to give an overall return of 16% to consumers and 12% to businesses. These very high returns partly reflect the cost of finance. Therefore, if the cost of finance could be reduced, the cost of funding the RHI could also be reduced. The annual funding cost in the mid-2020s could be further reduced by spreading payments over a longer time period. Extending the Green Deal to pay for investment in low-carbon heat offers the opportunity to reduce financing costs and spread these over longer periods; it should be done as soon as possible in order to limit RHI funding costs.
- **Limiting RHI funding costs: addressing non-financial barriers.** High returns paid under the RHI are also to offset non-financial barriers to uptake of low-carbon heat, including bias against new technologies and the hassle of changing heating technology. These could be reduced through improved information provision and confidence building. Further work on ways to reduce the costs of amenity loss (e.g. loss of space) would be useful.
- **Targeting the RHI.** There is significant potential for cost-effective investment in low-carbon heat in homes of the fuel poor, many of which are not connected to the gas grid. Given dual policy objectives to reduce emissions and alleviate fuel poverty, consideration should be given to targeting part of the RHI funding to the fuel poor. Additional incentives over and above providing access to low-cost finance are likely to be required in order to drive uptake.

- **Transport – Electric vehicles.** While there has been good progress improving fuel efficiency of conventional vehicles, progress on the uptake of electric vehicles (EVs, including both plug-in hybrids and pure battery electric vehicles) has been much more limited; they are therefore the focus of our recommendations. Early development of the EV market has begun (e.g. a range of models is available; funding has been committed for purchase subsidy, charging infrastructure and city schemes; some charging infrastructure has been deployed). To build on this, further action is required by the Government and industry to address financial and non-financial barriers to uptake. This action could be driven effectively by a strong EU target for new car emissions in 2030, which should be supported strongly by the Government. With progress addressing financial and non-financial barriers, purchase subsidy for electric vehicles could then be phased out.
  - **A strong EU 2030 target for new car emissions.** This should be designed to reflect significant penetration of EVs, so as to strengthen incentives for manufacturers to address financial and non-financial barriers, thereby minimising the costs of meeting the target.
  - **Addressing financial barriers: new financing approaches.** The Government should work with industry to explore new, low-cost approaches to financing electric vehicles, building on innovation to date (e.g. through battery leasing), including a possible role for the Green Investment Bank.

- **Addressing non-financial barriers: investment in infrastructure.** Further investment in electric vehicle charging infrastructure within currently agreed funding to 2020 will help address non-financial barriers to uptake. Specifically, access to charging points is needed for people without off-street parking and, whilst slow home charging should meet the bulk of charging needs, a national rapid charging network is needed to alleviate range concerns for longer journeys.
- **Addressing non-financial barriers: marketing EVs.** A key barrier is technology bias (i.e. a consumer preference for tried and tested conventional vehicles). This can be overcome – for example, this bias tends to disappear as people have experience of EVs. Car manufacturers are best placed to overcome this through their marketing, and would be incentivised to do so under a strong EU target. This could be usefully supplemented by time-limited use of softer measures for early adopters, which can often be made available by Local Authorities (e.g. access to bus lanes, preferential parking).
- **Phasing out subsidy.** Together with ongoing battery cost reduction, these measures could allow the phasing out of existing capital subsidy. The Government should recognise this and consider how to phase out EV subsidy and whether there is any benefit in announcing this in advance (e.g. in stimulating manufacturers to develop financing packages).

- **Power sector.** Good progress has been made on Electricity Market Reform (EMR). However, there is a high degree of uncertainty about investment in low-carbon capacity to come onto the system beyond 2020. This should be resolved as a matter of urgency through a package of measures including setting a power sector decarbonisation target for 2030, together with supporting funding, a commercialisation strategy for offshore wind and an approach to carbon capture and storage beyond the first demonstration projects.
  - **2030 decarbonisation target.** The Energy Act 2013 introduced long-term contracts for low-carbon power generation, which provide revenue stability for investors. However, there is currently no agreed objective beyond 2020 to guide the signing of contracts. Given the long lead-times for power investments, this should be resolved by setting a target range for carbon intensity in 2030, as legislated for in the Energy Act. Our previous analysis suggests a range of around 50-100 gCO_2/kWh would be consistent with the cost-effective path for a range of outcomes for fossil fuel prices, carbon prices and low-carbon technology costs.
  - **Offshore wind commercialisation.** Rates of deployment of offshore wind have been successfully increased, as required to meet the EU Renewable Energy Directive, and the Government has committed sufficient funding to continue deployment to 2020. To achieve the objective of commercialising this promising technology will require an ongoing programme beyond 2020. The Government should set out a strategy for that commercialisation that includes: a commitment to a critical mass of investment; a target cost-reduction schedule under which ambition will be maintained or increased; the point in time when the technology will be expected to compete with other low-carbon options without support; and any role for Government in driving cost reduction (e.g. investment in port infrastructure).

- **Carbon capture and storage (CCS).** Progress with CCS is well behind the schedule we set out in our earlier reports. However, an effective approach is now in place for the first two demonstration plants, which should be progressed urgently. The Government should also set out the approach to projects to follow these demonstrations and to development of a CCS infrastructure. It should include an approach to industrial as well as power sector CCS and complement approaches in other countries.

Progress in reducing emissions in the devolved administrations has contributed to UK reductions, but it will need to increase to meet stretching targets at the devolved level. In this report, we pick out examples of innovative devolved policies that could be considered for the rest of the UK.

The full set of recommendations in the report is summarised in Box 1 and the key analysis and findings from the report are set out in 12 sections:

1. Recap of the fourth budget review: economic benefits and impacts from early action to cut emissions
2. Economy-wide emissions
3. Meeting the first carbon budget
4. The non-traded sector
5. The traded sector
6. Progress reducing emissions in the devolved administrations
7. Progress reducing emissions in buildings
8. Progress reducing emissions in the power sector
9. Progress reducing surface transport emissions
10. Progress reducing industry emissions
11. Progress reducing emissions from agriculture
12. Progress reducing waste and F-gas emissions

Box 1: Summary of recommendations in 2014 progress report

Cross-sectoral

- Continue to **push for a combination of EU ETS reform and ambitious emissions targets for 2020 and 2030** that will put the EU on the cost-effective path to meeting its target for at least an 80% emissions reduction by 2050 relative to 1990 and will deliver an EU ETS price that is sufficient to incentivise emissions reduction activities in the power sector. The regulatory regime should also allow for negative emissions (e.g. from use of bioenergy with CCS) to count towards required emissions reduction.
- By 2016, **publish a strategy to develop carbon capture and storage (CCS) in both power and industry**, including CO_2 infrastructure development, minimum levels of deployment over the period to 2030, and an approach to funding for projects beyond current policy (including higher levels of deployment dependent on cost reduction).
- On **biomass sustainability for transport, power and heat**: continue to push for Indirect Land Use Change (ILUC) impacts to be fully taken into account in EU biofuel sustainability criteria; in the 2016/17 review of UK bioenergy strategy, add to the UK's criteria for biomass sustainability a requirement that all biomass is sourced from forests that can demonstrate constant or increasing carbon stocks, and push for this to be reflected in standards at the EU level.

Buildings

- **Strengthen the near-term framework for energy efficiency improvement in residential buildings**: increase ambition on insulating lofts and cavity walls while finalising the Energy Company Obligation (ECO); maintain fiscal incentives to 2017; by the end of 2014, publish proposals for minimum energy performance standards for the private-rented sector.
- **Build on the existing approach to incentivising low-carbon heat in residential buildings**: commit funding for the Renewable Heat Incentive to 2020 and commit to extending this approach beyond 2020 unless and until an alternative mechanism is in place; extend the Green Deal to cover the upfront cost of low-carbon heat technologies funded under the RHI and consider using Government guarantees to lower the financing cost; develop measures to improve consumer confidence in renewable heat.
- **Consider future options for the focus of the ECO** (i.e. whether this should be on delivering more difficult energy efficiency improvements for the fuel poor or across all households). This consideration should reflect evidence on costs of solid wall insulation, costs of alternative options for reducing emissions and whether an alternative delivery mechanism could better tackle fuel poverty.
- **Develop additional measures to tackle fuel poverty** in England to supplement the Affordable Warmth element of the ECO, possibly including targeting of the RHI.
- **Ensure that the Zero Carbon Homes standard requires investment in low-carbon heat** unless heating requirements are very low, and only grant exemptions where a clear economic rationale for these has been demonstrated.
- **In the commercial sector: simplify and rationalise existing policies for energy efficiency improvement**, with a view to strengthened incentives and decisions by the end of 2016, and publish proposals for minimum energy performance standards for the private-rented sector.
- By the end of 2014, **set carbon targets for central government** beyond 2015.

Power

- **Complete implementation of Electricity Market Reform (EMR)**; set appropriate strike prices and sign contracts for low-carbon capacity; ensure a suitable mix of low-carbon technologies is supported; ensure final market design recognises the value of demand-side measures, interconnection, storage and flexibility in generation; require that all biomass is sustainably sourced.
- In 2016**, set a carbon intensity target range for 2030** under the Energy Act 2013, consistent with cost-effective decarbonisation of the economy (e.g. 50-100 g/kWh).
- No later than 2016, **commit funding for low-carbon generation in the period beyond 2020**.
- By 2016, **publish a commercialisation strategy for offshore wind** that includes levels of ambition to 2030, cost reductions required to sustain that ambition and the Government's role in supporting those reductions.

Box 1: Summary of recommendations in 2014 progress report

Transport

- **Push for stretching EU targets for emissions of new cars and vans for 2030** in the context of negotiations around the overall 2030 EU emissions reduction package; these should take account of the scope for improving efficiency of conventional vehicles and the need to achieve greater take-up of electric vehicles (EVs) and other ultra-low emissions vehicles (ULEVs).
- Work with partner organisations (e.g. industry, local authorities, the Green Investment Bank) to **tackle financial and non-financial barriers to electric vehicle uptake** by providing: new, low-cost approaches to financing; on-street residential charge points and a national network of rapid charge points; softer time-limited measures such as access to bus lanes and parking spaces.
- With agreement of a strong EU target and/or financial and non-financial barriers being tackled there would be scope to phase out the existing capital subsidy for electric vehicles. The Government should **consider how to phase out EV subsidy and whether there is any benefit in announcing this in advance** (e.g. in stimulating manufacturers to develop financing packages).
- Over time, **adjust fiscal levers** (i.e. Vehicle Excise Duty, Company Car Tax and Enhanced Capital Allowances) to align to new vehicle CO_2 targets and provide additional incentives for ULEVs.
- Push for a swift conclusion to current EU work on **standards for HGVs** and press for new vehicle standards as soon as practical (e.g. soon after 2015).
- Ensure **demand-side opportunities** are realised: continue progress reducing car travel once the current Local Sustainable Travel Fund ends in 2015; encourage adoption of complementary technologies to support eco-driving, including pushing for fuel consumption meters to be reconsidered in future EU negotiations; monitor existing voluntary action in the freight sector aimed at improving fuel consumption and consider stronger levers as required, including ways to address barriers for smaller operators.
- **Fully evaluate the carbon implications of use of natural gas in vehicles** before any nationwide roll-out of gas infrastructure and support.
- When considering future **airport expansion**, plan on the basis of 2050 emissions at around 2005 levels, implying an increase in demand – provided aircraft efficiency continues to improve significantly – of around 60% on 2005 levels by 2050.

Industry

- Use the **"2050 decarbonisation roadmaps"**, planned for spring 2015, to identify and set out the opportunities for reducing emissions in industry, then by 2017 publish a strategy for delivering abatement in the 2020s, including milestones to monitor progress against.
- By the end of 2016, **set an approach to deploying initial industrial CCS projects** compatible with widespread deployment from the second half of the 2020s, and joined up with the approach to CCS commercialisation in the power sector
- **Review policies for compensating at-risk industries for costs of low-carbon policies**, by the end of 2016
- Work with industry and the EU to **improve knowledge sharing within industry and R&D** into opportunities to reduce emissions at low cost
- Investigate options to **overcome barriers to capital investment**.

Box 1: Summary of recommendations in 2014 progress report

Agriculture and land use

- Ensure that the agriculture sector **monitors the effectiveness of the GHG Action Plan**, including 'SMART' objectives, quantifiable targets and evidence of buy-in from farmers, to allow effective evaluation in the Government's review in 2016.
- Recognise the high delivery risk under the GHG Action Plan, and as part of the 2016 review **consider stronger policy options** to ensure savings are delivered.
- **The GHG inventory should include emissions from upland peat as soon as possible,** existing regulation should be enforced and the policy framework strengthened to enable further peatland restoration effort.

Waste & F-gases

- **Publish specific strategies for reductions in the amounts of the main biodegradable waste sources sent to landfill** (specifically food, paper/card, and wood), and introduce stronger levers to ensure these are met unless there is clear evidence that these are not required,
- **Set out an approach to increase methane capture rates**, towards best practice, with milestones and actions to ensure these are met.
- **Ensure UK businesses comply with new EU F-gas regulation and seek opportunities to go further** where cost-effective alternatives exist; if these are found, push for stronger implementation at the EU level.

Actions for specific departments and national authorities

The recommendations set out above imply various lead responsibilities across Government, set out here, and the need for joined-up action in implementation.

- **DECC** is the key department in ensuring that actions are taken in power, buildings and industry sectors.
- **DCLG** has an important role to play ensuring that building regulations for new homes are strong, minimum energy efficiency standards for non-residential buildings are set, and transport emissions fully accounted for as part of the planning process.
- **DfT** is responsible for actions to reduce surface transport emissions and decisions on airport infrastructure.
- **BIS** has an important role in relation to industry, including compensation for carbon policy costs, has the lead on the Green Investment Bank and an interest across these recommendations, many of which will require a business response and support the low-carbon economy.
- **Defra** is responsible for actions to reduce agriculture and other non-CO_2 emissions, including our specific recommendations on waste and F gases.
- **HM Treasury** is responsible for ensuring that there is sufficient funding, for example, in the Levy Control Framework, the Renewable Heat Incentive, and to support electric vehicle market development; and to ensure that fiscal levers such as Vehicle Excise Duty and the tax regime for ultra-low-emission vehicles are designed to ensure carbon efficient choice and investments.
- **Devolved Administrations.** Devolved policy needs to complement and reinforce UK instruments across the range of sectors. Devolved levers are particularly important for supporting energy efficiency improvement including addressing fuel poverty, making planning decisions for renewable power generation and renewable heat, delivering programmes to reduce car travel and support electric vehicle uptake, and developing approaches to reduce emissions from agriculture, land use and waste.

1. Recap of the fourth budget review: economic benefits and impacts from early action to cut emissions

The fourth carbon budget commits the UK to cut emissions by 31% from 2013 to 2025 (50% on 1990 levels). It can be met through a combination of energy efficiency improvement in buildings and industry, fuel efficiency improvement in vehicles, investment in low-carbon technologies in the power sector, extension of low-carbon power through electrification of heat and surface transport, use of sustainable bioenergy, and reductions of non-CO_2 greenhouse gases.

It is important to note that action is required in all areas to meet carbon budgets. Therefore while there are some trade-offs, these are not about whether for example to decarbonise power or heat, or to focus on supply rather than demand.

Our review of the fourth carbon budget, published in November/December 2013, updated our assessment of the cost-effective path to meet the 2050 target to reduce emissions by at least 80% on 1990 levels. It compared costs associated with this path against an alternative approach where investment to cut emissions in the 2020s was delayed until the 2030s. It showed that delayed action entailed additional costs of over £100 billion in present value terms under central case assumptions on fossil fuel and carbon prices, rising to £200 billion with high fossil fuel or carbon prices. Even if fossil fuel or carbon prices turn out to be low, early action is less costly than delay.

This reflects the more general observation that in order to stay on track to the stretching 2050 target, ongoing progress is needed. Costs are likely to increase if progress stalls for a significant period of time, as high-carbon investments are made that later need to be scrapped and deployment rates for low-carbon technologies have to increase subsequently at an implausibly fast rate.

Committing to continuing action through the 2020s would also improve conditions for low-carbon investment in the UK, allowing UK firms to position themselves to compete and prosper in growing markets for low-carbon goods and services. There are also various broader benefits to cutting emissions, such as improved air quality from reduced burning of fossil fuels.

Cost savings from early action accrue over time and require up-front investments in order to be unlocked. These will, in turn, result in higher energy prices over the near-to-medium term. Our assessment is that the impacts of these higher prices on affordability, fuel poverty and competitiveness are manageable

- **Energy affordability.** Higher energy prices are likely to add around £100 to the average annual energy bill for a typical household in 2020 compared to now; there is scope to more than offset this for many households through energy efficiency improvements, although stronger policies are required to incentivise this. Beyond 2020, a rising carbon price consistent with the UK's 2050 target would add up to a further £50 to the typical household bill by 2030, with a further £20 required to support low-carbon investment.
- **Fuel poverty.** Investment in low-carbon power generation will increase energy prices and therefore fuel poverty. Offsetting this, energy efficiency improvements in homes will decrease energy use. The net impact on fuel poverty is likely to be broadly neutral, provided energy efficiency improvement is targeted effectively at fuel-poor homes. This will still leave a large number of households in fuel poverty, leaving a significant challenge for Government to address through: increasing funding under the fuel poverty part of the ECO or replacing this with another instrument; targeting funding under the Renewable Heat Incentive; income transfers/social tariffs.
- **Competitiveness impacts.** Higher costs associated with policies to reduce direct emissions from energy-intensive industries are being addressed to 2020 through the design of the EU ETS. Post-2020 risks need to be addressed as part of the broader EU 2030 package currently being discussed. Electricity-intensive industries subject to international competition are at risk of higher electricity prices. Schemes to address higher prices from the EU ETS, Carbon Price Floor (CPF) and renewables investments to 2020 are in place or being planned.

The remainder of this summary considers progress and challenges in meeting carbon budgets and unlocking the associated economic benefits.

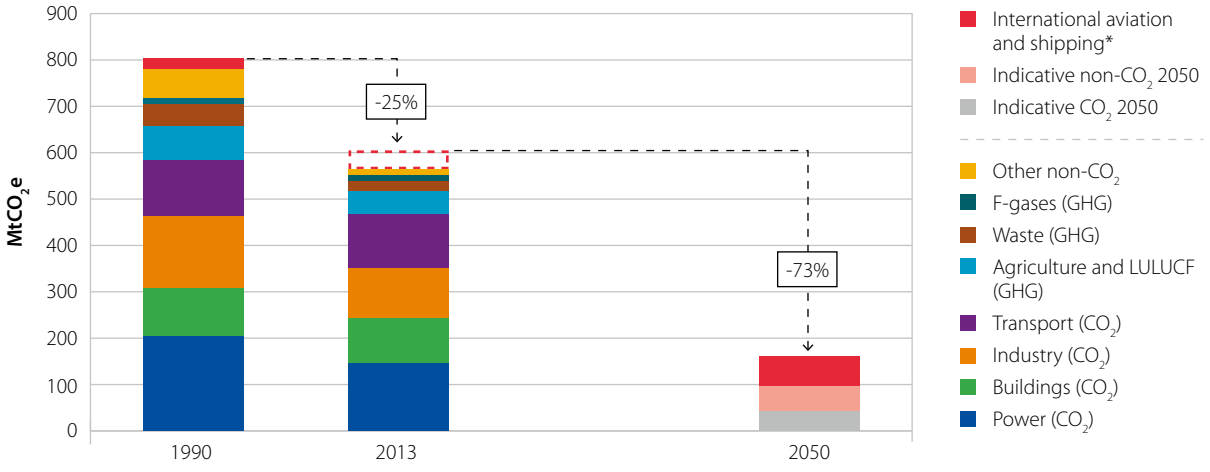
2. Economy-wide emissions

UK greenhouse gas emissions including international aviation and shipping were 605 $MtCO_2e$ in 2013. Emissions in 2013 are now 25% below their 1990 level, and will need to fall a further 73% to meet the 2050 target (Figure 1).[1]

Emissions are dominated by the energy sectors (i.e. electricity generation, heat in buildings, industry and transport) with some contributions from industrial processes and non-CO_2, including emissions from agriculture, waste and F-gases. There have been falls across these sectors since 1990 and 2007 and mixed results since 2012 (Table 1).

1 Carbon budgets do not currently include emissions from international aviation and shipping, but these are included in the 2050 target (see section 9).

Figure 1: UK Greenhouse gas emissions by sector (1990-2050)



Source: NAEI (2014) *Final emissions estimates*; CCC analysis.
Notes: *Emissions from international aviation and shipping are not currently included in carbon budgets. This will be reviewed by Government in 2016.

Table 1: UK greenhouse gas emissions

Sectors	2013 emissions ($MtCO_2e$)	% change		
		2012-2013	2007-2013	1990-2013
Power (CO_2)	145	-8%	-18%	-29%
Buildings (CO_2)	98	+3%	0%	-6%
Industry (CO_2)	108	+1%	-22%	-31%
Transport (CO_2)	117	0%	-12%	-2%
Agriculture and LULUCF (GHG)**	49	-2%	-6%	-33%
Waste (GHG)**	21	-1%	-24%	-55%
F-gases**	15	-1%	+10%	+5%
Other non-CO_2 (GHG)	12	-1%	-26%	-81%
Total CO_2	464	-2%	-15%	-21%
Total non-CO_2	100	-1%	-11%	-47%
Total GHGs	564	-2%	-14%	-28%
IAS* (2012 data)	41	–	-10%	+67%

Source: DECC (2014) UK Greenhouse gas emissions, provisional estimates ; NAEI (2014) Final emissions estimates.
Notes: *Emissions from international aviation and shipping are not currently included in carbon budgets, the government will review this in 2016. **Detailed emissions data for non-CO_2 is not yet available for 2013; these figures assume the same % of total non-CO_2 emissions for agriculture and waste as in 2012. GHG stands for greenhouse gas emissions.

Emissions in 2013

Emissions decreased 2% in 2013, driven by falling emissions from the power sector as several coal plants closed permanently.

- CO_2 emissions decreased 2% due to falling power sector emissions, which were somewhat offset by increases in buildings and industry, whilst transport emissions remained broadly flat.
- Non-CO_2 emissions estimates for 2013 will not be available until next year; provisional emissions statistics assume that non-CO_2 emissions continued long-term trends and decreased 1% in 2013.

Overall, conditions dampened energy demand in 2013. There was a moderate increase in GDP, increases in residential and industrial energy prices but a reduction in road fuel prices, and slightly lower winter temperatures than 2012.

Because temperatures in the winter months of 2013 were only slightly lower than 2012, the weather had a much smaller impact on emissions than in recent years when there have been large temperature swings. Adjusting for this suggests the decrease in greenhouse gas emissions would have been around 2.5%, compared to the outturn of 2%.

Moreover, most of the reduction was due to a switch away from coal in the power sector. Although there is scope to reduce coal use further in future, meeting carbon budgets will also require deep reductions across the rest of the economy, for which emissions rose 0.5% in 2013.

Therefore the underlying reduction in 2013 was relatively small compared to the average annual reduction of 3% required to meet the fourth carbon budget, especially for a year with low GDP growth and increasing energy prices.

Emissions trends from 2007

Over the period 2007-2012 emissions decreased 12%.

- CO_2 emissions decreased 13%, with emissions falling across all sectors. This was mainly due to the very large effect of the economic crisis reducing energy demand, as well as improved CO_2 intensity of the car fleet and a structural shift to less carbon-intensive industry.
- Non-CO_2 emissions decreased 10%. This reflects falling waste emissions as less biodegradable waste has been sent to landfill and an assumed reduction in agriculture emissions as livestock numbers fell.

Without the impact of the economic crisis, and allowing for fluctuations in temperature – there was a particularly cold winter in 2010 – the underlying rate of emissions reduction was around 1% per year, less than the 3% rate required to meet the fourth carbon budget.

The UK imports a large amount of products and services, which have embedded carbon. From 1997 to 2004 these embedded emissions from imports increased by 23%, but they have since fallen 29% to 252 $MtCO_2$ in 2011. The UK's overall carbon footprint has decreased by almost 20% between 2007 and 2011. We acknowledged the need to reduce the UK's imported emissions in our 2013 carbon footprint report, setting out approaches to achieve this.

3. Meeting the first carbon budget

The Climate Change Act requires that this report includes an assessment of whether the first carbon budget was met. Emissions data from the UK Greenhouse Gas Inventory show that this was the case, and that the UK net carbon account was around 1% below the level of the budget. The net carbon account was 2,982 $MtCO_2e$, compared to the legislated budget of 3,018 $MtCO_2e$.

The budget was met due to some progress implementing policies to reduce emissions, together with the impact of the recession; these effects were partially offset by an upward revision to the UK's Greenhouse Gas Inventory:

- The first budget was designed to reflect a limited rate of progress implementing actions to reduce emissions, to allow for the lead-time developing and implementing new policies. Progress implementing policies was made, most notably on energy efficiency improvement in the residential sector (although this dropped off in 2013), for wind generation and for new cars. However, with these exceptions, progress was generally at or below the level assumed when designing the budget.
- The impact of the recession on energy demand and emissions was not fully anticipated in the design of the budget, since this was undertaken in 2008 before the scale and length of the recession was known. In particular, the 5% reduction in GDP in 2009, together with low growth rates through the remainder of the first budget period, significantly reduced emissions compared to expectations.
- The greenhouse gas inventory was revised in 2014, largely to reflect improved information for estimating emissions in the waste sector. The effect of the revision was to increase emissions through the budget period by around 1%.

The Climate Change Act allows for the possibility to carry forward the difference between emissions and the legislated budget to the second carbon budget. We advised the Government that there was no basis to do this and that to carry forward the surplus would undermine incentives for further development and implementation of required policies, ultimately increasing long-term costs and risks.

The Government accepted this advice and decided in May 2014 not to carry the small difference forward.

The remainder of this summary focuses on further progress that is required if future carbon budgets are to be met. In particular, it identifies a significant gap between emissions projections based on progress to date, including developing new policies, and the fourth carbon budget; and it identifies options to close this gap.

4. The Non-Traded Sector

Progress to date

The non-traded sector of the economy comprises emissions not covered by the EU Emissions Trading System (EU ETS). They arise from burning of fossil fuels (mostly natural gas and some oil) for heat in buildings, non-energy-intensive industry, use of fossil fuels in surface transport, and non-CO_2 emissions, and do not include emissions from electricity used in these sectors. Non-traded sector emissions accounted for 60% of total greenhouse gas emissions in 2013.

Non-traded sector emissions decreased 1% (5 $MtCO_2e$) in 2013, to 339 $MtCO_2e$. This follows a 9% (36 $MtCO_2e$) decrease over the period 2007-2012, from 380 $MtCO_2e$ in 2007 to 344 $MtCO_2e$ in 2012.

Across the period of the first carbon budget (2008-12), there was good progress in improving fuel efficiency of new cars and installing insulation in homes. However, there is limited evidence of progress at required rates in relation to: energy efficiency improvement in the commercial and industrial sectors; development of markets for low-carbon heating (i.e. heat pumps or district heating from low-carbon sources); improvement of fuel efficiency for HGVs; behaviour change in surface transport; and in improving the carbon efficiency of agriculture. Uptake of heat pumps and electric vehicles was low.

Evidence from 2013 shows continued progress improving fuel efficiency of new vehicles, but the good progress in the residential sector did not continue, as the new Energy Company Obligation was introduced (see section 7 below). Progress was limited in other areas.

Consistency of current policies with future carbon budgets

The Climate Change Act requires that we assess whether future carbon budgets and targets are likely to be met based on progress made.

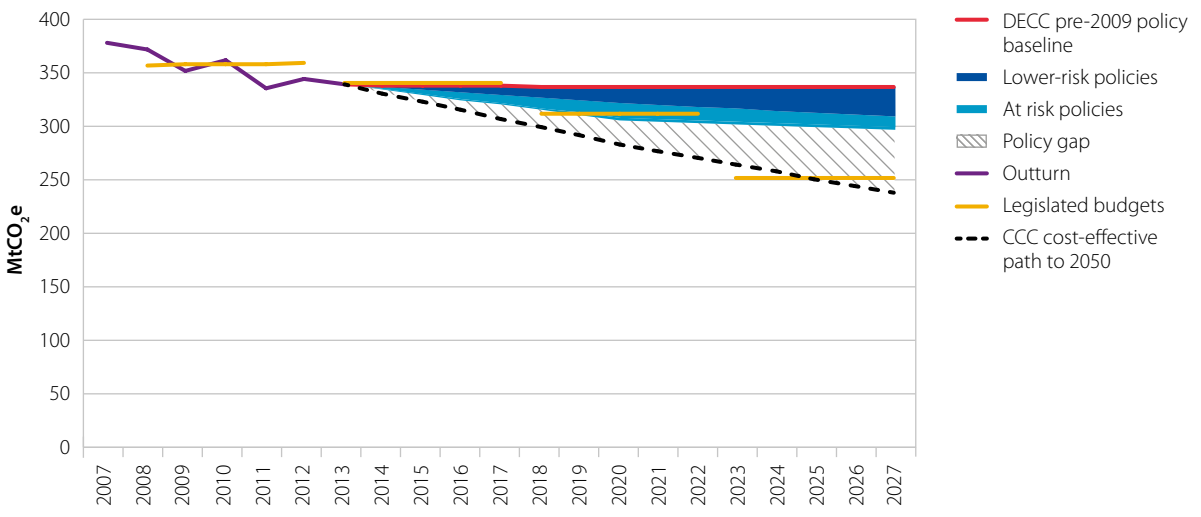
We make this assessment against a set of indicators, first laid out in our 2009 report to Parliament, for uptake of low-carbon technologies and behaviours, and development of policies to drive future uptake. In this report we assign a 'traffic light' rating to these indicators based on progress since the start of the first carbon budget (Table 2).

We conclude that if there were no further progress, then we would expect a significant shortfall in emissions reduction compared to the fourth carbon budget (Figures 2 and 3).

- We have assessed what emission reductions would follow from existing policies without significant risks to delivery. We estimate that these would result in roughly a continuation of the current rate of underlying emissions reduction and a level of emissions up to 60 $MtCO_2e$/year above the fourth carbon budget (i.e. 42% rather than 50% below 1990 emissions in 2025).
- Even if the Government's ambition for these existing policies could be fully delivered, this would still result in emissions around 45 $MtCO_2e$/year above the fourth carbon budget (i.e. 44% rather than 50% below 1990 emissions in 2025).

This highlights that much more is needed if future carbon budgets are to be met. Sections 7-12 of this summary set out the policy ambition and policy strengthening required.

Figure 2: Assessment of current and planned policy against future targets (non-traded sector)

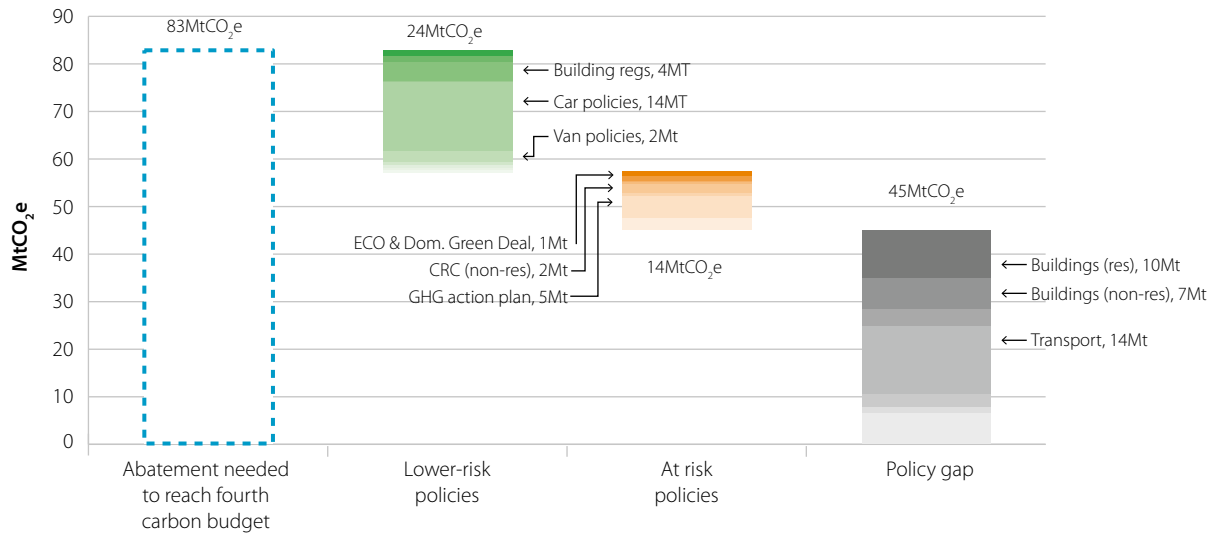


Source: DECC (2013) *Updated emissions projections*; CCC analysis.

Table 2: Non-traded sector traffic light assessment		
Indicator for progress to date	**Traffic light evaluation of progress**	**Comments**
Buildings		
Implementation		
Uptake of loft insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. Cumulative loft insulation levels in 2013 were 650,000 below our indicator (6.3 million).
Uptake of cavity wall insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. Cavity wall insulation levels at 2.9 million are 45% below our cumulative indicator for 2013 (5 million).
Uptake of solid wall insulation	Red	Very low uptake numbers (170,000 cumulatively by the end of 2013, compared to 500,000 in our indicator). Some success during 2012 (final year of Community Energy Saving Programme) but uptake numbers have fallen under Energy Company Obligation (ECO). Latest evidence suggests available cost-effective potential may be lower than expected.
Uptake of boilers	Green	High uptake of new efficient boilers, with cumulative uptake by 2013 1.8 million higher than our indicator (5.9 million).
Buildings, penetration of low-carbon heat (%)	Red	Progress in buildings is off-track, with 0.3% of heat coming from low-carbon sources in 2012 compared to 0.6% in our indicator trajectory.
Uptake of energy efficient appliances	Amber	Stock penetration for the most efficient appliances is low (e.g. wet appliances A+ or better are 9% of the stock versus 16% in the indicator). However, overall efficiency of the appliances on the market has improved significantly.
Policy		
New energy efficiency financing mechanism	Red	Green Deal introduced in 2013 but very low uptake. Scope for currently unattractive interest rates to fall in future as Green Deal lending is scaled up.
Domestic and Non-domestic Renewable Heat Incentive (RHI) schemes in operation	Amber	Delays to Domestic RHI launch, but some progress made in setting standards and improving evidence base. Non-domestic scheme up and running since 2011, but low uptake apart from biomass.

Table 2: Non-traded sector traffic light assessment		
Indicator for progress to date	**Traffic light evaluation of progress**	**Comments**
Industry (non-traded)		
Implementation		
Industry penetration of low-carbon heat	Green	1.25% uptake compared to 1% in indicator.
Policy		
Publish industry strategy including milestones, incentives and mechanisms for meeting carbon budgets	Red	No strategy to meet carbon budgets has been published, but 2050 Roadmaps underway.
Transport		
Implementation		
New car CO_2	Green	Outperforming trajectory. Evidence of a growing gap between real-world and test-cycle emissions suggest real-world improvements were smaller; however likely still to have met trajectory.
Electric vehicle sales	Red	Uptake well below trajectory, although market developments (e.g. availability of a range of models) have been positive and in hindsight uptake in the proposed trajectory was too high.
Policy		
Biofuel policy	Amber	Biofuel penetration in line with our trajectory for first few years, falling short in past two years but improvements in sustainability.
Smarter Choices policy	Amber	Local Sustainable Transport Fund is funding a number of projects across England but evaluation framework is not comprehensive.
Waste and F-gases		
Implementation		
Biodegradable waste sent to landfill	Green	47% fall compared to 30% in trajectory.
Percentage of methane captured at landfill sites	Amber	Indicator suggested maintain at 75%, but a re-estimation suggests that the rate was 59% in 2012, although rising from 54% in 2007.
Policy		
Develop comprehensive waste policy	Amber	National Waste Prevention Programme published December 2013 but slow progress developing effective policy across waste streams.
Update to the EC's F-gas regulation to make it fit for purpose by end 2013	Amber	New EU F-gas regulation published in April 2014 and to come into force in 2015; Government still to transpose within UK legislation.

Figure 3: Getting from the DECC pre-2009 policy baseline to the fourth carbon budget in 2025



Source: DECC (2013) *Updated Emissions Projections*; CCC analysis.

5. The Traded Sector

The traded sector of the economy comprises those industries covered by the EU ETS, i.e. power generation and energy-intensive industries; it accounts for around 40% of economy-wide emissions.

Under the current accounting rules of the Climate Change Act, the traded sector part of the carbon budget is defined in terms of net rather than gross emissions. In other words, gross emissions are adjusted for any purchase or sale of carbon allowances by UK firms and for banking of allowances for future periods.

However, while the purchase of allowances may result in the budget being met, it is important also to focus on actual (gross) emissions, given the need to reduce these in the context of meeting longer-term carbon targets.

Gross emissions from sources currently included in the traded sector fell 3% from 2012 to 2013, leaving emissions 19% below 2007 levels. This reflects similar contributions from the power sector, where emissions fell 18% from 2007 to 2013, and from energy-intensive industry, for which emissions fell 19%.

The reduction in emissions since 2007 largely reflects the impact of the recession, during which there were significant reductions in output from energy-intensive industries and in electricity demand.

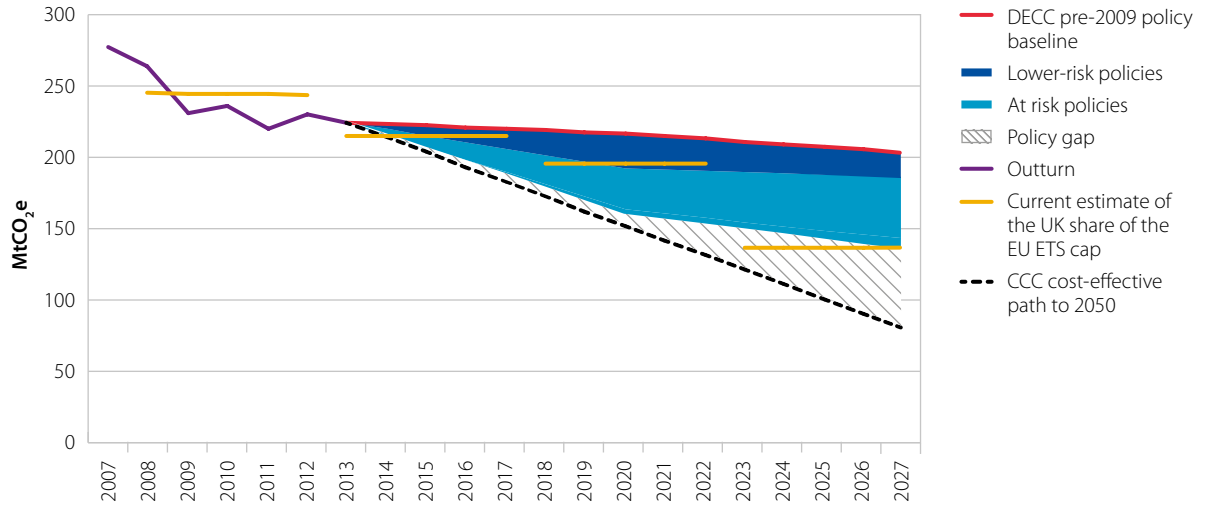
There has also been some progress in decarbonising electricity supply, both in deploying new low-carbon generating capacity and developing the policy framework, albeit with some areas showing very poor progress (Table 3).

Table 3: Traded sector traffic light assessment		
Indicator	**Traffic Light**	**Comments**
Power sector		
Implementation		
Onshore and offshore wind	Green	Capacity in line with indicator and a strong pipeline of projects to 2020. However, longer-term uncertainty could undermine the flow of projects from the pipeline to delivery.
Nuclear new build	Amber	Delayed new-build programme by at least 5 years, with expected completion date of first new plant pushed back from 2018 to 2023. However, strike price and terms of contract now agreed and potential programme of future projects.
Policy		
Review of electricity market to begin in first budget period	Amber	Energy Act legislated in 2013 including key elements of reform (long-term contracts and funding to 2020), but lack of clarity beyond 2020 and no decarbonisation objective could undermine delivery.
Carbon Capture and Storage (CCS) Front End Engineering and Design (FEED) studies complete by 2010, with first CCS project online 2014	Red	FEED studies now due to complete in 2015 (i.e. 5 years behind indicator). However, some lessons learned and programme due to deliver 2 plants by 2020.
Industry covered by the EU ETS		
Policy		
Publish industry strategy including milestones, incentives and mechanisms for meeting carbon budgets	Red	No strategy to meet carbon budgets has been published, but 2050 Roadmaps underway.

Looking forward, our assessment is that there will be insufficient emissions reduction under current policies, both in power generation and energy-intensive industries (Figure 4).

This shortfall must be addressed if carbon budgets are to be met in a cost-effective manner; we set out options to drive the deep emissions cuts required in sections 8 and 10 below.

Figure 4: Assessment of current and planned policies against future targets (traded sector)



Source: DECC (2013) *Updated emissions projections*; European Commission (2014) *Verified emissions data*; CCC analysis.

EU ETS emissions and carbon prices

The effectiveness of the EU ETS is undermined by the current oversupply of allowances and consequent weak carbon price. In order to restore the long-term value of the EU ETS as a policy instrument and for the credibility of EU climate policy more broadly, it is vital that the cap to 2030 is sufficiently stretching. This in turn requires that the EU adopts a stretching level of overall ambition for 2030.

The European Commission put forward its proposal for the 2030 framework in January 2014. Its key provisions included a target of a 40% emissions reduction below the 1990 level, met through domestic action (i.e. without purchase of international carbon credits), together with plans for structural reform of the EU ETS. Enacting both the structural reform and the proposed 2030 framework would be a significant step forward towards a fully functioning ETS; given the importance of UK action within both EU and international action, this is something that the Government should continue to strongly support.

However, given the relatively low level of current emissions, it is not clear that the proposed EU ETS cap will require significant effort to reduce emissions for some time. This suggests that the EU could increase its ambition without a large escalation in costs. The UK should push for a combination of ETS reform and emissions targets for 2020 and 2030 that will put the EU on the cost-effective path to meeting its target for 2050 and deliver a strong ETS price.

This supports the UK Government's position that the EU should aim for a reduction of 50% in 2030 relative to 1990 as part of an international effort to combat climate change.

6. Progress reducing emissions in the devolved administrations

From 2007 to 2012 emissions fell by 15% in Scotland, 6% in Wales and 7% in Northern Ireland, compared to a 12% reduction across the UK. The different rates of reduction in part reflect the relative dominance of different sectors (e.g. agriculture has a very high share in Northern Ireland and has fallen less quickly than other sectors across the UK). It also reflects the importance of individual power and industry installations at the devolved level (e.g. one reactor closing at Wylfa nuclear power station and being replaced by fossil fuel generation had a very large impact on emissions in Wales).

In some policy areas the devolved administrations lead the UK, in particular in residential energy efficiency, waste and agriculture where there are devolved competencies:

- **Energy efficiency and fuel poverty**. Unlike England, the devolved administrations operate tax-payer funded schemes to tackle fuel poverty in addition to the supplier obligations. These often focus on area-based delivery and work with local authorities.
- **Waste**. Ambitious household waste recycling targets have been set in Scotland and Wales. Wales met its target of 52% for 2012/13, but Scotland missed its first target for 2010/11 and – without a substantial improvement – is likely to have missed the 50% target for 2013. Northern Ireland is progressing towards its 2015 target of 45%.
- **Agriculture**. Like England, the devolved administrations place considerable emphasis on a collaborative approach with the farming industry. However, Scotland has made it clear that it will introduce regulation if sufficient progress is not made through the current voluntary approach – as we have recommended at the UK level.
- **Forestry**. Scotland has yet to reach its target of 10,000 ha afforestation per year, and Wales and Northern Ireland have been falling well short of their targets.

For the future the devolved administrations have adopted stretching targets. If these are to be achieved, stronger action will be required in key areas including energy efficiency programmes, increasing low-carbon heat penetration, encouraging greater uptake of electric vehicles, and increasing the rate of tree planting.

7. Progress reducing emissions in buildings

(i) Emissions trends

Emissions from buildings accounted for 37% (206 $MtCO_2e$) of all UK GHG emissions in 2013, split broadly equally between direct (i.e. from burning fossil fuels for heating) and indirect emissions (i.e. from generation of electricity used by lights and appliances). The residential sector accounts for 65% of these emissions, the commercial sector 26%, and the public sector 10%.

From 2007 to 2012, buildings CO_2 emissions declined by 5%. Emissions would have fallen further if the winter months of 2012 had not been particularly cold; adjusting for this effect, emissions would have fallen by around 10% over the period. This is more than the 7% reduction we had assumed in our carbon budget indicators, however given the context of

rising energy prices and the economic crisis this does not imply that low-carbon policy was more effective than we expected.

In 2013, buildings emissions fell by another 3%. This was mainly due to the 8% decrease in the emissions intensity of electricity consumed from the grid, whilst direct emissions rose.

(ii) Progress improving energy efficiency in the residential sector

Progress implementing energy efficiency improvements

Whereas up to 2012 there had been good progress insulating lofts and cavity walls, there was a significant reduction in the implementation of these measures in 2013 due to policy changes. Progress insulating solid walls remained very limited, as was uptake of the most efficient appliances. There was good progress on boiler replacement.

- **Loft and cavity wall insulation.** Progress insulating lofts and cavity walls was good until the end of 2012. From 2013, the Government expected that loft and easy-to-treat cavity wall insulation would be delivered mainly under a new market-based approach (the Green Deal). However, incentives under the Green Deal were insufficient and the scheme was perceived as complex by consumers, resulting in a significant reduction in the number of lofts and cavity walls insulated.
- **Solid wall insulation.** Under the Energy Company Obligation (ECO), introduced in 2013, energy companies were required to switch their focus from providing loft and cavity wall insulation (which was restricted to low-income homes) to solid wall insulation and hard-to-treat cavity walls. However, these measures are expensive and difficult to deliver, and actual numbers insulated fell compared to 2012 (e.g. 29,000 solid walls were insulated in 2013, compared to 82,000 in 2012, and the 43,000 projected in 2013 in the ECO Impact Assessment).
- **Boilers.** Progress replacing old inefficient boilers with new, efficient models was good throughout the first carbon budget period and in 2013.
- **Appliances.** Penetration of the most efficient appliances in the stock has been slow (e.g. the best – A++ or better – fridges and freezers only represent 1% of the stock).

Strengthening incentives for near-term delivery of energy efficiency improvement

In late 2012, following claims by energy suppliers that ECO costs were escalating, the Government proposed changes – yet to be finalised – to its design. In line with the Committee's advice that there should be a greater focus on low-cost measures, this shifted the focus of the largest element of the ECO from solid wall and hard-to-treat cavity wall insulation to measures such as loft and easy-to-treat cavity wall insulation.

However, the level of ambition in the redesigned policy has been reduced significantly and is low relative to the potential for insulation of lofts and cavity walls and the amount of money available to pay for this.

- The ambition in the new policy has been reduced by around 50% in carbon terms and to around £900 million notional delivery costs; the Government now expects the ECO to lead to the insulation of 440,000 lofts, 720,000 cavity walls (250,000 of which are easy-to-treat) and 85,000 solid walls between April 2014 and March 2017.
- This compares to several million lofts that could benefit from top-up insulation, 0.7-1.6 million cavity walls which are easy to treat and would be cost-effective to insulate, and around 10 million solid walls and hard-to-treat cavity walls where the economics of insulation is uncertain (see below).
- Even with the reduced amount of money notionally available under ECO, as set out in the Government's Impact Assessment, more lofts and cavity walls could be insulated (e.g. the Association for the Conservation of Energy identify potential to increase ambition by around 10% within this funding limit).
- Furthermore, given that it is not transparent by how much bills have been reduced following the revised policy, it is not obvious why less funding should be available. Under the previous level of funding (a notional £1.3 billion), considerably more could be achieved, for example almost all of the easy-to-treat cavity walls (constituting the majority of the low-cost abatement) could be insulated.

Given potential to go further on loft and cavity wall insulation, and the benefits that this would bring in terms of cost-effective emissions reduction and energy affordability, the Government should increase the ambition in the Energy Company Obligation to 2017.

The costs and risks associated with delivering increased ambition could be reduced through extending current financial incentives further out in time, and introducing minimum standards for the private rented sector.

- **Financial incentives.** As part of the redesigned ECO, new financial incentives were introduced in June 2014 through the Green Deal Home Improvement Fund. These have already stimulated consumer demand, and should be maintained and developed in the light of take-up to 2017. As we have previously recommended, there may also be a case for additional incentives such as stamp duty relief to ensure people maximise energy efficiency improvements when carrying out general refurbishments (e.g. on moving home).
- **Minimum standards.** In recognition of landlord-tenant split incentives (i.e. tenants receive the benefits of energy efficiency improvements but these are paid for by landlords), the Energy Act 2011 provides for the introduction of minimum standards for energy performance in the private rented sector, to be introduced from 2018. To provide certainty for landlords, the Government should set the minimum standards for 2018 now and a clear timetable for tightening these over time. Standards should require the implementation of cost-effective efficiency improvements such as loft and cavity wall insulation.

The above relates primarily to the part of ECO available to fund efficiency improvements in any households, accounting for around 60% of the total funding. There is also an element ('Affordable Warmth') specifically reserved to reduce heating costs for low-income

households, including the fuel poor. Most of the initial target (which runs to March 2015) has already been met.

As a result, many eligible vulnerable households in England (the devolved administrations have additional fuel poverty programmes) have been left unable to access ECO funding at a time when the number of fuel-poor households has been rising (to an estimated 2.9 million in England in 2013). There is therefore a need to explore other instruments to ensure more widespread action on fuel poverty in the near term.

Options for the Energy Company Obligation beyond 2017

Beyond 2017, as low-cost potential is increasingly exhausted, there is an open question of where the ECO should focus. We identify three options:

- **Option 1: Focus on solid wall insulation and other hard-to-treat measures.** As the majority of low-cost opportunities are taken up, it might then be justified to move the focus to more expensive measures such as solid wall insulation. However, considerable uncertainty remains over the potential costs of such a large-scale programme. If this option were pursued, safeguards may be appropriate to ensure that solid wall insulation is not installed in very expensive cases (e.g. a possible buy-out mechanism could be included in the Energy Company Obligation).
- **Option 2: Focus on fuel poverty.** Currently, around half of the ECO is targeted at low-income households. The proportion targeted at the fuel poor could be increased to help achieve the Government's forthcoming fuel poverty target (which is likely to be based on achieving a minimum energy performance rating in fuel-poor homes).
- **Option 3: Reduce the scope of the ECO.** If a wider solid wall insulation programme is shown to be prohibitively costly and if other ways are found to address fuel poverty (e.g. through taxpayer funding, using local authorities as the delivery vehicle as currently done in Scotland) it might be appropriate to reduce the scope of the ECO. This would allow energy bill savings against the £55 currently paid by the typical household. But it would also raise questions about how future carbon budgets would be met, requiring additional actions in other sectors of the economy, and about how to roll out low-carbon heat for homes with solid walls (e.g. this would be more challenging for heat pumps, for which the economics are more favourable in well-insulated homes with lower peak heating requirements).

Further evidence on the cost of solid wall insulation and other options for hard-to-treat properties is required before a choice between these options can be made; and any choice should be made in conjunction with the development of a broader strategy for addressing fuel poverty.

Zero carbon homes

The Government committed in 2006 to ensuring that new homes should be zero carbon from 2016. Building regulations have been tightened twice (in 2010 and 2013) in preparation for the new standard, although the 2013 changes have been less stringent than initially proposed.

Typically 'zero carbon' implies that new homes are highly energy efficient, have their heating supplied by a low-carbon source (e.g. a heat pump or low-carbon district heating) and include on-site electricity generation from a low-carbon source (e.g. solar photovoltaic panels).

There is merit in the principle of zero carbon homes given that these measures are considerably cheaper to install in new homes than to retrofit to existing homes, and that new homes will still be standing in 2050 by when buildings emissions may need to be reduced to very low levels. Furthermore, new homes are a key cost-effective segment of the low-carbon heat market and a potential driver for developing this market.

However, there may be specific cases where individual measures are prohibitively expensive – for example, site conditions may not be supportive to on-site generation, or capital-intense heating technologies (e.g. heat pumps) may be inappropriate in extremely efficient houses with very low heating needs. There could therefore be a case for specific off-site solutions, provided these do not undermine the principle that new houses should be responsible for no more than a minimal amount of emissions.

In June 2014, the Government announced more details of the design of the Zero Carbon Homes policy, including an "allowable solutions" mechanism and a small developments exemption.

- The 'allowable solutions' mechanism allows developers to construct homes that do not fully meet the zero carbon standard (i.e. they do not have low-carbon heating or do not include on-site generation) if they instead make payments into an energy efficiency fund.
- Small developments are to be exempt from the zero carbon requirement, with a consultation to determine the specific coverage of the exemption.

Applied to on-site electricity generation the 'allowable solutions' mechanism is sensible, given that large-scale off-site generation is often a cheaper way to provide low-carbon electricity. However, when applied to heat and efficiency measures it is problematic. For all new houses policy should require that either low-carbon heating is installed or efficiency is so high that heating requirements are minimal.

No rationale has been provided for the exemption for small developments. It is not clear why the economics of efficiency measures or low-carbon heating should significantly differ from larger developments. Therefore, this proposal should be dropped unless the Government can show clear evidence of its value.

More generally, the scope of the Zero Carbon Homes policy has been changed a number of times in recent years. While policy changes can be justified in some circumstances, too frequent change creates uncertainty and can result in badly designed policies, and should therefore be avoided in future.

(iii) Progress improving energy efficiency in the non-residential sector

While there are specific examples where organisations have cut energy consumption significantly, there is no clear evidence of energy efficiency improvement in the commercial

and public buildings sector overall, with both energy use and emissions remaining broadly flat over the first carbon budget period. This is despite rising energy prices and reduced economic activity during the economic crisis.

The current policy landscape is complex, with multiple carbon price instruments and information requirements. Policies have been developed separately over time and, as a result, they are not mutually reinforcing, entail excessive administrative burden and have incomplete coverage (e.g. for SMEs).

Given this complex landscape, we have previously highlighted scope for rationalisation, and the need to fill gaps. The lack of progress reducing emissions to date also suggests the need for strengthening of incentives.

Any redesigned policy framework should provide a combination of information on energy performance and scope to improve this, financial incentives, and regulation. Policies should provide a clear and consistent signal, should be stable over time, and should be designed as part of an integrated and mutually reinforcing package.

Assessing the current policy framework against these principles suggests the following options:

- **Financial incentives: Rationalising carbon price instruments.** The carbon price signal should be uniform and consistent across firms and fuels. Therefore, the carbon price aspect of the Carbon Reduction Commitment should be abolished, and the Climate Change Levy increased, unless there is compelling evidence to suggest that this would undermine incentives.
- **Regulation.** Around 60% of space is rented in the commercial sector. As a result of the landlord-tenant split, therefore, even with strengthening of financial incentives and improvement in information, much unexploited potential for energy efficiency improvement is likely to remain. Regulation is required to address this. In particular, the Government should now introduce minimum standards consistent with take up of cost-effective abatement, as provided for under the Energy Act 2011. Given long refurbishment cycles, setting out a clear timetable for tightening standards over time would improve investor confidence and unlock additional abatement from retrofit.
- **Information.** It is essential that organisations understand their energy consumption – and scope to improve this. This requires only one good source of information, rather than the multiple but often weak information sources currently in place. This one source could be the energy audits, although these would have to be significantly enhanced relative to the current design. Alternatively Display Energy Certificates (DECs) could be rolled out across the non-residential sector. If one of these were to be implemented, it may also be justified to drop the information requirements associated with the Carbon Reduction Commitment (CRC).

Improving policies in the ways described above would strengthen incentives for organisations to make changes which will both save them money and put the economy on the cost-

effective path to meeting longer-term objectives, whilst reducing the administrative burden associated with current policies. It should therefore be a priority for the Government.

(iv) Progress investing in low-carbon heat

Trends in low-carbon heat penetration

Progress on low-carbon heat over the first carbon budget period has been slow. Whilst the economy-wide production of low-carbon heat was on track with our indicator in 2012, much of this was due to the use of biomass boilers, with investment in heat pumps remaining particularly low (only £500,000 has been spent on supporting heat pumps out of a total spend since 2011 of £65 million under the non-domestic RHI).

At current rates of investment, low-carbon heat is unlikely to reach the Government's economy-wide ambition of 12% penetration by 2020; and is likely to be very far from the indicative 25% in 2030 suggested in our fourth carbon budget review, to be delivered in buildings mainly through heat pumps.

Progress in policy development

The fact that the non-residential Renewable Heat Incentive (RHI) has been almost entirely focused on biomass is a source of concern, as bioenergy resources are limited and for heat should be targeted at industrial process heat where few low-carbon alternatives exist, rather than in buildings where alternatives are available in the form of heat pumps or district heating.

The Government has responded with a new set of tariffs in the non-residential scheme which should help address limited uptake of non-bioenergy options, although more work is required to address non-financial barriers.

The residential RHI was launched several years late in April 2014, so support to date has been limited to a small-scale grant scheme. This has nonetheless generated useful evidence on technology performance and consumer feedback, which are critical for securing savings and boosting consumer confidence.

Future low-carbon heat policy compatible with carbon budgets

A very significant scaling up of investment in low-carbon heat is required to meet future carbon budgets, particularly as regards heat pumps.

It is possible that alternative ways could be found to support investment in low-carbon heat (e.g. subjecting heat consumption to a carbon price or requiring low-carbon heat investment under buildings regulations). While these alternatives should be considered, they are unlikely to be technically or politically feasible in the near-to-medium term, implying that the RHI is the only realistic delivery mechanism for the foreseeable future.

Given that it is the only feasible mechanism, there is a need to reduce current uncertainty about the RHI by committing funding to 2020, and committing to its continued existence beyond 2020.

- **Committing funding to 2020.** Funding for the RHI has only been committed for the period to 2016. This undermines incentives for supply chain development and should be addressed as a matter of urgency through committing funding to 2020.
- **Committing to continued existence of the RHI in the 2020s.** A very significant ramp up of investment in low-carbon heat is needed to meet carbon budgets in the 2020s. The Government should commit to the continued existence of the RHI in the 2020s until and unless an adequate replacement is in place.

To support this commitment, measures should be put in place to address financial and non-financial barriers to investment, which would otherwise result in funding costs for the RHI being prohibitive.

- **Reduce funding costs through addressing non-financial barriers.** The RHI is a subsidy paid quarterly to consumers and businesses, based on the additional upfront cost of low-carbon heat installations, along with operating costs or savings. In the case of the domestic scheme, the net upfront cost is annuitised across a seven-year period. The tariff is calculated so as to give an overall return of 16% to consumers and 12% to businesses. These very high returns are in part to overcome non-financial barriers to uptake. These barriers should be addressed through improved information and confidence building.
  - Sustained large-scale marketing campaigns through multiple channels are required to raise the profile of low-carbon heat technologies and awareness of the finance available.
  - Consumer confidence can be improved through basic installer training for all heating engineers, along with support for consumers at initial set up, plus follow-up for those installing heat pumps.
  - Further work on ways to reduce the costs of amenity loss (e.g. loss of space) would be useful.
- **Reduce funding costs by introducing new financing instruments.** The high return offered under the RHI also partly reflects the cost of finance to consumers. Therefore if the cost of finance could be reduced, the cost of funding the RHI could also be reduced. The annual funding cost in the mid-2020s could be further reduced by spreading payments over a longer time period. Extending the Green Deal to pay for investment in renewable heat offers the opportunity to reduce financing costs and spread these over longer periods. It should be done as soon as possible in order to limit RHI funding costs.
  - If the cost of finance for households could be reduced from 7.5% to 3.5% this would reduce the annual funding cost in 2025 by £300 million.

- Spreading costs over the life of the heat pump, rather than seven years as under the RHI currently, could further reduce the required annual funding (e.g. by around £300 million in 2025).
- There is scope to achieve this by extending the Green Deal to cover the full upfront cost of heat pumps. This assumes that the Green Deal interest rate falls from its currently high level, which should be possible as the instrument becomes established and could be facilitated by Government guarantee.

As part of strengthening the approach to supporting investment in low-carbon heat, there may be scope to join this up with policy to reduce fuel poverty. In particular, there is a significant opportunity for cost-effective investment in low-carbon heat to replace inefficient heating systems in fuel-poor households. The Government should work to understand and address barriers to uptake of low-carbon heat in fuel-poor households. It should consider targeting part of the RHI to the fuel poor, which together with provision of low-cost finance may be sufficient to encourage uptake. There may also be a case for additional subsidy, for example, through the Energy Company Obligation.

8. Progress reducing emissions in the power sector

(i) Power sector emissions trends

The Committee's indicator framework sets out a path towards a largely decarbonised power sector by 2030.

Annual emissions fell by 11% from 2007 to 158 $MtCO_2$ in 2012, as a result of falling demand for electricity and reduced carbon intensity of electricity supply.

Emissions would have been lower given the large impact of the recession, but for increased coal burn, especially in 2012. This reflected falls in the price of coal and the collapse of the EU carbon price, resulting from the economic crisis.

In 2013 emissions fell 8 % as a result of increasing renewables and coal plant closures (having reached the end of their allocated hours under EU legislation).

We also monitor underlying progress, based on the achievable emissions intensity (AEI). This is emissions per unit of electricity if plant were dispatched in order of emissions intensity, beginning with renewables and nuclear, followed by gas and finally coal. The AEI has fallen by 38% since the start of the first carbon budget period to 285 gCO_2/kWh in 2013. This reflects falling demand, increased capacity for renewable generation and increased gas capacity (able to displace coal).

Over time we would expect actual emissions intensity (currently around 500 gCO_2/kWh) to converge on achievable, as coal comes off the system. In theory, the system could be dispatched at an emissions intensity close to the achievable level now (i.e. around 285 gCO_2/kWh) at limited additional cost to consumers, given that electricity prices are currently set by gas plants for most of the year.

Looking ahead, our assessment of the cost-effective path for the power sector under carbon budgets implies achievable and actual emissions intensity falling towards approximately 50 gCO_2/kWh in a central case. Intensity could be as high as 100 gCO_2/kWh if some low-carbon options prove harder than expected to deploy, or if, for example, coal provides a significant amount of back-up generation.

(ii) Progress investing in renewable power generation

There has been good progress to date investing in new renewable generating capacity, particularly wind, which has increased from 3 GW in 2008 to 11 GW in 2013. There is also a strong pipeline of potential future projects in development, in planning and in or ready to enter construction.

However, the pipeline is at risk given current uncertainties about whether there will be ongoing support for investment and, if so, which technologies will be supported.

The Government should resolve this uncertainty through deciding which portfolio of technologies it will support and then provide assurance about this.

In making this decision, the Government should recognise that onshore wind is a cost-effective technology; that offshore wind is currently expensive but promising, and an important part of a portfolio; and that the economic case to support investment in solar generation in the near term is limited.

- **Onshore wind.** If the objective is to bring forward investments on the cost-effective path to power sector decarbonisation, then onshore wind should continue to be supported. Debate and discussion over the future of onshore wind should be framed in this context: that a failure to invest in it is a departure from the cost-effective path, which will ultimately result in higher energy bills at a time when energy affordability is a significant concern.
- **Offshore wind.** This remains a relatively expensive technology. However, it is promising, in the sense that there is a large potential and strong evidence to suggest that costs can be reduced significantly to the point where offshore wind will be competitive in the future (e.g. larger, 6 MW, turbines are now available in the market, and 8 MW turbines are expected by 2017). There is significant value having offshore wind as part of a portfolio, given the need to decarbonise the power sector, limits on scope for investment in onshore wind and nuclear, together with uncertainties over CCS, and the importance of UK deployment in driving cost reduction.

- **Solar.** Internationally the costs of solar have come down considerably in recent years, and even in the UK its generation costs are approaching other mature low-carbon options (e.g. onshore wind). However, the economics of solar generation in the UK are undermined because its generation profile is poorly matched to UK demand (i.e. solar output is high in summer and demand is high in winter). Until cost-effective seasonal storage or low-carbon back-up options are developed further, it is appropriate to limit investment in solar power, while not ruling out that much higher penetration may become appropriate in future. The Government should consider imposing limits on funding for solar generation under the Levy Control Framework, in the absence of which investment in other technologies may be displaced, or affordability issues exacerbated.

The context for decisions related to specific renewable technologies should be the broader approach to Electricity Market Reform, where there are key decisions to be made about the setting of a decarbonisation target, funding to achieve this, and technology commercialisation.

(iii) Progress investing in CCS

Carbon capture and storage (CCS) has a potentially crucial role to play in long-term decarbonisation of the economy, in power, heavy industry and in conjunction with bioenergy. Whilst the UK emissions targets could in principle be achieved without CCS, our previous analysis suggests that the associated costs would be considerably higher. As a key technology option for decarbonisation pathways across several sectors, it is therefore urgent to move CCS quickly towards commercialisation.

The first CCS projects will be important not only to help prove the set of technologies, but also to establish a CO_2 transportation and storage infrastructure to which subsequent projects could connect.

There has been slow progress in CCS against an ambition of four demonstration plants by 2020 set out in the Coalition Agreement and in our indicators. This is in part due to the failure of the first competition, but there has also been little sign of urgency for the subsequent process.

The near-term priority is to move ahead quickly with the two initial projects, so that they are operational this decade and, crucially, so that the infrastructure is then available for further projects to follow on.

It is also important to provide visibility to project developers outside of the preferred bidders, so that interest can be maintained and projects are available for deployment in subsequent phases. As we have previously set out, the Government should set out a strategy to reduce costs and commercialise CCS through the 2020s on the path to a level of ambition by 2030 of up to 10 GW, or potentially more if feasible and the technology proves to be cost competitive.

The UK's CCS programme is part of a wider international effort to develop the technology. Projects in other countries are also behind original plans, although there have been some encouraging developments recently: 2 power projects are expected to enter into operation in North America this year, and a steel plant in Abu Dhabi has awarded contracts for construction.

(iv) Progress investing in nuclear power

Nuclear power can play an important role in the decarbonisation of the power sector through cost-effective baseload low-carbon generation.

Nuclear accounted for 20% of all generation in the UK in 2013 and life extensions were granted to several plant; only 1.1 GW out of 8.8 GW is now scheduled to retire by the end of the decade.

In 2013 the terms of contract and level of support were agreed for the first new nuclear reactor at Hinkley Point C. The agreed strike price (£92.50) falls within the range suggested by our analysis (£85-100/MWh) and implies significant potential cost savings from a new nuclear programme in the UK compared to unabated gas generation facing a carbon price consistent with tackling climate change. State Aid clearance is now required for this project to proceed and be operational by 2023, on which a decision is expected by the European Commission later in 2014.

Other projects also remain in the pipeline, with potential for deployment up to around 17 GW by 2030 across the three consortia with existing plans to build new nuclear reactors in the UK.

In order for a successful program of new nuclear generation to be deployed, projects need to deliver to time and budget. We will closely monitor this and any announcements of cost overruns. If costs rise further and the benefits of a programme do not translate to lower costs than for the first plant, then the value of a nuclear programme would be called into question, particularly if other low-carbon options (i.e. renewables and CCS) are making good progress.

(v) Challenges and next steps in Electricity Market Reform

Good progress has been made on Electricity Market Reform in recent years, notably: the passage of enabling legislation; the introduction of long-term contracts to provide revenue stability for investors, thereby reducing the cost of capital and bringing forward investment at least cost to the consumer; agreement on funding to support investment coming on the system to 2020; publication of prices to be paid for generation from different technologies; and agreement on contracts for particular projects.

In order to gain the economic benefits from what has been achieved to date, and the commitments that have been made to 2020, continuing investment will be required through the 2020s. A failure to invest beyond 2020 would imply that earlier investments are largely wasted, in that they were aimed at technology commercialisation which did not ensue.

In order to secure investment beyond 2020, current uncertainty about the direction of travel for Electricity Market Reform will have to be addressed; this is undermining incentives for project development and supply chain investment, both of which are necessary for technology commercialisation.

To address the uncertainty will require that the Government provides investors with confidence that there will be a market for low-carbon technologies in the 2020s. Success

here requires a package that balances certainty of a future market with incentives for cost reductions, while retaining some flexibility to safeguard consumer interests.

The package should include a target range for decarbonisation, approaches to developing emerging technologies, funding commitments to support these and an assessment of how these fit together in an efficiently run electricity system:

- **A carbon intensity target range.** As legislated for in the Energy Act 2013 the Government should set a range for the carbon intensity of power generation in 2030. The range should balance the need for flexibility with the need to provide a valuable signal to industry on the direction of EMR – that the focus in the 2020s will be on low-carbon investment. Our previous analysis suggests a range of around 50-100 gCO_2/kWh would be consistent with the cost-effective path for a range of outcomes for fossil fuel prices, carbon prices and low-carbon technology costs.
- **Approach to less-mature technologies.** Alongside this objective the Government should set out its approach to driving cost reductions for the important less-mature technologies, including offshore wind and CCS.
  - For offshore wind this should include: a commitment to a critical mass of investment to drive costs down, recognising the likely market in other countries; target cost reduction schedules under which ambition will be maintained or increased; the point in time when the technology will be expected to compete with other low-carbon options without support and any role for Government in driving cost reduction (e.g. investment in port infrastructure). It is important to note that this goes well beyond the Government's current *Offshore Wind Industrial Strategy*.
  - For CCS the strategy should set out the approach to projects beyond the two being funded in the current competition and to development of a CCS infrastructure. It should include an approach to industrial as well as power sector CCS and complement approaches in other countries.
- **Funding, and funding limit.** To make these strategies credible requires that funding is committed consistent with their delivery and based on realistic assumptions of cost reduction. If costs turn out significantly higher for some options, which would question the economics of investment in these, this would suggest a change in ambition for these rather than an automatic increase in funding.
- **Optimising the system.** Increased flexibility and back-up capacity will be required as the power sector is decarbonised. There is a risk that the new market arrangements could undermine signals for this flexibility. Market signals should reflect the different value of alternative generating technologies and of flexibility mechanisms. All options (including demand changes, interconnection, existing plant and new gas plant) should be allowed to compete in the capacity market in a way that brings forward the lowest-cost options.

We will develop and recommend approaches to commercialisation and cost-reduction as part of our advice on the fifth carbon budget (2028-32), which will include an updated recommendation for the appropriate target range for power sector decarbonisation in 2030.

9. Progress reducing transport emissions

(i) Emissions trends

UK domestic transport CO_2 emissions accounted for 25% (117 $MtCO_2$) of all UK CO_2 emissions in 2013. The majority of these are from surface transport (94%). Domestic aviation and shipping account for 3% with the remainder from other sources. Cars are the biggest contributor to surface transport emissions (58%), followed by heavy goods vehicles (22%) and vans (14%).

Domestic transport CO_2 emissions were flat from 2012 to 2013, having fallen by 12% between 2007 and 2012.

Key drivers of this reduction were improvements in efficiency for cars and vans and a small decrease in demand, reflecting the impact of rising fuel costs and the economic recession.

There are also 41 $MtCO_2$ of emissions from international aviation (32 $MtCO_2$) and shipping (9 $MtCO_2$) – based on latest available data from 2012. These are not currently included in carbon budgets but are covered by the 2050 emissions target for at least an 80% reduction on 1990.

(ii) Supply-side progress reducing emissions

Progress reducing new car and van emissions

There has been good progress reducing emissions from new cars and vans, driven by efficiency improvements as manufacturers strive to meet EU legislation, with little contribution from consumer purchase decisions.

- Average test cycle emissions for new cars fell by 19% from 2007 to 2012 and by a further 3.6% in 2013 to reach 128 gCO_2/km, meeting the EU 2015 target of 130 gCO_2/km two years early. There have been improvements in emissions intensity across all classes of new cars but particularly in top models within classes.
- Over the first carbon budget period there was a polarisation of consumer purchases towards both larger and smaller cars away from mid-class models. There was also increasing purchase of more-efficient diesel vehicles; both trends continued in 2013. The net effect on emissions has been broadly neutral.
- New van CO_2 intensity fell by 8% between 2009 (the earliest date for which data are available) and 2012, and by a further 1.4% in 2013 to 186 gCO_2/km, ahead our indicator (192 gCO_2/km).

In order to maintain momentum, it is important that stretching new EU targets are set for 2030, which reflect the move to the new Worldwide Harmonized Light Vehicles Test Procedure (WLTP), and take full account of the role of electric cars and vans and other ultra-low emission vehicles (ULEVs) in delivering emissions reductions. Government should strongly push for this in the context of negotiations around the overall 2030 EU emissions reduction package.

Progress reducing heavy goods vehicle (HGV) emissions.

Emissions from HGVs declined by 7.7% over the first carbon budget period, slightly more than our indicator trajectory reduction of 7%. Sharp falls in HGV travel during the economic downturn have been partly offset in recent years as the economic outlook has improved; and implied emissions intensity has increased. Although data on actual changes are limited, it is likely that emissions rose in 2013.

- HGV km fell by 14% from 2007 to 2012, but rose 1% in 2013. This reflected the steep decline in manufacturing output over this period, where recessionary impacts were greater than for the rest of the economy.
- Average emissions intensity per vehicle-km rose for HGVs over this period, despite increased biofuel penetration. However there was a move to heavier vehicles and higher loading factors suggesting some improvement in vehicle utilisation.
- Data on HGV emissions in 2013 are not available, but information on distance travelled and biofuel penetration suggest that there was a small rise in emissions last year.

There is no comprehensive EU policy aimed at reducing emissions from this sector, partly due to the diverse nature of trucks and activities. Work is being carried out to measure and report whole-vehicle emissions from heavy-duty vehicles (HDVs, i.e. HGVs, buses, coaches and so on). This will open the way for the setting of mandatory limits for new HDV emissions. The Government should push for this to be resolved swiftly, soon after 2015.

Increasing penetration of biofuels

Despite being on track with our indicator for most of the first carbon budget period, biofuel penetration fell below our indicator in 2012 and 2013, largely as a result of changes in the accounting rules for more sustainable biofuels.

- In 2013 biofuel penetration reached 3.5% by volume, 1.5 percentage points short of our indicator.
- Following an EU move to encourage feedstocks with a lower risk of indirect land-use impacts, double-counting of waste-derived biofuels, residues and advanced biofuels was introduced in the Renewable Transport Fuels Obligation (RTFO) in 2012.

The primary concern for biofuels is for them to be sourced from sustainable feedstocks. The recent EC proposal for suppliers to report on indirect land-use change (ILUC) impacts should be seen as a first step towards their full inclusion in EU sustainability criteria.

Progress, challenges and responses developing electric vehicle markets

Growth in the electric vehicle (EV) market in the UK has been slow to date, with cumulative sales of 9,800. However, there are a number of positive developments, both here and in other countries, which provide some confidence about the market in future.

- Following recent launches, a wider range of models is now available in the UK market, with a range of price and quality characteristics providing some choice for consumers.
- There has been good progress investing in charging infrastructure, which should help to address the issue of range anxiety. This has been focused on slow charge points (i.e. 3-7 kW), with only a few (<5%) fast or rapid (20-50 kW) chargers. The Plugged-in Places (PiP) programme provided over 4,000 charge points by March 2013, of which around 65% were publically accessible, while non-PiP organisations may have also installed about 5,000 charge points nationwide.
- The Government has committed funding of £500 million between 2015 and 2020, aimed at improving take-up. This covers continuation of Plug-in Car Grants; support for vans and taxis; continued development of rapid-charge infrastructure; R&D and a competition for a new city scheme to promote EVs.
- Market development and commitments in other countries have led to rapid deployment. For example, in Norway EVs comprise 6% of new car sales, resulting from a mix of financial incentives and attractive softer measures such as access to bus lanes and road and ferry toll exemptions, as well as strong public procurement. Similar measures have been implemented in the Netherlands, which has also had a highly innovative and successful awareness raising campaign with opportunities to test drive EVs easily accessible to the public.

Nevertheless, significant barriers to mass uptake of electric vehicles remain, both as regards financial and non-financial barriers.

- **Financial barriers.** Evidence suggests that people heavily discount operating cost savings from electric vehicles, making them less financially attractive. If this is not addressed, prohibitively large subsidy could be required to encourage mass uptake.
- **Non-financial barriers.** Awareness and acceptance of EVs is currently low and negative perceptions amongst some consumers need to be addressed. Additionally, buyers value range and the option to complete longer trips if desired, which is currently limited for pure battery electric vehicles (but not for plug-in hybrids).

These barriers can be addressed through a combination of innovative financing; investment in charging infrastructure; facilitation of on-street residential charging; and car manufacturers engaging consumers through innovative marketing strategies.

- **New financing instruments.** The key to making electric vehicles more attractive from a financial perspective is to spread upfront battery costs over time, and to do this at as low a rate of interest as possible. Our analysis suggests that by the early 2020s this could remove the need for continued purchase subsidy

- **Investment in charging infrastructure.** A rapid charging network is needed to address range constraints for longer journeys by pure battery electric vehicles. These should be strategically located, easy to use, easy to find and offer convenient access and payment options. An initial rapid charging network can be achieved within current committed spending.
- **On-street residential charging.** Around 30% of households do not have access to off-street parking. In order for these households to purchase electric vehicles, they would have to be able to charge at home overnight. This could be achieved through investment in a network of slow-charging points in areas without off-street parking, with parking by these charging points reserved for those who own electric vehicles.
- **Innovative marketing approaches**. A key barrier is technology bias (i.e. a consumer preference for tried and tested conventional vehicles). This can be overcome – for example, this bias tends to disappear as people have experience of EVs. Car manufacturers are best placed to overcome this through their marketing, if incentivised to do so. This could be usefully supplemented by time-limited use of softer measures for early adopters, which can often be made available by Local Authorities (e.g. access to bus lanes, preferential parking), and increased exposure (e.g. through public procurement, taxis and car clubs).

To make this happen, the Government should:

- Strongly support the setting of an EU target for new car emissions in 2030 that reflects significant penetration of electric vehicles. This would strengthen incentives for manufacturers to promote EV uptake.
- Work with industry to explore scope for new ways to finance battery investment costs, building on innovations to date (e.g. battery leasing), including a possible role for the Green Investment Bank
- Ensure appropriate development of charging infrastructure, including strategically located rapid charge points to facilitate longer journeys, and access to overnight charging for people without off-street parking.
- Encourage Local Authorities to use powers available to them to promote EV uptake through softer, sometimes time-limited, measures (e.g. bus lane access, parking policy, car clubs, public procurement policies), ensuring winners of OLEV's city scheme competition act as exemplars.
- Consider how to phase out current purchase subsidy, given progress in these areas, and consider whether there would be value in announcing this in advance (e.g. this could spur industry action in addressing the barriers).

This set of actions to address financial and non-financial barriers would support the very significant growth in the electric vehicle market required to meet future carbon budgets; and to be on the cost-effective path to economy decarbonisation.

(iii) Demand-side progress reducing emissions

Complementing the move to more efficient and electric vehicles, our fourth carbon budget trajectory involves actions to reduce travel demand. Smarter Choices are being funded and, if sustained, could deliver savings in line with our trajectory. Savings from measures to encourage efficient driving and limit speeding are more at risk. There is more financial incentive for efficient running of freight operations but the current voluntary industry approach to streamline logistics may need strengthening.

- Funding through the Local Sustainable Travel Fund (LSTF) is available to local authorities to promote sustainable travel. Types of action being supported include workplace travel plans, walking and cycling, and car sharing, which have proved to be effective in reducing car travel, but need to be sustained to ensure benefits last.
- The industry-led Low Carbon Reduction Scheme has driven improvements in efficiency in the freight sector through changes such as better routing, improving vehicle fill and in-cab telematics. The scope and ambition of this scheme may need to be extended to encourage take-up among a wider range of operators.
- Uptake of eco-driving training is far short of our trajectory and likely to remain so, but future savings could be delivered through technology-based solutions (e.g. gear shift indicators and fuel use displays, which also encourage more fuel efficient driving).

(iv) Aviation and shipping

In 2012 emissions from domestic aviation and shipping (included in carbon budgets) were 4.0 $MtCO_2$, representing 3% of domestic transport emissions.

Emissions in aviation and shipping fell in the first carbon budget period, with reductions in both domestic and international emissions (currently excluded from carbon budgets but in the 2050 target).

- Domestic aviation emissions fell 28%; international emissions fell 10%. This largely reflected falling demand in the UK due to the economic crisis and improvements in fuel efficiency.
- Reductions in emissions from domestic and international shipping were both around 10% over the first carbon budget.

In December 2013, the Airports Commission released its interim report which recommended the need for an additional runway in the south east by 2030. It also suggested there could be a case for a second additional runway by 2050.

We have previously suggested that returning aviation emissions to around 2005 levels in 2050 is an appropriate level of ambition. Both Airports Commission and CCC analysis suggest an additional runway by 2030 can be compatible with this approach, provided that aviation demand growth is limited to around 60% above 2005 levels and that there are significant improvements in carbon intensity of aviation (e.g. of around one-third by 2050).

This approach should continue to be the basis for government policy unless and until technology improvements allow higher passenger demand growth – and associated infrastructure investment – to be demonstrated compatible with the 2050 target.

10. Progress reducing industry emissions

(i) Industry emissions trends

Emissions from industry accounted for around a third of UK greenhouse gas emissions in 2013 (around 170 $MtCO_2e$), of which around 90% are CO_2. Industry CO_2 emissions comprise around 74% direct emissions (of which 92% are from the combustion of fossil fuels and 8% are from chemical processes) and 26% indirect emissions (i.e. electricity-related).

Between 2007 and 2012 industrial GHG emissions fell 19% and direct CO_2 emissions fell by 26%. The fall in direct CO_2 emissions was more than the 15% reduction we had assumed for our indicator. However, emissions reduction did not reflect the unlocking of energy efficiency potential. Rather, large emissions cuts were a result of the economic recession reducing output and disproportionately impacting the more carbon-intensive sectors (e.g. iron and steel).

In 2013 direct CO_2 emissions from industry increased by 1%. This reflected a shift towards more carbon-intensive production, specifically the reopening of Teesside steelworks. An overall 2% reduction in industry emissions in 2013 was mainly due to the 8% reduction in the carbon-intensity of electricity consumed from the grid.

(ii) Implementation of measures to cut industry emissions

Progress improving industrial energy efficiency

Significant improvements in industrial energy efficiency are possible, and needed to meet the fourth carbon budget. However, there is no clear evidence to date of energy efficiency improvement sufficient to reduce the carbon intensity of production across industry.

The lack of progress might be expected given weak policy incentives currently in place:

- The EU ETS carbon price remains very low, undermining cash flows of projects to improve energy efficiency.
- Ambition in Climate Change Agreements is low relative to the potential for cost-effective energy efficiency improvement.

Close monitoring is required to understand better what is being done in industry to improve energy efficiency. Depending on the results of this monitoring, strengthened incentives may be needed so that measures are implemented and carbon budgets met in the most cost-effective manner.

Progress demonstrating CCS in industry

We have repeatedly recommended that the Government should publish an approach to demonstration and commercialisation of industrial carbon capture and storage (CCS) compatible with deployment in the 2020s.

This is now urgent, given the timeline to deployment, and the opportunity for substantial CCS abatement if deployed alongside expected industrial plant refurbishments from the late 2020s, by when CCS should be approaching commercialisation. Failure to address industrial CCS now will result in missing opportunities in plants' refurbishment cycles, raising the costs and risks of industrial decarbonisation.

Industry roadmaps

CCS is a major option for industry decarbonisation that should be included in the Government's industry roadmaps. Other key options include increased electric-arc steel production, clinker substitution in cement and optimisation of refineries.

In developing roadmaps, the risk is that these remain high level, and do not result in required investment. To mitigate this risk, it is important that they include key milestones for each technology, together with policies to ensure that milestones are met in practice, noting that policies are likely to go beyond reliance on the carbon price in EU ETS, even if this is strengthened significantly.

(iii) Progress managing competitiveness risks

It is important to ensure that increased energy costs resulting from low-carbon policies do not result in offshoring of UK industry. Output moving abroad would not have any benefits for the UK's overall carbon footprint (i.e. including consumption emissions) and therefore global emission reductions, and would not be desirable from a wider economic perspective. The Committee's assessment in 2013 concluded that there has been no significant industry relocation to date as a result of low-carbon policies and there is no reason to expect this in future, given current and planned policies to limit competitiveness risks.

Competitiveness risks arise from higher costs associated with policies to reduce direct emissions for energy-intensive industry. These are being addressed to 2020 through the design of the EU ETS, with a need to address post-2020 risks as part of the broader EU 2030 package currently being discussed.

There are also potential competitiveness risks for electro-intensive industries that are subject to international competition and face higher electricity costs relative to competitor countries. We have previously recommended that at-risk sectors are compensated for these additional costs and that the Government should aim to provide greater long-term certainty. These proposals are in place or being planned.

- A scheme to compensate industry from the indirect impacts of the EU ETS is in place and proposals to exempt industry from the effect of the Carbon Price Floor (CPF) recently received State Aid approval. Budget 2014 extended these schemes to 2019-20, in line with our previous advice.
- Government plans to introduce a new compensation scheme to help energy-intensive sectors with higher electricity costs resulting from renewable energy schemes from 2016-17. These are due to be consulted on shortly. Revisions to EU Energy and Environment Aid guidelines (EEAG) published in April 2014 extended the list of sectors that could potentially be eligible for help from this scheme.

The combined funding available from these compensation measures is in line with our previous estimates of support needed to address competitiveness risks of energy-intensive sectors in 2020.

Our previous analysis demonstrated the largest impacts occur due to electricity price increases to 2020; incremental impacts from higher electricity prices in the 2020s are relatively small. It is important that competitiveness impacts this period are closely monitored as regards appropriate approaches to support specific sectors at further risk of competitiveness impacts.

11. Progress reducing emissions from agriculture

Agriculture emissions are highly uncertain, with an estimated range of 42-91 $MtCO_2e$ in 2012.

When reporting emissions trends, we use the best estimate within this range, while recognising the need to improve the methodology for estimating emissions and to get better information about farming practices. The current methodology is largely based on applying IPCC Tier 1 global emissions factors that do not reflect soil and climatic conditions in the UK, and is in part based on livestock numbers. It suggests that agriculture emissions were around 57 $MtCO_2e$ (10% of UK greenhouse gas emissions) in 2012.

Estimated agriculture emissions fell 3% from 2007 to 2012. While this is broadly consistent with our high-level indicators, it does not imply that the underlying potential for emissions reduction that we identified has been addressed, given the lack of evidence that changes in farming practice have driven emissions reductions.

Our indicators also include carbon intensity of arable and pasture land and livestock productivity. In each case, there is no clear evidence that farming practice has become more carbon efficient in recent years.

- Nitrous oxide intensity of arable land – largely related to use of fertiliser for growth of crops – increased slightly over the first carbon budget period.
- While nitrous oxide intensity of grasslands fell, this reflects lower livestock numbers feeding on this land rather than more efficient use of fertiliser.
- Although livestock productivity has improved, it is unclear whether this has been achieved through more carbon-intense diets.

Better data are needed to be able to assess fully what has is happening in terms of farming practice. The new Smart Inventory will help in this respect, as will data collected to assess progress against Defra's indicators.

However, further monitoring and evaluation of the industry GHG Action Plan is needed to fully assess its effectiveness in driving changes in this sector. This will make it possible to take an informed view on whether the current light-touch policy approach to reduce agriculture emissions is working, or whether new policies with stronger incentives are required.

12. Progress reducing waste and F-gas emissions

(i) Waste and F-gas emissions trends

Waste emissions (predominantly methane emissions arising from biodegradable waste degrading anaerobically in landfill sites) and F-gases (mainly from their use as coolants in refrigeration and air conditioning) accounted for around 4% and 3% respectively of total UK emissions in 2012, the latest year of available data.

Estimates of waste emissions have been revised upwards by around 30% since our last progress report, due to a review of the methane capture rates at landfill sites. The Committee previously recommended that capture rates should be measured rather than assumed, and the new estimates reflect the latest attempts to measure performance.

Between 2007 and 2012 waste emissions fell by 24%, continuing a longer-term trend where emissions have fallen by 54% since 1990, largely due to reduced waste landfilled and increased capture of landfill methane. F-gas emissions rose by 12% in this period, continuing a longer-term trend where emissions have risen by 33% since 2000, and largely driven by growth in demand for products such as air conditioning and refrigeration units.

(ii) Drivers of progress reducing waste emissions

Progress to date has been driven by the landfill tax, which has increased from £7/tonne on its introduction in 1996 to £80/tonne in 2014, supplemented by voluntary responsibility deals, information awareness campaigns and strategies to support anaerobic digestion. These have led to a reduction in the amount of waste arising and in the share that is sent to landfill.

However, large volumes of paper/card, food, wood and textile waste continue to be sent to landfill and barriers may prevent the landfill tax from driving effective action throughout the waste chain (collection and disposal, as well as prevention).

We therefore repeat our recommendation for the Government to publish specific strategies on how to reduce each of the main biodegradable waste sources, to consider mandating UK-wide provision of separate food waste collection services by local authorities, and to consider bans on major sources of biodegradable waste from landfill on a case-by-case basis.

- We made these recommendations in our 2013 progress report to Parliament. The Government responded that priority should be placed on waste prevention to reduce biodegradable waste sent to landfill; that it is for local authorities to decide on provision of separate collection of food waste; and that they did not believe landfill bans were the best way to achieve this goal.
- Nevertheless, action needs be taken at every step along the waste chain including collection and disposal. Wales and Scotland already have or are planning both separate food waste collection and biodegradable waste landfill bans. Such actions to divert biodegradable waste from landfill could further unlock potential for producing energy through anaerobic digestion.

There may also be potential to reduce emissions by improving the average rate of methane capture at landfill sites, given that the new estimates suggest this is lower than previously thought and below levels being achieved in other countries and under best practice. Therefore, we recommend that the Government publish an approach to increase methane capture rates based on their improving evidence base, towards best practice, with milestones and actions to ensure these are met.

(iii) Achieving reductions in F-gas emissions

The EU F-gas Regulation introduced in 2006 reduced the growth in F-gas emissions, which have been flat since 2010 at an EU level, although UK F-gas emissions increased by 2% between 2010 and 2012.

An update to this regulation, which applies from January 2015, aims to cut the EU's F-gas emissions by two-thirds from 2014 to 2030. The new regulation limits the total amount of the most important F-gases that can be sold in the EU from 2015 onwards, phasing them down in steps to one-fifth of 2014 sales in 2030. This now needs to be transposed to UK legislation.

We recommend that Defra ensures UK businesses comply with the new regulation and seek opportunities to go further where cost-effective alternatives exist; if these are found, the Government should push for stronger implementation at the EU level.

Chapter 1

1. Introduction and key messages
2. Emissions drivers and trends
3. The indicator framework for monitoring carbon budgets
4. Progress reducing emissions in the non-traded sector
5. Progress reducing emissions in the traded sector
6. Comparison of progress with other countries
7. Impact of current policies on future emissions

Chapter 1: Overview

1. Introduction and key messages

This Progress Report fulfils our statutory duty under the Climate Change Act 2008 to set out our views on progress made to date towards meeting carbon budgets, and the further progress needed to meet both future budgets, and the UK's 2050 target to reduce emissions by at least 80% from 1990 levels.

In this chapter we address these questions:

- Section 2 sets out changes in greenhouse gas (GHG) emissions across the economy between 2012 and 2013 and over the first carbon budget period 2008-12, and confirms that the first carbon budget was met.
- Section 3 describes our indicator framework, which reflects our assessment of the cost-effective path to the 2050 target, and against which we monitor progress towards meeting carbon budgets.
- Sections 4 and 5 assess progress made towards meeting carbon budgets in the non-traded and traded sectors (i.e. the sectors outside and covered by the EU Emissions Trading System respectively). We compare progress made against our indicator framework, and evaluate progress against key indicators over the first carbon budget period using a traffic light system. For comparison, Section 6 sets out UK progress within the context of action in a number of other EU countries.
- Section 7 summarises our evaluation of current policies (set out in Chapters 2-8), identifying those that are expected to achieve their intended reduction in emissions and those that are at risk. This shows that there is a "policy gap" between emissions projections under current policies and the cost-effective path that would meet the fourth carbon budget. Section 7 also makes recommendations on how current policies identified as at risk can be strengthened, and how the policy gap can be bridged with new policies reflecting higher ambition.

Our key messages are:

- UK domestic greenhouse gas emissions decreased 2% in 2013, to 564 $MtCO_2e$. This was in a context generally supportive of emissions reductions: higher gas and electricity prices, coal plant closures under EU air-quality regulations, a moderate increase in GDP, and slightly colder winter temperatures than in 2012.
- The UK's net carbon account for the first carbon budget period was 2,982 $MtCO_2e$, 36 Mt below the level of the first carbon budget of 3,018 $MtCO_2e$. The UK has therefore met the first carbon budget. This is due to the significant dampening effect of the economic downturn on energy demand and emissions, somewhat offset by an upward revision to emissions estimates, reflecting updates to the estimation methodology.

- Over the first carbon budget period there has been good progress in implementing some policies, for example deployment of onshore and offshore wind, efficient boilers and new car efficiency.
- However, much remains to be done. Progress in many areas has been limited, for example, energy efficiency improvement in commercial and industrial sectors, low-carbon heat penetration in buildings, and demonstration of carbon capture and storage.
- Overall UK progress in reducing emissions is in line with our EU and international commitments, and is broadly keeping pace with other countries (e.g. over the first carbon budget period UK emissions fell 12%, compared to 11% in the EU-28 overall and 12% in the EU-15). Internationally, coverage of low-carbon laws and policies continues to increase.
- The underlying rate of emissions reduction remains low relative to what is required to achieve the cost-effective path that would meet the fourth carbon budget. Our assessment is that based on firm and funded policies, the gap between emissions and the fourth carbon budget could be up to 60 $MtCO_2e$/year in 2025.
- Closing this policy gap will require improving existing policies to address design and delivery risks, extending commitments towards 2030 and developing strategies to reduce emissions in new policy areas, across all sectors of the economy, including residential and commercial energy efficiency, electrification of heat and transport, and power sector decarbonisation.
- The UK should push for a combination of EU ETS reform and ambitious emissions targets for 2020 and 2030, and for high sustainability criteria for bioenergy in all sectors.

We set out our analysis underpinning these findings in six sections:

- Emissions drivers and trends
- The indicator framework for monitoring carbon budgets
- Progress reducing emissions in the non-traded sector
- Progress reducing emissions in the traded sector
- Comparison of progress with other countries
- Impact of current policies on future emissions

2. Emissions drivers and trends

Our focus in this chapter is on emissions currently covered by carbon budgets. These are UK emissions of the six greenhouse gases in the Kyoto basket from all sectors of the economy except international aviation and shipping. Although not currently included in carbon budgets, international aviation and shipping emissions are an important part of the 2050 target, and we consider them in Chapter 5.

In outlining changes in emissions and drivers that cause them, we compare data for 2012 and 2013 In order to assess progress over the first carbon budget period (2008-12), we also compare the last year of the first carbon budget (2012) with the year preceding the first carbon budget (2007).

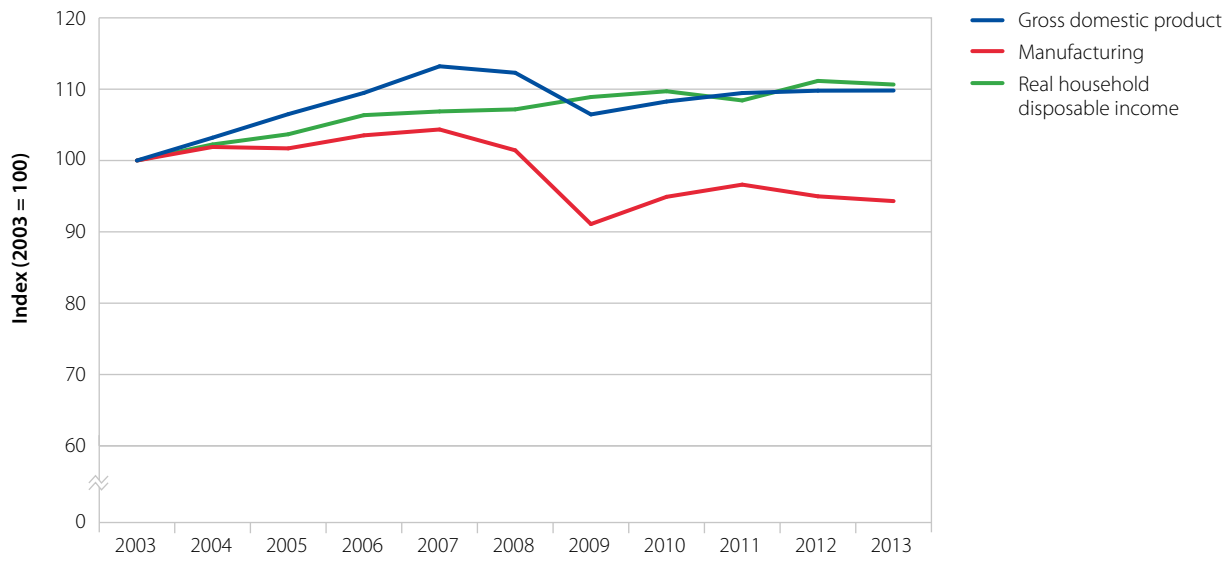
In 2013, UK domestic greenhouse gas emissions were 564 $MtCO_2e$, a decrease of 2% on 2012, having fallen 12% between 2007 and 2012. Emissions in 2013 were 28% below their 1990 level.

Drivers of emissions

The level of greenhouse gas emissions is affected by a range of factors, including economic activity, fossil fuel prices and temperature. There was a moderate increase in GDP in 2013, increases in residential and industrial energy prices but a reduction in road fuel prices, and slightly colder winter temperatures than in 2012. Over the first carbon budget period, comparing 2007 and 2012, there was an overall decline in GDP and an increase in energy prices.

- Economic activity.
  - GDP increased by 1.7% in 2013, having fallen 3% between 2007 and 2012. GDP in 2013 was therefore 1.4% below the pre-recession peak in 2007.
  - Manufacturing output fell by 0.7% in 2013, having fallen 9% between 2007 and 2012.
  - Real household disposable income decreased by 0.5% in 2013, having increased 4% between 2007 and 2012 (Figure 1.1).

Figure 1.1: UK economic indicators (2003-2013)

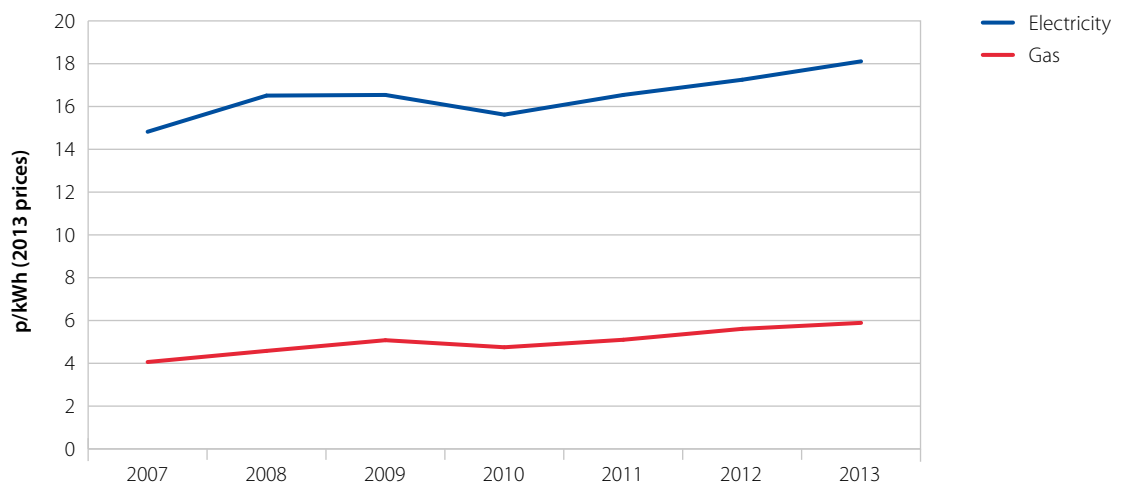


Source: ONS (March 2014) *Quarterly National Accounts.*

- Energy prices.
  - Residential gas prices increased by 5% in real terms in 2013, and by 38% between 2007 and 2012, reflecting increases in wholesale gas prices in the UK and across Europe.
  - Wholesale coal prices fell 9% in real terms in 2013 reflecting the continued slump in demand for coal in the USA, following a 42% increase between 2007 and 2012. This is in comparison to wholesale gas prices which rose 6% in 2013 and 53% from 2007 to 2012. Coal prices, therefore, have fallen relative to gas prices.
  - Residential electricity prices increased 5% in real terms in 2013, and 16% between 2007 and 2012, driven mainly by the rising gas price (Figure 1.2).
  - Petrol and diesel prices decreased by 3% in real terms in 2013, following 27% and 29% increases, respectively, between 2007 and 2012 (Figure 1.3).
- Temperature.
  - 2013 had slightly colder winter months than 2012, with average winter temperatures (i.e. January, February and December) 0.3°C lower, and a 3% increase in heating degree days across the year (Figure 1.4). Within the first carbon budget period, there was a particularly cold winter in 2010.

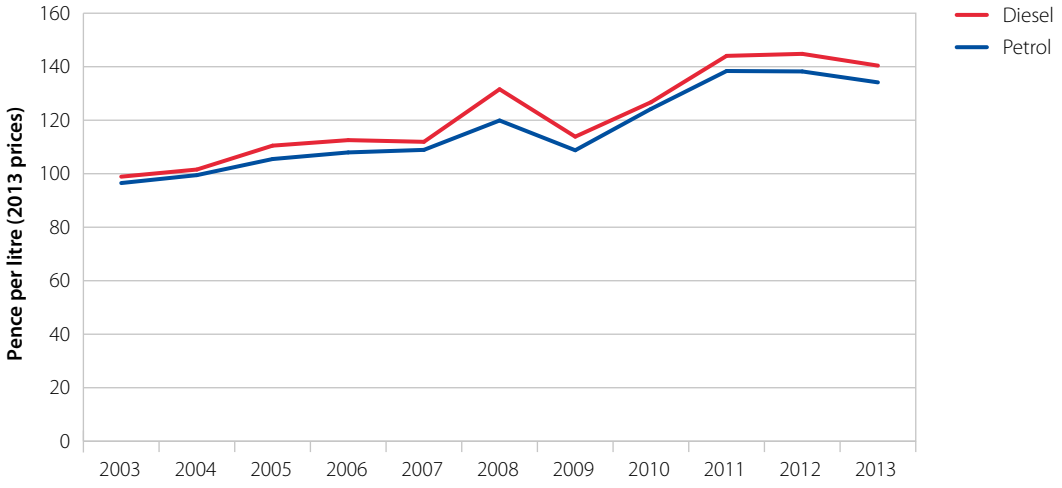
Overall, conditions would have been expected to reduce emissions in 2013, and significantly so over the first carbon budget period (when the recession had a very large dampening effect on energy demand and emissions, somewhat offset by a very cold winter in 2010).

Figure 1.2: Residential fuel prices in the UK (2007-2013)



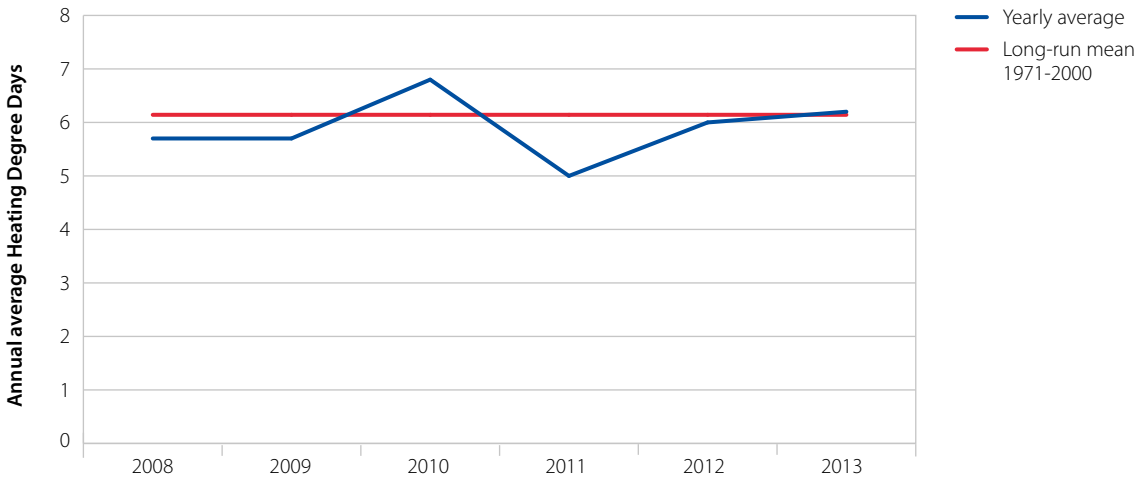
Source: DECC (March 2014) *Quarterly Energy Trends*.

Figure 1.3: Road fuel prices in the UK (2003-2013)



Source: DECC (March 2014) *Quarterly Energy Trends.*

Figure 1.4: Average temperature deviation from the long-term mean (2012-2013)



Source: DECC (March 2014) *Quarterly Energy Trends.*
Notes: The number of heating degree days is the number of degrees by which the average temperature in a single day is below a baseline temperature, below which buildings need to be heated. Heating degree days can be expressed for a single day, or aggregated over a number of days.

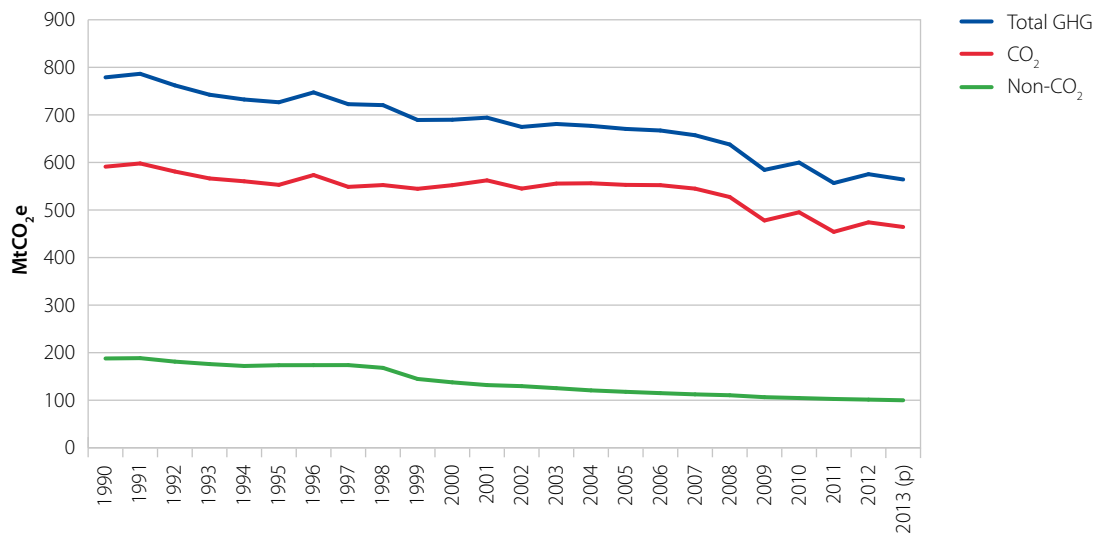
Greenhouse gas emissions trends

We report on the six targeted greenhouse gases covered under the Climate Change Act and the Kyoto Protocol. These targeted greenhouse gases comprise:

- Carbon dioxide (CO_2), accounting for 82% of total GHG emissions in 2013;
- Non-CO_2 emissions, accounting for 18% of total GHG emissions in 2013, and comprising methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

UK domestic greenhouse gas emissions decreased 2% (11 $MtCO_2e$) in 2013, to 564 $MtCO_2e$, mainly a reflection of falling emissions from the power sector as several coal plants closed permanently. This follows a 12% (82 $MtCO_2e$) decrease over the period 2007-2012, with the recession contributing significantly to the fall from 657 $MtCO_2e$ in 2007 to 575 $MtCO_2e$ in 2012 (Figure 1.5).

Figure 1.5: UK Greenhouse gas emissions (1990-2013)



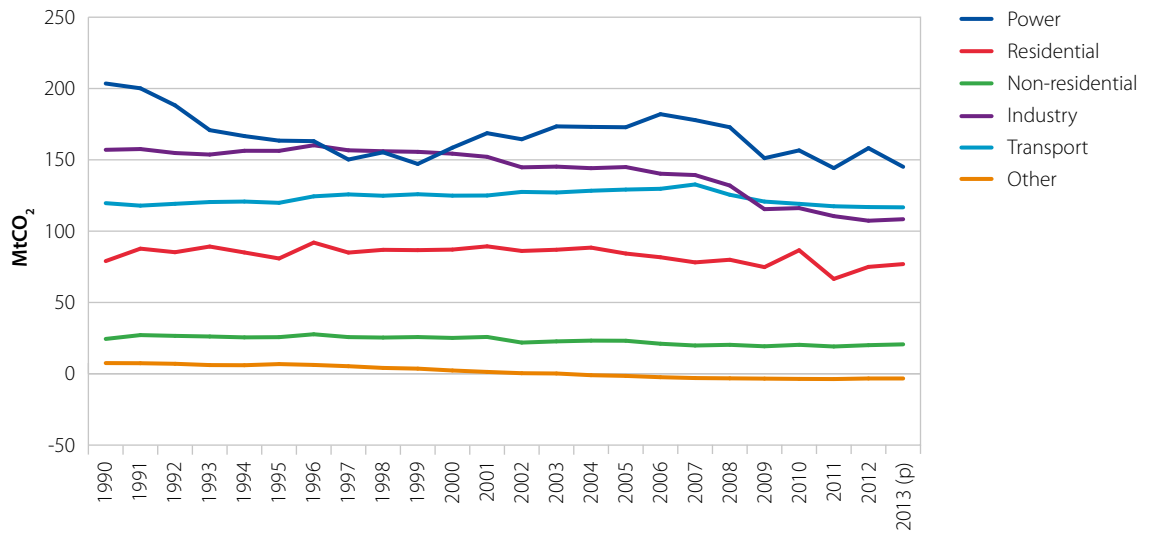
Source: DECC (2014) *2013 UK Greenhouse gas emissions, provisional estimates.*

Emissions reductions in 2013 and over the first budget period have comprised falls in emissions of CO_2 and non-CO_2 gases, with contributions across all sectors of the economy:

- CO_2 emissions decreased 2% (10 $MtCO_2e$) in 2013 to 464 $MtCO_2e$, due to falling power sector emissions, partially offset by increases in buildings and industry. This follows a 13% (71 $MtCO_2e$) decrease over the period 2007-2012, from 545 $MtCO_2e$ in 2007 to 474 $MtCO_2e$ in 2012, with emissions falling across all sectors. This was mainly due to the recession, as well as improved CO_2 intensity of the car fleet and a reduction in industry output, particularly in the more carbon-intensive industry sectors (e.g. iron and steel) (Figure 1.6).
  - **Power.** CO_2 emissions from power generation decreased 8% in 2013, to 145 $MtCO_2e$, following an 11% decrease over the period 2007-2012. The decrease in 2013 was a result of both increasing renewable generation and coal plant closures (having reached the end of their allocated hours under EU air quality legislation). The decrease between 2007 and 2012 reflected a 1.5% fall in emissions intensity, due to an increase in gas and low-carbon generation relative to coal generation, together with reduced electricity consumption of 7%[1]. Emissions could have been even lower during the first budget period, but for nuclear outages in 2010 and increased coal burn in 2012. Coal burn increased in the latter part of the first carbon budget because of reductions in the price of coal relative to gas, triggered by US exports following the shale gas boom, and the collapse of the EU ETS carbon price.

1 While electricity consumption fell 7% between 2007 and 2012, generation within the UK fell further, by 10%, due to an increase in imports.

Figure 1.6: UK CO_2 emissions by sector (1990-2013)



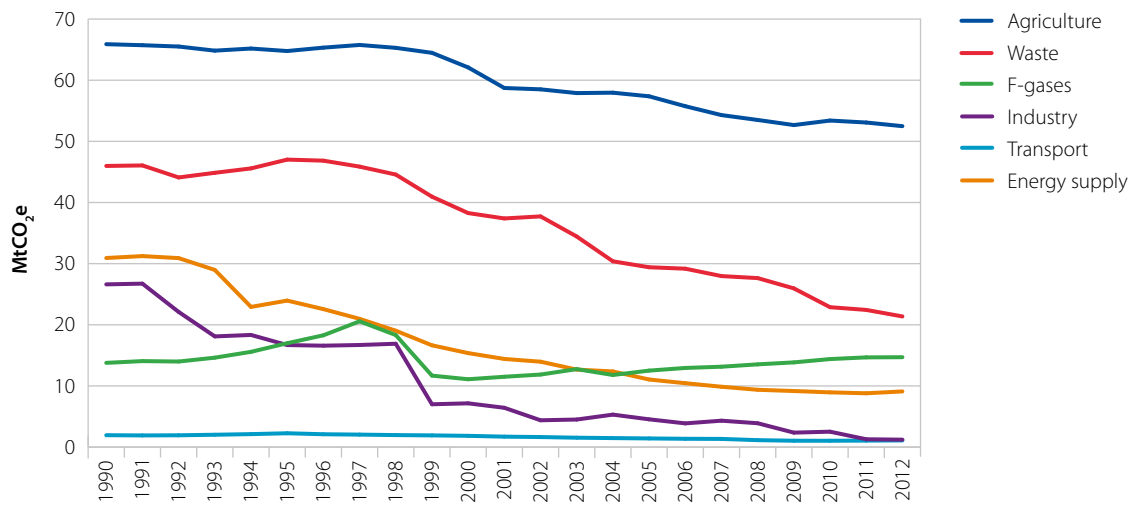
Source: DECC (2014) *2013 UK Greenhouse gas emissions, provisional estimates.*

- **Buildings.** CO_2 emissions from buildings increased 3% in 2013, to 98 $MtCO_2e$, following a 3% decrease over the period 2007-2012. Within this, CO_2 emissions from residential buildings and non-residential buildings both increased 3% in 2013, driven by increased gas consumption due to slightly colder winter temperatures. During the first carbon budget period there were large fluctuations, with emissions declining in 2009 due to the impact of the recession and rising fuel prices, and rising in 2010 and 2012 due to colder weather.
- **Industry.** CO_2 emissions from industry increased 1% in 2013, to 108 $MtCO_2e$, following a 23% decrease over the period 2007-2012. The increase in 2013 was due to an increase in output in the more carbon-intensive sectors, including the reopening of the Teesside steelworks. The decrease over the first carbon budget period was mainly due to a reduction in output, particularly in the more carbon-intensive industry sectors (e.g. iron and steel).
- **Transport.** CO_2 emissions from transport decreased negligibly in 2013, to 117 $MtCO_2e$, following a 12% decrease over the period 2007-2012. Falling emissions over the first carbon budget period can be explained by a decrease in distance travelled by cars, vans and HGVs, an increase in the biofuel content of petrol and diesel, and improvements in the fuel efficiency of the car and van fleets as more-efficient vehicles penetrated the stock. Detailed data on transport CO_2 emissions in 2013 are not yet available.

- Provisional emissions statistics assume that non-CO_2 emissions continued long-term trends and decreased 1% (1 $MtCO_2e$) in 2013, to 100 $MtCO_2e$; a more detailed estimate for 2013 will be available next year. This follows a 10% (11 $MtCO_2e$) decrease over the period 2007-2012, from 112 $MtCO_2e$ in 2007 to 101 $MtCO_2e$ in 2012 (Figure 1.7). Non-CO_2 emissions are measured with less confidence than CO_2 emissions, with an estimated uncertainty bound of -12% to +27% (compared to –2% to +2% for CO_2). In addition to the estimation uncertainty, there has also been a revision to final estimates for the historical time series due to UNFCCC requirements. This revision increased emissions in 2012 by 11% relative to provisional data released last year.

The slightly colder temperatures in the winter months of 2013 had a much smaller impact on emissions than temperature changes in recent years. Adjusting for this (Box 1.1), suggests the decrease in greenhouse gas emissions would have been around 2.5%, compared to the outturn of 2%. This is slightly faster than annual underlying reductions during the first carbon budget (around 1%) and is attributable mainly to the coal closures in the power sector – without these closures emissions would have fallen less than 1% in 2013.

Figure 1.7: UK non-CO_2 emissions by sector (1990-2012)



Source: NAEI (2014) *Final emissions estimates.*

Box 1.1: The impact of temperature on energy demand and the Committee's approach to temperature adjustment

As noted in our previous progress reports, weather can have a significant impact on energy consumption and therefore emissions. Winter temperatures in particular can affect demand for heating fuels (summer temperatures currently have a much smaller effect given that energy demand for cooling remains significantly lower than demand for heating in the UK).

The winter months of 2013 (January, February and December) were slightly colder than those of 2012 resulting in higher emissions, particularly in the residential sector. We have used DECC estimates of the "temperature-adjusted" change in energy consumption from 2012 to 2013 (i.e. how energy consumption would have changed without the decrease in winter temperatures). We have then applied our own estimates of emissions intensity in 2013 to calculate the effect on emissions. This allows us better to assess underlying progress, abstracting from year-to-year variations in weather, which is useful in assessing future prospects for emissions.

Total CO_2 emissions in 2013 fell by 2%, but adjusting for temperature they would have fallen 2.5%. The adjustment is primarily in energy use for heating buildings, with the largest impact in the residential sector.

DECC release their own estimates of temperature-adjusted emissions which suggest a slightly larger impact, such that after adjusting for temperature total emissions in 2013 would have fallen 3%. DECC's methodology adjusts emissions directly (as opposed to energy consumption) and as such, may capture second-order impacts such as fuel switching. Our approach is to identify the impact of fuel switching separately and we therefore continue to temperature-adjust energy consumption rather than emissions.

The first carbon budget (2008-2012)

The UK's net carbon account for the first carbon budget period (2008-2012) was 2,982 $MtCO_2e$, 36 $MtCO_2e$ (1.2%) below the level of the legislated budget of 3,018 $MtCO_2e$. The UK has therefore met the first carbon budget, with emissions on average 24% below 1990 levels.

On 14 April 2014 we wrote to Minister of State Gregory Barker, recommending that the 36 $MtCO_2e$ difference should not be carried forward through to the second budget.[2] This recommendation was based on analysis of the factors that contributed to meeting the first carbon budget:

- The evidence overall suggests that low-carbon policy did not deliver ahead of schedule. For measures for which data are available, the rate of implementation was no higher than that envisaged in our indicator trajectory. For measures for which data are not available, proxy data do not provide credible evidence of higher implementation.
- The economic downturn is likely to have had a significant dampening effect on energy demand and emissions. Analysis we commissioned from Cambridge Econometrics suggested that the overall impact of conditions, including the economic downturn and weather, reduced emissions over the first budget period by 1-4%.
- Improved approaches to measuring emissions for the UK's greenhouse gas inventory[3] have led to an upward revision in estimated emissions, by up to 2.5% over the budget period.

2 CCC (2014) *Decision on whether to carry forward emissions* http://www.theccc.org.uk/publication/letter-decision-on-whether-to-carry-forward-emissions-from-first-to-second-carbon-budget/

3 The National Accounts Emissions Inventory (NAEI), http://naei.defra.gov.uk/

In our letter, we advised that the UK should not carry forward these emissions to the second carbon budget (2013-17), as this would dampen incentives for implementation of measures on the cost-effective path to the 2050 target, increasing costs and risks further out in time.

The Government accepted this advice and chose not to carry forward the emissions to the second carbon budget. The second carbon budget therefore remains at its legislated level of 2,782 $MtCO_2e$, and requires a reduction in emissions of 29% relative to 1990 and 8% relative to the first carbon budget. This provides a useful signal that the Government is committed to effective implementation of planned policies and reducing emissions in line with the cost-effective path to the 2050 target.

The next sections in this chapter focus on progress implementing measures, the challenges faced and how these might be addressed.

3. The indicator framework for monitoring carbon budgets

In our first (October 2009) progress report to Parliament, we developed our indicator framework for monitoring progress against carbon budgets. This framework sets out trajectories for delivery based on our 'Extended Ambition' scenario, and includes a range of indicators:

- Headline indicators, such as economy- and sector-wide GHG emissions, GHG emissions intensity and energy demand;
- Implementation indicators for measures that reduce GHG emissions (e.g. additional low-carbon power generation capacity, roll-out of loft, cavity wall and solid wall insulation, take up of electric cars);
- Policy milestones for an appropriate framework enabling future implementation of measures.

Our original indicator framework covered the first three carbon budget periods (2008-2022). In December 2010 we published our advice on the fourth carbon budget, and extended our abatement scenario to cover the period 2023-2027.

Our indicators represent our best assessment of the technologies and behaviours required to meet the cost-effective path to the 2050 target and the fourth carbon budget, based on the latest evidence. However, it is important to acknowledge that there is inevitable uncertainty over the rates at which technologies will become available and their future costs, and at which behaviour change will be taken up. It is likely that new evidence will lead to a reassessment of these technologies and behaviours over time, and that we will revise our indicators, and include new indicators, accordingly. The indicators, therefore, are generally not prescriptive (it may be possible to meet near-term carbon budgets while underperforming in some indicators, provided the increase in emissions is offset by outperformance of other indicators) and not exhaustive (it is possible that some technologies that are not currently included in our indicator framework become more cost-effective than we originally envisaged).

Many technologies are likely to require significant research and development before they can be successfully deployed. We considered the case for research and development of these technologies at the UK level in our 2010 review of low-carbon research and innovation (Box 1.2)

Box 1.2: The role for UK research and development in low-carbon technologies

In October 2009 the Government's then Chief Scientific Adviser, Sir John Beddington, asked us to review the adequacy of research and innovation arrangements in the UK related to achieving our climate change goals. We published our Innovation Review: *Building a low-carbon economy – the UK's innovation challenge* in August 2010.

In the innovation Review we considered those technologies that are likely to play a role in helping the UK meet its 2050 target to reduce emissions by 80% on 1990 levels, but are not yet competitive with high-carbon alternatives. We considered technologies at all stages of technological innovation, including research, development, demonstration and deployment (RDD&D), and, for each technology, the business case for the UK to contribute to each of these stages.

Based on our assessment of technology portfolios required to deliver climate objectives, current stages of technology development and the UK's research and industrial capabilities, we recommended that the UK should:

- Develop and deploy offshore wind, marine, carbon capture and storage (CCS) for power generation and potentially industry, aviation technologies, smart grids, and electric vehicle technologies.
- Deploy nuclear power, advanced insulation materials, heat pumps and CCS for energy intensive industries.
- Research and develop hydrogen fuel cell vehicles, technologies in agriculture and industry, 3rd generation solar PV technologies, energy storage and advanced biofuels technologies.

We also recommended that the Government should set out its strategy for developing the technologies required to meet the 2050 emissions reduction target, identifying which technology portfolios will be developed, setting out the level and form of public support and policy to address deployment barriers, and identifying clear responsibilities for delivery within Government.

In December 2014 we published our review of the fourth carbon budget (Box 1.3), and further refined our abatement scenario to take account of the latest evidence on technology performance and cost. Our abatement scenario was designed to reflect the cost-effective path to the 2050 target, comprising measures that cost less than the projected carbon price across their lifetimes, together with measures that may cost more than the projected carbon price, but are necessary in order to manage costs and risks of meeting the 2050 target.

In this report, we revise our indicator framework to take account of outturn data and new evidence, and extend it to 2027 to cover the fourth carbon budget period. We have also made minor changes to our indicators (e.g. substituting new van CO_2 for the CO_2 intensity of the van fleet, due to better data availability) and added new indicators where our revised assessment indicates there is value in monitoring take up (e.g. deployment of smart meters).

Box 1.3: The Fourth Carbon Budget Review

The fourth carbon budget, covering the period 2023-7, was legislated in June 2011 at 1,950 $MtCO_2e$. As part of the agreement to set the budget, the Government scheduled a review for 2014. The Climate Change Act sets out the basis for the review: it must be based on advice from the Committee and the budget can only be changed if "there have been significant changes affecting the basis on which the previous decision was made".

In November and December 2013 we published our Review of the Fourth Carbon Budget.

The Review advised that there is no legal or economic basis to support a change in the fourth carbon budget: in respect of science, and international and EU criteria, there had been no significant change in the circumstances upon which the budget was set; and the currently legislated budget remains feasible and economically sensible, and continues to have manageable impacts:

- **Climate science**. If global emissions were to continue to increase throughout the century it is likely that global temperature would rise by 4°C or more. In order to limit risks of dangerous climate change and preserve close to a 50% chance of keeping temperature rise below 2°C, global emissions need to peak by around 2020, with deep cuts through the 2020s and in the following decades. The currently legislated budget is a minimum UK contribution to this global emissions pathway.
- **International action**. The UK is not acting alone. While the UN process is moving slowly and there have been backward steps in some countries (e.g. Australia), many countries around the world have made commitments comparable to the UK and are acting to reduce emissions. These include the largest emitters (i.e. China, the US and the EU, accounting for 57% of global emissions). Required global emissions cuts consistent with limiting warming to 2°C are still feasible if very challenging, and remain an appropriate basis for UK policy.
- **EU developments**. The fourth carbon budget is at the low end of the range of ambition currently being discussed by the EU for emissions pathways through the 2020s. If the UK Government is successful in achieving its stated objectives in these EU discussions, the budget would have to be tightened significantly.
- **Feasibility of the budget**. The budget can still be met based on more prudent assumptions on implementation of measures than in our original advice. This is because official projections of energy demand have been revised down to reflect updated evidence on key demand drivers and improved approaches to projecting emissions in line with previous Committee advice.
- **Cost savings of early action**. The budget provides insurance against risks of dangerous climate change and rising energy bills, offering an estimated cost saving, relative to delaying action until the 2030s, of over £100 billion in present value terms. There would still be a moderate cost saving in a world of low fossil fuel or carbon prices, while with high fossil fuel prices the benefit could be as high as £200 billion.
- **Social and economic impacts from meeting the budget**. Our assessment of the budget's impacts on the circumstances specified in the Climate Change Act is broadly unchanged from our original advice. Impacts on energy affordability, fuel poverty, competitiveness and the public finances are important but manageable, and positive in the long run, in a carbon-constrained world.

4. Progress reducing emissions in the non-traded sector

Non-traded sector emissions are those outside the European Union Emissions Trading System (EU ETS) and include direct emissions from use of fossil fuels in buildings, non-energy-intensive industry (primarily for heat) and transport, as well as almost all non-CO_2 emissions (e.g. from agriculture and waste).

Non-traded sector emissions accounted for 60% of total emissions in 2013. These decreased 1% (5 $MtCO_2e$) in 2013, to 339 $MtCO_2e$. This follows a 9% (35 $MtCO_2e$) decrease over the period 2007-2012, from 380 $MtCO_2e$ in 2007 to 344 $MtCO_2e$ in 2012 (Figure 1.8). Total non-traded sector GHG emissions were 1,755 $MtCO_2e$ across the first carbon budget period 2008-2012, compared to the budget share for the non-traded sector of 1,792 $MtCO_2e$.

Figure 1.8: Non-traded sector emissions vs. carbon budgets (2007-2027)

Source: DECC (2014) *2013 UK Greenhouse gas emissions, provisional estimates*; DECC (2014) *Energy Trends*; CCC calculations.
Notes: *As proposed in our 2008 report, the Intended budget (2008-2022) corresponds to the UK share of an EU 30% 2020 target. We recommended it should be enacted in the context of a global deal to reduce emissions.

Underlying progress in the non-traded sectors

In this progress report we use a traffic light system to present progress against selected key indicators over the first carbon budget period (2008-12) and in 2013. For each sector, we select the most important indicators, that represent:

- A substantial proportion of abatement in that sector; and/or
- Development of options for "critical path" technologies (i.e. those required to meet the 2050 target, such as electric vehicles or heat pumps).

For each indicator, we evaluate progress against our indicator trajectory over the period 2008-13, and assign it a red, amber or green traffic light, where:

- **Green =** progress which has met our indicator (i.e. lower outturn emissions, greater implementation of measures, policy that is more comprehensive or implemented earlier).
- **Amber =** progress which has slightly underperformed our indicator.
- **Red =** progress which has significantly underperformed our indicator.

Clearly, a good rate of progress in implementing important measures reduces the risks of meeting future carbon budgets, while a poor rate of progress increases the risks. However, it is important to note that our traffic lights compare outturn to our indicators, and are intended to be an evaluation of progress to date, rather than the likelihood of meeting future carbon budgets. Therefore, where we assign a Green traffic light for measures that have met our indicator, this does not imply that there are no risks to continued implementation of measures to meet carbon budgets; equally, where we assign a Red traffic light for measures that have significantly underperformed our indicator, it could be that changes are underway to improve progress in future. We separately consider prospects for future action to meet carbon budgets

in Section 7. It is also important to note that in some cases, we are revising our indicators to be more realistic and reflect better evidence on the appropriate rate of implementation. Where this is the case, we make this clear in our evaluation.

Below, we summarise the underlying progress in the non-traded sector, and Table 1.1 sets out a summary of our traffic light assessment. Further detail on underlying progress, and our complete traffic light assessments, are set out in each sector chapter. Against our indicator framework, there has been good progress in some areas, most notably in efficient boilers, new car efficiency and investment in wind generation, both onshore and offshore. However, there has been limited progress in other areas, for example solid wall insulation and low-carbon heat penetration in buildings. There are also threats to continuing progress, for example relating to the new policy framework for residential energy efficiency and the lack of an industry strategy for meeting carbon budgets.

- **Buildings.** Emissions of 98 $MtCO_2e$ from buildings in 2013 accounted for around 28% of non-traded sector emissions. This mainly consists of emissions from heating. Progress has slowed down markedly in 2013 with the exception of uptake of efficient boilers, and following the introduction of the Green Deal and Energy Company Obligation. In the non-residential sector, data availability is poor but there are few signs of major energy efficiency performance improvements.
  - **Boiler replacement.** Boiler replacement continued at a steady pace throughout the first carbon budget period, with an annual average of 1.6 million new efficient boilers installed. In 2013 a further 1.5 million A-rated boilers were installed which means that cumulative uptake by 2013 was 1.8 million higher than our indicator.
  - **Loft insulation.** Loft insulation rates plummeted by 92% in 2013, to just under 130,000 installations. This also compares unfavourably with the first carbon budget period when an average of around 1.1 million lofts were being treated each year.
  - **Cavity wall insulation.** While the volume of cavity wall installations averaged around 500,000 per year during the first carbon budget period, levels in 2013 only reached 170,000, down 73% on 2012.
  - **Solid wall insulation.** The ramp-up of activity in 2012 (68,000 installations) as energy suppliers strove to meet obligations in the final year of the supplier obligation schemes (CERT – the Carbon Emission Reduction Target and CESP – the Community Energy Saving Programme), was not continued into 2013, with the number of installations returning to levels seen before 2012 of less than 30,000 per year.
  - **Low-carbon heat.** This is off-track, with 0.3% of heat coming from low-carbon sources in 2012 compared to 0.6% in our indicator trajectory.

- **Industry.** Non-traded sector emissions from industry were 28 $MtCO_2$ in 2013, accounting for around 8% of non-traded sector emissions. These emissions are also primarily from heating. Around 5 TWh of low-carbon heat was produced in industrial sectors, slightly outperforming our indicator of 1% of heat in industry from low-carbon sources. There is currently no over-arching strategy to reduce emissions in line with carbon budgets.
- **Transport.** Emissions from transport were 177 $MtCO_2$ in 2013 accounting for around 34% of non-traded sector emissions. We track a range of indicators for transport including improvements in conventional vehicle efficiency, uptake of low-carbon vehicles and behavioural measures.
  - **New car efficiency.** Average new car test-cycle emissions intensity fell by 19% over the first carbon budget period, from 165 gCO_2/km in 2007 to 133 g/km in 2012. This trend continued in 2013, when new car CO_2 fell to 128 g/km – below our indicator value of 142 g/km and meeting the EU 2015 target of 130 g/km two years early.
  - **New van efficiency.** Average new van test-cycle emissions intensity has fallen from 204 g/km in 2009 to 188 g/km in 2012, and 186 g/km in 2013. This compares to our trajectory value of 192 g/km.
  - **Electric vehicle market development.** Electric vehicle penetration remains low in the UK, with 3,584 vehicles sold in 2013, and cumulative sales to date of around 9,800 vehicles.
  - **Biofuels.** Despite being on track with our indicator for most of first carbon budget period, biofuel penetration fell below our indicator in 2012 and 2013. This reflects changes in the accounting rules for more sustainable biofuels.
  - **Demand-side measures.** There has been progress on Smarter Choices measures through both the Local Sustainable Transport Fund (LSTF) launched in 2011, which supports 96 schemes in 77 Local Authorities, and a variety of earlier Local Authority measures, although data to estimate the impact of these measures on emissions are not yet available. Evidence suggests levels of eco-driving training are lagging well behind our indicators, and are likely to continue to do so.
- **Agriculture, waste and other non-CO_2.** Emissions of non-CO_2 gases were 100 $MtCO_2e$ in 2013, comprising 29% of non-traded sector emissions. Detailed data for 2013 are not yet available but the majority of non-CO_2 emissions come from methane and nitrous oxide emissions in agriculture and waste, with the rest from leakage of fluorinated gases (F-gases). There are limited data available on agricultural indicators so they are not included in the traffic light assessment. In waste there has been good progress in reducing biodegradable waste sent to landfill.

Table 1.1: Non-traded sector traffic light assessment		
Indicator for progress to date	**Traffic light evaluation of progress**	**Comments**
Buildings		
Implementation		
Uptake of loft insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. Cumulative loft insulation levels in 2013 were 650,000 below our indicator (6.3 million).
Uptake of cavity wall insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. Cavity wall insulation levels at 2.9 million are 45% below our cumulative indicator for 2013 (5 million).
Uptake of solid wall insulation	Red	Very low uptake numbers (170,000 cumulatively by the end of 2013, compared to 500,000 in our indicator). Some success during 2012 (final year of Community Energy Saving Programme) but uptake numbers have fallen under Energy Company Obligation (ECO). Latest evidence suggests available cost-effective potential may be lower than expected.
Uptake of boilers	Green	High uptake of new efficient boilers, with cumulative uptake by 2013 1.8 million higher than our indicator (5.9 million).
Buildings, penetration of low-carbon heat (%)	Red	Progress in buildings is off-track, with 0.3% of heat coming from low-carbon sources in 2012 compared to 0.6% in our indicator trajectory.
Uptake of energy efficient appliances	Amber	Stock penetration for the most efficient appliances is low (e.g. wet appliances A+ or better are 9% of the stock versus 16% in the indicator). However, overall efficiency of the appliances on the market has improved significantly.
Policy		
New energy efficiency financing mechanism	Red	Green Deal introduced in 2013 but very low uptake. Scope for currently unattractive interest rates to fall in future as Green Deal lending is scaled up.
Domestic and Non-domestic Renewable Heat Incentive (RHI) schemes in operation	Amber	Delays to Domestic RHI launch, but some progress made in setting standards and improving evidence base. Non-domestic scheme up and running since 2011, but low uptake apart from biomass.
Industry (non-traded)		
Implementation		
Industry penetration of low-carbon heat	Green	1.25% uptake compared to 1% in indicator.

Table 1.1: Non-traded sector traffic light assessment		
Indicator for progress to date	**Traffic light evaluation of progress**	**Comments**
Policy		
Publish industry strategy including milestones, incentives and mechanisms for meeting carbon budgets	Red	No strategy to meet carbon budgets has been published, but 2050 Roadmaps underway.
Transport		
Implementation		
New car CO_2	Green	Outperforming trajectory. Evidence of a growing gap between real-world and test-cycle emissions suggest real-world improvements were smaller; however likely still to have met trajectory.
Electric vehicle sales	Red	Uptake well below trajectory, although market developments (e.g. availability of a range of models) have been positive and in hindsight uptake in the proposed trajectory was too high.
Policy		
Biofuel policy	Amber	Biofuel penetration in line with our trajectory for first few years, falling short in past two years but improvements in sustainability.
Smarter Choices policy	Amber	Local Sustainable Transport Fund is funding a number of projects across England but evaluation framework is not comprehensive.
Waste and F-gases		
Implementation		
Biodegradable waste sent to landfill	Green	47% fall compared to 30% in trajectory.
Percentage of methane captured at landfill sites	Amber	Indicator suggested maintain at 75%, but a re-estimation suggests that the rate was 59% in 2012, although rising from 54% in 2007.
Policy		
Develop comprehensive waste policy	Amber	National Waste Prevention Programme published December 2013 but slow progress developing effective policy across waste streams.
Update to the EC's F-gas regulation to make it fit for purpose by end 2013	Amber	New EU F-gas regulation published in April 2014 and to come into force in 2015; Government still to transpose within UK legislation.

5. Progress reducing emissions in the traded sector

Traded sector emissions are those covered by the European Union Emissions Trading System (EU ETS). These include emissions from power generation and energy-intensive industries (e.g. refineries, production of cement, iron and steel), emissions from domestic aviation (but

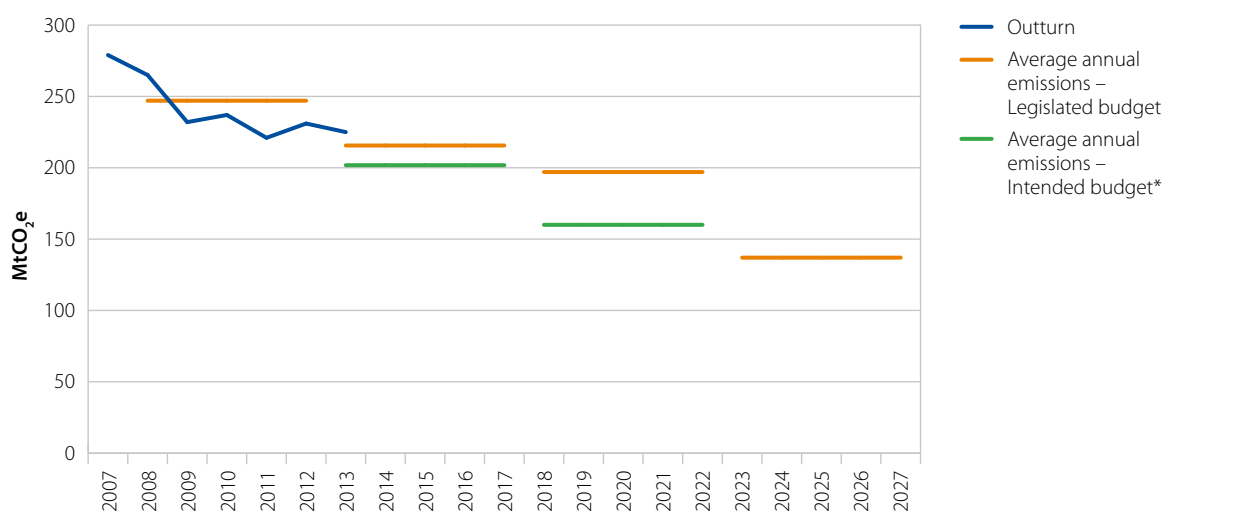
currently not international aviation) and non-CO_2 emissions from production of aluminium and nitric and adipic acids.

Carbon budgets are based on *net* emissions in the traded sector. Net emissions are defined by the UK share of the EU ETS cap, and are equal to gross emissions adjusted for any sales or purchases of allowances in the EU ETS (or other emissions credits) and any banking of allowances towards future caps. Performance against the carbon budget is therefore not determined by the actual level of traded sector emissions – where these differ from the UK share of the EU ETS cap the difference will be exactly offset by net sales/purchases of allowances.

However, the importance of power sector decarbonisation for reducing economy-wide emissions, as well as the need to decarbonise energy-intensive industry over time, means it is important to reduce gross traded sector emissions, and to monitor progress in doing so.

Traded sector GHG emissions accounted for 40% of total GHG emissions in 2013. Gross emissions from sources currently in the traded sector decreased 3% (6 $MtCO_2e$) in 2013, to 225 $MtCO_2e$[4]. This follows a 17% (47 $MtCO_2e$) decrease over the period 2007-2012, from 277 $MtCO_2e$ in 2007 to 231 $MtCO_2e$ in 2012 (Figure 1.9).

Figure 1.9: Traded sector emissions vs. carbon budgets (2007-2027)



Source: European Commission (2014) Verified emissions data; CCC analysis.
Notes: *As proposed in our 2008 report, the Intended budget (2008-2022) corresponds to the UK share of an EU 30% 2020 target. We recommended it should be enacted in the context of a global deal to reduce emissions.

Underlying progress in the traded sector

Below, we summarise the underlying progress in the traded sector over the first carbon budget period (2008-12) and in 2013, and Table 1.2 sets out a summary of our traffic light assessment. Against our indicator framework, there has been good progress in some areas, most notably in deployment of onshore and offshore wind. However, there has been limited progress in nuclear new build, and there are also threats to continuing progress, for example

4 The scope of the EU ETS has increased since 2007.

the slow pace of progress on carbon capture and storage, and the lack of commitment beyond 2020 for the power sector.

- **Power.** Emissions from power were 145 $MtCO_2$ in 2013, accounting for 64% of traded sector emissions. We track progress in deployment of renewable and other low-carbon technologies as well as investment.
  - In 2013 total renewable generation increased to 51 TWh (16% of generation), up from 38 TWh (12%) in 2012 and 19 TWh (5.4%) in 2007.
  - Over the first carbon budget period renewable capacity increased in line with our indicator framework and a strong pipeline of projects for future investment has been established.
- **Industry.** Traded sector CO_2 emissions from industry were around 80 $MtCO_2e$ in 2013, accounting for 36% of traded sector emissions. Industry energy consumption and emissions are on track with our indicators. However, this has been mainly due to the impact of the recession, rather than policy or investment in abatement technologies.

Table 1.2: Traded sector traffic light assessment

Indicator	Traffic Light	Comments
Power sector		
Implementation		
Onshore and offshore wind	Green	Capacity in line with indicator and a strong pipeline of projects to 2020. However, longer-term uncertainty could undermine the flow of projects from the pipeline to delivery.
Nuclear new build	Amber	Delayed new-build programme by at least 5 years, with expected completion date of first new plant pushed back from 2018 to 2023. However, strike price and terms of contract now agreed and potential programme of future projects.
Policy		
Review of electricity market to begin in first budget period	Amber	Energy Act legislated in 2013 including key elements of reform (long-term contracts and funding to 2020), but lack of clarity beyond 2020 and no decarbonisation objective could undermine delivery.
Carbon Capture and Storage (CCS) Front End Engineering and Design (FEED) studies complete by 2010, with first CCS project online 2014	Red	FEED studies now due to complete in 2015 (i.e. 5 years behind indicator). However, some lessons learned and programme due to deliver 2 plants by 2020.
Industry covered by the EU ETS		
Policy		
Publish industry strategy including milestones, incentives and mechanisms for meeting carbon budgets	Red	No strategy to meet carbon budgets has been published, but 2050 Roadmaps underway.

EU ETS emissions and carbon prices

Across the EU, the carbon price is determined by the level of effort required to limit gross EU traded sector emissions to the level of the EU ETS cap. That price, and the cost of abatement options available in the UK, is then a factor in determining UK (gross) traded sector emissions.

Gross EU traded sector GHG emissions decreased 3.5% in 2013 to 1,904 $MtCO_2e$, following a 14% decrease from 2007 to 2012, and were 7% below the level of the 2013 cap (Figure 1.10).

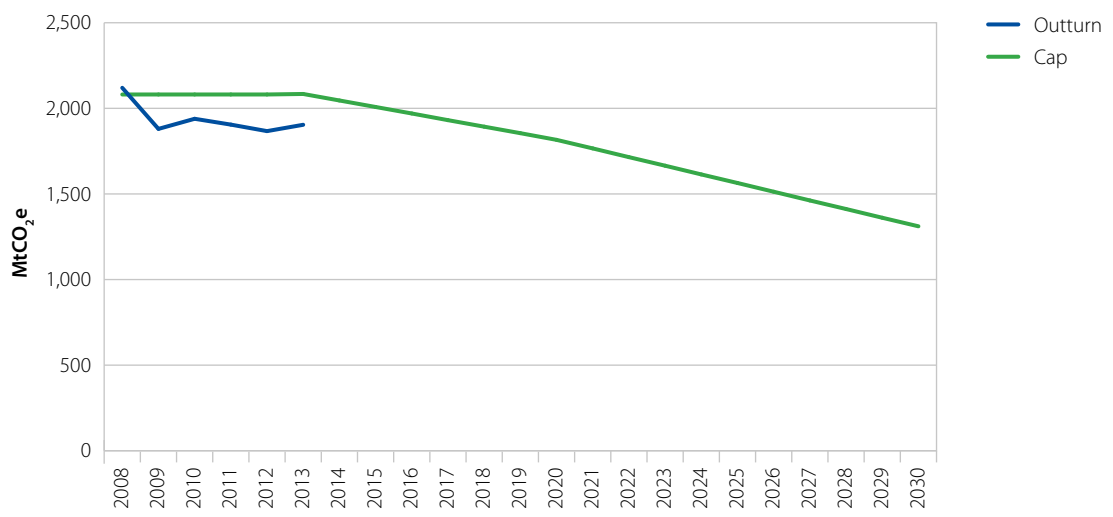
- The decrease in emissions in 2013 was driven primarily by the ongoing recession in parts of the EU (e.g. Italy and Greece), leading to a decline in fossil fuel generation.
- This was offset in some countries by increased GDP growth driving emissions up.

During Phase II (2008-2012) EU traded sector emissions were 7% (732 $MtCO_2e$) below the cap. Unused allowances can be banked and will be available to meet the ETS cap in future years. The combination of current emissions being lower than the cap and banking of credits from Phase II means that the level of future caps can be met with minimal effort.

The outperformance of the cap and the consequent surplus in allowances have exerted a persistent downward pressure on the price of EU Allowances (EUAs) and thus the cost of emitting carbon. During 2013, the EUA price ranged from €3 to €6 per tonne with an average of €4, a 40% decrease from the average of €7 in 2012. This follows a 70% decrease from 2008 to 2012, from an average of €24 in 2008[5] (Figure 1.11).

Given the current headroom in the cap, the outlook is for future prices to remain low, underscoring the need for structural reform of the EU ETS, as well as additional instruments to drive investment in low-carbon technologies, such as the Electricity Market Reform in the UK.

Figure 1.10: Emissions within the EU ETS versus cap (2008-2030)



Source: European Commission (2014) *Verified emissions data*; European Commission (22 October 2010) *Commission Decision 2010/364/EU.*
Notes: Excludes international aviation.

5 Prices from 2007 (Phase I) are not included as the EUAs in this phase were a different commodity and were not transferable across phases.

The oversupply of allowances undermines the effectiveness of the EU ETS, which is a key pillar of European climate policy. Under a suitably tight emissions cap, a low carbon price would be a sign of success (i.e. that firms are finding low-cost ways to reduce emissions). This is clearly not the case in the current EU scheme, where the price is low because limited action to reduce emissions is required.

In order to restore the value of the EU ETS as a policy instrument (and the credibility of EU climate policy more broadly), it is vital that the cap to 2030 is sufficiently stretching. This in turn requires that the EU adopts a stretching level of overall ambition for 2030.

The European Commission put forward its proposal for the 2030 framework in January 2014. Its key provisions were:

- A target of a 40% emissions reduction below the 1990 level, met through domestic measures alone (i.e. without purchase of international carbon credits from outside the EU).
- The linear annual reduction in the EU ETS cap from 2020 would be increased to 2.2%, from the currently legislated 1.74%. This would mean that the EU ETS cap in 2030 would be 43% below the 2005 level.

These proposals were supplemented by plans for structural reform of the EU ETS, largely involving delayed release of allowances when prices are low, and proposals for a non-binding renewable energy target (Box 1.4).

Enacting both the structural reform and the proposed 2030 framework would be a significant step forward towards a fully functioning ETS; this is something that the Government should continue to strongly support.

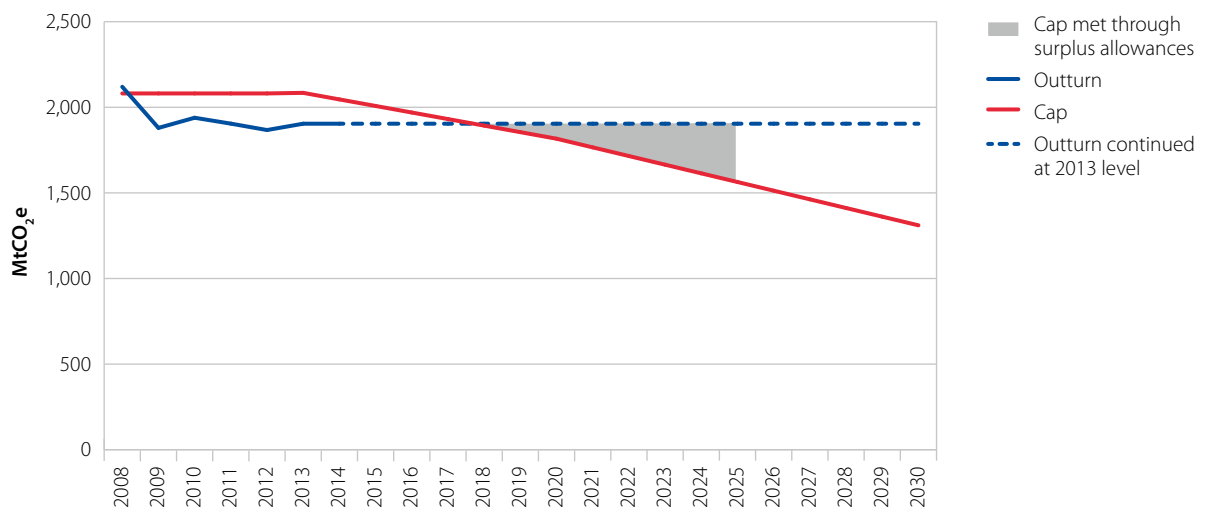
Figure 1.11: Carbon price in the EU ETS

Source: ICE.

However, the proposed 40% reduction in emissions by 2030 is at the less ambitious end of the 40-44% range for the cost-effective path to the EU's 2050 targets (an 80-95% reduction by 2050 on 1990 levels), as outlined by the EC in its 2011 Roadmap. Given further economic weakness in Europe since then, with EU emissions now likely to fall to a level at least 25% below 1990 levels by 2020, it is questionable whether a 40% reduction is now on the cost-effective path to the deep reductions planned for 2050[6], which would imply a significant acceleration in the rate of emissions reduction after 2030.

Given the relatively low level of current emissions, it is not clear that the proposed EU ETS cap will require significant effort to reduce emissions for some time. At the current level of emissions, the cumulative surplus within the cap could persist until 2024 (Figure 1.12). Whilst economic growth could put upward pressure on emissions, energy efficiency policy, coal closures under air-quality legislation and other instruments driving low-carbon investment could all mean that future emissions may fall further even if the EU ETS price remains low.

Figure 1.12: Emissions and surplus within the EU ETS versus cap (2008-2030)



Source: European Commission (2014) *Verified emissions data*; European Commission (22 October 2010) *Commission Decision 2010/364/EU*.
Notes: Excludes international aviation.

This raises the possibility that the EU could increase its ambition without a large escalation in short-term costs. The UK should push for a combination of ETS reform and emissions targets for 2020 and 2030 that will put the EU on the cost-effective path to meeting its target for 2050 and deliver a strong ETS price. This supports the UK Government's position that the EU should aim for a reduction of 50% in 2030 relative to 1990 as part of an international effort to combat climate change:

- The level of gross EU emissions (i.e. before purchase of credits from outside the EU) in 2030 should be on a cost-effective path to achieving at least an 80% reduction in emissions by 2050.

6 Recent analysis suggests that a 40% reduction is below the lower end of the appropriate range of ambition for emissions reduction by 2030. An Energy Modeling Forum review of bottom-up modelling studies (Knopf et al (2013), *Beyond 2020 – Strategies and Costs for Transforming the European Energy System* indicated that the appropriate 2030 level of GHG emissions is in the range of a 43-52% reduction against 1990 levels, with a median of 48%.

- In order to stay on track for longer-term reductions, such a target for 2030 should be achieved without significant contribution from surplus allowances accrued in previous years.
  - A mechanism is needed to prevent excessive surpluses building up within the market. It is not clear whether the proposed Market Stability Reserve achieves this, as withdrawn allowances can still be returned to the market – it will be important that the criteria for their return are sufficiently tight.
  - Whether using this mechanism or separately, it is likely to be necessary for the surplus currently building up to be removed from the ETS permanently, or effectively so. Given the damage to the credibility of the EU ETS while the price remains so low, it would be helpful if this were implemented as early as possible.
- Reform of the EU ETS should also include recognition of the emissions savings from 'negative emissions' technologies, such as use of bioenergy in conjunction with CCS. While their contribution during the 2020s is likely to be relatively small, it is important that the incentive exists in order to encourage their development given their potential importance in meeting longer-term emissions targets.

UK policy therefore needs to recognise that the EU carbon price is likely to remain low for some time, but could have to increase rapidly in future if the EU commits to significant action to reduce emissions as part of a wider international effort.

Box 1.4: EU proposals for EU ETS reform and supplementary targets in the 2030 package

The proposals for reform of the EU ETS are based around the 40% target:

- Structural reform
  - On 25 February 2014 the European Commission committed to postponing the auctioning of 900 million allowances until 2019-2020 to allow demand to pick up ('back-loading' of allowances)
  - In January 2014 the Commission also proposed to establish a "market stability reserve" at the beginning of the next trading period in 2021.
  - The reserve is intended to both address the surplus of emission allowances that has built up and improve the system's resilience to major shocks by automatically adjusting the supply of allowances to be auctioned.
  - The legislative proposal, put forward in January 2014 at the same time as the framework for climate and energy policies up to 2030, requires approval by the Council and the European Parliament to become law.
- An EU-wide target for renewable energy of at least 27% in 2030. It is not proposed that this would be translated into national targets through EU legislation.
- Renewed ambitions for energy efficiency policies. The current proposal does not include a target, but the role of energy efficiency in the 2030 framework will be further considered in a review of the Energy Efficiency Directive due to be concluded later this year.
- A decision on the EU ETS reform and 2030 package is expected over the coming months.

Source: European Commission

6. Comparison of progress with other countries

The Climate Change Act requires the Committee to consider EU and international circumstances when advising on carbon budgets.

In this section we compare UK progress towards reducing emissions and meeting 2020 targets to the rest of the EU. We also consider wider international developments and progress, including in UN negotiations. Detailed comparisons of UK progress relative to EU countries in each sector are set out in Chapters 2-7.

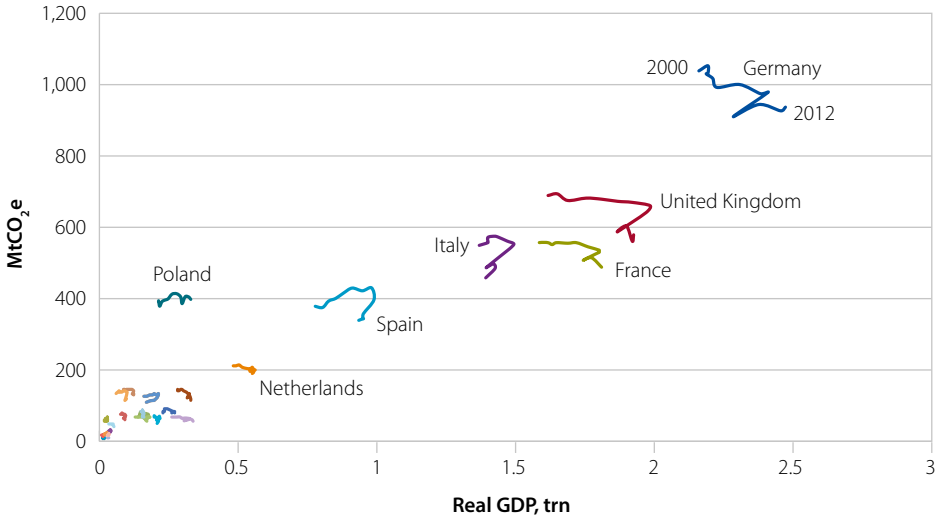
Overall UK progress towards reducing emissions is in line with our EU and international commitments, and is broadly keeping pace with other countries.

UK and EU emissions over the first carbon budget

The UK is the EU's second largest economy and emitter. Emissions fell in the UK and across the EU over the first carbon budget period (2008-12), largely due to the recession.

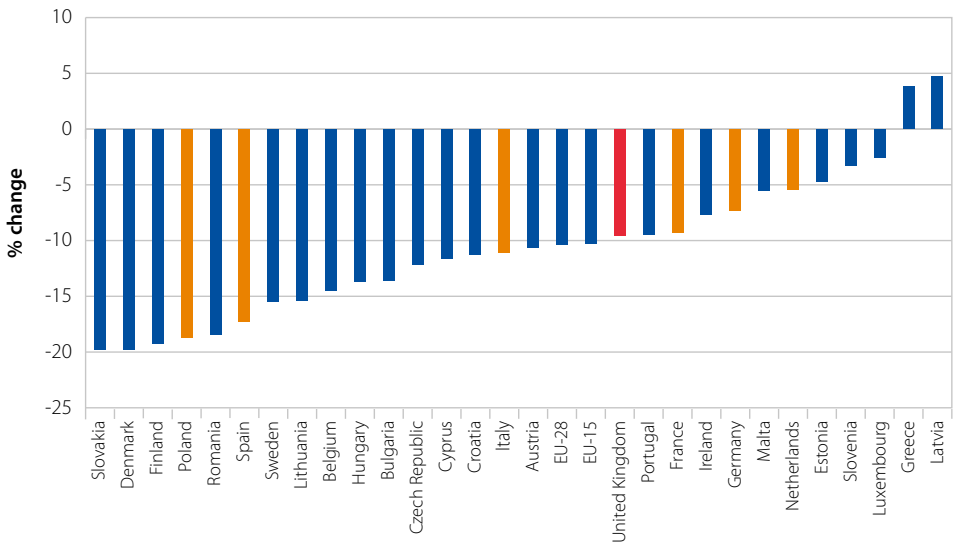
- UK emissions fell 12% from 2007 to 2012, compared to 11% in the EU-28 overall and 12% in the EU-15 (Figure 1.13). Emissions fell across all countries, even where GDP increased, suggesting that structural changes were at least partly responsible for the fall.
- GDP fell across the EU in real terms, by 1% in the EU-28 and 1.5% in the EU-15 from 2007 to 2012. There was wide variation across countries: UK GDP fell by 3% but other countries grew (e.g. Germany 4%, Poland 18%) or were flat (e.g. France).
- Emissions fell by more than GDP across most countries, implying that emissions intensity (i.e. emissions produced per unit of GDP) fell. This continues the historical trend. UK emissions intensity fell 10%, which is in line with the overall EU-28 and EU-15 reduction (10%) and close to similar-sized EU countries such as France and Germany (Figure 1.14).
- For most countries, including the UK, emissions fell more in the sectors covered by the EU ETS (i.e. power, industry). This suggests some common factors across countries were behind the reduction in emissions (e.g. reflecting lower demand for electricity, switching away from fossil fuels in power generation).

Figure 1.13: EU country emissions against GDP (2000-2012)



Source: European Environment Agency (2014), Eurostat.
Notes: Emissions data excludes LULUCF, international aviation and international shipping. GDP is valued at 2005 prices.

Figure 1.14: Change in emissions intensity by EU country (2007-2012)



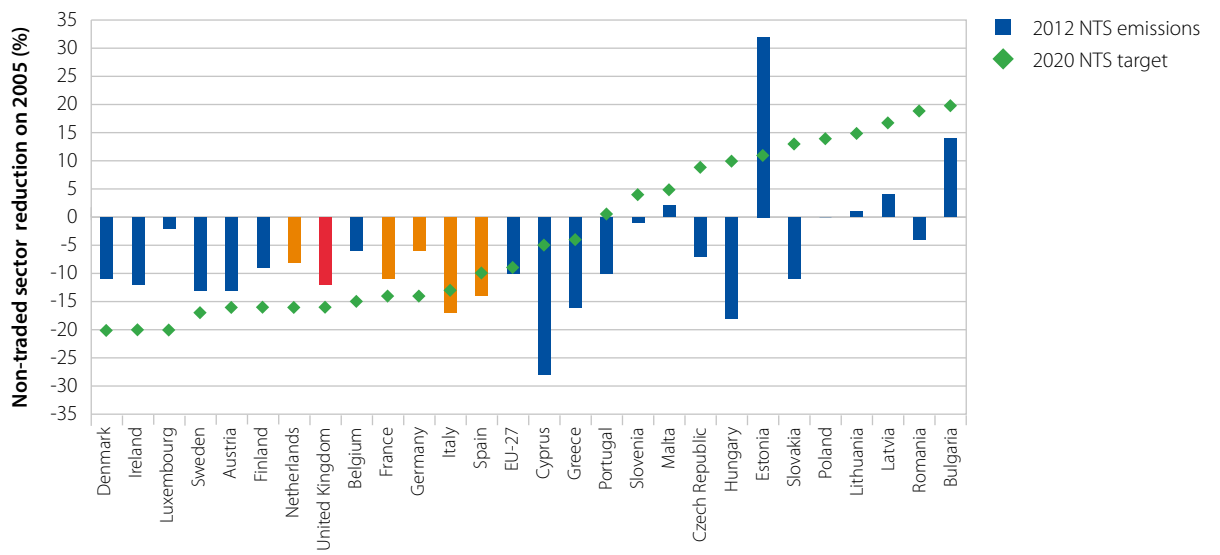
Source: European Environment Agency (2014), Eurostat.
Notes: Emissions data exclude LULUCF, international aviation and international shipping. Orange bars represent largest six countries labelled in Figure 1.13.

Progress towards EU 2020 targets

The EU has set 2020 targets for emissions, renewable energy and energy efficiency. The UK has made most progress towards the target for emissions, with more limited progress on renewable energy. The target for energy efficiency is difficult to assess at this stage.

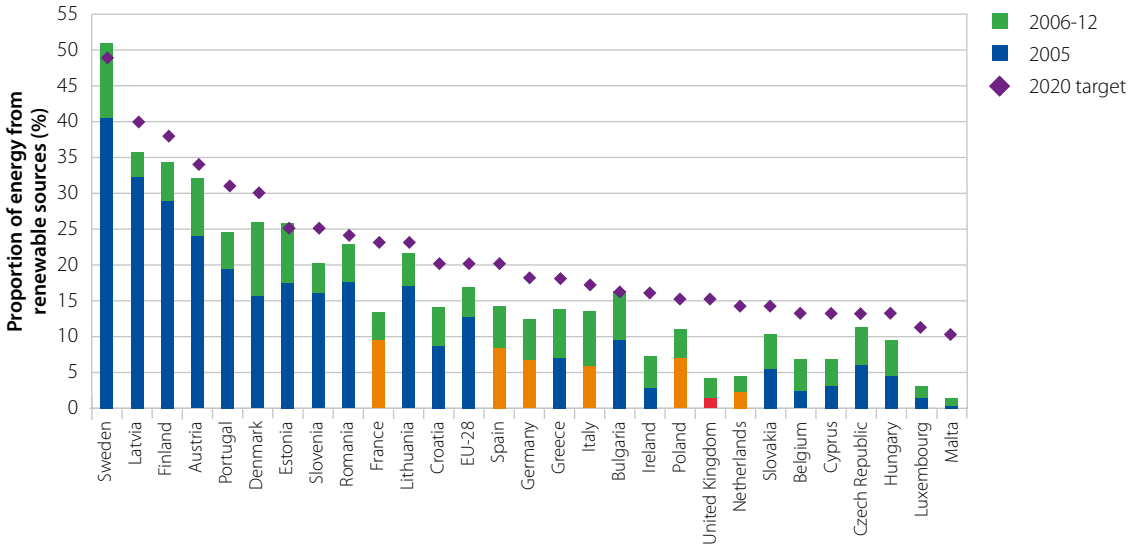
- **Emissions.** By 2012 the UK was 75% of the way towards its 2020 emissions target of a 16% reduction on 2005 emissions for the non-traded sectors, compared to 80% towards the EU-15 target of a 14% reduction. In large part due to the recession, emissions at the EU-27 level have fallen by more than the 2020 target of a 9% reduction on 2005 levels (Figure 1.15).
- **Renewable energy.** The UK has made good progress towards its EU renewable energy target, especially in the power sector, but still has a long way to go (Figure 1.16). This reflects a combination of a very low initial level of penetration and a stretching target. Given investment lead-times, planned trajectories for achieving the target were necessarily back-loaded with less progress expected in initial years:
  - The investment pipeline for renewable electricity is broadly on track (Chapter 2).
  - Renewable heat requires further development. Progress with heat pumps in particular has been slow (Chapter 3).
  - The share of renewables in transport has risen faster in the UK than the EU average (albeit from a low base) but deployment remains lower than the EU-28 average (Chapter 5).
- **Energy efficiency.** Whilst the EU has an energy efficiency target for 2020, this is not binding on individual countries. Countries have submitted their own non-binding targets and the European Commission is currently reviewing the compatibility of these with the overall target. It is therefore difficult to compare progress on energy efficiency at this stage. More detailed discussion of energy efficiency is set out in Chapter 3.

Figure 1.15: EU country progress in 2012 towards 2020 emission targets (non-traded sector)



Source: European Environment Agency (2013), *Trends and projections in Europe 2013.*
Notes: Orange bars represent largest six countries labelled in Figure 1.13.

Figure 1.16: EU country progress in 2011 towards 2020 renewable energy targets



Source: European Environment Agency (2013), *Trends and projections in Europe 2013*, EC (2013), *Renewable energy progress report.*
Notes: Orange bars represent largest six countries labelled in Figure 1.13.

Developments in international circumstances

We assessed international developments in detail for our *Fourth Carbon Budget Review* (November 2013). Over the first budget period there has been progress in international negotiations and the first phase of the Kyoto Protocol has ended:

- **UNFCCC developments.** The UNFCCC has formally adopted the objective of limiting temperature rise to 2°C and has agreed to work towards a global deal to be agreed in Paris in 2015. While progress towards that global deal has been slow, there have been a number of significant steps since 2008. For example, in Cancun in 2010 many countries formalised emissions reduction pledges for 2020 made at the 2009 Copenhagen conference (the Cancun pledges)
- **Kyoto Protocol.** The first commitment period of the Kyoto Protocol, like the first carbon budget, covered the years 2008 to 2012. Both the UK and EU comfortably achieved their Kyoto targets. In 2012 UK emissions were 25% below 1990 levels and therefore outperformed the target of a 12.5% reduction. At the EU level, emissions fell 15% against a target of an 8% reduction.

Importantly, many countries are taking actions to deliver their 2020 UN pledges, including the US and China. Coverage of low-carbon laws and policies has increased internationally (e.g. 80% of global road transport emissions are covered by fuel efficiency/emissions standards; 20% of non-transport emissions are covered by carbon pricing). New policies continue to be introduced: there have been a number of significant positive announcements since the fourth carbon budget review was published (Box 1.5).

Box 1.5: International developments in climate change policy

We published a detailed review of the latest developments in climate change policy around the world in our November 2013 Review of the Fourth Carbon Budget[7].

Since 2013 there have been further new policy announcements and milestones from some of the highest-emitting countries, including:

- **EU 2030 targets.** In January 2014 the European Commission proposed new EU targets for 2030 (see section 5 for more details). These included a 40% reduction in domestic emissions on 1990 levels, and an EU-wide target for renewable energy of at least 27%. The proposal also included a reform package for the EU ETS, intended to manage the over-supply of allowances. The package is expected to be agreed at the EU Council meeting in October 2014.
- **US power sector emission rules.** In June 2014 the US Environmental Protection Agency (EPA) announced draft proposals governing emissions from existing power plants. The proposal sets carbon intensity goals for each state. By 2030 the EPA projects that these will lead to a 30% reduction in US power sector emissions compared to 2005 levels. The plan is expected to be finalised in 2015.
- **South Korea's ETS cap.** In May 2014 the South Korean Government announced the cap for their emission trading system. Emissions will be capped at 1.64 $GtCO_2$ over 2015-17, making it the second largest ETS in the world after the EU's.
- **Chinese ETS pilots and solar targets.** In June 2014 the Chongqing ETS launched, meaning that all seven planned official pilot programmes are now active. In total these cover emissions over 1 $GtCO_2$/year, around twice the UK's emissions. In May 2014 the Chinese Government increased targets for solar power, and is now aiming for 70 GW of capacity by 2017 compared to the previous target of 50 GW by 2020.
- **Danish and Finnish Climate Acts.** In June 2014 both Denmark and Finland agreed Climate Acts. The Danish legislation specifies a 40% reduction in emissions by 2020. The Finnish legislation sets a target for at least an 80% reduction by 2050. In addition, both Acts create independent advisory committees to the Government.

The Government in Australia is planning to repeal legislation that underpins their emissions trading scheme. However, significant aspects of the policy framework look likely to remain, including funding for renewables and key low-carbon institutions.

7 http://www.theccc.org.uk/publication/fourth-carbon-budget-review-part-1

7. Impact of current policies on future emissions

Under the Climate Change Act we have a statutory duty to set out our views on the further progress needed to meet carbon budgets, and whether they are likely to be met. Here we set out our view on measures to achieve the cost-effective path and evaluate current policies, identifying those that we expect to achieve their intended reduction in emissions, and those that are at risk. We also show that there is a "policy gap" between emissions projections under current policies and the cost-effective path that would meet the fourth carbon budget, and make recommendations on how current policies identified as at risk can be strengthened, and how the policy gap can be bridged with new policies to achieve higher ambition.

Required measures on the cost-effective path to a low-carbon economy

In our recent *Fourth Carbon Budget Review*, we identified the likely cost-effective path to the 2050 target based on the most recent evidence on abatement options and their costs. Achieving the cost-effective path requires action across all sectors of economy, to address emissions within the energy system (e.g. power, transport, heat) and outside it (e.g. industrial processes, waste, agriculture). Necessary measures range from major capital investments to small household investments and behaviour change. Therefore, responsibility to oversee these measures is shared across all levels of government and the private sector, including the EU, the UK Government Departments, the Devolved Administrations, local authorities, firms and households.

The cost-effective path involves deployment of measures with abatement cost lower than the carbon price, and measures required to develop important options to meet the 2050 target. This delivers a major cost saving (e.g. over £100 billion in present value terms under central assumptions for fossil fuel and carbon prices) relative to delayed action. These measures include:

- **Power.** Our scenario is based on the power sector reaching an average grid intensity of around 50 gCO_2/kWh in 2030. This target can be achieved through a portfolio of low-carbon technologies including nuclear, renewables and carbon capture and storage (CCS). We also include scenarios where progress is somewhat slower, resulting in grid intensity of around 100 gCO_2/kWh in 2030.
- **Buildings.** Our buildings scenario includes extensive deployment of energy efficiency measures (e.g. wall, loft and other insulation, more efficient lights and appliances and improved energy management) and of low-carbon heat, especially heat pumps and district heating from low-carbon sources, in residential buildings and in the commercial and public sectors.

- **Industry.** Our industry scenario focuses on energy efficiency measures, supplemented by low-carbon heating particularly from biomass and biogas. Our scenario also includes some applications of CCS in the late 2020s.
- **Transport.** Our scenario includes improvements in conventional vehicle efficiency (e.g. new car CO_2 intensity improves to 110 gCO_2/km by 2020 and to 80 gCO_2/km by 2030), uptake of ultra-low-emission vehicles (e.g. in 2030 60% of new cars and vans are plug-in hybrids, battery electric vehicles or hydrogen fuel cell vehicles), use of sustainable biofuels and some demand-side measures.
- **Agriculture.** Our scenario incorporates emissions reductions from nutrient management, livestock breeding, livestock feeding, anaerobic digestion and manure management.
- **Waste and other non-CO_2.** Our scenario does not assume further abatement beyond that delivered by pre-2008 policies in waste, although we recognise the potential to go further, and include a small amount of abatement from substituting F-gases with other compounds with lower climate impact.

Delivering these measures will require significant policy ambition and development of effective policies. We now address existing plans before considering the required changes.

Current policies to deliver emissions reductions

Here we set out the current suite of policies to reduce emissions to which the Government is committed, and evaluate them to identify those that are expected to achieve their intended reduction in emissions, and those that are at risk.

Current policies to reduce emissions span all the major emitting sectors of the economy: power, buildings, industry, transport, agriculture, waste and other non-CO_2, and include:

- **Power.** A suite of policies is in place to support deployment of low-carbon generation to 2020, including the renewables obligation (RO), feed-in tariffs (FITs), capital funding for CCS demonstrations and the new long-term contracts being introduced by Electricity Market Reform (EMR). Some early EMR contracts have been signed under the Final Investment Decision Enabling Regime (FIDER), but others for the late-2010s are still to be offered. EMR contracts will be available beyond 2020, but no funding has been committed yet for this and the Government has not set an objective to signal what contracts will be signed.
- **Buildings.** Policies for residential buildings target energy efficiency (including the Energy Company Obligation and Green Deal, building regulations and Zero Carbon Homes, and products policy) and low-carbon heat, through the Renewable Heat Incentive (RHI). For non-residential buildings policies are complex, but contain a mix of information requirements, carbon price instruments, regulations and finance.

- **Industry.** Policies for industry target fuel switching, energy efficiency and low-carbon heat. The traded sector of industry faces a carbon price under the EU ETS. Other financial and tax incentives such as Climate Change Agreements (CCAs), Enhanced Capital Allowances and the Electricity Demand Reduction scheme aim to incentivise energy saving measures. There is also direct support for low-carbon heat through the Renewable Heat Incentive (RHI) and Combined Heat and Power support.
- **Transport.** Policies for transport are aimed at improvements to conventional vehicle efficiency, development of ultra-low-emission vehicles, take-up of biofuels and demand reduction. Regulations are in place at the EU level requiring improvements in new car and van efficiency; the UK has a support package for take up of Electric Vehicles; the Renewable Transport Fuels Obligation (RTFO) mandates a blend of biofuels in both petrol and diesel; there is industry-led action to increase HGV efficiency and training to improve eco-driving levels, and the Local Sustainable Transport Fund (LSTF) is available to local authorities for schemes that promote walking, cycling and use of public transport.
- **Agriculture.** The main agriculture policy is the GHG Action Plan, currently in Phase 2 (2012-2015), which is a voluntary agreement with industry intended to promote improvements in farming practices in target sectors (i.e. crop nutrition improvements, promoting low emission animal diets and improvements to animal health). Phase 3 (2015-2020), is planned to promote additional cost-effective measures, should these be identified following expected improvements in the emissions inventory.
- **Waste and other non-CO_2.** The main policy lever in the waste sector is the landfill tax, which is levied per tonne of waste sent to landfill and has been increased significantly over its history (from a starting level of £7/tonne in 1996 to £80/tonne in 2014). This is supplemented by voluntary responsibility deals, information awareness campaigns, support for anaerobic digestion and permitting requirements for methane capture at landfill sites. F-gases are regulated at the EU level.

DECC forecast the impact on GHG emissions of all policies to which the Government is committed. The most recent forecast, *Updated Emissions Projections (UEP) 2013*, sets out the estimated impact of policies introduced in the 2009 *Low Carbon Transition Plan* or later, against a baseline ("business as usual") projection without these measures. Supplier obligation policies CERT and CESP are therefore included, despite being replaced by the Energy Company Obligation.

In Chapters 2-7 of this report we assess these policies' chances of success against a set of criteria (Box 1.6). Where these policies are expected to deliver we classify them as "lower risk" (Table 1.3). Where they fail to meet our criteria, we consider these to be "at risk" (Table 1.4), either due to design and delivery problems, or because they are currently unfunded.

We also identify those parts of our scenario for which there is no existing policy to drive delivery (Table 1.5). Many of these relate to the period after 2020, for which the Government recognises the need to develop new policies. It is an expected part of the policy process that as budgets stretch out further in time and require deeper emissions reductions, so policies will need to be developed further. However, given the lead-time for new policy to deliver emissions reductions and the value of stability and visibility for business, these policy changes now need to be made.

Box 1.6: 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 lobbying, lack of coherence, or lack of political support. We also assess whether the 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".

Table 1.3: Lower-risk policies	
Policy	**Why the policy is expected to deliver**
Power	
Renewables Obligation, feed-in tariffs (FITs) and the Final Investment Decision Enabling Regime (FIDER)	Policies target the right technologies and have been effective in the past. Support is broadly matched to technology costs and funding is sufficient
Buildings (residential)	
Real-time displays/ smart meters	Energy suppliers have an obligation to deliver full roll-out by 2020. A central delivery body has been set up to promote behaviour change via consumer engagement activities in order to achieve energy demand reduction.
CERT (2009-12) and CESP (2008-12)	CERT (Carbon Emission Reduction Target) 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) achieved 85% of the carbon savings target.
EU Products Policy Tranche 1	The Ecodesign Directive sets minimum standards for appliances which ratchet up over time. Energy labelling helps overcome consumer awareness barriers. Most of tranche 1 standards are now in place. Some questions remain over rate of stock replacement and number of consumers choosing the most efficient appliances.
Buildings Regulation Part L 2010	Long-standing effective policy, 2010 tightening of standards significant, provided level of compliance and future build rates are adequate.
Renewable Heat Incentive (RHI) to April 2016	Despite delays to its introduction, the RHI was implemented in 2014 and targets the relevant financial barriers. Incentivises the right mix of low-carbon technologies. Issues around low awareness and consumer confidence still to be addressed, but it should stimulate the market in key off-gas segments and in social housing, although landlord-tenant issues remain in the private-rented sector. Incentives broadly at the right level. Funding has been committed until April 2016.
Buildings (non-residential)	
Business Smart Metering	Although the estimated savings for businesses are based on a single study (in contrast with smart metering in homes, where there is better evidence), smart metering addresses a key information gap, with roll-out driven by the requirement on energy suppliers.
RHI to April 2016	Right mix of technologies are targeted. Policy savings have been revised downwards based on market forecasts, and are now reasonably cautious. Although uptake to date has been mainly biomass, government has responded with recent changes to the scheme including new tariffs, which are now broadly at the right level. Funding has been committed until April 2016.

Table 1.3: Lower-risk policies	
Policy	**Why the policy is expected to deliver**
Industry	
RHI to April 2016	As in buildings.
Transport	
New car & van CO_2 (EU regulations)	Regulation with stiff penalties for non-compliance, supported by UK fiscal policies. Targets legislated to 2020. More representative test cycle due to be introduced.
Electric vehicle support package to 2020	Funding package tackles all major barriers with combination of measures shown to be effective in leading markets. £500 million overall, inc. min £200 million for PiCG to 2017 or 50,000 cars; £32 million for infrastructure; £35 million for city schemes & £20 million for taxis; £100 million for R&D. Plug-in Car Grant of up to £5,000 per car is about right in the near term.
Local Sustainable Transport Fund	£600 million of DfT funding to 2015 (62.5% revenue, 37.5% capital), plus £535 million from LAs, for measures to tackle information and organisational barriers (e.g. school & workplace travel plans) and complementary infrastructure investment (e.g. cycle lanes). Level of funding per head broadly comparable to successful Sustainable Travel Towns pilot projects. Local Growth Fund providing funding in 2015/16.
HGV Low Rolling Resistance Tyres/ Gear Shift Indicators	Mandated by EU regulation
Low Carbon Buses	£30 million m funding provided by OLEV from 2015-2020 to stimulate uptake of 1,000 Low Carbon buses. Funding will be provided on a declining basis as the cost differential between these and conventional buses narrows. DfT is working with the Green Investment Bank to assist potential buyers with financing.
Rail Electrification	Work is currently ongoing to electrify a number of lines in the North of England, as well as the Great Western Mainline. Electrification is at varying levels of completion, however progress is currently on-track.

Table 1.4: At risk – policies with design/delivery problems or lack of funding	
Policy	**Why the policy is 'at risk'**
Power	
Carbon Capture and Storage (CCS) demonstration	Targets the right CCS applications; continuing risks to delivery of technology and reaching the final investment decision; £1 billion funding has been allocated.
Fuel switching	Some existing coal plant will close under LCPD & IED. However, other plant may stay open for some time due to weakness of EU ETS and low coal prices. No new unabated coal plant due to EPS. Capacity mechanism is an incentive for new gas plant
Contracts for Difference (CFDs) to 2020	Programme is in place, however lack of support beyond 2020 may increase uncertainty for bidders pre-2020. Support broadly appropriate (EMR report). Support in two pots, respective sizes and detailed design (e.g. maxima & minima) yet to be announced
Nuclear – first 2 reactors at Hinkley	Agreement on terms for proposed first contract but risks around state aid. Level of agreed strike price appropriate, contract terms have been agreed, but contract is not in place.
Buildings (residential)	
ECO and domestic Green Deal	While it is aiming to target the right measures and customer types (e.g. fuel poor, hard- to-treat homes and rural households), uptake to date has been very low due to low ambition and poor design, and carbon saving targets are off track. Furthermore, current proposals to amend the ECO are creating a lot of uncertainty. No commitment post-2017.
EU Products Policy Tranche 2	As above for tranche 1 but question marks over implementation as significant process delays. Estimate of savings in UEP is high – it is not clear how robust the model on which these are based is.
RHI from April 2016	No committed RHI funding after the 2015-16 financial year.
Zero Carbon Homes	Policy to be introduced from 2016 but Government has proposed exemptions for small developments. Scale of exemptions to be consulted on but could be significant.
Buildings (non-residential)	
EU Products Policy tranche 1	As with domestic products, minimum standards for products are set under the Ecodesign directive and ratcheted up over time. Realised savings are at risk due to delays to implementation and uncertainty around stock replacement rates. Assumptions underpinning modelled savings are unclear and under review. Overall, the risks are greater than with tranche 1 domestic appliances due to a less developed evidence-base.
EU Products Policy tranche 2	Shares same risks as tranche 1, with additional risks due to delays to implementation process.
Non-domestic Green Deal	Whilst the policy tackles a gap around finance for energy efficiency in SMEs, demand for the finance at the currently high interest rates is low. Pay-as-you-save model from the domestic sector is less well adapted to complex landlord-tenant relationships in the commercial sector.
CRC energy efficiency scheme	The scheme is targeting energy use not covered by existing policies, incentivising energy efficiency and addressing an information barrier. However, its credibility has been weakened due to the changes to the scheme, including the loss of the reputational lever of the performance league table. It is now a modest carbon tax which is hampered by the original trading scheme design architecture.

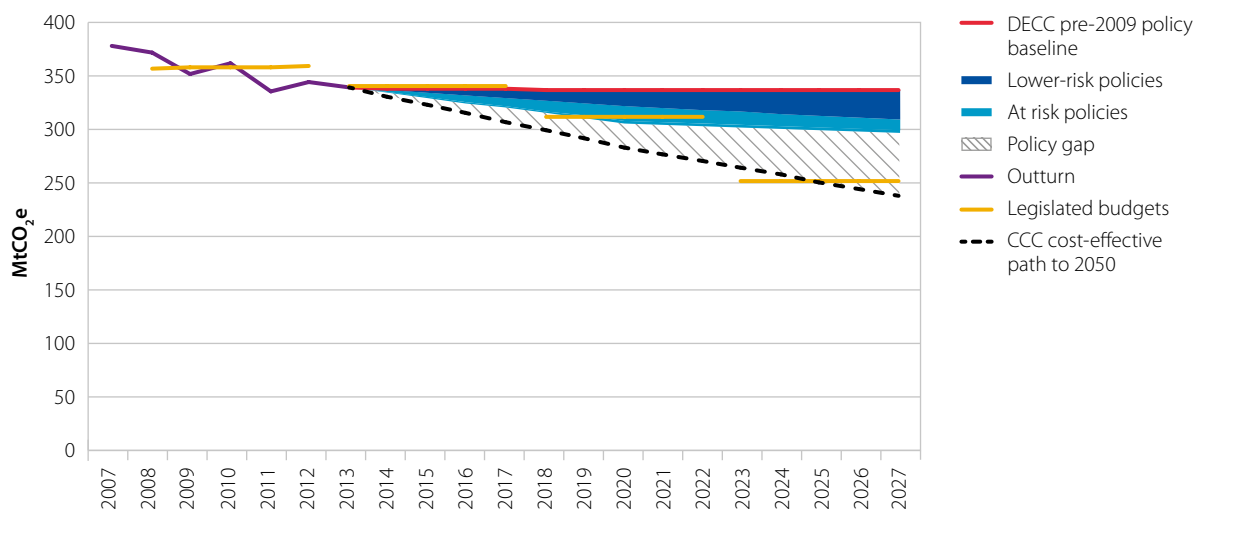
Table 1.4: At risk – policies with design/delivery problems or lack of funding	
Policy	**Why the policy is 'at risk'**
Building Regulations part L 2010	Focuses on the right barrier by regulating that developers meet certain CO_2 reducing standards compared to previous 2006 regulations. There are however some questions around the modelled savings based on the SBEM model, which are being reviewed in light of new bills data. This leads to uncertainty around compliance and the 'performance gap' between buildings as designed, built and in-use.
RHI from April 2016	As in residential buildings
Industry	
EU Products Policy tranches 1 and 2; Building Regulations part L 2010; RHI from April 2016	As in buildings.
Transport	
Biofuels policy	Renewable Transport Fuels Obligation (RTFO) currently flat-lined at 4.75% (by volume) pending EU decisions on limiting first generation biofuels, indirect land use change and the role of second generation biofuels. Current level insufficient to deliver levels assumed to 2020 (penetration assumed to revert to current level post-2020).
HGV industry led action	Schemes such as the Logistics Carbon Reduction Scheme (LCRS) encourage voluntary action and help members share best practice; LCRS has emissions intensity target for 2015. But dominated by larger operators; no policy addressing financial barriers for smaller operators.
Low Carbon Buses	Uptake projected by OLEV appears optimistic given experience with Green Bus Fund round 4. Even if the full 1,000 buses are achieved this remains below the necessary uptake to 2030 to be consistent with UEP projections.
Agriculture	
GHG Action Plan	Targets cost-effective measures but reliance on a voluntary approach risks the delivery of carbon savings. No mechanism in place to evaluate if the policy is delivering emissions reductions in line with the ambition of the Plan.

Table 1.5: Missing policies	
Measure	**Comment**
Power	
Power sector deployment beyond 2020	Moving the power sector from 200 gCO_2/kWh in 2020 to 50-100 g/kWh by 2030.
Buildings	
Residential energy efficiency post-2017	The ECO is currently proposed to be in place until 2017 but a large potential for energy efficiency will remain (e.g. 2.6 million cavity walls and 7-8 million solid walls could benefit from insulation measures). Further measures will be needed either through an extended ECO or other approaches (e.g. local authority-led area-based energy efficiency programmes).
Low-carbon heat beyond 2020	No proposed policies to drive low-carbon heat beyond 2020. The RHI should be extended until and unless there is an alternative framework in place. Financing costs need to be reduced and non-financial barriers addressed. Further abatement opportunities exist in new-build properties, which could be unlocked through the planning framework.
Industry	
Low-carbon heat beyond 2020	As in buildings
Energy efficiency	The forthcoming "2050 decarbonisation roadmaps" should be used to identify opportunities for cost-effective abatement from energy efficiency in detail, and set out mechanisms for delivering this abatement.
Industrial CCS	An approach to deploying initial industrial CCS projects needs to be set out, compatible with widespread deployment from the second half of the 2020s.
Transport	
Electric vehicles beyond 2020	No policy to address upfront cost barrier post-2020.
Biofuels	No policy post-2020 at UK or EU level.
Passenger demand reduction	No policy beyond 2015-2016. Important that measures are sustained in order to sustain changes in travel behaviour.
HGV demand side reduction	Demand side action expected to be led by the Logistics Carbon Reduction Scheme (LCRS); currently no LCRS target beyond 2015; membership is limited.
Agriculture	
Further ambition in agriculture policies	No policy post 2022.

Figures 1.17 and 1.18 set out the expected impact of policies that are lower risk, and policies that are at risk, against the cost-effective path to the 2050 target and the legislated carbon budgets, for the non-traded and traded sectors.

- In the non-traded sector, lower-risk policies alone are likely to be sufficient to outperform the second carbon budget (2013-2017), but not the third (2018-2022) which requires strengthening of existing policies assessed as 'at risk'. Even if 'at risk' policies deliver fully this will not be sufficient to meet the fourth carbon budget (2023-2027), which requires new policies to be developed.
- In the traded sector, lower-risk policies alone may be sufficient to meet the UK share of the EU ETS cap in the second and third carbon budget periods (2013-2017 and 2018-2022). However, even if existing policies are strengthened so that 'at risk' policies deliver, there would be a large gap to the cost-effective path from the late 2010s, implying that consumers would be exposed to higher costs in the long run.

Figure 1.17: Assessment of current and planned policy against future targets (non-traded sector)

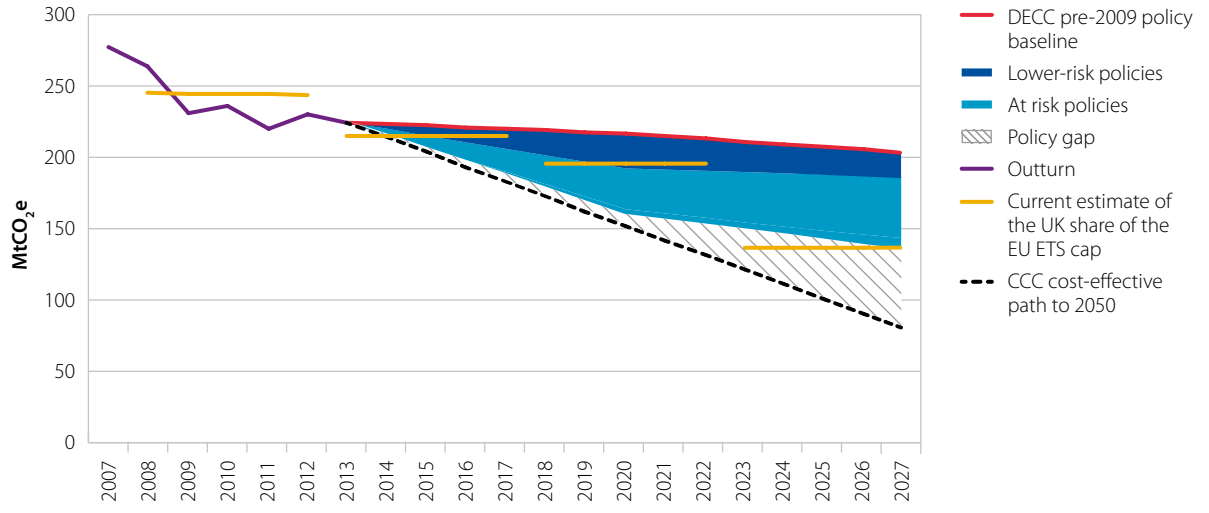


Source: DECC (2013) *Updated emissions projections*; CCC analysis.

The expected shortfall in the impacts of policy in both traded and non-traded sectors indicates there is a large policy gap, where new policies are required to meet the cost-effective path and the fourth carbon budget.

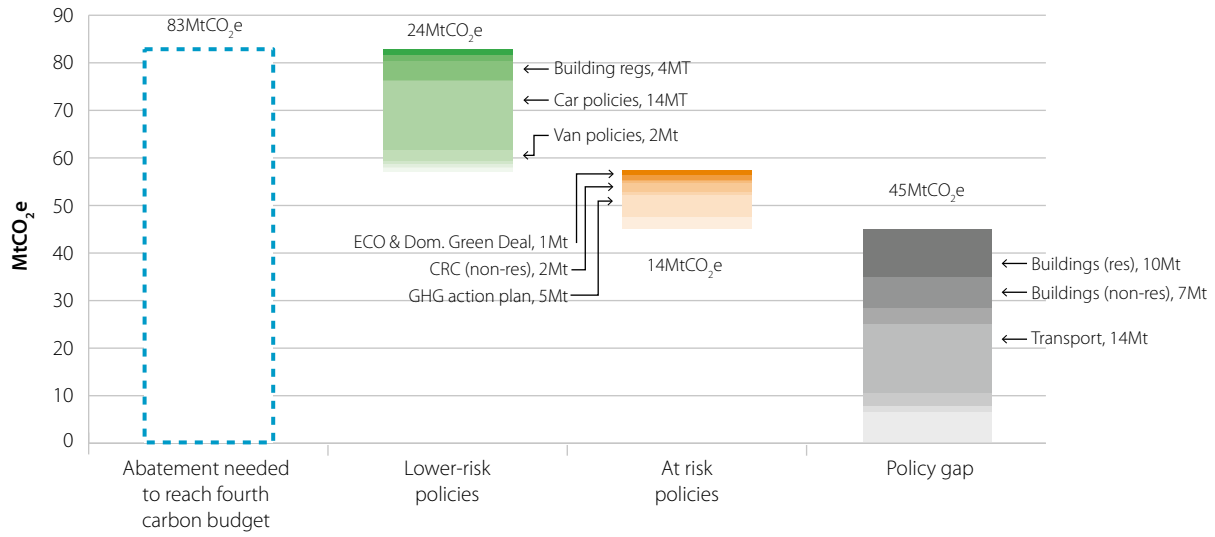
The details of the gap for the non-traded sector are set out in Figure 1.19 for 2025. Of a total of 83 $MtCO_2e$ of abatement required to meet the fourth carbon budget in 2025, policies assessed as lower risk are expected to deliver 24 Mt, while those assessed as at risk are expected to deliver 14 Mt. This leaves a policy gap of 45 Mt to meet the cost-effective path and the fourth carbon budget.

Figure 1.18: Assessment of current and planned policies against future targets (traded sector)



Source: DECC (2013) *Updated emissions projections*; European Commission (2014) *Verified emissions data*; CCC analysis.

Figure 1.19: Getting from the DECC pre-2009 policy baseline to the fourth carbon budget in 2025



Source: DECC (2013) *Updated Emissions Projections*; CCC analysis.

Ensuring that policies deliver emissions reductions on the cost-effective path

In order to ensure a sufficient reduction in emissions to achieve the cost-effective path and meet the fourth carbon budget, it will be important both to strengthen current policies assessed as at risk, and to close the policy gap, where new policies are required.

This will require improving existing policies to address design and delivery risks, extending commitments towards 2030 and developing strategies to reduce emissions in new policy areas. Our detailed recommendations are set out in Chapters 2-8 and in Box 1 of the executive summary.

- Our recommendations for improving existing policies are most focused on the energy sectors, where the existing policy landscape is currently most developed:
  - **Buildings:** Strengthen the Green Deal and Energy Company Obligation (ECO); simplify and rationalise policies for energy efficiency in the commercial sector; set energy performance standards for the private rented sector; ensure Zero Carbon Homes requires either low-carbon heating or very high heating efficiency standards; alongside the Renewable Heat Incentive (RHI) tackle financial and non-financial barriers to uptake of low-carbon heating. The Green Deal should be extended to cover the up-front cost of low-carbon heat technologies funded under the RHI.
  - **Transport:** Work with partner organisations to tackle financial and non-financial barriers to uptake of electric vehicles; align fiscal levers over time with improving car efficiency; address potential for demand-side reductions.
  - **Power:** Complete implementation of Electricity Market Reform (EMR); set appropriate strike prices and sign contracts for low-carbon capacity; ensure a suitable mix of low-carbon technologies is supported; ensure final market design recognises the value of demand-side measures, interconnection, storage and flexibility in generation; push for EU ETS reform backed by strong emissions targets; require that all biomass in sustainably sourced.
- Extended commitments are needed across the emitting sectors and are particularly important in the power sector, for low-carbon heat and for electric vehicles:
  - **Power.** The long-term contracts for low-carbon power generation introduced by EMR provide revenue stability for investors. However, there is currently no agreed objective beyond 2020 to guide the signing of contracts. Given the long lead-times for power investments, this should be resolved by setting a target range for carbon intensity in 2030, as legislated for in the Energy Act. Our previous analysis suggests a range of around 50-100 gCO_2/kWh would be consistent with the cost-effective path for a range of outcomes for fossil fuel prices, carbon prices and low-carbon technology costs.

- **Low-carbon heat.** While it is possible that alternative delivery mechanisms could be found in the future, the RHI is the only realistic support mechanism for investment in low-carbon heat for the foreseeable future. Given the need to increase low-carbon heat uptake and encourage development of this market, funding for the RHI should be committed to 2020, and a commitment should be made to its continued existence beyond 2020. This would resolve current uncertainty, where funding has been committed only until 2016, and the policy is due to end in 2020.
- **Electric vehicles.** To build on early development of the EV market, further action is required to address financial and non-financial barriers to uptake. Industry is best placed to tackle many of these barriers through marketing EVs and developing innovative financing approaches. To incentivise the necessary industry action, Government should support a strong EU target for new car emissions in 2030 designed to require significant penetration of EVs, and consider how to phase out the EV subsidy.

- New strategies for emissions reduction are needed in areas where policy is currently less developed. That includes industry, agriculture, waste and F-gases. New strategies are also needed for development of carbon capture and storage (in power and in industry), for commercialisation of offshore wind and for the approach to fuel poverty.

We also make the following cross-cutting recommendations:

- The Government should continue to **push for a combination of EU ETS reform and ambitious emissions targets for 2020 and 2030** that will put the EU on the cost-effective path to meeting its target for at least an 80% emissions reduction by 2050 relative to 1990 and will deliver an EU ETS price that is sufficient to incentivise emissions reduction activities in the power sector. The regulatory regime should also allow for negative emissions (e.g. from use of bioenergy with CCS) to count towards required emissions reduction.
- On **biomass sustainability**, the Government should continue to push for Indirect Land Use Change (ILUC) impacts to be fully taken into account in EU biofuel sustainability criteria; in the 2016/17 review of UK bioenergy strategy, add to the UK's criteria for biomass sustainability a requirement that all biomass is sourced from forests that can demonstrate constant or increasing carbon stocks, and push for this to be reflected in standards at the EU level (Box 1.7).

Progress is possible in all of these areas, and has generally been recognised by the Government as being needed. Taken together they would put the UK well on the path towards the fourth carbon budget and the 2050 target, avoiding the higher costs associated with delaying action until after the fourth budget period (2023-27), which would require very rapid action, entailing escalating costs.

Box 1.7: Sustainability of bioenergy

In order that bioenergy provides genuine emissions reductions, it is important that there are appropriate regulations in place to ensure that feedstocks are sustainable. There are mandatory EU sustainability standards for use of bioenergy in transport; in the power and heat sectors there is a voluntary approach, whereby the EU provides recommended criteria that individual member states could use if they wish to introduce a scheme at national level. Within the UK, bioenergy is subject to sustainability standards in the transport and power sectors, and from Spring 2015, also in use for heat generation.

It is important that sustainability criteria cover the full range of relevant considerations and that quantitative limits are set at appropriate levels. While some progress has been made on developing standards at EU and UK levels, they need to go further on their treatment of indirect land-use change (ILUC) impacts and carbon stocks.

Indirect land-use change impacts

Indirect land-use change (ILUC) emissions occur when growth of bioenergy crops displaces an existing economic activity (e.g. agricultural or timber production) to new land which, on conversion, leads to the release of CO_2. For some types of bioenergy crops, ILUC has the potential to outweigh the carbon savings from displacement of fossil fuels.

While ILUC is a bigger issue for transport, as first-generation liquid biofuels tend to compete with food production, it can also apply to feedstocks used for power and heat markets.

Currently, no allowance is made for ILUC in EU bioenergy standards:

- A recent EC proposal would mandate transport biofuels suppliers to report on ILUC impacts. While this does not go far enough, it is a first step towards their full inclusion in EU sustainability criteria (see Chapter 5).
- At present, there are no plans to include consideration of ILUC impacts for biomass used in power and heat.

The UK Government should continue to push for ILUC impacts to be fully taken into account in EU transport biofuel sustainability criteria, in order that these fuels deliver genuine emissions savings. While ILUC emissions are likely to be less important for the power and heat markets, relevant criteria should also take account of them if evidence shows that they are significant.

Carbon stocks

In our 2011 Bioenergy Review we recommended a life-cycle emissions standard for biomass electricity generation of 200 gCO_2/kWh, falling over time, which was adopted by the UK Government in 2013. Alongside this, we stated that in order for use of forest biomass to lead to emissions reductions on a life-cycle basis, it should be sourced from forests with constant or increasing carbon stocks. However, current standards do not require this.

The UK Government has proposed to resolve methodological challenges (e.g. whether stocks should be maintained for each forest or at a broader geographical area) and bring this issue into the criteria for new biomass power-generation capacity installed from April 2019, as part of the planned 2016/17 UK Bioenergy Strategy Review.

As this issue affects both new and existing biomass capacity, as well as forest biomass used for heat, we recommend that in this Review the Government should:

- Add to the UK's sustainability criteria a requirement that all forest biomass (i.e. that used in both new and existing power capacity, and also in heat and any other relevant sectors) is sourced from forests that can demonstrate constant or increasing carbon stocks.
- Push for this criterion to be reflected in standards at the EU level.

We will continue to monitor the available evidence in relation to ILUC and carbon stocks, together with developments on sustainable bioenergy supply more generally.

Uncertainty analysis

There is considerable uncertainty over the future level of UK emissions. As set out above there is a significant uncertainty over the effectiveness of planned policy, which can be resolved to some extent through policy redesign and appropriate commitments.

There are other uncertainties, for example over economic conditions, population, fuel prices and winter temperatures, which are not within the full control of policy-makers, but can significantly affect the level of emissions for a given set of policies.

To capture this uncertainty we have drawn on DECC's analysis for the published emissions projections to estimate the range of emissions outcomes over the second, third and fourth carbon budget periods against the legislated budgets (Box 1.8).

This analysis demonstrates that even with full delivery against DECC's policy assumptions there could be a shortfall to the third carbon budget, and the gap to the fourth carbon budget could be even larger than set out above:

- Even if all existing policies (i.e. both lower-risk and at-risk policies) deliver as planned, there could be a gap to the third carbon budget of up to 50 $MtCO_2e$. Given that we have identified significant risks to that delivery, the gap could be up to 120 $MtCO_2e$ if only lower-risk policies deliver (Table 1.6).
- For the fourth carbon budget, DECC's own analysis implies a gap of 135-315 $MtCO_2e$, reflecting that policies to meet the fourth carbon budget have not yet been introduced. Given the risks to policy delivery we have identified, the emissions gap could be as high as 370 $MtCO_2e$.

In conclusion, the Government's set of planned policies is not currently sufficiently well designed to give confidence in delivery against the third carbon budget and even if successful would fall well short of the fourth carbon budget. Existing policies need to be strengthened and extended and new policies need to be introduced in order to close this gap and meet future carbon budgets, and close monitoring of progress will be needed given the inherent uncertainties.

Table 1.6: Abatement shortfall against legislated carbon budgets under different levels of policy delivery

	Abatement shortfall ($MtCO_2e$)		
$MtCO_2e$	**Budget 2 period (2013-2017)**	**Budget 3 period (2018-2022)**	**Budget 4 period (2023-2028)**
Delivery of lower-risk policies only	-30 to +20	+30 to +120	+260 to +370
Delivery of lower-risk + design/delivery problem policies	-50 to -10	-30 to +60	+210 to +310
Delivery of lower-risk + design/delivery problem + unfunded policies	-50 to -10	-40 to +50	+200 to +300

Source: CCC calculations and DECC modelling, detailed in Box 1.8.
Notes: Ranges given are the 10-90% confidence intervals rounded to the nearest 10 $MtCO_2e$; a positive number indicates that emissions would exceed the Budget level. Shortfalls are presented cumulatively across the 5-year budget periods.

Box 1.8: Range of future emissions due to economic growth, population and other factors

Future emissions depend not only on the uptake of low-carbon measures, but also on wider factors such as population, economic growth, temperature (which affects heating and cooling demand) and fuel prices. Forecasts for each of these carry some uncertainty. This leads to a range of possible emissions outcomes over the carbon budget periods.

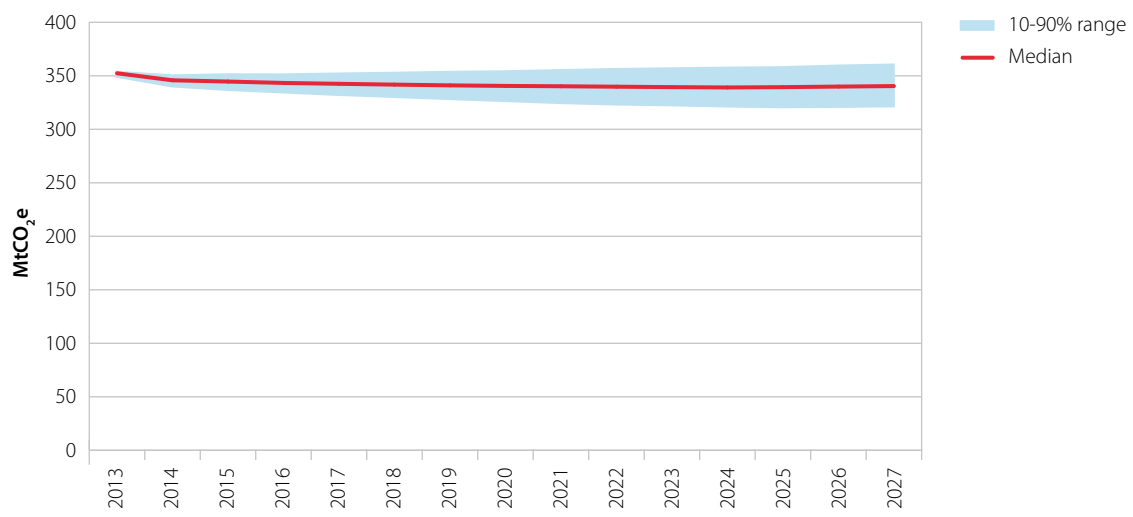
DECC has estimated this future emissions uncertainty using their energy demand model. They identified the parameters that most influenced emissions, developed plausible distributions for these parameters, and then sampled from them to generate a "fan chart" time series.

We worked with DECC to rerun their analysis for the baseline scenario of no further policy action, sampling future uncertainty in the following parameters:

- National Gross Domestic Product (GDP), plus other parameters that are highly correlated with it: population, number of households, and Gross Value Added (GVA) from the commercial sector.
- The number of annual heating degree days for gas and electric heating.
- Steel production.
- We also add uncertainty in agricultural emissions of methane and nitrous oxide taken from Defra's updated baseline projections for agriculture.

The results show a range of uncertainty of the order of 30 $MtCO_2e$ for UK non-traded sector emissions by 2027, the end of the legislated carbon budgets (Figure B1.7); this range is 10% of total non-traded sector emissions in 2027. Uncertainty in traded sector emissions does not affect carbon budgets since they are fixed by the EU cap.

Figure B1.7: Uncertainty in baseline projections of non-traded sector emissions (2013-2027)



Source: DECC & CCC analysis.

These numbers are likely to be an underestimate of the total uncertainty in future emissions and should be seen as indicative only. This is because they only sample a subset of all relevant factors and are dependent on the model used, which is primarily set up for making projections rather than for testing sensitivities. Uncertainty in fossil fuel prices, for instance, is not included here because it contributes little to emissions uncertainty in the DECC model. Our own analysis indicates that the range of uncertainty may be around double that allowed for in the DECC fan chart analysis, when higher elasticities for fuel prices are included.

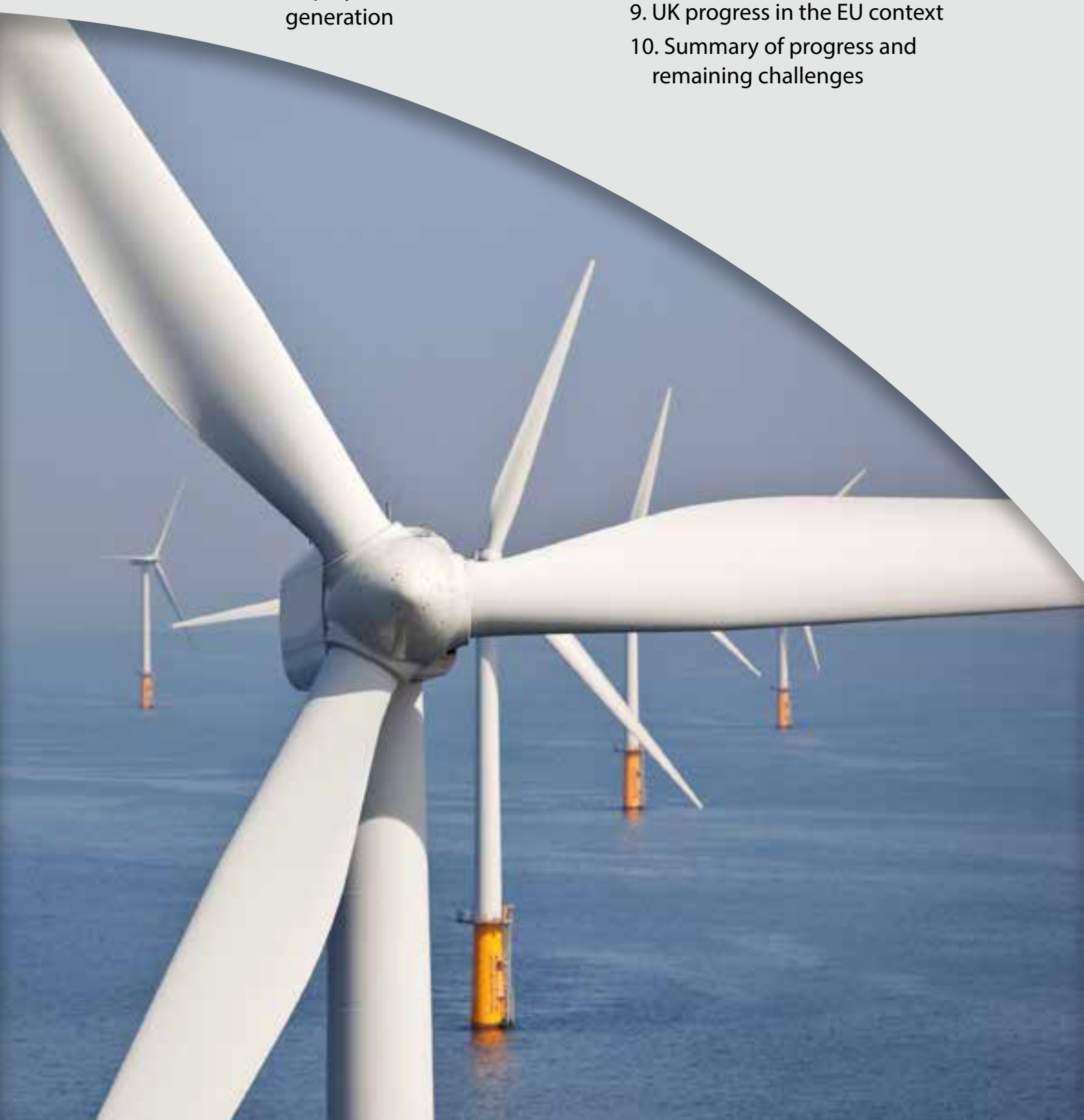
We provide emissions ranges under the different policy scenarios, based simply on applying the same proportional uncertainty from the baseline. We will investigate further the uncertainty in future emissions for our advice on the Fifth Carbon Budget and our next progress report, both to be published in 2015.

Source: DECC (2013) Updated Energy and Emissions Projections 2013; DECC & CCC calculations.

Key findings

- UK greenhouse gas emissions **decreased 2%** in 2013.
- Emissions decreased 12% over the period 2007-2012. As a result the UK's net carbon account for the first carbon budget period was 2,982 $MtCO_2e$, 36 Mt below the level of the first carbon budget of 3,018 $MtCO_2e$. The UK has therefore **met the first carbon budget**.
- Over the first carbon budget period there has been **good progress** on implementing some measures, for example deployment of **onshore and offshore wind**, **efficient boilers** and **new car efficiency**.
- However, progress on many measures has been **limited**, for example, **energy efficiency improvement** in commercial and industrial sectors, **low-carbon heat** penetration in buildings, and demonstration of **carbon capture and storage**.
- Overall UK progress in reducing emissions is **in line with our EU and international commitments**, and is broadly keeping pace with other countries.
- We expect that current policies will not be sufficient to achieve the cost-effective path and meet the fourth carbon budget; a **further reduction in emissions** of 45 $MtCO_2e$ in 2025 will be required.
- There is therefore a "policy gap", which will require developing **strategies in new policy areas**, developing **new policies**, and **raising the ambition and extending the time frame** of current policies, across all sectors of the economy.

Chapter 2



Chapter 2: Progress reducing emissions in the power sector

1. Introduction and key messages

In this Chapter we consider progress investing in new low-carbon power generation and associated infrastructure over the first carbon budget period, as well as examining the latest emissions data for 2013. We outline priorities for taking forward the policy framework to ensure we build on this progress and meet future carbon budgets.

Deep decarbonisation of the power sector by 2030 is central to emissions reduction across the economy and meeting the UK's legislated commitments at lowest cost. This reflects that:

- Power is a major source of emissions (around one quarter of total UK emissions)
- Low-carbon technologies are available for power generation which are or are likely to become cost effective (i.e. cheaper than fossil fuel generation facing a rising carbon price)
- In the period to 2030 there will be significant capital stock turnover in the UK's power system as assets retire, creating an opportunity for early investment in low-carbon generation
- Power can be used as a route to decarbonisation in other sectors (buildings, transport and industry).

Furthermore, decarbonisation through investment in a portfolio of low-carbon technologies is a low-regrets strategy with potentially significant benefits in a carbon-constrained world. Even if gas prices were to fall significantly or carbon price were to remain low, there would be no more than a small cost saving from the alternative strategy of investment in gas-fired generation in the 2020s, followed by investment in low-carbon technologies in the 2030s.

Our key messages are:

- Power sector emissions fell by 11% over the first carbon budget period from 2007 to 2012 as a result of lower electricity generation (due to the recession) and investment in new gas-fired and low-carbon capacity. In 2013, emissions decreased a further 8% on 2012 levels.
- There has been a step-change in the rate of investment in renewables, in particular wind. There is enough in the pipeline to sustain this rate of progress to 2020 as required by the EU Renewable Energy Directive; however stronger signals are required over commitments beyond 2020.
- Nuclear and carbon capture and storage (CCS) have experienced substantial delays but they are now better placed to move forward. Nuclear investment was delayed at least 5 years in part as a result of a nuclear safety review and negotiations associated with reform of the electricity market. The first CCS competition did not deliver any demonstration projects, although a second competition is now underway and two preferred bidders have been identified. Both these technologies need to be progressed urgently, and the basis for a programme of deployment now exists.

- The Energy Act was passed in 2013, enabling a transition to a low-carbon power sector; this is a major step forward in the move to a low-carbon economy. This includes the introduction of long-term contracts, which will provide revenue certainty for low-carbon projects once contracts are signed. However, there is a high degree of uncertainty about investment beyond 2020. An unambiguous commitment to decarbonising the power sector is needed to provide investors with confidence that there will be a market for low-carbon technologies in the 2020s (e.g. to support supply-chain investment, which has long payback periods, and development of new projects, which have long lead-times). A failure to invest beyond 2020 would imply that earlier investments are largely wasted, in that they were aimed at technology commercialisation which did not ensue.
- The Energy Act provides for a carbon intensity target range for 2030 to be set in 2016. The signal provided by the carbon intensity target should be backed up by a commitment of funding consistent with meeting the target, and commercialisation and cost reduction strategies for emerging technologies. Success here requires a package of measures that balances certainty of a future market with incentives for cost reductions, while retaining some flexibility to safeguard consumer interests.
- Our recommendations for the power sector are summarised in Box 2.1.

Box 2.1: Power sector recommendations

- **Complete implementation of Electricity Market Reform (EMR)**; set appropriate strike prices and sign contracts for low-carbon capacity; ensure a suitable mix of low-carbon technologies is supported; ensure final market design recognises the value of demand-side measures, interconnection, storage and flexibility in generation; require that all biomass is sustainably sourced.
- **Add to the UK's criteria for biomass sustainability**, in the 2016/17 UK Bioenergy Strategy Review, a requirement that all biomass (i.e. both new and existing capacity) is **sourced from forests that can demonstrate constant or increasing carbon stocks**, and push for this to be reflected in standards at the EU level.
- In 2016**, set a carbon intensity target range for 2030** under the Energy Act 2013, consistent with cost effective decarbonisation of the economy (e.g. 50-100 g/kWh).
- No later than 2016, **commit funding for low-carbon generation in the period beyond 2020**.
- By 2016, **publish a commercialisation strategy for offshore wind** that includes levels of ambition to 2030, a target cost reduction schedule under which ambition will be maintained or increased; the point in time when the technology will be expected to compete with other low-carbon options without support; and the Government's role in supporting those reductions.
- By 2016, **publish a strategy to develop carbon capture and storage (CCS)** in both power and industry, including CO_2 infrastructure development, minimum levels of deployment over the period to 2030, and an approach to funding for projects beyond current policy (including higher levels of deployment dependent on cost reduction).
- **Continue to push for a combination of EU ETS reform and ambitious emissions targets for 2020 and 2030** that will put the EU on the cost-effective path to meeting the at least 80% target for 2050, deliver an EU ETS price that is sufficient to encourage emissions reduction activities in the power sector. ETS reform should include allowing for negative emissions (e.g. from use of bioenergy with CCS) to count towards required emissions reduction, as currently they cannot do so.

We set out analysis underpinning these messages in the following sections:

- Power sector emissions
- The Committee's approach to tracking progress in the power sector
- Investment in renewable generation
- Deployment of new nuclear generation
- Cost reduction and commercialisation of CCS
- Supporting infrastructure for low-carbon generation
- Progress and remaining challenges in Electricity Market Reform
- UK progress in the EU context
- Summary of progress and remaining challenges

2. Power sector emissions

Emissions over the first carbon budget

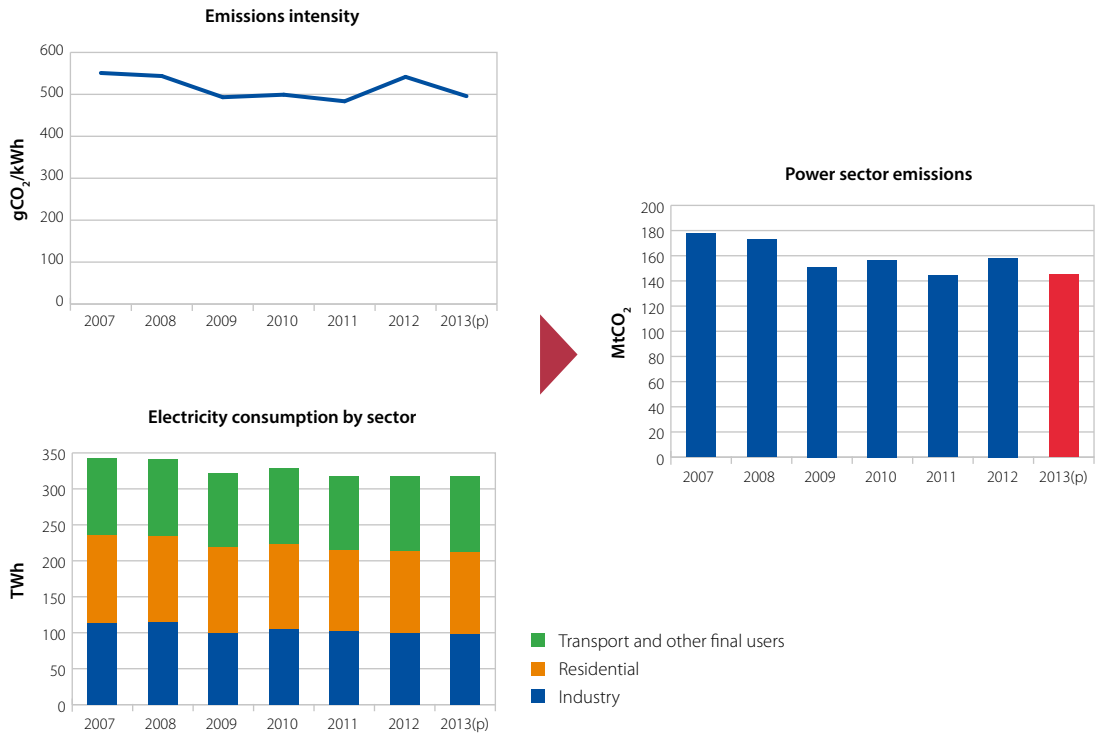
The Committee's power sector emissions framework sets out a path towards a largely decarbonised power sector by 2030. Emissions over the first carbon budget period (2008-12) were 783 $MtCO_2$, in line with expectations when the budget was set (784 $MtCO_2$). Annual emissions fell by 11% from 2007 to 158 $MtCO_2$ in 2012 (26% of total UK greenhouse gas emissions), as a result of falling demand for electricity and reduced carbon intensity of electricity supply (Figure 2.1, Figure 2.2).

- Demand for electricity fell by 7% over the first carbon budget period, and was below our expectations throughout the first carbon budget (averaging 324 TWh/year, compared with 342 TWh in 2007). Much of this demand reduction has been a result of the recession, with some energy efficiency in end-use sectors.
- Emissions intensity of the electricity grid[1] fell from 551 gCO_2/kWh in 2007 to 484 gCO_2/kWh in 2011 and then rose to 544 gCO_2/kWh in 2012. This reflected increasing shares of low-carbon generation and a decrease in the share of gas, offset by increased coal burn in 2012.
- Coal burn increased in the latter part of the first carbon budget because of improved economic conditions for coal, triggered by cheap US exports following the shale gas boom and the collapse of the EU carbon price. Some operators increased generation as they exhausted their allowable hours ahead of closure as part of EU air-quality regulations.

Higher coal burn in the short term is not necessarily a risk for meeting carbon budgets (see Box 2.2).

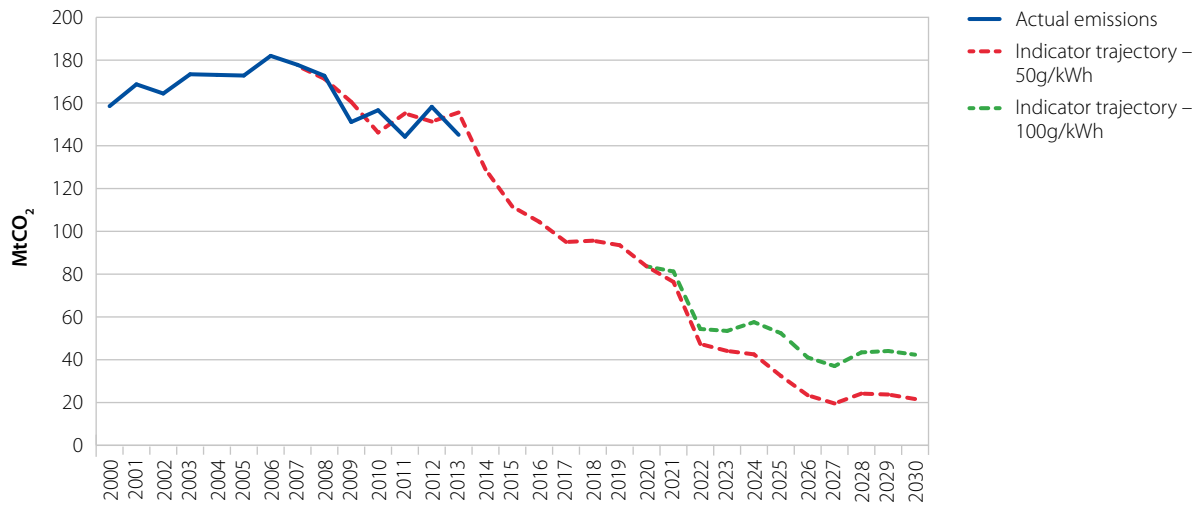
1 Includes electricity exported to the grid from solar PV.

Figure 2.1: Emissions intensity of electricity supply, electricity demand and CO_2 emissions from the power sector (2007-2013)



Source: Source: DECC (2014) *Energy Trends*; DECC (2014) *UK Greenhouse Gas Emissions 1990-2013 (provisional)*; CCC calculations.
Notes: Emissions intensity is UK based useable generation, i.e. excluding losses. Electricity consumption includes imported power. 2013 data are provisional.

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



Source: DECC (March 2014) *Energy Trends*; DECC (March 2014) *Provisional 2013 results for UK greenhouse gas emissions and progress towards targets*; CCC calculations.
Notes: 2013 actual emissions data are provisional.

Emissions in 2013

In 2013 emissions fell 8% (on 2012) to 145.1 $MtCO_2$ due to increasing renewables and coal plant closures (having reached the end of their allocated hours under EU legislation):

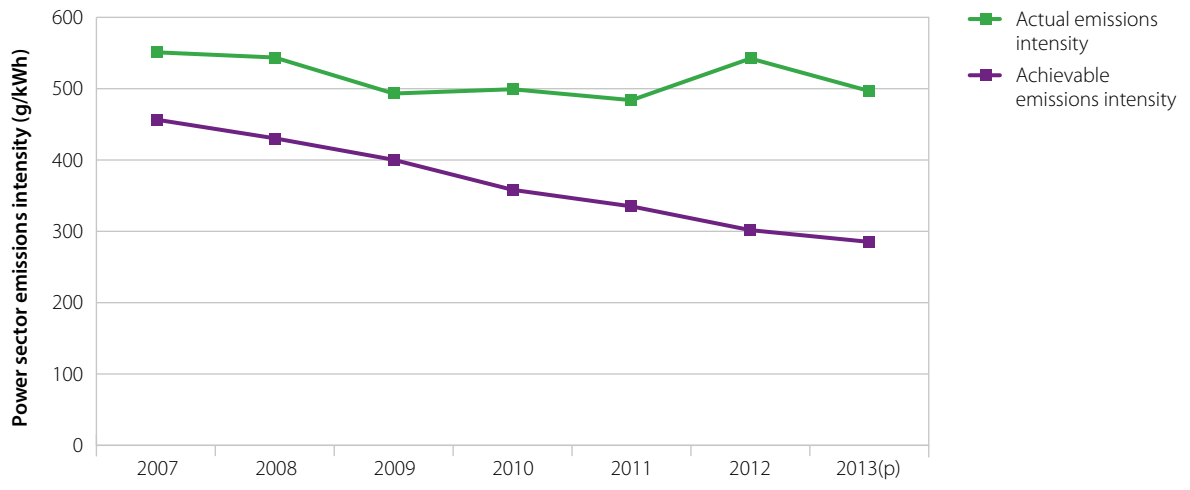
- Demand stayed broadly flat at 316 TWh.
- Emissions intensity fell by 8% to 497 g/kWh. Renewable generation increased by 34% to 51 TWh, and coal generation decreased by 7% to 124 TWh.

Achievable emissions intensity

While actual emissions intensity gives an indication of current progress in the power sector, it may not signal clearly whether underlying progress in low-carbon generation has been made (for example, because it fluctuates based on coal generation in any given year). The 'achievable emissions intensity' provides a better representation of underlying progress, as it shows the emissions intensity of the grid if it were operated to minimise emissions. Put differently, it is the emissions per unit of electricity that could be achieved if plant were dispatched in order of emissions intensity, beginning with renewables and nuclear, followed by gas and finally coal.

AEI fell from 457 gCO_2/kWh in 2007 to 285 gCO_2/kWh in 2013 (Figure 2.3). AEI reductions in recent years were driven by new renewables capacity coming online, whereas in earlier years this was primarily due to falling demand (2009) and increased gas capacity (2010).

Figure 2.3: Achievable Emissions Intensity (2007-2013)



Source: CCC Calculations based on DECC *Energy Trends* (March 2014).
Notes: Achievable emissions intensity is the minimum average emissions intensity that could be achieved in a year, given the installed capacity, demand level and profile of that demand. Emissions intensity is UK useable generation, i.e. excluding losses.

In recent years coal has been dispatched before gas, so that actual emissions intensity has been far higher than AEI. There is, however, enough low-carbon and gas capacity to meet demand at almost every point of the year (e.g. 54 GW de-rated capacity[2], compared to 56 GW peak demand).

Although actual emissions intensity is currently much higher than AEI, we would expect these to converge as coal comes off the system over time. This process has begun with around 6 GW of closures under European air quality legislation (the Large Combustion Plant Directive) in 2013 and a further 2 GW to close in 2014. The remaining around 18 GW of coal capacity have the option either to close or to upgrade their equipment and opt-in to the Industrial Emissions Directive (IED) (Box 2.2).

Box 2.2: Drivers of recent increased coal generation and further options under the IED

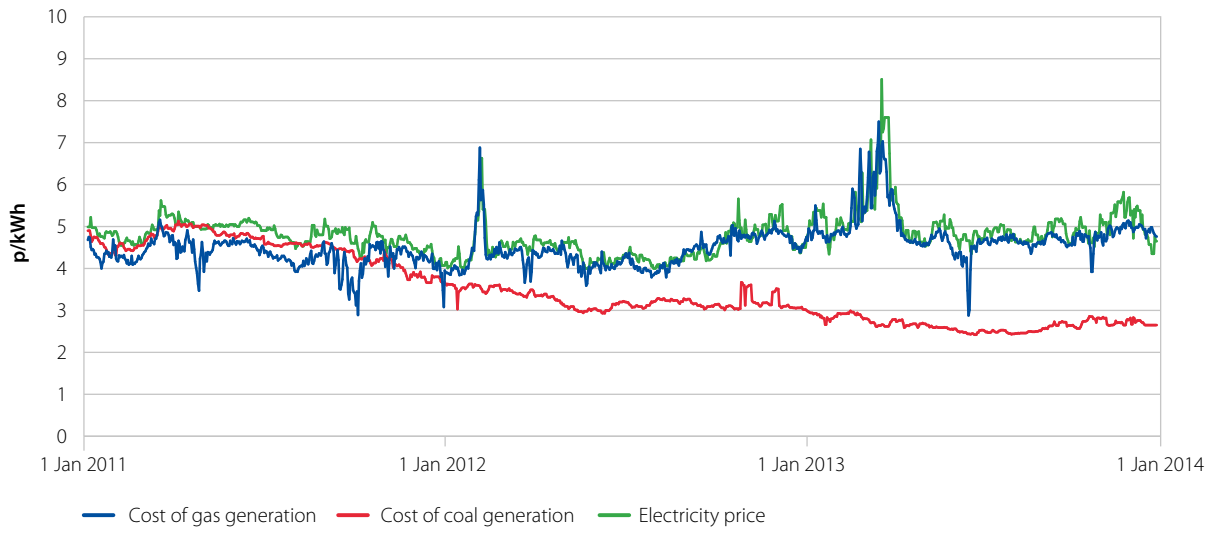
Within Europe, it was previously expected that EU-wide air quality directives would lead to widespread closure of existing coal-fired capacity, supported by the carbon price in the EU emissions trading system (EU ETS).

The switch towards coal in 2012 and 2013 was driven by a reduction in the cost of coal generation compared to gas:

- A rising trend in the gas price (10% in 2012, 6% in 2013) and falls in the coal price (-19% in 2012, -9% in 2013).
- The carbon price in the EU ETS remaining at low levels. During 2013, the EUA price ranged from €3 to €6 per tonne with an average of €4, a 40% decrease from the average of €7 in 2012. This follows a 70% decrease from 2008 to 2012, from an average of €24 in 2008[3]. The carbon price drives a wedge between the cost of coal and gas generation as coal is more than twice as carbon-intensive as gas.

Given these favourable conditions for coal compared with gas generation, the "clean dark spread" (i.e. the difference between the short-run cost of coal generation and the electricity price, which is driven by the cost of gas generation) has been rising since early 2012 (Figure B2.1).

Figure B2.1: Short-run cost of gas and coal generation and electricity price (January 2011-January 2014)



Source: *UK Power day-ahead data, LEBA* (accessed 2 April 2014); *System Average Price data, National Grid* (accessed 2 April 2014); *Coal ARA data, ICIS,* (accessed 17 April 2014); CCC calculations.
Notes: Carbon intensity 378 g/kWh for gas and 930 g/kWh for coal. Based on day-ahead electricity and gas prices, and coal monthly forward price.

2 De-rated capacity: Table 5.6 DECC (2013) *Digest of UK Energy Statistics*. Available at: www.gov.uk/government/publications/ ; Peak demand available at: www.nationalgrid.com

Box 2.2: Drivers of recent increased coal generation and further options under the IED

Looking ahead, the remainder of UK coal plants face restrictions from 2016 and could be forced to close by the end of 2023 under the Industrial Emissions Directive (IED)[4]. Plants which opt into the IED must agree to stricter emissions limits, which involve fitting expensive NOx abatement equipment.

Although the directive requires that a decision on whether to opt-out of the IED was made by the beginning of 2014, there is flexibility offered out to 2020 under the Transitional National Plan (TNP), which was introduced to allow phased upgrading of plant. Under the TNP, generators have between 2016 and the end of June 2020 to move towards full compliance with the IED. After 2020 the plant must fully comply with the directive, close, or limit generation to 1500 hours per year.

Provided that investment in low-carbon technologies proceeds, by the 2020s existing coal plant will either close or run at very low load factors to balance the system. It is therefore important to have clear signals for investing in low-carbon technologies, such as a decarbonisation target for 2030 and associated funding as set out in section 8.

Looking ahead, the cost-effective path for economy-wide decarbonisation implies achievable emissions intensity falling towards 50-100 gCO_2/kWh in 2030.

Achieving such a trajectory will require deployment of established technologies, such as onshore wind and nuclear, and the cost reduction and commercialisation of emerging technologies, such as offshore wind and CCS, as set out in the rest of this Chapter.

3. The Committee's approach to tracking progress

We track progress against our detailed indicator framework, which we set out in our first progress report in 2009 based on trajectories consistent with meeting carbon budgets. Our indicators are designed to provide early warning of problems that might affect future emissions reductions and to identify areas where action is required. They are indicative in the sense that weak progress in one area could be compensated by strong progress elsewhere, including in areas not previously covered in our indicators.

- **Renewables:** Our indicators cover capacity on the system and progression through the project cycle (i.e. in and entering construction, in planning, etc.), generation, planning approval rates and progress in developing the transmission network (required reinforcements, access to the network, investment in the onshore and offshore grid), and are designed to meet requirements under the EU renewables target.
- **Nuclear:** We monitor progress towards building a new generation of plants, including indicators on planning and regulation.
- **CCS:** Our indicators for the first three budget periods focus on progress with the UK's programme of demonstration projects, together with preparation for wider roll-out in the 2020s.
- **Infrastructure:** We have expanded our focus on future electricity infrastructure; developing indicators for smart meters and interconnection.

3 Prices from 2007 (Phase I) are not included as the EUAs in this phase were a different commodity and were not transferable across phases.
4 In 2010 the Large Combustion Plant Directive (LCPD) was combined with six other existing directives to form the IED. Plants which opted in to the LCPD but choose not to opt in to the IED will have their hours capped at 17,500 for 2016-2013.

- **Electricity Market Reform:** We monitor the Government's progress in implementing new market arrangements for low-carbon investment.

In this report we specifically consider whether progress has been sufficient in key measures over the whole first carbon budget period, and allocate a 'traffic light' rating according to this progress (see Chapter 1).

In this report, we also extend our indicator framework to 2027, in line with levels of ambition required to meet the fourth carbon budget, and update our trajectories to align to progress to date. We add some new indicators for important areas we did not previously include (e.g. smart meters).

4. Investment in renewable generation

Over the first carbon budget period, levels of investment in renewable energy increased and a strong pipeline of projects for future investment has been established in key technologies. In 2013, around 16% of electricity generated was from renewables (51 TWh), up from 12% in 2012 (38 TWh) and 5% in 2007 (19 TWh).

Costs of low-carbon technologies increased over the first carbon budget period. However, research conducted by UKERC suggests that this was largely due to factors that impact both low-carbon and conventional generation, such as commodity price increases (Box 2.3).

Box 2.3: Cost increases in low-carbon and fossil generation

Cost estimates for both low-carbon and fossil fuel technologies have increased over the first carbon budget period due to commodity price fluctuations, exchange rate movements, cost of capital increases and fossil fuel price trends.

Recent research by UKERC[5] suggests that between the mid-2000s and 2010, rising commodity prices – particularly steel, copper and cement – pushed up the capital and levelised costs of all generating technologies except solar PV. Prices have declined since the economic turndown, but there is a time lag before this translates to lower capital costs.

There are also technology-specific cost increases. For example, in offshore wind, steel typically accounts for around 10% of a project's cost, and can be seen as a contributing factor in turbine costs rising 67% and foundation costs rising 180% in the mid-to-late 2000s. The weakening of the pound against the euro may also have increased costs, as much of the manufacturing is within Europe. As the UK supply chain develops, and the UK manufacturing content increases, developers will be less exposed to this risk.

For gas generation, increases in fuel costs – which account for 60-80% of levelised costs – have pushed up costs. Fuel prices will remain one of the most uncertain elements of future levelised cost forecasts for both unabated gas and gas CCS capacity.

Costs of low-carbon technologies may be higher in early years of commercialisation due to supply-chain constraints and bottlenecks, suggesting that there is scope for cost reduction as deployment increases over time. In the following sections, we address the scope for cost reduction in offshore wind and CCS.

Challenges remain to the delivery of renewable energy to meet future carbon budgets, particularly after 2020, given uncertainties about whether there will be ongoing support for investment and, if so, which technologies will be supported.

In this section we consider progress and delivery risks for the following renewable technologies – onshore wind, offshore wind, biomass, solar, wave and tidal.

5 UKERC (2013) *Presenting the Future*. Available at: www.ukerc.ac.uk

(a) Onshore wind

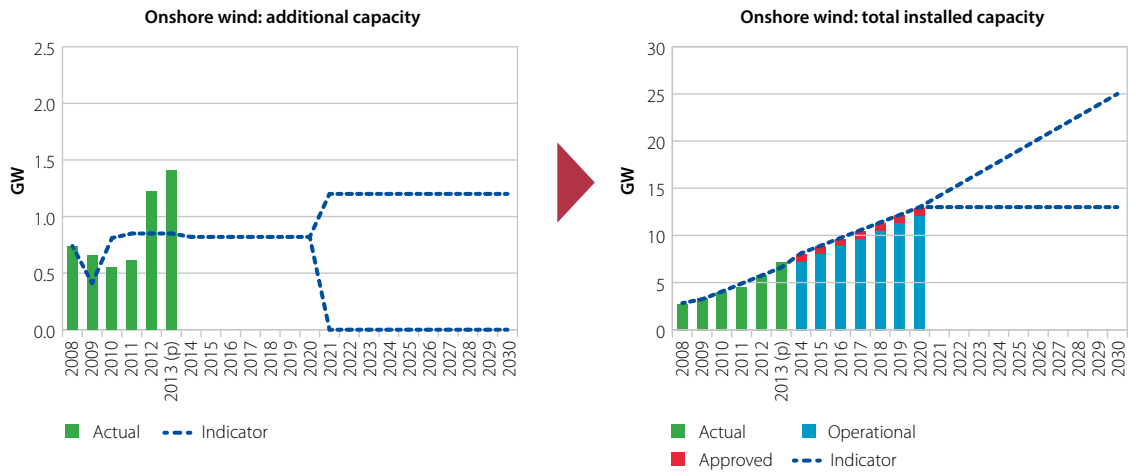
Onshore wind has established itself as one of the most cost-effective low-carbon technologies with potential for increased deployment to 2020 and beyond, although this is ultimately limited by long-term site availability and concerns around landscape impacts.

Investment on the path to 2020

Investment in onshore wind has made good progress and installed capacity is consistent with the level of ambition set out in our indicator framework (Figure 2.4):

- Over the first carbon budget period, installed capacity of onshore wind increased by 3.1 GW, compared with the 2.9 GW increase set out in our indicator framework.

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



Source: DECC (March 2014) *Energy Trends*; Pöyry (2013) Technology Supply Curves for Low-Carbon Power Generation; CCC estimates.
Notes: 2013 data are provisional. Other indicators begin from 2007, however for renewables a consistent data set is only available from 2008.

- Performance of wind capacity throughout the year has been in line with our assumptions (i.e. estimated load factors have been around 26%, in line with our estimated level of performance[6]).
- In 2013, there was a further 24% increase (1.4 GW) in installed onshore wind capacity, leading to a total installed capacity of 7.3 GW.

In 2011, estimated costs of onshore wind were in the range £80-95/MWh[7], and subsequently costs have stayed fairly stable (in 2013 estimated costs were £80-100/MWh). Recent price stability may reflect the fact that onshore wind has established itself as a mature generation technology. At these costs, onshore wind is already one of the cheapest low-carbon options,

6 DECC (2014) *RESTATS Statistics 2012*. Load factors reflect capacity that has been running for the whole of the year. Generation levels in our indicator framework are based on this. Therefore, reported generation is below the level in our indicator framework (42.3 TWh over the whole budget period, compared with 45.7 TWh), because in reality new generation has not been operating for the whole year.

7 CCC (2011) *The Renewable Energy Review*; CCC (2013) Next Steps on Electricity Market Reform. Available at: www.theccc.org.uk

and we expect it to remain part of the cost-effective mix for further roll-out in the 2020s as long as acceptable sites continue to be available.

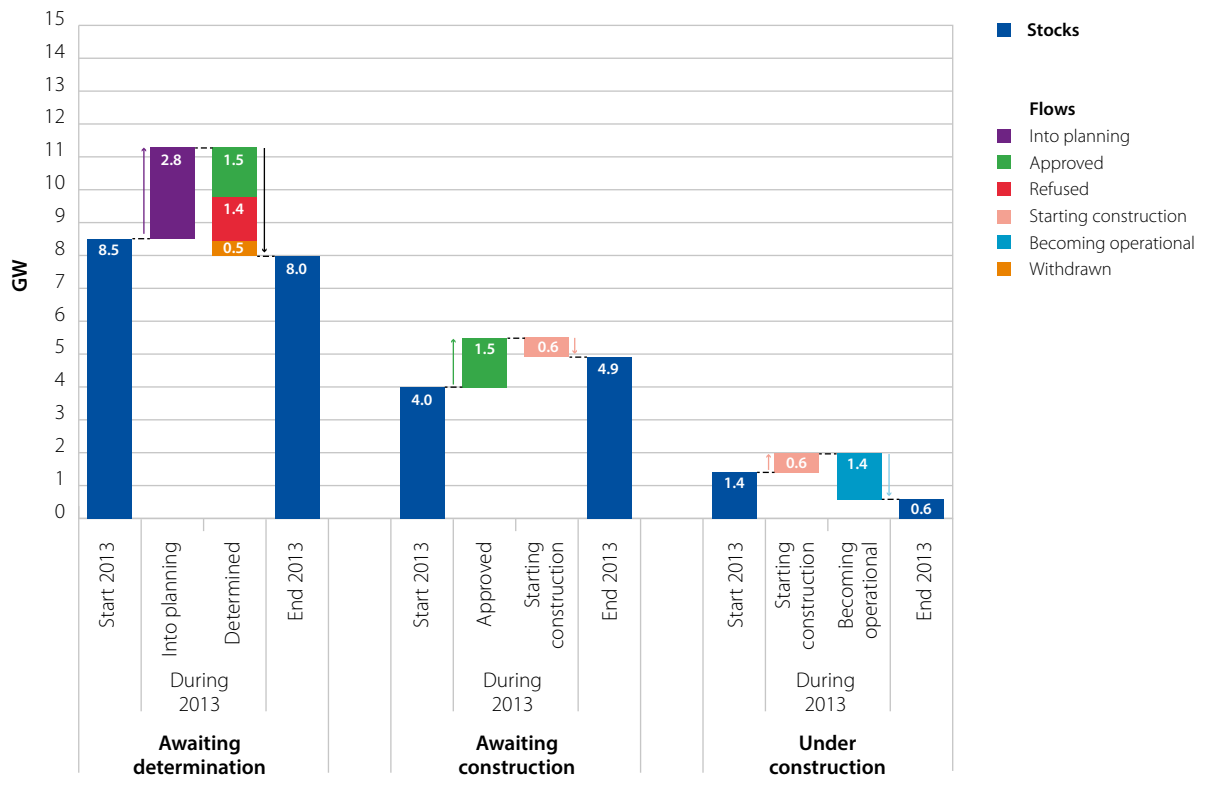
In our first progress report in 2009 we estimated that 15 GW of onshore wind would be required by 2020. The pipeline at the end of 2013 suggests this is achievable: 7.3 GW has been built, 5.5 GW is either under construction or has been approved in the planning system and 8 GW is awaiting planning consent.

DECC's final delivery plan for Electricity Market Reform envisaged 11-13 GW of onshore wind capacity by 2020; we will monitor progress against the top of this range. Although this is slightly lower than our previous indicator (15 GW), lower demand following the recession implies less wind capacity is needed.

Although there has been a decreased approval rate and slowdown in capacity entering construction in 2013, sufficient approvals have already occurred to reach the 2020 ambition (Figure 2.5):

- There was a decrease in project approvals from 64% on average over the first carbon budget period to 53% in 2013.

Figure 2.5: Onshore wind capacity moving through planning and construction (2013)



Source: DECC (March 2014) *Renewable Energy Planning Database.*
Notes: Numbers may not sum due to rounding.

- Approved capacity entering into construction fell from 1.3 GW in 2012 to 0.6 GW in 2013, potentially reflecting policy uncertainty (for example, political debates relating to landscape impacts) and tightness in the supply chain. The average annual build rate will need to be around 0.8 GW to reach 13 GW of installed capacity by 2020.
- 12.8 GW of approvals had occurred by the end of 2013, and an additional 0.5 GW had been approved as of the second quarter of 2014 – in total more than our 13 GW ambition for 2020.

Ambition beyond 2020

Beyond 2020, there is potential for further investment in wind generation. In our 2013 report *Next Steps on Electricity Market Reform* we identified potential for onshore wind capacity to rise to 25 GW in 2030. This reflects potential to increase capacity through repowering of existing sites with larger turbines, the expectation that some projects awaiting consent will be approved and that new projects continue to be proposed (e.g. 2.8 GW in 2013 alone).

Concerns about landscape impacts and related political debates have resulted in a high degree of uncertainty about the level of onshore wind beyond 2020, which undermines incentives to develop new onshore wind projects. If the objective were to bring forward investments on the cost-effective path to power sector decarbonisation, then onshore wind would continue to enjoy support in the context of the Electricity Market Reform and the planning process. Debate and discussion over the future of onshore wind should be framed in this context: that a failure to invest in it is a departure from the cost-effective path, which will ultimately result in higher energy bills at a time when energy affordability is paramount.

Given the uncertainty around future ambition, we will monitor against a range of 13-25 GW of onshore wind capacity by the end of the 2020s, whilst acknowledging that there is a trade-off that arises from not pursuing one of the most cost-effective low-carbon generating technologies in the 2020s.

Overall assessment

Over the first carbon budget period, investment in onshore wind has scaled up at a level consistent with meeting the UK's renewable energy targets and carbon budgets, and a healthy pipeline of projects exists to meet an ambition of around 13 GW in 2020. We therefore allocate a green traffic light to onshore wind.

Beyond 2020, further investment would be desirable from the perspective of cost-effectiveness, up to around 25 GW. Concerns about landscape impacts may ultimately result in a lower level of deployment, with the implication of higher system costs as more deployment is required from other, more expensive low-carbon technologies.

(b) Offshore wind

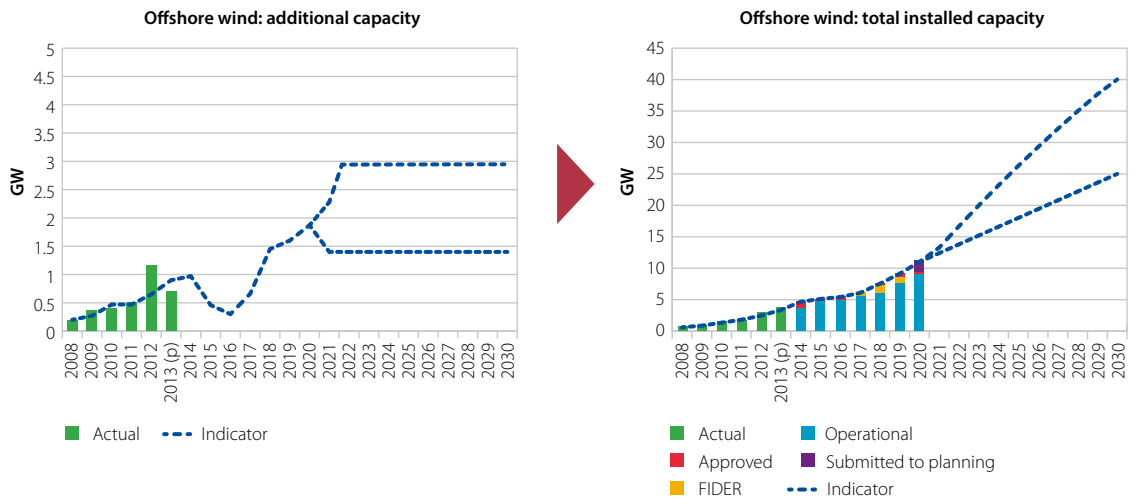
Although currently more expensive than some other low-carbon technologies, in the long term offshore wind is potentially a substantial contributor to low-carbon power generation due to a large-scale natural resource in the UK, reduced local landscape impact compared with

onshore wind and the potential for significant cost reduction. Deployment of offshore wind in the near term will help meet the UK's renewable energy target and could drive cost reductions that will make it competitive with established forms of low-carbon generation in the 2020s. Although it is an intermittent source of power generation, this can be managed at reasonable cost[8] and its seasonal pattern of generation is similar to UK demand (i.e. generation is higher in winter).

Offshore wind deployment

Deployment of offshore wind has made good progress and installed capacity is consistent with the level of ambition set out in our indicator framework (Figure 2.6):

Figure 2.6: Offshore wind: annual additional and cumulative capacity against our indicators (2008-2030)



Source: DECC (March 2014) *Energy Trends*; Pöyry (2013) Technology Supply Curves for Low-Carbon Power Generation; CCC estimates.
Notes: 2013 data are provisional. Other indicators begin from 2007, however for renewables a consistent data set is only available from 2008. Volatility in offshore wind additional capacity indicator to 2020 reflects expected dates that specific projects in pipeline commence operation.

- Installed capacity has increased from 0.6 GW in 2008 to 3 GW in 2012, compared with a level of 2.5 GW that we set out as the level to be on track to meet carbon budgets.
- Performance has been broadly in line with our assumptions – estimated load factors suggest that offshore wind has been generating at a 34% load factor[9], compared with expected performance of 37%, resulting in a generation of 10.9 TWh in 2013.
- In addition, 0.7 GW was added during 2013, bringing the total offshore wind capacity to 3.7 GW.

8 CCC (2011) *The Renewable Energy Review.*
9 DECC (2014) *RESTATS Statistics 2012.* Load factors for 2012 reflect capacity operational throughout the year. For the same reasons as in the preceding footnote on onshore wind, reported generation over the first carbon budget period was below our indicator (17.4 TWh compared to our indicator of 22.7 TWh).

Offshore wind costs to date and potential for reductions

Our levelised cost estimates in 2011 for this technology reflected high levels of uncertainty around deployment costs, at £110-155 /MWh[10]. Outturn costs have been at the higher end of this range (£140-165/MWh), although there is evidence to suggest that costs of offshore wind can be reduced significantly, for example through bigger turbines, larger field sizes and a competitive supply chain (Box 2.4).

Box 2.4: Offshore wind cost reductions

The Crown Estate Cost Reduction Task Force report suggests that cost reductions of up to 39% are possible by 2020 (at investment decision, compared to 2011 levels), from a combination of new and larger turbines, competition, scale, installation and support structures and changes in contracts and costs of capital.

There are some signs that costs have now stabilised and cost reductions are beginning to be realised:

- **Larger turbines:** The Crown Estate had previously envisaged 6 MW turbines become standard towards 2020. However, some sites are already installing 6 MW turbines as early as 2014, and 8 MW turbines are expected in 2017.
- **Larger fields:** Round 3 sites that are under development are in the multi-GW range, compared to the hundred MW ranges of the earlier sites.
- **Standardising components:** Final arrangements allow for projects to be delivered in several phases of equal MW, which enables standardising of some components (e.g. specification of transmission cables).
- **Types of investors:**
  - The UK's Green Investment Bank (GIB) is playing an important role in capital recycling, having invested more than £500 million in offshore wind activities, and recently announcing plans for a £1 billion fund to acquire stakes in operational offshore wind farms. In addition, the GIB is looking to complement its capital recycling approach, by moving towards providing construction finance.
  - Bond finance and institutional investors are beginning to play a role in financing both operating offshore wind farms and the offshore transmission assets required to connect them to the grid.
- **Diversity of supply companies:** Contracts currently in market have been agreed by multiple supply companies.
- **Cost of capital:** Contracts for Difference should reduce the risk of developing offshore wind projects, by removing the wholesale price risk from developers, which should have the effect of reducing the cost of capital. Developers that are part of the Final Investment Decision Enabling Regime (FIDER) should in theory be able to access a lower cost of capital, although a risk remains around longer-term projects, because of a lack of visibility of funding under the Levy Control Framework (LCF).

To secure this path of cost reduction, a robust commercialisation strategy should be developed for this technology. We will consider potential cost-reduction pathways and advise on key elements of a commercialisation strategy as part of our 2015 advice on the 2030 decarbonisation target as legislated for in the Energy Act 2013 (see section 10).[11]

The 2012 Crown Estate *Offshore Wind Cost Reduction Pathways Study* emphasised that economies of scale (rather than passage of time per se) will have the greatest impact on cost reduction. They suggest that a UK market of at least 2 GW per year from 2015 to 2025 is needed to ensure significant cost reductions, assuming market developments in the rest of Europe remain on track.

With these conditions in place, our analysis suggests that costs could be reduced to around £100/MWh in 2030, while industry has adopted an earlier target date of 2023 for such costs.

10 *CCC (2011) The Renewable Energy Review.*

11 UKERC (2010) *Great Expectations.* Available at: www.ukerc.ac.uk ; The Crown Estate (2012) *Offshore Wind Cost Reduction* Task Force Report. Available at: www.gov.uk ; Green Investment Bank (2014) *Summary of Transactions.* Available at: www.greeninvestmentbank.com

We will monitor overall progress in cost reduction against a schedule to around £100/MWh in 2030, as well as the components in cost reduction (e.g. availability of larger turbines, supply-chain competition) compared to these trajectories. This would make offshore wind competitive with established low-carbon technologies such as onshore wind and nuclear.

Previously we have monitored offshore wind capacity against the 13 GW in 2020 consistent with the Government's renewable energy roadmap[12] and we have suggested that this could be slightly reduced if other, lower-cost, ways can be found to meet the renewable target. That is now possible, given demand reductions resulting from the recession. DECC's revised delivery plan suggests 8-15 GW of offshore wind by 2020, with most scenarios around 10 GW.

Given the delayed cost reduction in offshore wind and lower levels required to meet the renewables target we will now monitor against a slightly lowered ambition of 11 GW achievable by 2020. The important goal is to deliver cost reductions for offshore wind, which requires stable investment conditions and an ongoing commitment beyond 2020 (see section 8).

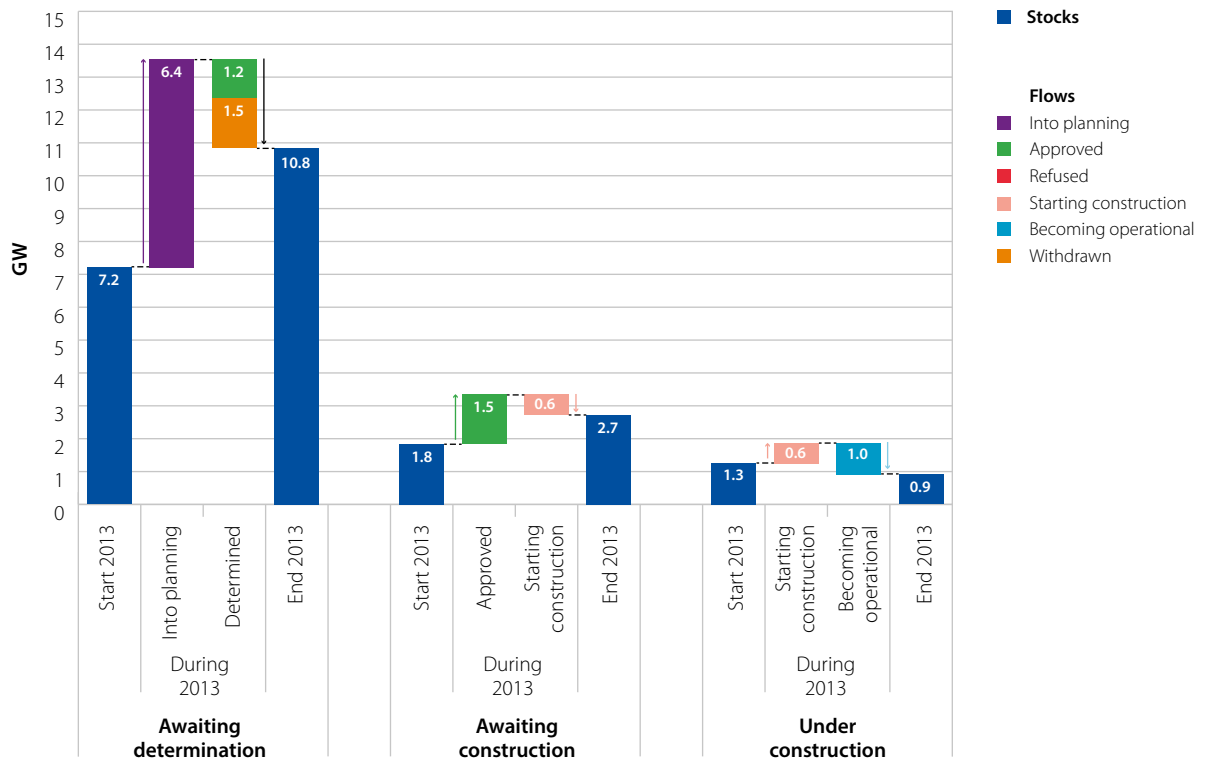
Investment pipeline

At the end of 2013, there was sufficient capacity in the pipeline, building on the 3.7 GW already in operation, to exceed our 11 GW level of ambition by 2020, notwithstanding recent project withdrawals and a slowdown in build rates (Figure 2.7):

- Of the 10.8 GW projects awaiting approval, 2.8 GW has been offered an investment contract through FIDER[13]. Historical approval rates are close to 100% and determination periods[14] are down to around 1.5 years, compared to an average of 3-4 years in 2012.
  - Recently announced project withdrawals could continue under different ownership. In early 2014, SSE withdrew its 50% stake in the Galloper project, which already has planning approval and for which RWE is actively seeking a new project partner.
  - Further project cancellations have been announced, but these are at an early stage and do not materially impact the ambition to 2020 (these include DONG/E.On/Masdar's London Array Extension, RWE nPower's Atlantic Array and SSE's Islay project).
- Of the 3.6 GW of capacity that has been approved, 0.9 GW is in construction.
  - Capacity entering into construction in 2013 (0.6 GW) was half that in 2012, likely to reflect policy uncertainty as the new mechanisms are introduced through EMR. Although projects could also proceed under the existing RO regime, many firms will want to know the details of the new scheme before committing the large costs involved in construction.

12 DECC (2011) *UK Renewable Energy Roadmap*. Available at: www.gov.uk
13 A further 0.4 GW has been awarded projects through the FIDER process but already has planning approval.
14 The determination period for a project is defined as the time between being submitted to the relevant planning authority and a decision being made by the planning authority. Determination periods have fallen recently as a result of new powers introduced in the Energy Act 2008 (but which only took effect in 2010) which allow the Secretary of State to approve projects through the National Infrastructure Planning Service (NIPS).

Figure 2.7: Offshore wind capacity moving through planning and construction (2013)



Source: DECC (March 2014) *Renewable Energy Planning Database.*
Notes: Numbers may not sum due to rounding.

– DECC has acted to reduce policy uncertainty by moving projects through the Final Investment Decision Enabling Regime[15], and extending the Renewables Obligation. This should see capacity build rates increase over the next few years.

Although there is capacity in the pipeline, it is unclear whether the full ambition will be achieved to 2020 under the prices proposed. The Government should monitor closely and adjust support (e.g. adjusting degression in line with cost reduction) accordingly.

Beyond 2020, a high degree of uncertainty around offshore developments remains. In our 2013 report *Next Steps on Electricity Market Reform* we suggested that 25-40 GW of offshore wind capacity would be appropriate to 2030; DECC's final EMR delivery plan suggested a broader range of 12-41 GW. We will monitor progress in offshore wind against our range, and recommend that DECC should rule out their lowest scenarios, given that these do not imply stable investment conditions and cannot support the learning by doing required to drive costs down for this important technology.

Given that costs have not fallen as anticipated, but that there is potential for them to fall, the Government should prepare and publish a commercialisation strategy for the technology. This should build on the work done to date on cost reduction, set out a plan for driving cost

15 The FIDER has awarded CfD FiT contracts to eight projects ahead of the first CfD auctions in 2014. This aims to reduce uncertainty around the new regime while ensuring key projects can advance without waiting for the first CfD auctions.

reductions and make the necessary commitments that implies, so that this technology can become competitive in the 2020s.

The Crown Estate's *Offshore Wind Market Study*[16] assessed the current and future state of the UK offshore wind industry and identified key challenges that industry stakeholders perceive as potentially constraining offshore wind deployment. Major barriers to development identified by stakeholders included political and regulatory uncertainty as well as the Government's longer-term commitment to decarbonising the power sector.

The study concludes that it is crucial that the Government gives as much certainty as possible about its commitment to decarbonisation and supporting offshore wind to maturity. This could occur through consistent messaging from the Government on its commitment to decarbonising the power sector (e.g. through specific 2030 targets) and timely developments of details of EMR proposals (see section 8).

Overall assessment

Offshore wind has undergone a step-change in its rate of deployment and has a strong pipeline of projects with potential to deliver as required to 2020 (11 GW). We therefore allocate a green traffic light for progress over the first carbon budget period. Beyond 2020, there is a lack of direction regarding the level of support and this uncertainty is feeding into project development today. To secure the benefits of progress to date, a commercialisation strategy is required to drive cost reductions so that this technology can become competitive in the 2020s.

(c) Biomass

Power generation from biomass has risen from 8.7 TWh in 2008 (around 3% of electricity supply) to 16.5 TWh (5% of electricity supply) in 2013. The composition of biomass feedstock used in electricity generation has shifted from a reliance on waste derived fuels in 2008 (around 85%, the remainder a mix of plant and animal biomass) towards a greater proportion of plant biomass (27% of feedstock in 2013).

Given the limited availability of sustainable resource, use of biomass should be focused in high-value applications. In the long term, for example, this could include use in conjunction with CCS to achieve negative emissions in the power sector, or in industry where there are few other low-carbon alternatives. In the near term this implies avoiding uses that could lock in resources to applications – like power generation – where other alternatives are available, while ensuring feedstocks come from genuinely sustainable sources.

We therefore recommended in our 2011 Bioenergy Review that use of biomass in the power sector should be subject to strict sustainability standards, and investment should focus on conversion of existing coal plants rather than new dedicated plants, which would lock in biomass resource for longer. Subject to these conditions, we concluded that power generation from sustainable biomass could have a useful role in meeting UK renewables targets at least cost.

16 The Crown Estate (2012) *UK Offshore Wind Market Study*. Available at: www.thecrownestate.co.uk

Deployment of biomass power generation

DECC's final Delivery Plan for EMR considers 3.8 – 5.9 GW of total biomass capacity by 2020[17]. Current plans are on track to meet this scenario:

- Around 2 GW of large-scale dedicated biomass or biomass conversion is already on the system, with a further 1.4 GW of co-firing and other biomass capacity (e.g. energy from waste, anaerobic digestion) operational or under construction.
- DECC has now awarded contracts for biomass conversions at Drax, Lynemouth and Teesside with a total capacity of 1.4 GW.
- There are further plans to convert another unit at Drax (0.65 GW) and potentially at Eggborough (1.4 GW).
- 1.7 GW of existing biomass conversion capacity is set to come offline by 2016.
- Taken together, around 5 GW of biomass capacity is under development[18], with higher levels possible if new projects emerge.

The costs of biomass power generation have remained within our range over the first budget period of around £70-90/MWh for co-firing and £80-90/MWh[19] for the conversion of existing plant to burn biomass.

Biomass sustainability

In our 2011 Bioenergy Review we emphasised the importance of safeguards to ensure that the use of biomass results in genuine emissions reductions. This included a recommendation for a biomass life-cycle emissions standard of 200 gCO_2/kWh, falling over time, which was adopted by the Government in 2013.

For this standard to be met it is important that the Government has a high degree of confidence that biomass is sourced from sustainably managed forests. In order to ensure that forest biomass used in the UK results in life-cycle emissions reductions forest carbon stocks must be constant or increasing.

Developing criteria on carbon stocks are currently subject to methodological challenges, for example whether stocks should be maintained for each forest or at a broader geographical area. The Government has proposed to resolve these issues and bring this issue into the criteria for new biomass capacity installed from April 2019, as part of the planned 2016/17 UK Bioenergy Strategy Review.

Given that preserving carbon stocks is an issue for both new and existing biomass, we recommend that the Government should add to the UK's criteria for biomass sustainability, in the 2016/17 UK Bioenergy Strategy Review, a requirement that all biomass (i.e. both new and existing capacity) is sourced from forests that can demonstrate constant or increasing carbon stocks, and push for this to be reflected in standards at the EU level.

17 DECC (2013) *Electricity Market Reform Delivery Plan*, p40. Available at: www.gov.uk. This includes Biomass conversion, dedicated biomass, Energy from Waste, Landfill gas, AD and Sewage Gas.
18 Around 1.7 GW is likely to come off the system in around 2016 with closures at Ironbridge and Tilbury.
19 CCC (2011) *The Bioenergy Review*. CCC (2013) Next Steps on Electricity Market Reform.

Overall assessment

While the uptake of biomass is consistent with the level of ambition to meet 2020 ambition, questions remain regarding the source and sustainability of biomass. We will monitor against a reduced ambition of 3.6-5 GW in 2020, and recommend that the Government move to ensure appropriate safeguards be implemented for both existing and new biomass generation.

(d) Solar

Since the beginning of the first carbon budget period, solar photovoltaic (PV) capacity has increased from very low levels (less than 0.1 GW in 2008) to 2.7 GW at the end of 2013. Load factors for solar PV in the UK are around 10%, producing 2 TWh of generation in 2013 (0.5% of total electricity supply).

To date, solar deployment in the UK has been dominated by rooftop installations, driven by feed-in tariffs (FITs) for small-scale installations (the majority of installations are <50 kW) on domestic and commercial buildings. However in 2013, there was an increase in medium and large scale (50kW+) installations, which now represent approximately 30% of installed capacity (0.9 GW)[20].

While solar is an established low-carbon generation technology, its load factors are higher in summer, when demand is relatively low (and lower in winter, when demand is higher). It therefore faces a challenge relative to other low-carbon technologies (e.g. wind) in incorporating generation onto the electricity system cost effectively.

Generation cost

Since the beginning of the first carbon budget period, solar PV costs have dropped substantially (Figure 2.8), although in the UK they remain above cost estimates for other established low-carbon technologies (e.g. onshore wind and nuclear power).

DECC estimates a levelised cost of around £122/MWh (based on a hurdle rate of 5.3%[21]), substantially lower than our 2011 cost estimates of £315-460/MWh[22]. DECC's cost projections suggests these may drop further to levels that are cost competitive with onshore wind and nuclear power by 2020.

Internationally, solar represents a success story with costs falling more quickly than expected and supply chains building up rapidly to deliver increasing capacity. Solar also offers an opportunity to access alternative sources of financing (e.g. directly from households), often at low cost. We now consider how this opportunity can best be built on in the UK.

System costs, seasonality and storage

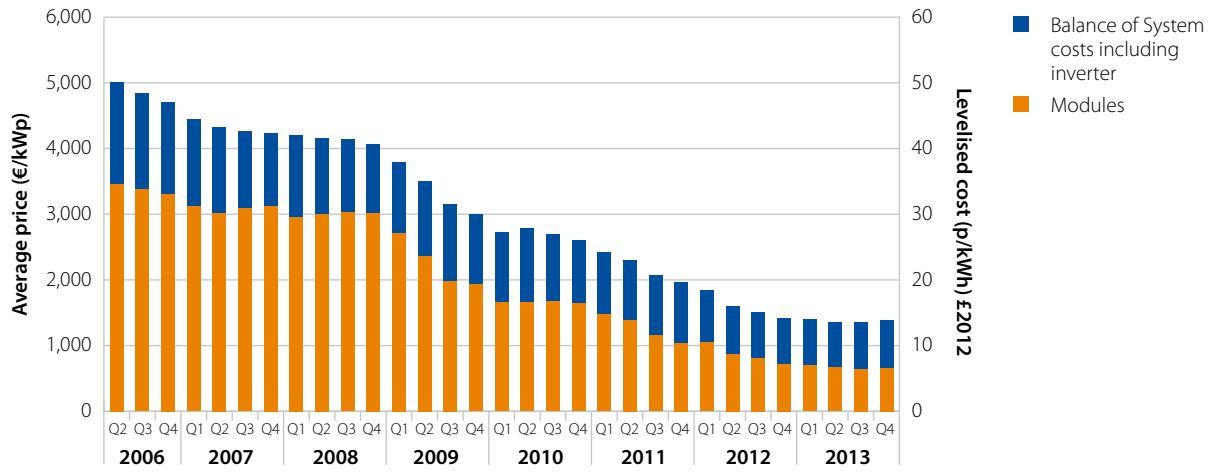
As well as costs per unit of electricity generated, it is important to consider how low-carbon technologies fit together within the wider UK power system. In particular, a full assessment of

20 As of April 2014, see: DECC (2014) *Energy Trends*. Table 6.4. Available at: www.gov.uk.

21 Solar may face lower project development risks compared to other low-carbon technologies due to small module size, the established and widely available nature of the technology, and short construction times.

22 CCC (2011) *The Renewable Energy Review*. DECC (December 2013) Electricity Generation Costs. Available at: www.gov.uk.

Figure 2.8: Reduction in capital costs of mid-scale solar PV



Source: Fraunhofer Institute for Solar Energy Systems (2013) Photovoltaics Report; CCC Calculations.
Notes: Average price for mid-scale rooftop PV in Germany. Assumes a 7.5% discount rate. Similar reductions reflected globally, e.g. 45% reduction in global module prices between early 2010 and mid-2012. The majority of cost reductions are from capital cost, with some reduction in Balance of System costs, although this may vary between countries.

costs must recognise challenges posed by intermittent and inflexible generation in matching supply and demand.

Our previous analysis[23] has demonstrated that very high penetrations of renewables are technically feasible and that costs of intermittency for a wind-dominated renewables portfolio are manageable (e.g. in 2030 we estimated these were of the order of £10 per MWh of additional intermittent renewable generation). Keeping costs low relies on extensive use of options to increase flexibility – demand-side response (e.g. scheduling clothes washing overnight or when renewables output is high), storage, interconnection and back-up capacity operating at low load factors.

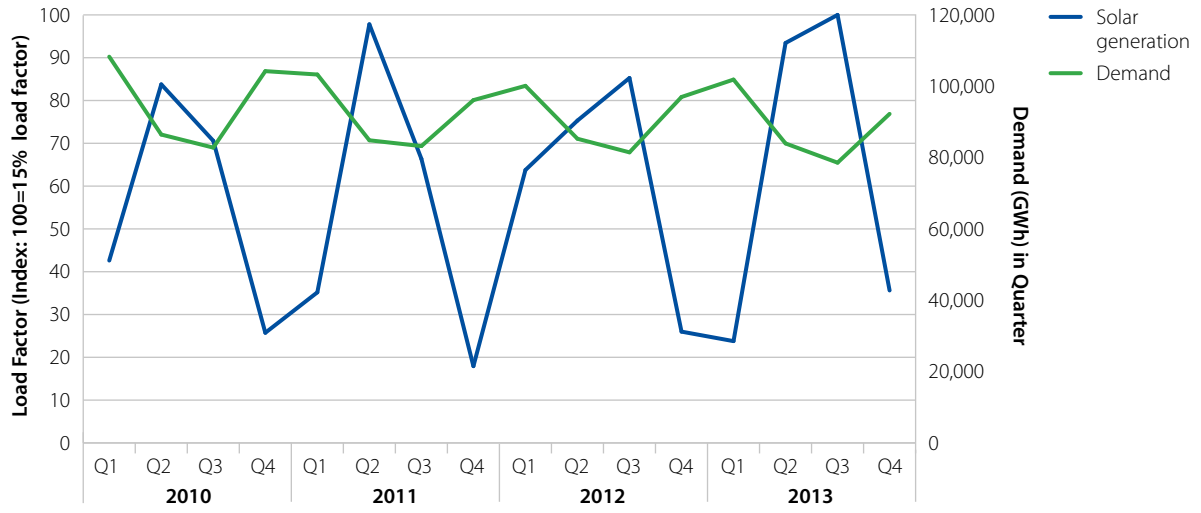
However, solar generation in the UK faces an additional challenge in that its load factors are high in summer, when demand is relatively low, and low in winter, when demand is relatively high (Figure 2.9).

A low-carbon power system would therefore have to have enough non-solar power capacity to meet winter (peak) demand, when solar load factors are low. Since this capacity would generally also be available in summer, this would imply an abundance of low-marginal-cost generation in the summer. In the long run, in a low-carbon power system, additional generation from solar in summer might be surplus, and of limited value.

Solar power capacity could be backed up by gas-fired generation in the winter (potentially with CCS). However, in the longer term this would be problematic, given the large amounts of back-up capacity that would be needed, and the need to fully decarbonise the power sector including in winter. Offshore wind could provide a complementary role to some extent, given that wind has higher load factors in winter, and higher levels of interconnection could help provide a market in summer given relatively higher demand in summer in mainland Europe.

23 CCC (2011) *The Renewable Energy Review.*

Figure 2.9: Solar Load factors and demand through the year



Source: DECC (March 2014) *Energy Trends 6.1*; CCC Calculations.

Electricity storage across seasons could provide an alternative route to addressing seasonality constraints. There are currently challenges to development of these options. For example, current and near-term battery technology is likely to be limited to providing grid storage over short periods of time, whereas options for longer-term storage in the UK (such as Pumped Hydro, hydrogen storage and Compressed Air Energy Storage (CAES)) are currently expensive, and typically require extensive infrastructure development.

Until cost-effective storage options or low-carbon back up options are developed further, it is appropriate to limit investment in solar power, whilst not ruling out that much higher penetration may become appropriate in future. To enable this, Government should consider how best to support development of seasonal storage options (e.g. either through market arrangements that ensure this value is captured or through research and development funding).

Recommendations on solar PV

In order to find the right balance between cost-effective investment, limiting affordability impacts and technology commercialisation, the Government should:

- Limit spending on solar power under the Levy Control Framework to 2020; this may involve lower roll-out than the highest levels (e.g. 20 GW) envisaged in the Government's recent solar strategy[24]. For a given subsidy, investment in solar power could displace more valuable investment in other low-carbon technologies. The Government is currently considering how to respond to this risk, including through its consultation on restricting funding for solar projects under the RO.

24 DECC (2014) *UK Solar PV Strategy Part 2*. Available at: www.gov.uk.

- Develop an approach to investment in solar power beyond 2020 in the context of the broader approach to power sector decarbonisation and recognising the challenges posed by its seasonal generation profile.
- Consider how best to support development of seasonal storage options, either through market arrangements that ensure this value is captured or through direct research and development funding.

We will consider the role for solar power in the context of broader sector decarbonisation when we advise the Government and Parliament in 2015 on the 2030 decarbonisation target range provided for under the Energy Act 2013 (see section 10).

(e) Marine generation

Wave and tidal stream

Both wave and tidal stream technologies are currently at an early stage and involve very high costs but both could play a role in the future UK energy mix, depending on demonstration success and subsequent cost reductions.

Over the first carbon budget period the Crown Estate leased 38 sites to wave and tidal stream projects. Subsequently a small number of demonstration projects have emerged, though representing a small fraction of renewable energy generation. Total installed capacity increased from 2 MW in 2009 to 8 MW (across 11 prototype technologies) in 2013, and generated 6 GWh during that year.

Both wave and tidal stream are likely to remain expensive low-carbon technologies for some time and should play a limited role in the UK's renewable energy portfolio in the near term.

- Our 2011 Renewable Energy Review estimated a cost range for tidal stream of £125-250/MWh, for delivery in 2020. DECC's most recent estimates[25] put the range at £130-205/MWh for 2025, although recent estimates of current costs suggest the technology is more expensive, in the range of £200-300/MWh[26].
- In 2011 we estimated a cost range of £190-345/MWh for wave power (for delivery in 2020), compared with DECC's estimates of £215-260/MWh (for delivery in 2025). Estimates of current costs suggest a range of £350-400/MWh.

In order to encourage demonstration projects, deployment to date has been incentivised through the Renewables Obligation. DECC has now extended this support by including strike prices for Contracts for Difference in its EMR delivery plan of £305/MWh for both wave and tidal stream technologies.

As these technologies are far from maturity, capital funding rather than revenue support is likely to be more effective in encouraging their development. To date, capital support schemes have focused on tidal stream given that this technology is relatively more advanced than wave.

25 DECC (2013) *Electricity Generation Costs*. Available at: www.gov.uk
26 LCICG (2012) *Technology Innovation Needs Assessment: Marine*. Available at: http://www.lowcarboninnovation.co.uk/working_together/technology_focus_areas/marine/

- DECC's Marine Energy Array Demonstrator (MEAD) scheme, in 2013, awarded £20 million of capital funding to two tidal stream projects[27], subject to State Aid review; a further two demonstration projects are also being funded under the EU's New Entrant Reserve (NER300) programme.
- The Scottish Government's Marine Renewable Commercialisation Fund (MRCF) is providing array commercialisation support for tidal stream devices, whilst acknowledging that wave array projects won't be delivered within the MRCF's time and spending constraints.

For wave power, progress is still extremely limited in relation to other low-carbon technologies, although a focus should be maintained on exploring the long-term role for the technology. Internationally, the world's first wave farm (20 MW) is currently in development in Portugal[28] 2010 and a 60 MW project is underway in Australia. China is also pursuing marine (both wave and tidal) projects, with around £100 million invested since 2010. Performance improvements and cost reductions for wave energy would be facilitated if a dominant design were to emerge.

Tidal range

Tidal range power is a proven technology (e.g. La Rance, a 240 MW power station in France, has been operating since 1966) that could start to provide a significant source of low-carbon electricity within the coming decade. It also has the benefit of predictable output, and projects are generally expected to have very long lifetimes (e.g. over 100 years). There is also the potential that future projects could be paired to provide a source of baseload low-carbon generation (i.e. individual projects with different generation profiles).

In 2014, plans for a series of tidal lagoons around the UK were proposed, with the potential to deliver 25 TWh/year of low-carbon electricity. Some estimates suggest these projects could have levelised costs averaging £110/MWh[29], although the first two projects are likely to be more expensive (e.g. £130-170/MWh). It is important that these proposals proceed with careful assessment of the potential environment impacts. Previous tidal range proposals in the UK, such as the Severn barrage, have been halted for such concerns.

There may be a role for tidal lagoon power in providing predictable low-carbon electricity in the UK if projects can be delivered at acceptable costs. We will continue to monitor progress with project proposals and expected costs.

5. Deployment of new nuclear generation

New nuclear power can play an important role in the decarbonisation of the power sector through cost-effective baseload low-carbon generation. However, various developments over the first carbon budget period have delayed the timeline for new-build nuclear power in the UK by around 6 years. These included the Weightman Review of nuclear power safety in light of the Fukushima disaster in Japan in 2011; delays in construction at other nuclear sites in

27 Funding has since been retracted for one project, as it did not meet agreed deadlines.
28 This is an expansion of a 2.25 MW 'wave farm' that was in operation in 2008.
29 Pöyry (2014) Levelised Costs of Power From Tidal Lagoons. Available at: www.tidallagoon.opendebate.co.uk

development in Europe; EMR, and the negotiations around an investment contract for the first new-build nuclear reactor in the UK (Hinkley Point C).

In 2011 we estimated a range of £60-100/MWh, refined in our most recent cost estimates to £85-100/MWh. Despite increases in cost estimates for new-build capacity over the first carbon budget period, nuclear power remains, prospectively, one of the cheapest low-carbon technologies and can play an important role as part of a cost-effective portfolio of technologies to decarbonise the power sector.

Whilst the indicators that we set out for new-build nuclear development in our 2009 progress report (e.g. Strategic Siting Assessment, a National Policy Statement, Regulatory Justification of the new-build programme and regulations around a funded decommissioning programme) have been completed, achievement of each of these milestones were also delayed. The combination of these factors has set back our expectations of the first low-carbon power from new nuclear generation from 2018 to 2023, when Hinkley Point C is now expected to start generating. State Aid approval is now required for this project to proceed and be operational by 2023 and decision is expected from the European Commission later in 2014.

Progress in 2013

Nuclear generation accounted for 20% of all generation in the UK in 2013. In 2013 life extensions were granted to several plant and only 1.1 GW out of 8.8 GW is now scheduled to retire by the end of the decade.

In 2013 the contract terms and level of support were agreed for the first new nuclear reactor at Hinkley Point C (the contract has not yet been signed). The agreed 'strike price' of £92.50/MWh falls within the range suggested by our analysis (i.e. £85-100/MWh[30]). Given that we expect developers to require a strike price slightly higher than the levelised cost (e.g. because nuclear generators currently face a discount of around £5/MWh in Power Purchase Agreements compared to the wholesale price) this suggests a levelised cost of electricity towards the lower end of our estimates for the first new nuclear plant in the UK. The agreed strike price therefore offers good value for money and the potential for significant cost savings from a new nuclear programme in the UK.

Nuclear New Build to 2030

In our 2013 report *Next Steps on Electricity Market Reform* we identified the potential for nuclear capacity to rise to 17 GW in 2030 (of which 16 GW is new capacity added during the 2020s). DECC's final delivery plan for Electricity Market Reform set out a plan for a programme of new plant that would lead to nuclear capacity of 14-19 GW (under 100 g/kWh and 50 g/kWh scenarios for overall carbon intensity respectively) in 2030.

A significant amount of new capacity is currently in development with a view to coming on line in the 2020s:

30 CCC (2013) Next Steps on Electricity Market Reform.

- EDF has agreed terms of contract and a strike price for Hinkley Point C (3.2 GW) in 2013. State Aid approval is now required for this project to proceed and be operational by 2023. A decision on this is expected from the European Commission later in 2014. EDF are also actively developing plans for a further 3.2 GW at Sizewell.
- Horizon are aiming to submit a planning application next year for a 2.6 GW plant at Wylfa ahead of commencement of major on-site work in 2018 with a view to being online in the mid-2020s (with potential for a possible further 1.3 GW reactor). Development is also continuing at Oldbury (2.6 GW), although this may not begin operation until after 2030. This venture is using the UK Advanced Boiling Water Reactor (AWBR) which is currently being assessed under the UK's Generic Design Assessment process (GDA[31]), and is expected to complete by January 2018.
- Also aiming to be in operation in the mid-2020s, the NuGen (3.6 GW) venture at Sellafield expects to enter planning in 2015/16. The GDA has commenced for this reactor design (Westinghouse AP1000) however this has been delayed given that the negotiations over the reactor are yet to be finalized. Once the GDA process recommences it is expected to take less than the usual 5 years.

We will monitor progress in new nuclear against a benchmark of between 12.6 and 16.5 GW (the high scenario would include, for example, all these sites and an additional reactor) of new capacity by 2030.

Given the delayed progress to date but recognising that there is still potential for new nuclear to generate a significant amount of low-carbon power in the 2020s, we have allocated an amber traffic light to deployment of new nuclear.

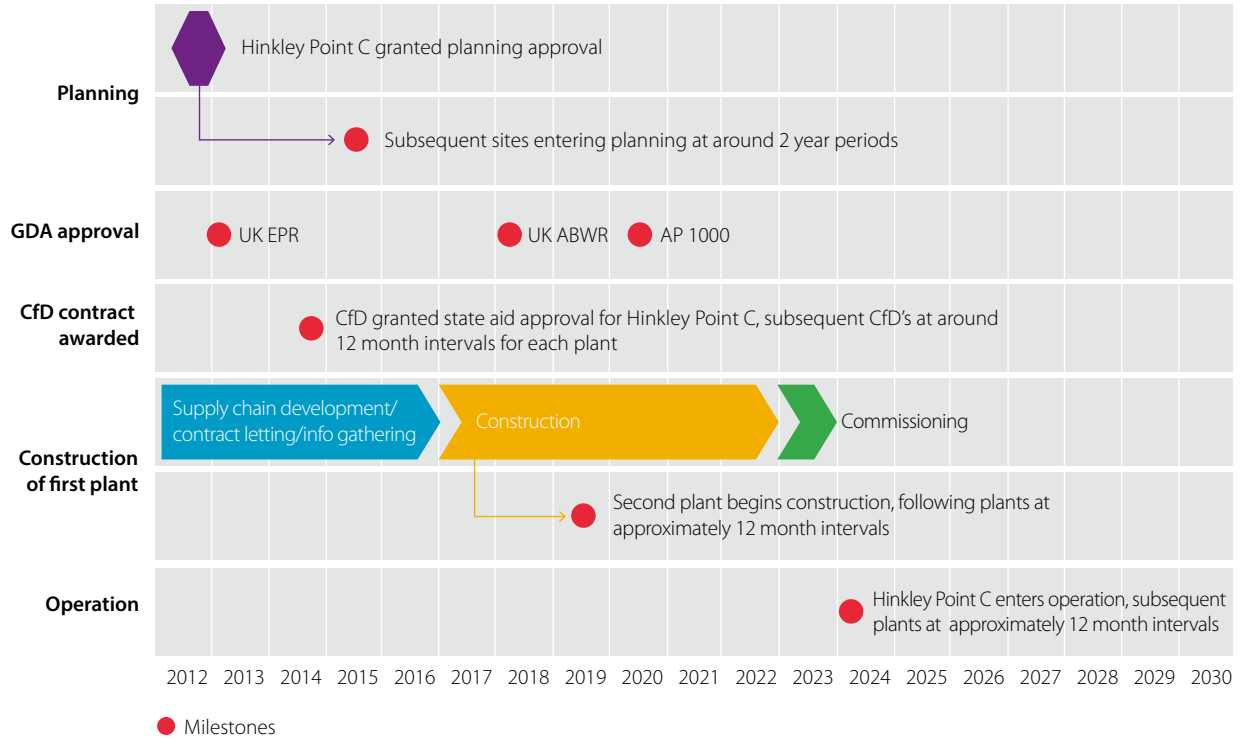
We will monitor against key milestones on the path to delivering a cost-effective level of uptake of new nuclear (Figure 2.10):

- GDA assessment approvals for Horizon (2018) and NuGen and planning applications being submitted for new sites during the second carbon budget period.
- Construction of the first new plant beginning by 2017 and operational by 2023, with an additional reactor (1.3-1.6 GW) every approximately 12 months. This timeline builds in allowance for some further potential delays in construction and planning (6-7 year construction time compared with an expected construction time of 5-6 years, see box 2.5).
- Approval and construction of a safe geological disposal facility towards the Government's estimated timeline, which envisages the first higher-activity waste entering the facility in 2040[32].

In order for a successful programme of new nuclear plant to be deployed, projects also need to deliver to time and budget. We will closely monitor this and any announcements of cost overruns. If costs rise further and the benefits of a programme do not translate to lower costs than for the first plant then the value of a nuclear programme would be called into question, particularly if other low-carbon options (i.e. renewables and CCS) are making good progress.

31 GDA is also known as pre-licensing, which allows them to assess the environmental, safety and security aspects of reactor designs.
32 Defra (2008) *Managing Radioactive Waste Safety*. Available at: www.gov.uk.

Figure 2.10: Timeline of nuclear projects in the UK and indicator



Source: Expected project milestones from energy company public statements.
Notes: Three reactor designs are currently under consideration for the UK's new build nuclear program: the UK European Pressurised Reactor (EPR) for EdF's sites, the UK Advanced Boiling Water Reactor (ABWR) for Horizon, and the AP 1000 for NuGen. Though the GDA process is expected to take five years, it can be subject to delay, therefore future dates are indicative only.

Box 2.5: International nuclear power projects

Delays with the construction of other nuclear reactors in Europe have been due to site-specific factors, as well as a focus on more stringent safety standards, and consequent design changes post-Fukushima.

- Progress building a new nuclear plant at EdF's Flamanville plant in France has been delayed due to a combination of structural and economic reasons, including rising material costs, design changes post-Fukushima and some on-site accidents[33].
- Similarly, budget and time overruns are being experienced at TVO's plant at Olkiluoto in Finland, with construction periods at both sites being delayed by at least 2 years.
- Areva, which is developing the European Pressurised Reactors (EPRs) used in both these projects (and for Hinkley Point C) suggests that delays are due to project specific factors and not the EPR technology, as its EPRs are currently being delivered on schedule and to budget in China.

Progress has been made in Asia, including for reactor designs included in the UK's new-build programme.

- International construction times averaged 4.75 years in 2012, for projects coming online in China and South Korea[34], although these projects did not involve reactor designs proposed in the UK.
- Of the reactors proposed in the UK, the EPR (EdF) has been approved for use by the Office for Nuclear Regulation (via the Generic Design Assessment (GDA) process) and construction experience has been positive in China; Horizon's UK Advanced Boiling Water Reactor (ABWR) is moving through the GDA and though this process has been stalled for the AP 1000 (which NuGen proposes to use), the reactor is being successfully developed in China.

Reflecting these international developments, we now incorporate 6-7 year construction and commissioning periods for new nuclear build into our scenarios[35].

33 EdF (2011) EDF are due to start selling the first KWh produced by the EPR at Flamanville in 2016. Available at: www.edfenergy.com
34 IAEA (2013) Nuclear Power Reactors in the World. Available at: www-pub.iaea.org
35 Pöyry (2013) *Technology Supply Curves for Low-Carbon Power Generation.* Available at: www.theccc.org.uk.

6. Cost reduction and commercialisation of CCS

Carbon capture and storage (CCS) has a potentially very important role to play in long-term decarbonisation of the economy, as it is a low-carbon and relatively flexible form of power generation, has a crucial role in decarbonising heavy industry, provides the potential for negative-emissions if used in conjunction with bioenergy, and can open up other decarbonisation pathways (e.g. based on hydrogen).

In our first report in 2008, we set out the very important role that CCS could potentially play, and the urgency with which it needed to be proven. It is a crucial means of reducing emissions over the long term, and can affect the approach to decarbonisation across multiple sectors, which means that delays in its development could create widespread uncertainty and potentially increase costs of meeting emissions targets.

While cost estimates are higher than earlier assessments, there is scope for CCS to compete with other low-carbon electricity generation technologies during the 2020s, albeit there is a high degree of uncertainty around future technology cost reductions:

- Estimates for generation costs of the initial demonstration projects are £150-200/MWh[36]. These are high because of the cost of infrastructure development, a high cost of capital associated with perceived risks around management of the complex CCS chains and the scale of the initial projects being relative small.
- In work done for our 2011 Renewable Energy Review, estimated costs for CCS were £75-150/MWh for coal CCS and £60-150/MWh for gas CCS, for delivery in 2020. The wide range of costs reflects uncertainty over technology costs and fossil fuel prices.
- DECC's and our latest estimates suggest that CCS costs could fall by 2030 to £80-140/MWh for gas CCS, and £90-170/MWh for coal, depending on future fuel prices and technology cost reductions[37].
- In bridging the gap between the costs of the initial projects and that of deployment in the second half of the 2020s, the CCS Cost Reduction Task Force highlighted that only 25% of the anticipated reduction in levelised cost will derive from reductions in the cost of component technologies. The remainder of the reductions result from a lower cost of capital and from increasing the scale and utilisation of CO_2 transport and storage infrastructure.

Given the potential for cost reductions and its strategic importance to economy-wide decarbonisation, it is sensible and necessary for the Government to facilitate and incentivise investment in CCS over the period to 2030.

We previously envisaged multiple demonstration plants by 2020, spanning a range of different fuels and capture technologies. Delivering multiple demonstrators is important in order to generate a critical mass that will help to commercialise these technologies and to establish a CO_2 transportation and storage infrastructure to which subsequent projects could connect.

36 CCS Cost Reduction Task Force (2013) The potential for reducing the costs of CCS in the UK – final report. Available at: www.gov.uk.
37 DECC (Dec. 2013) *Electricity Generation Costs*. Available at: www.gov.uk.

Such a programme will also help in the international development and deployment of CCS, which has also been slower than planned (Box 2.6), and could open up export opportunities.

There has been slow progress in CCS against an ambition of four demonstration plants set out in the Coalition Agreement and in our indicators. This is in part due to the failure of the first competition, but there has also been little sign of urgency for the subsequent projects:

- In our initial 2009 assessment of required ambition for CCS, we envisaged Front End Engineering and Design (FEED) studies by 2010 and the first demonstration project operational in 2014. While FEED studies for the Kingsnorth and Longannet projects were undertaken, and provided valuable learning, the first competition did not result in funding for a CCS plant.
- A second process (the Commercialisation Programme) began in 2012, with a view to plants becoming operational between 2016-20. Under this process, four plants were shortlisted in 2013, with two preferred bidders identified (the White Rose project in Yorkshire and Peterhead in Scotland); in winter 2013/14, FEED studies for these two plants began.
  - The White Rose project is an oxy-fuel coal project of 304 MW[38], at the Drax site in Yorkshire, with an associated CO_2 pipeline and storage infrastructure capable of taking CO_2 volumes around 10 times those of the project itself. The consortium comprises Drax, Alstom, BOC and National Grid, so will provide an opportunity to prove the viability of managing a CCS chain with multiple partners. In July, White Rose was awarded €300m funding under the EU New Entrant Reserve (NER 300) mechanism.
  - The Peterhead project is a 340 MW post-combustion project on an existing gas-fired CCGT plant owned by SSE, and will use an existing pipeline as part of the infrastructure. Shell are the lead partner on this project, taking the flue gas from SSE's plant and managing the full chain of CO_2 capture, transportation and storage in their Goldeneye depleted gas reservoir. As this project has fewer partners and utilises an existing pipeline and power plant, it is expected to be operational first.
- The rate of progress to date and DECC's most recently announced expectation of the timing of the final investment decisions on these plants (late 2015) mean that the earliest that these projects will be operational is now the second half of the 2016-20 window, assuming that the timeline does not slip further.

The near-term priority is to move ahead quickly with the two initial projects, so that they are operational by 2020 and, crucially, so that the infrastructure is then available for further projects to follow on. We will monitor progress on the path to this level of ambition and interim milestones for the announced demonstration projects:

- 2015: FEED studies for Peterhead (340 MW) and White Rose (304 MW) complete, and final investment decisions (FIDs) taken.
- 2016: Construction commences.
- 2018: First plant (Peterhead) operational.
- 2019: Second plant (White Rose) operational.

38 On a net output basis, after taking off parasitic loads including that to run the air-separation unit.

It is also important to provide visibility to project developers beyond the preferred bidders, so that interest can be maintained and projects are available for deployment in subsequent phases. Should interest beyond these first two projects fall away, requiring others to be developed from scratch, it is likely that subsequent plants would not be operational until the mid-2020s, causing further delay to CCS commercialisation.

As we have previously recommended, the Government should set out a strategy to reduce costs and commercialise CCS through the 2020s on the path to a level of ambition by 2030 of 5-10 GW, or potentially more if feasible and the technology is cost competitive. The Minister of State for Business and Industry has tasked the Office of Carbon Capture and Storage (OCCS) with producing a scoping document by summer 2014 on the second and subsequent phases of CCS deployment. This should be followed by a full strategy, covering both power and industrial projects, including:

- A vision for how CCS will be deployed over the period to 2030, under what conditions.
- A strategy for CO_2 infrastructure development, including considering business models that allow for investment in infrastructure capacity ahead of CCS projects.
- An approach to funding for projects beyond the current process (e.g. through another competition or with contracts under EMR).

We will develop recommendations on commercialisation and cost reduction on CCS for the UK as part of our 2015 update on progress under EMR. We will also monitor international developments and applications of CCS.

Overall Assessment

Severe delays in progressing CCS have resulted in the programme for deployment being around five years behind schedule. Given the length of this delay and the critical role of CCS in decarbonising both the power sector and industry, we allocate a red traffic light to progress in CCS. While we recognise that the situation regarding initial projects is currently promising, we urge the Government to move quickly to enable final investment decisions for these plants and to develop a strategy for the phase beyond this.

Box 2.6: International progress in CCS[39].

Although much of the initial cost reduction for CCS will occur as a result of its de-risking and in appropriate scale of infrastructure within the UK, there is also an important role for learning and cost reduction via demonstration and deployment, as well as ongoing research and development. Initial CCS projects in the UK will contribute to this process, but it is important to recognise that the UK is not acting in isolation.

Progress in developing CCS globally has been slower than would be ideal. However, the first two large-scale CCS power generation projects globally are expected to become operational this year, while progress elsewhere is mixed:

- The two power projects expected to enter operation this year are both in North America, driven by enhanced oil recovery opportunities. The Boundary Dam project in Canada is a post-combustion retrofit to an existing coal plant, while the Kemper County project in the US is a new-build pre-combustion (IGCC) coal plant.
- In an important development, a CCS project on a steel plant in Abu Dhabi has now awarded contracts for construction, and is expected to be operational in 2016.
- However, outside the UK, the outlook for CCS in Europe is very weak. The ROAD post-combustion power project in the Netherlands is the only project with the prospect of going ahead in the near future, while several projects have been cancelled or put on hold recently. The UK's White Rose project was the only CCS proposal contending for funding under the EU New Entrant Reserve (NER300) mechanism.

The UK remains towards the forefront of CCS development. It will be important to ensure that the UK programme interfaces effectively with international action in order to maximise the global benefits of the initial projects.

7. Supporting infrastructure for low-carbon generation

The transition to a low-carbon electricity system places new demands on supporting electricity infrastructure and system security. This is due to both higher levels of intermittent renewables and increased demand during peak periods as low-carbon electricity is extended to new markets such as electrification of vehicles and heat in buildings.

Transmission infrastructure – investment and access

Our indicators for transmission investment are based on the major network upgrades identified by the Electricity Network Strategy Group (ENSG)[40] as 'least-regrets' to accommodate the ambition for new renewable generation capacity in the UK.

ENSG identified 45 GW of transmission capacity was required of which 1.5 GW has been installed, 10.1 GW is under construction (of which 3.8 GW is anticipated to be delivered over the next 12 months) and 29 GW of capacity is under development.

Whilst there have been some delays compared to our indicator framework (Table 2.1), transmission infrastructure is still likely to be able to accommodate 2020 renewables output; we therefore allocate an amber traffic light rating to transmission investment.

39 Global CCS Institute (February 2014), The Global Status of CCS. Available at: www.globalccsinstitute.com
40 ENSG (2009) Our Electricity Transmission Network: A Vision for 2020. Available at: webarchive.nationalarchives.gov.uk

Table 2.1 Detail of transmission progress on each investment and reasons for delays		
Transmission Asset	**Project status and expected delivery date**	**Reason for delay**
Scotland Stage 1	2016	Minimal (< 1 year) delay.
Wales Stage 1 (Central)	2019	Planning delays and land access issues.
South East	2023	Planning: previously waiting for decision from Planning Inspectorate and Secretary of State. Decision granted April 2014.
English East Coast Stage 1	2018	Subject to review of needs case
South West	2019	No delay.
Wales Stage 1 (North)	i – 2014; ii – 2018; iii – 2021; iv – 2024	Programme under review pending potential generator programme revisions
Scotland Stage 2	2021	Three onshore TOs reassessing needs and determining most economic and efficient reinforcement.

The transmission regimes for connection and ownership have ensured renewable energy technologies are connected to the grid in a timely manner.

- Ofgem's 'Connect and Manage' policy allows renewable electricity to connect to the grid before large-scale transmission network upgrades are in place (i.e. they can use existing infrastructure rather than wait for the full upgrade). This has allowed more than 1.1 GW of renewable capacity to be connected but also resulted in 'constraint payments' (See Box 2.7).
- The Offshore Transmission Operator (OFTO) Regime allows assets to be owned by an independent third party. Whilst this process provides a competitive means of ensuring the transmission capacity is installed, a recent RAE report suggests that this can act as a deterrent to investment, as developers are reluctant to commit capital to constructing a wind farm without a guarantee of a grid connection, and OFTOs are reluctant to invest in a new connection without guarantees that the capacity will be used[41]. A more strategic approach to investment that fully recognises the value of shared infrastructure could be necessary, and further monitoring will be required in order to ensure the smooth operation of the enduring regime.

Ofgem is reviewing the Transmission Network Use of System (TNUoS) charges under Project TransmiT to ensure that prices are fairer for generators using the transmissions system, based on their location and load factor. There have been multiple delays to the process. However in 2013, Ofgem set out its 'minded to' position, with a view to implementing the new regime in 2016. Completion of changes to the pricing regime will help to reduce investor uncertainty.

41 Royal Academy of Engineering (2014) *Wind Energy*. Available at: www.raeng.org.uk.

Box 2.7: Constraint Payments

Under Ofgem's Connect and Manage policy, generators are compensated for not generating at times of peak capacity on the transmission system. The costs of this policy are likely to rise in the near future, before falling as planned transmission capacity is installed. There will however be some level of constraint payments, reflecting a trade-off between 'gold-plating' the transmission system, and managing it effectively.

In the 2013-14 financial year constraint payments for wind generation paid through the Balancing Mechanism totalled £47.4 million, which accounted for 14% of total balancing payments in the year; by comparison gas generators were paid £254 million for similar services[42]. Constraint payments to wind generators were less than 5% of the total support cost for wind in 2013-14.

This policy has been effective in reducing carbon emissions, by allowing renewable energy capacity to connect to the transmission network as required; Ofgem suggests this has resulted in 1.3 $MtCO_2$ of emissions savings so far.

Since both Connect and Manage and the OFTO regime have been implemented successfully and are addressing important issues around connections, we assign a green traffic light to the transmission access and offshore regimes.

To date our indicators have focused on the period to 2020, but transmission investment will continue beyond 2020. To cater for future increases in low-carbon generation, we commissioned Element Energy and Imperial College to assess the investment required to meet the *Fourth Carbon Budget Review* decarbonisation scenarios. Their work suggested that between 2020 and 2030, a further 22 GW of transmission infrastructure would be needed in order to cost-effectively accommodate increasing levels of low-carbon generation, at a total cost of over £2 billion. This includes upgrades of the transmission network in Scotland and Northern England, where most of the renewable generation deployed in the abatement scenario is expected to be located, and two High Voltage Direct Current (HVDC) bootstraps (Western and Eastern) between Scotland and England.

The exact transmission requirement will depend on the evolution of demand and the precise pattern of new capacity build in the sector. The important implication is that, as in the 2020s, a significant expansion is likely to be required. The Government and Ofgem should again work with their partner organisations to ensure that the ENSG work is updated and extended to the 2020s, with sufficient lead-time to allow investments to be delivered as required. We will update and extend our indicators for the 2020s in line with this update.

Infrastructure to support increased flexibility

Flexibility over the time of electricity generation and demand is important in a decarbonising electricity system with high levels of intermittent renewables. In this section we cover the development of supporting infrastructure for flexibility – smart meters and interconnectors. The mechanisms to support the uptake of these options are discussed in section 8.

42 National Grid (2014) *Monthly Balancing Services Summary 2013/14*. Available at: www2.nationalgrid.com.

Smart meters

Smart meters provide information to energy users about their consumption and enable consumers to change the time at which they use electricity, for example:

- **Response to real-time tariffs:** Consumers may shift their demand such as charging electric vehicles or running washing machines overnight when other demand is low.
- **Automated services:** Energy companies or third parties could provide remote management of energy consumption during peak periods, such as switching off fridges for a few minutes or delaying charging of EVs until prices fall.

The Government's Smart Metering programme will ensure that energy suppliers install smart meters in almost all UK households and small businesses by 2020. Energy consumers will be offered a display device that enables them to track how much energy is being consumed and at what cost.

We will monitor developments of installed smart meters and the associated regime, in order to ensure that the foundations are laid for a flexible electricity system in the 2020s.

Interconnection

Interconnection to other electricity markets can help manage variability of demand and supply and reduce system costs by taking advantage of differences between linked jurisdictions (i.e. a market with high demand and limited available capacity can buy electricity more cheaply from a linked market with spare capacity). Flows are price-driven in either direction according to relative demand and supply.

Interconnection already provides a valuable source of flexibility to the UK, with around 4 GW of capacity with France and the Netherlands.

As the penetration of intermittent and inflexible generation increases (e.g. wind and nuclear), interconnection will become more valuable and should increase if overall electricity costs are to be minimised. Our analysis suggests a significant expansion of interconnection capacity (e.g. to reach 18 GW) will be possible and desirable to 2030:

- Three interconnectors, totalling 3.4 GW, are currently under development, connecting the GB market to France (1 GW, expected 2015), Belgium (1 GW, expected 2018) and Norway (1.4 GW, expected 2019)[43].
- Our work with Element Energy suggested that around a further 10 GW of additional capacity would be required by 2030, as part of the lowest cost decarbonisation trajectory.

While the system benefit from interconnection will increase over time, this may not be reflected in the market value that developers can capture, or may have large risks attached (see section 8).

Ofgem have made progress with the regulatory regime to deal with these challenges, but the capacity market is not yet able to reward the capacity value of interconnection.

43 Policy Exchange (2014) *Getting Interconnected*. Available at: www.policyexchange.org.uk

- Ofgem has recently published its proposals for an enduring regime for interconnection aimed at reducing the risks for interconnection developers. This is based on a 'cap and floor' model[44] which provides for semi-regulated returns from the price differential of two interconnected markets (i.e. from buying and selling electricity in both directions). This should balance incentives to fully participate in the electricity market with risks for developers of insufficient returns and for consumers of excessive returns.
- Interconnection will not be eligible to bid into the first capacity auction at the end of 2014. Ofgem are considering its role in future capacity market auctions, and will take this into account in the design of the cap and floor arrangements.

We will monitor development and implementation of Ofgem's proposals and rules relating to interconnectors in the UK capacity market under EMR (see section 8), and we will track progress of projects towards a significant expansion of interconnection by 2030 (e.g. to reach 18 GW in total).

8. Progress and remaining challenges in Electricity Market Reform

Given the UK's statutory 2050 emissions target, early and deep power sector decarbonisation through a portfolio of low-carbon technologies is desirable to minimise overall costs and manage risks.[45] In our first progress report in 2009 we questioned the scope for the existing electricity market structure to deliver this decarbonisation and recommended that the market be reformed.

The Government accepted that recommendation and has now passed enabling legislation for a system of long-term contracts in the Energy Act 2013. These will provide revenue certainty to low-carbon investors, thereby providing more confidence that investment will come forward and at lower cost to the consumer. This is a major step forward in the move to a low-carbon economy.

Progress implementing Electricity Market Reform

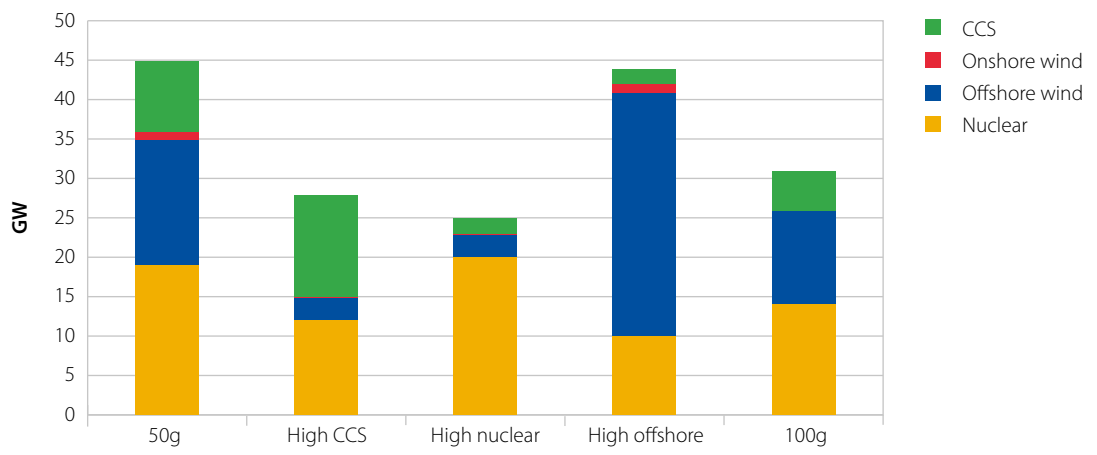
As well as passing the enabling legislation, in the last year the Government has progressed with the implementing arrangements for the reforms. The Delivery Plan set out the first five years of strike prices for renewable technologies and the first contracts were offered under FIDER; however these still leave significant uncertainty over ambition in the 2020s:

- The Delivery Plan was published in December 2013, setting out the strike prices that would be offered to renewable technologies out to 2018-19 (Table 2.2). The Government revised these prices compared to the draft plan published in July, to include a slower rate of degression in offshore wind strike prices, as supported by the evidence and as advised by the Committee in September 2013[46].

44 This model guarantees developers a minimum rate of return for 25 years, as well as a cap on revenue.
45 CCC (2013) *Next Steps on Electricity Market Reform*, p18.
46 CCC (2013) *EMR Delivery Plan – clarity over medium-term ambition.*

- In April the Government announced the first set of contracts to be offered under the FIDER. These incentivise 3.2 GW of offshore wind and 1.4 GW of biomass up to 2020 at strike prices set out in the Delivery Plan. The contracts have now been signed and laid in parliament, giving them legal effect and committing the Government to paying project developers at the rates agreed.
- In this year's Budget the Carbon Price Support (the UK's top up to the ETS price applying to the power sector) was frozen from 2016/17 at £18. If the EU ETS price remains at around £4 (€5) to 2020, the price in the UK will be £22 rather than £32 per tonne. The resulting lower electricity price[47] will also increase required funding for low-carbon investments under the Levy Control Framework (LCF) by around £0.3 billion/year by 2020, although this is well within the 20% 'headroom' available. Low-carbon investment, therefore, should not be materially impacted in the near term, notwithstanding the uncertainty that is created through introducing a policy such as the carbon price floor and changing it soon afterwards.
- The Delivery Plan and supporting documents[48] also set out scenarios for delivery of low-carbon capacity to 2020 and 2030. These included ranges of 11-13 GW for onshore wind and 8-15 GW for offshore wind in 2020, which together with the announced funding in the Levy Control Framework and announced strike prices provide some confidence to developers of a market for these technologies. However, the Delivery Plan scenarios for 2030 imply very limited build of key technologies (CCS, onshore and offshore wind) in several scenarios (Figure 2.11)

Figure 2.11: DECC 2020-30 new build scenarios of key low-carbon generation technologies



Source: DECC (2013) *Electricity Market Reform Delivery Plan*; CCC (2013) *Fourth Carbon Budget Review*.
Notes: Nameplate capacity (i.e. not adjusted to reflect lower availability of wind).

47 This change is likely to mean that electricity prices are lower than they would otherwise have been, saving the average household up to £15/year by 2020.
48 National Grid (2013) *National Grid EMR Analytical Report*. Available at: www.gov.uk.

Table 2.2 Strike prices for key low-carbon technologies in the 2013 DECC EMR delivery plan (£/MWh)					
Technology	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**
Biomass Conversion	105	105	105	105	105
Dedicated Biomass (with CHP)	125	125	125	125	125
Offshore wind	155	155	150	140	140
Onshore wind (>5 MW)	95	95	95	90	90
Solar Photo-Voltaic (>5 MW)	120	120	115	110	100
Tidal Stream	305	305	305	305	305
Wave	305	305	305	305	305

The Government has announced its intention to allocate contracts differently for mature and less-established technologies. This is a suitable approach given the different needs and the importance of both in a cost-effective path to decarbonisation:

- Mature technologies (i.e. onshore wind, solar, energy from waste with CHP, hydro, landfill gas and sewage gas) will move immediately to a competitive allocation process, with contracts awarded to the lowest price offers in a sealed-bid auction. These will be funded from a dedicated part of the Levy Control Framework, with the remainder reserved for less-established technologies (e.g. offshore wind, wave, tidal stream, advanced conversion technologies, anaerobic digestion, dedicated biomass with CHP and geothermal). The less-established technologies will also move to competition when there are sufficient projects to allow this and subject to any delivery thresholds for certain technologies.
- This approach of splitting the funding pot between mature and emerging technologies is a sensible way to proceed, which allows a move to competitive price discovery while still supporting those technologies that require higher support now in order to drive cost reductions for the future.
- The Government will announce an initial indication of the shares of these two pots in mid-July. Our analysis suggests around half the additional funding to 2020 should be allocated to emerging technologies.

The first auction for contracts will be held in autumn 2014 with the first contracts from auction awarded in early 2015. It will be important for developer confidence that these auctions run smoothly and that any changes to incorporate lessons learnt are made transparently and well in advance of the next auction round in 2015. The Government has also recognised the possible value of setting maxima or minima for certain technologies – these should be considered as they could help support a stable investment programme and ensure a portfolio of generation options are supported.

Providing capacity in a decarbonising system

Increased back-up capacity will be required as the power sector is decarbonised. This includes existing gas and coal plant, as well as new investment in gas:

- Our previous analysis has demonstrated that increased back-up capacity will be required (e.g. over 35 GW of gas-fired capacity) as the power sector is decarbonised.
- Both existing coal and existing/new gas plant could be candidates to provide this capacity, while demand-side reduction/response, interconnection and storage could reduce the need for new capacity.

Much of this fossil fuel capacity would operate at low load factors (e.g. some at less than 10% by 2030), and is unlikely to earn sufficient return in an electricity-only market to justify investment. Moreover, capacity would be reliant on a very high price for a small period of the year, with these hard to predict in advance, given intermittency of wind and demand uncertainty.

Demand changes (both demand reduction and demand shifting) could also play a role in the capacity market by reducing the need for generating capacity by securing and aggregating demand reduction from multiple consumers.

The Energy Act introduced powers to introduce a GB capacity market, for which the first auction is planned for 2014, to incentivise capacity from 2018. This is an important step in ensuring security of supply in a decarbonised system.

The appropriate mix between demand response, existing plant and new gas plant in meeting capacity requirements will depend on the opportunities on the demand side and the relative costs of coal and gas including carbon costs. All options should be allowed to compete in a way that provides system security at lowest cost.

There are challenges associated with some of these options, for example achieving adequate levels of customer participation and market entry for service providers. DECC and National Grid are currently working to understand and address these challenges through a set of demand-side pilots.

- Initial trials suggest that the introduction of time-of-use tariffs could contribute to an average peak load reduction of over 10%, reducing the level of back-up capacity required to be contracted.
- Recent proposals by National Grid will contract for demand-side balancing reserve services (e.g. via demand aggregation) of around 300 MW in 2014/15 (and similar levels in the years up to 2018/19) as a trial for the inclusion of Demand Side Response (DSR) in the capacity market. If successful, these demonstrations will encourage the participation of DSR in National Grid's capacity market (beginning 2018/19).

- Whilst these pilots are focused on demand-side response (i.e. shifting demand away from times of peak demand) there may also be potential to reduce overall demand. In exploring that opportunity it will be important to consider the potential contribution though EMR mechanisms in the context of other instruments (e.g. regulations and EU product design standards have been crucial in driving improved appliance and lighting efficiency).

Interconnection will not be eligible to bid into the first capacity auction at the end of 2014. However the Government is considering its participation in future capacity market auctions.

We will monitor the results of the capacity auctions and the development of options for DSR and interconnection and consider any implications for the low-carbon investment programme.

The role of unabated coal

Globally, the shift away from unabated coal is a very important part of reducing emissions. This should occur together with the ramping up of low-carbon power generation, rather than just a shift from coal to gas that fails to prepare for the deeper emissions reduction required over the longer term.

Within Europe, it was expected that policies (i.e. EU air-quality regulations, renewables targets and the EU ETS) would drive both of these changes. However, low carbon prices, driven by economic weakness within Europe, together with low coal prices and lower than expected costs for compliance with air-quality regulations, raise the possibility that old coal plants will continue running in the UK for some time (see section 2).

Existing coal plants staying open in the near term could have negative implications for air quality and UK/EU leadership on climate change, but need not significantly affect EU-wide emissions in the near term or whether the UK is on track to meet carbon budgets and longer-term emissions targets:

- Even with air quality regulations that require coal plants to reduce their local pollution, a greater role for existing UK coal plants going forward would be likely to lead to worse air quality.
- Enabling coal to stay open longer could also make it more difficult for the UK and EU to push for reductions in coal use internationally, which are required to meet the agreed UNFCCC climate objective.
- However, for a given EU ETS cap, keeping UK coal plants open would not increase overall EU emissions unless, as a result of their closure, emissions allowances (EUAs) are withdrawn from the market permanently. This would not occur under current ETS rules, although depending on the final details of the new mechanism to avoid ETS surpluses (e.g. the EC's Market Stability Reserve proposal) this may be possible in future (see Chapter 1).
- Keeping UK coal plants open in the near term would also be compatible with meeting carbon budgets, as under the accounting rules of the Climate Change Act the contribution of the traded sector to meeting carbon budgets is determined by the UK's share of the cap in the EU ETS.

- Provided that the UK continues to deploy low-carbon capacity at the rates set out in our indicators, it will still be able to meet longer-term targets, as long as coal eventually comes off the system.

In the longer term, coal use will have to fall as new low-carbon capacity comes on. Investors should be clear on this when making decisions, along with the prospect that carbon prices will have to rise considerably under an effective global deal.

Contracts for Difference under Electricity Market Reform should provide a secure market for low-carbon capacity whether or not existing coal stays on the system, although the size of this market could be made clearer (i.e. with a decarbonisation target for 2030), as discussed below. This would also provide a clear signal to coal generators that their load factors will fall as the room for unabated fossil generation reduces over time.

We also recommend that the Government pushes for an ambitious EU ETS cap to 2030, with associated reforms to avoid excessive surpluses of allowances, in order to generate a sufficient carbon price for a switch away from coal (see Chapter 1).

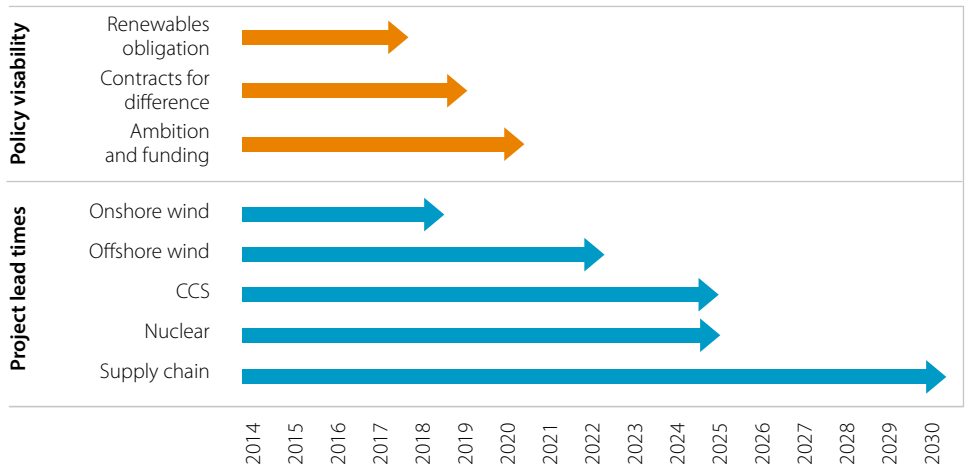
Next steps on Electricity Market Reform

The most pressing challenge to address in order to secure investment beyond 2020 is the current uncertainty about the direction of travel for the Electricity Market Reform (i.e. as apparent in DECC's scenarios for 2030). This is undermining incentives for project development and supply-chain investment, both of which are necessary for low-carbon investment and cost reduction. It is becoming increasingly problematic as the lead-times for key investments stretch well into the 2020s (Figure 2.12), and risks increasing the costs of UK power sector decarbonisation (Box 2.9).

To address the uncertainty will require that the Government provides investors with confidence that there will be a market for low-carbon technologies in the 2020s. The best way to do this is to announce strategies for the commercialisation of emerging technologies along with the overall ambition for decarbonisation and the limit for funding of low-carbon generation in the 2020s. This will provide the visibility necessary to encourage investment, while retaining flexibility to respond to cost information and safeguard consumers against excessive costs.

- The Government have taken powers in the Energy Act to set in 2016 a carbon intensity target as a range for 2030. A carbon intensity target should provide a balance of confidence and incentives to industry, signalling the Government's intention to invest in a portfolio of low-carbon technologies to 2030.
- Under central projections of GDP, fuel and carbon prices, power sector emissions intensity would fall to approximately 50 g/kWh, or as high as 100 g/kWh if some low-carbon options prove harder than expected to deploy, or if, for example, coal provides a significant amount of back-up generation. Since the target will be set as a range, the Government should also announce the factors that will determine where on the range they expect to end up, and circumstances under which the target range will be reconsidered.

Figure 2.12: Approximate project lead times (development and construction) compared with policy visibility



- A commercialisation strategy should set out ambition for investment in offshore wind, building on the current evidence base, including a commitment to a critical mass of investment; a target cost reduction schedule under which ambition will be maintained or increased; the point in time when the technology will be expected to compete with other low-carbon options without support; and any role for Government in driving cost reduction.
- A strategy should also by published to develop CCS in both power and industry, including CO_2 infrastructure development, minimum levels of deployment to 2030 (including higher levels of deployment dependent on cost reduction), in both power and industry. The programme of investment in the UK should be designed to fit with what is happening in other countries (e.g. for CCS the strategy should design the level of deployment and specific applications in a way that complements what is happening in China, the US and elsewhere).

Progress in the policy framework in 2013/14 could lay the foundation for decarbonising the power sector, including the key elements of long-term contracts and funding to 2020, although a lack of clarity beyond 2020 puts at risk investment and benefits to the UK.

We allocate an amber traffic light rating to progress on market reform and will continue to work on the components of an effective strategy for EMR. We will report on the appropriate range for a 2030 decarbonisation target as part of our statutory work to advise on the fifth carbon budget (2028-32).

Box 2.9: The importance of low-carbon investment in the 2020s in minimising costs of decarbonisation

Investment beyond 2020 will be required to secure the benefits from the large funding commitments that have been made to support investment coming on the system to 2020.

This is because much of the investment to 2020 is for commercialisation of less mature technologies (e.g. offshore wind, CCS). Further investment will be required to make these technologies competitive.

The recently agreed nuclear investment is the first step in a clear programme which is expected to bring significant economic benefit to the UK. A failure to invest beyond 2020 would imply that earlier investments are largely wasted, in that they were aimed at technology commercialisation which did not ensue.

In our 2013 report *Next Steps on Electricity Market Reform* we estimated the economic benefits associated with continued investment in low-carbon technologies through the 2020s, compared to a counterfactual of investment in conventional gas-fired generation. Our assessment was that portfolio investment in low-carbon technologies would save around £25-45 billion in present value terms under assumptions of central gas and carbon prices; rising to over £100 billion with high gas and carbon prices.

Decarbonisation through investment in a portfolio of low-carbon technologies is a low-regrets strategy with potentially significant benefits in a carbon-constrained world. Even if gas prices were to fall significantly or carbon price were to remain low, there would be no more than a small cost saving from the alternative strategy of investment in gas-fired generation in the 2020s, followed by investment in low-carbon technologies in the 2030s. Only if the world were to abandon attempts to limit the risk of dangerous climate change would there be significant cost savings from a strategy focused on investment in gas-fired generation.

Investment in low-carbon technologies can be seen as insurance against risks of climate change and rising energy bills in the future, with a near-term premium that is manageable. For households, we estimate that energy bills may increase by around £100 per year by 2020 and that impacts can be offset through energy efficiency. For energy-intensive industry, competitiveness risks arise through unilateral increases in energy bills, but can be managed through compensation or exemptions such as those currently in place (e.g. exemption for EMR costs).

Beyond 2020, bills will increase by up to £50 due to the rising carbon price, with an additional £20 due to support for low-carbon investment. A lesser increase in the carbon price would imply the need for a higher increase to support portfolio investment (e.g. up to £75 due to the rising carbon price, with £20+ to support low-carbon investment).

9. UK progress in the EU context

The UK's share of the renewable energy target under the Renewable Energy Directive is to achieve 15% of total final energy consumption by 2020. The implication for the power section is for 30-35% of electricity generation from renewables in 2020, although a specific target for power generation is not set at the EU level.

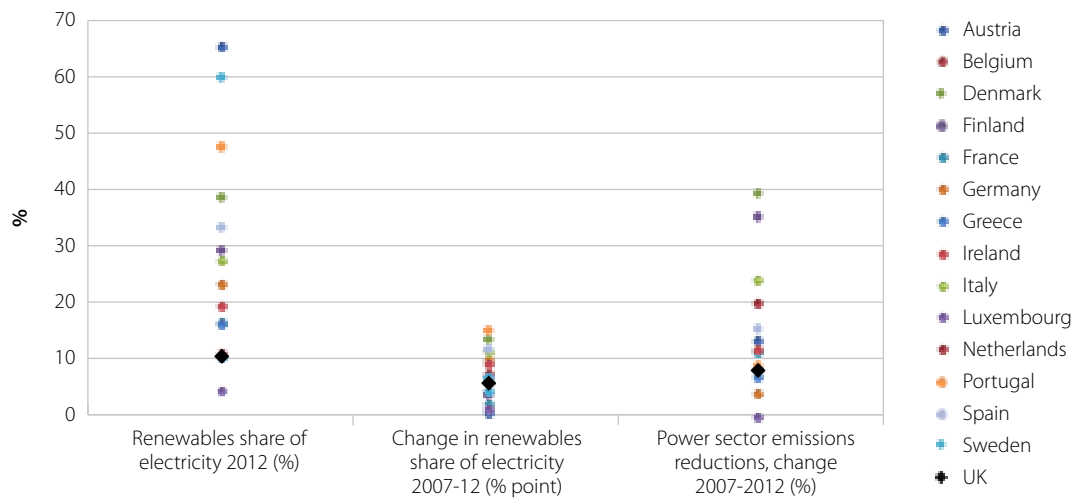
Given that the UK started from a low base of renewables penetration in electricity generation, the UK is required to undergo one of the most ambitious increases across the EU. Comparing progress to other EU member states, the rate of increase in penetration has been close to the average:

- The UK had 5% renewables in 2007, which is lower than most of its competitors, reflecting in part a relatively large endowment of fossil fuel resources.
- In 2012, the UK had increased its share to 11% mainly due to increases in wind and biomass generation. The UK has made particularly good progress in offshore wind, which increased to 4 GW in 2013, as is the world leader in installed capacity of offshore wind.

- This still positions the UK towards the back of key competitors in the EU, although the rate of increase in renewables is in around the average (Figure 2.13):
  - The Netherlands had a similar level of renewables penetration to the UK in 2007 at 5%, increasing to 10% in 2012.
  - Germany increased renewables share of electricity from 14% to 24% between 2007 and 2012.
  - Spain increased from 22% to 33% from 2007 to 2012.

The UK faces a challenging task to achieve a 30-35% penetration of renewables in the power sector by 2020. However our assessment of the pipeline (section 4) suggests that this is achievable, through maintaining the current rate of progress and within the funding available for low-carbon contracts under EMR. International comparisons of current investment conditions also tend to rate the UK fairly highly for attractiveness of renewable investment.[49]

Figure 2.13: EU comparisons



Source: Eurostat (2014) *Short Assessment of Renewable Energy Sources*. CCC Calculations.

49 For example, see EY (2014) *Renewable Energy Country Attractiveness Index*. Available at: www.ey.com

10. Summary of progress and remaining challenges

In this chapter we have assessed whether progress in power sector decarbonisation over the first carbon budget period was in line with the level of ambition implied by the first carbon budget (Table 2.3). We also assessed progress at a detailed level against our indicator framework, which allows us to monitor whether we are on track implementing low-carbon measures and associated infrastructure, planning and policy.

Table 2.3 Power sector traffic lights

Indicator	Traffic light	Comment
Onshore and offshore wind	Green	Capacity in line with indicator and a strong pipeline of projects to 2020. However, longer-term uncertainty could undermine the flow of projects from the pipeline to delivery.
Nuclear new build	Amber	Delayed new-build programme by at least 5 years, with expected completion date of first new plant pushed back from 2018 to 2023. However, strike price and terms of contract now agreed and potential programme of future projects.
CCS FEED studies complete by 2010, first project online 2014	Red	FEED studies now due to complete in 2015 (i.e. 5 years behind indicator). However, some lessons learned and programme due to deliver 2 plants by 2020.
Transmission investment	Amber	Some delays compared to our indicator framework. Transmission infrastructure is still likely to be able to accommodate 2020 renewables output without significant losses.
Transmission regimes	Green	Connect and Manage and the OFTO regime have been implemented successfully and are addressing important issues around connections
Review of electricity market to begin in first budget period	Amber	Energy Act legislated in 2013 including key elements of reform (long-term contracts and funding to 2020), but lack of clarity beyond 2020 and of any decarbonisation objective could undermine delivery.

This assessment showed that good progress has been made regarding investment in renewables technologies and associated infrastructure. Internationally, progress driving down costs has been strongest in solar PV, but in the UK questions remain over how to deal with its seasonal generation profile. Long-term contracts for low-carbon electricity have been introduced, which achieves a major policy milestone in line with our advice, and the challenge is now to move towards implementation and smooth functioning of auctions.

In order to gain the economic benefits from what has been achieved to date, and the commitments that have been made to 2020, continuing investment will be required through the 2020s. A failure to invest beyond 2020 would imply that earlier investments are largely wasted, in that they were aimed at technology commercialisation which did not ensue.

To address the uncertainty will require that the Government provides investors with confidence that there will be a market for low-carbon technologies in the 2020s. Success here requires a package that balances certainty of a future market with incentives for cost reductions, while retaining some flexibility to safeguard consumer interests.

To secure the benefits of these efforts it is now a priority that the Government confirms, by 2016, commitment to levels of ambition and associated funding beyond 2020, including commercialisation strategies for emerging technologies. Delays to these commitments would increase risks for investors – with the implication of affordability impacts for the consumer – and put at risk substantial low-carbon investments that are now in the pipeline.

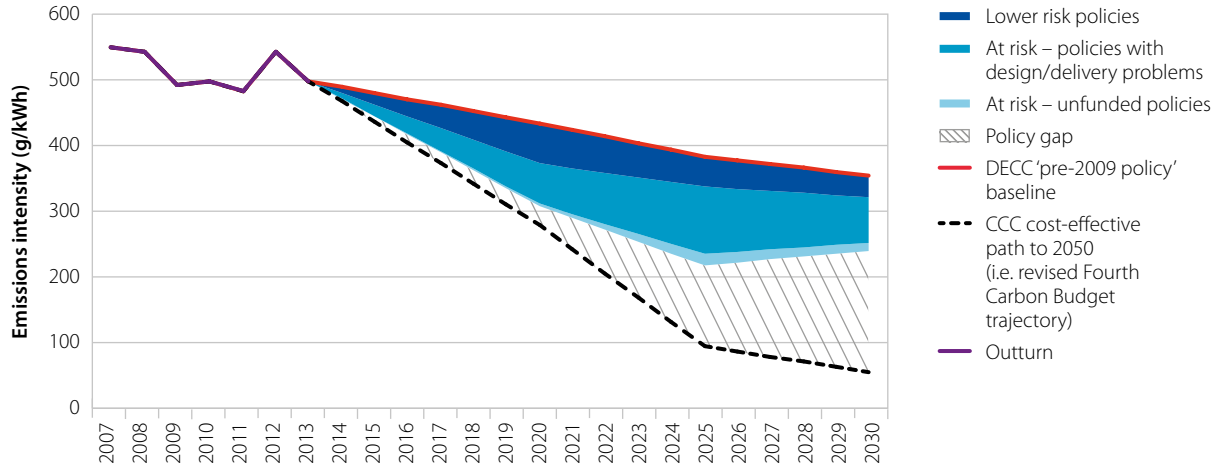
We have also updated our indicator framework based on progress to date and extended this to the end of the fourth carbon budget period (2027), and we have added new areas to track that become important in this period.

- Based on the Fourth Carbon Budget Review, our scenarios allow the flexibility for one technology to substitute for another, but specify around 25-40 GW of offshore wind, up to 10 GW of CCS, 13-25 GW of onshore wind and 12-17 GW of new nuclear installed by 2030.
- We will also monitor progress with low-carbon flexibility options to support the increase in low-carbon generation, including 18 GW of interconnection and learning from pilots for demand-side response.
- Under central projections of GDP, fuel and carbon prices, power sector emissions intensity would fall to approximately 50 g/kWh. Intensity could be as high as 100 g/kWh if some low-carbon options prove harder than expected to deploy, or if, for example, coal provides a significant amount of back-up generation. We will monitor against both these possible scenarios.
- Given the sensitivity of actual emissions intensity to in-year changes we also monitor achievable emissions intensity which is currently 285 g/kWh, falling to 50-100 g/kWh in 2030.

Whereas the aim should be to reduce emissions intensity of electricity to 50 g/kWh and possibly as high as 100 g/kWh to be on the cost-effective path, we can have limited confidence that this will be achieved under existing and planned policies (Table 2.4). Our analysis therefore suggests emissions intensity could be as high as over 200 g/kWh under current committed policy (Figure 2.14).

As well as emissions intensity of supply, demand reduction makes decarbonising electricity easier by lowering requirements on new low-carbon generation. It also directly reduces emissions by reducing the amount of electricity for a given intensity and in many cases can displace high-carbon marginal sources of supply. The opportunities and challenges of achieving demand reduction potential are covered in Chapter 3 for buildings and 4 for industry.

Figure 2.14: Potential shortfall of existing policies compared to the cost-effective path.



Source: DECC (2013) *Updated emissions projections*; CCC analysis.

Table 2.4 Risk assessment of power sector policies

Policy	Comment
Lower-risk policies	
Renewables Obligation, FITS and FIDER;	Policies target the right technologies and have been effective in the past. Support is broadly matched to technology costs and funding is sufficient
Policies with design/delivery problems	
CCS demonstration	Targets the right CCS applications; continuing risks to delivery of technology and reaching the final investment decision; £1 billion funding has been allocated.
Fuel switching	Some existing coal plant will close under LCPD & IED, however other plant may stay open for some time due to weakness of EU ETS and low coal prices. No new unabated coal plant due to EPS. Capacity mechanism is an incentive for new gas plant
CFDs to 2020	Programme is in place, however lack of support beyond 2020 may increase uncertainty for bidders pre-2020. Support broadly appropriate (EMR report). Support in two pots, respective sizes and detailed design (e.g. maxima & minima) yet to be announced
Unfunded policies	
Nuclear – first 2 reactors at Hinkley	Agreement on terms for proposed first contract but risks around state aid, level of agreed strike price appropriate, contract terms have been agreed, however contract is not in place.
Missing policies	
Power sector deployment beyond 2020	Moving the power sector from 200 g/kWh in 2020 to 50-100 g/kWh by 2030.

Major challenges to get to the level of ambition in 2030 include achieving cost reductions in offshore wind in line with the degression of support levels and budget management to ensure a portfolio of technologies is deployed.

Significant investments in transitioning the UK's electricity infrastructure towards a low-carbon system have been made to date. If progress does not continue beyond 2020, the learning and other benefits of this investment to the UK could be reduced. It is therefore important that:

- Government confirms, by 2016, commitment to levels of ambition and associated funding beyond 2020. Delays beyond this would increase risks for investors – with the implication of affordability impacts for the consumer – and put at risk substantial low-carbon investments that are now in the pipeline.
- The goal for offshore wind should be to drive costs down to a level where they can compete with other low-carbon technologies. This requires an approach to commercialisation which includes required rates of cost reduction and minimum levels of deployment to achieve a critical mass.
- A strategy is needed for how CCS will be deployed over the period to 2030 and under what conditions, a strategy for CO_2 infrastructure development and an approach to funding for projects beyond the current process (e.g. competition or CFDs)

We will develop and recommend approaches to commercialisation and cost reduction as part of our advice on the 2030 target range for power sector decarbonisation and update on progress under EMR in 2015.

Key findings

- Power sector **emissions fell by 11%** from 2007 to 2012 in line with the level of ambition set out in our indicators. This was driven by lower electricity generation (due to the recession) and investment in new gas and low-carbon generation.
- **In 2013 emissions fell 8% (on 2012)** due to increasing renewables and around 6 GW of coal plant closures (having reached the end of their allocated hours under EU legislation).
- There has been **a step change in the rate of investment in both on and offshore wind generation** over the first carbon budget period. There is enough wind in the pipeline to sustain this rate of progress to 2020 as required by the EU Renewable Energy Directive; however **stronger signals are required over commitments beyond 2020**.
- Over the first carbon budget period, **nuclear investment was delayed around 5-6 years**. Contract terms and level of support are now agreed for the first new nuclear reactor.
- There has been **slow progress in CCS (at least a 5-6 year delay)** The near-term priority is to move ahead quickly with the two initial projects, so that they are operational by 2020 and, crucially, so that the infrastructure is then available for further projects to follow on.
- **The Energy Act was passed in 2013**, enabling reform of the electricity market to support the transition to a low-carbon power sector. This includes **the introduction of long-term contracts**, which will provide revenue certainty for low-carbon projects once contracts are signed.
- **Industry needs a strong signal about the future direction of travel** for the power system, particularly beyond 2020, in order to support supply chain investment, which has long payback periods, and development of new projects, which have long lead-times. Without this, full benefits for investment to date would not be realised.
- **This should be provided** through a 2030 target for carbon intensity, commercialisation strategies for less mature technologies, and extending funding. Success here requires a package of measures that balances certainty of a future market with incentives for cost reductions, while retaining some flexibility to safeguard consumer interests.

Table 2.1: The Committee's Power sector indicators

POWER		Budget 2	Budget 3		Budget 4		2013 outturn
Headline indicators							
			50g	*100g*	*50g*	*100g*	
Emissions intensity (g/kWh)		328	151	174	53	100	497
Total emissions (% change from 2007 in final year of budget period)		-57%	-78%	-75%	-91%	-80%	-19.4%
Achievable Emissions Intensity (g/kWh)		205	103	122	53	100	
Generation (TWh/year)	Wind	43	83	82	116	116	27.4
	Nuclear	58	57	57	140	118	64.1
	CCS	0	13	5	33	5	0
Supporting indicators							
Transmission							
Agreement on incentives for anticipatory investment for Stage 1 reinforcements†							All business plans approved, effective as of April 2013
Implementation of enduring regime for accessing grid†							In place 2012
Grid reinforcement planning approval		2013: English East Coast Stage 1, South West 2014: Wales Stage 1 (Central), Wales Stage 1 (North) 2015: Scotland Stage 2					Central Wales still a concern, with potential for future delays. Eastern HVDC bootstrap delivery date put back to 2021, still working on preferred design solution
Grid reinforcement construction begins		2014: English East Coast Stage 1, South West 2015: Wales Stage 1 (North) 2016: Scotland Stage 2					Scotland Stage 1 in construction and on track, continued delays in planning for Wales Central Stage 1
Grid reinforcements operational		2016: Scotland Stage 1, 2018: English East Coast Stage 1, 2019: South West	2018: Wales Stage 1 (North), 2019: Wales Stage 1 (Central), 2021: Scotland Stage 2		2023: South East		n/a in 2013

Table 2.1: The Committee's Power sector indicators

POWER		Budget 2	Budget 3		Budget 4		2013 outturn
Transmission (continued)							
Agreement on long-term charging regime		Project TransmiT confirmed and adopted in 2016					
Tendering for first offshore connections under enduring OFTO regime		TR3 Began in January 2014					Continuing to tender under the transitional regime
Construction of first offshore connections under enduring OFTO regime begins		2014					Still under transitional regime. First Enduring Regime tender round in February 2014
First offshore connections under enduring OFTO regime operational		2016					First connections under enduring regime are delayed, but connections being built successfully under transitional regime
Planning							
IPC set up and ready to receive applications†							MIPU in place
Market							
Next steps on EMR, and long-term vision for energy sector		2014: First CfDs and Capacity Market auctions 2016: Set decarbonisation target for 2030. Confirm LCF funding post-2020. Launch cost reduction strategies for CCS and offshore wind					Energy Bill legislated, secondary legislation to follow in 2014 (pending EU State Aid approval): introduces long-term Contracts for Difference for low carbon generators, and capacity market but fails to add long-term certainty
Wind							
			50g	*100g*	*50g*	*100g*	
Generation (TWh/year)	Onshore	23	33	31	42	43	16.5
	Offshore	20	51	50	74	73	10.9
			High	*Low*	*High*	*Low*	
Total capacity (GW)	Onshore	10.1	15.4	13	21.4	13	7.3
	Offshore	6.3	16.7	13.8	32.2	20.8	3.7

Table 2.1: The Committee's Power sector indicators

POWER		Budget 2	Budget 3		Budget 4		2013 outturn
Wind (continued)							
Capacity entering construction (GW)	Onshore	0.9	1.2	0.0	1.2	0.0	0.6
	Offshore	0.8	2.9	1.4	2.9	1.4	0.6
Capacity entering planning	Onshore	New planning applications will be required from the end of the second budget period at the latest to maintain flow into construction					2.8
	Offshore	New planning applications will be expected in line with site leasing					6.4
Average planning period (months)		<12	<12		<12		20
Cost reduction and commercialisation strategy for offshore wind		In place	Monitor cost reductions in line with objectives identified in commercialisation strategy				
Nuclear							
Regulatory Justification process†							In place
Generic Design Assessment		Westinghouse's AP1000 (NuGen) resumes GDA	Horizon's UK-ABWR approved in 2018				Final approval for EdF in December 2012. GDA for Hitachi began April 2013
National Policy Statement for nuclear (including Strategic Siting Assessment)							Approved July 2011
Regulations for a Funded Decommissioning Programme in place†							In place
Agreement on long-term plan for waste disposal facility		Agreement on host for long-term geological disposal facility	Planning and development in line with Government timeline		Construction of facility to begin in line with Government's 2040 target for first placement of legacy waste		No agreement has been reached
Entering planning		Subsequent applications at at approximately 2 year intervals					n/a for 2013
Planning approval; site development and preliminary works begin		State Aid approval from the European Commission for Hinkley Point C in 2014. Subsequent application approvals, site development and preliminary works at approximately 12 month intervals					Hinkley Point C approved by planning inspectorate in March 2013, currently awaiting state aid approval from the European Commission

Table 2.1: The Committee's Power sector indicators

POWER	Budget 2	Budget 3	Budget 4	2013 outturn
Nuclear (continued)				
Construction begins		First plant in 2017, subsequent plants at approximately 12 month intervals		Delayed, construction expected 2017
Plant begins operation			First plant in 2023, with subsequent plants at approximately 12 month intervals. Site potential for 16 GW by 2030	n/a for 2013
CCS				
Launch Commercialisation Program				Initiated 2012
Front-End Engineering and Design (FEED) studies for competition contenders initiated	FEED studies start in 2014			Initiated: White Rose (Drax) – December 2013; Peterhead (SSE/Shell) – February 2014
FEED studies for competition contenders completed	FEED studies complete in 2015			FEED studies for first competition completed in 2011. Second competition awaiting completion
Final Investment Decision for Demonstration projects	For both preferred bidders by the end of 2015			Funding not awarded, 2011
Quantification of saline aquifer CO2 storage potential	No later than 2015			Storage potential estimated in 2013, under the UK Storage Appraisal Project, managed by the British Geological Survey, Energy Technologies Institute and Crown Estate
Review of technology (including cost reduction and commercialisation strategy), strategic plan for infrastructure development and decision on framework for future support	No later than 2016*			n/a
Planning and authorisation approval, land acquisition, and storage site testing completed, construction commences	2015-2016 for first demonstrations			First demo not yet commissioned
Demonstrations operational		first plant in 2018, subsequent plant in 2019		n/a for 2013
First new full CCS plants supported via the post-demonstration mechanism				n/a for 2013

Table 2.1: The Committee's Power sector indicators

POWER	Budget 2	Budget 3	Budget 4	2013 outturn
Grid Requirements for Decarbonisation				
Interconnection	Interconnection Regime in place by 2016. Phase 1 assets (pre-2020) entering construction. Phase 2 assets (pre-2030) entering development and planning	Additional 3.4 GW by 2020	Additional 10 GW by 2030	n/a
Smart Meter Deployment (Electricity)	On track to the Government's trajectory of 17m installed by 2017	Full rollout (28m) complete by 2020		n/a
Other drivers/wider monitoring				
Total demand (TWh), coal and gas prices, nuclear outages				
Average wind load factors, availability of offshore installation vessels, access to turbines				
Monitor technology costs				
Nuclear supply chain, availability of skilled staff				
International progress on CCS demonstration and deployment				
Uptake of solar power, and developments in seasonal storage				
Planning approval rates and frequency of public inquiries to decisions of Infrastructure Planning Commission				
Monitor participation of demand response and demand reduction in Capacity Market auctions and in the wider electricity market				

Notes: 1. Numbers indicate amount in last year of budget period i.e. 2017, 2022, 2027.

2. While we present outturn figures for 2013, it is not our expectation that our trajectories will be achieved precisely for every indicator in every year. There may be some year to year variation, which is acceptable. Similarly it may be the case that some indicators are not met while others are over-achieved; this may still on average constitute sufficient progress. A problem will be signalled however if under-achievement persists, if a large number of indicators are off-track or if specific indicators or milestones which are key to unlocking abatement in the longer term are not met.

3. The 50 g/kWh and 100 g/kWh indicators represent possible scenarios that achieve these emissions intensities by 2030. Several other scenarios exist which could meet these objectives.

* The Energy Act 2010 requires a rolling review of CCS progress, to report on the appropriate regulatory and financial framework by 2018.

† Old Indicators that will be removed.

Key: Headline indicators Supporting indicators Other drivers

Chapter 3

Chapter 3: Progress reducing emissions from buildings

1. Introduction and key messages

In this chapter, we examine progress in the buildings sector, which accounts for 37% of total UK greenhouse gas emissions. Buildings emissions are split broadly equally between direct (i.e. from burning fossil fuels) and indirect emissions (related to the burning of fossil fuels to generate electricity). There is significant emission reduction potential from energy efficiency measures (e.g. insulation and more efficient appliances) and the deployment of low-carbon heat.

Since we started reporting on progress in 2009, the policy framework for both the residential and non-residential sector has seen major changes. As a result, after five years of good progress on many measures, there has been a slow-down in 2013, especially on home insulation. In the non-residential sector, data availability is poor but there are few signs of major energy efficiency performance improvements in the sector.

Key messages:

- **Emission trends:** Buildings CO_2 emissions fell by 8% between 2007 and 2013 due to a mix of energy efficiency improvements, the recession and changes in the electricity sector. There have been large year-to-year fluctuations related to winter temperatures and electricity sector emissions.
- **Residential buildings.** After five years of good progress, insulation rates fell sharply with the introduction of the new energy efficiency policy framework at the beginning of 2013. Implementation should pick up following the redesign of the Energy Company Obligation (ECO) to include more low-cost measures, in line with the Committee's recommendations, and the introduction of new financial incentives under the Green Deal. However, the ECO's carbon ambition has been cut, is low relative to underlying potential and funding, and should be increased. It is not clear whether the package of new incentives, while welcome, will compensate for the cuts in the ECO. Beyond 2017, there is an open question of whether ECO should focus on solid wall insulation and other hard-to-treat measures across all households or in fuel poor homes, or whether a new approach would better address fuel poverty. To support delivery under the ECO and Green Deal, minimum standards for the private rented sector should now be set.
- **Non-residential buildings.** In the non-residential sector, there is not much evidence of energy efficiency improvement. While there are specific examples of organisations that have made progress, much potential remains unexploited. There is a need to strengthen incentives and at the same time rationalise the number of policy instruments, leading to lower administrative costs as well as better delivery. A new approach should have one instrument for each of information provision, financial incentives and regulation.

- **Low-carbon heat.** Increasing uptake of low-carbon heat (i.e. renewable heat and district heating from low-carbon sources) is a priority. Despite the fact that the current instrument to incentivise this – the Renewable Heat Incentive (RHI) – is very generous, take-up to date has been low. The appropriate response is not to increase the subsidy; rather it is to overcome financial and non-financial barriers to uptake. Changing the Green Deal so that this can finance low-carbon heat investment would reduce RHI funding costs. Funding costs could be reduced further through improved information provision and confidence building. Given that the RHI is likely to remain the main policy lever for delivering low-carbon heat for the foreseeable future, funding should be committed to 2020, and a commitment should be made to its continued existence beyond 2020. Consideration should also be given to targeting more of the RHI funding to fuel-poor households, given cost-effective potential here, but additional incentives may be needed. For new-build properties, the Zero Carbon Homes standard from 2016 should require investment in low-carbon heat.

Our recommendations to Government are summarised in Box 3.1. We set out the analysis that underpins these conclusions in the following sections:

- Buildings emission trends
- The Committee's buildings indicator framework
- Residential buildings
- Non-residential buildings
- Low-carbon heat
- Summary of progress and revised progress indicators

Box 3.1: Policy recommendations – Buildings

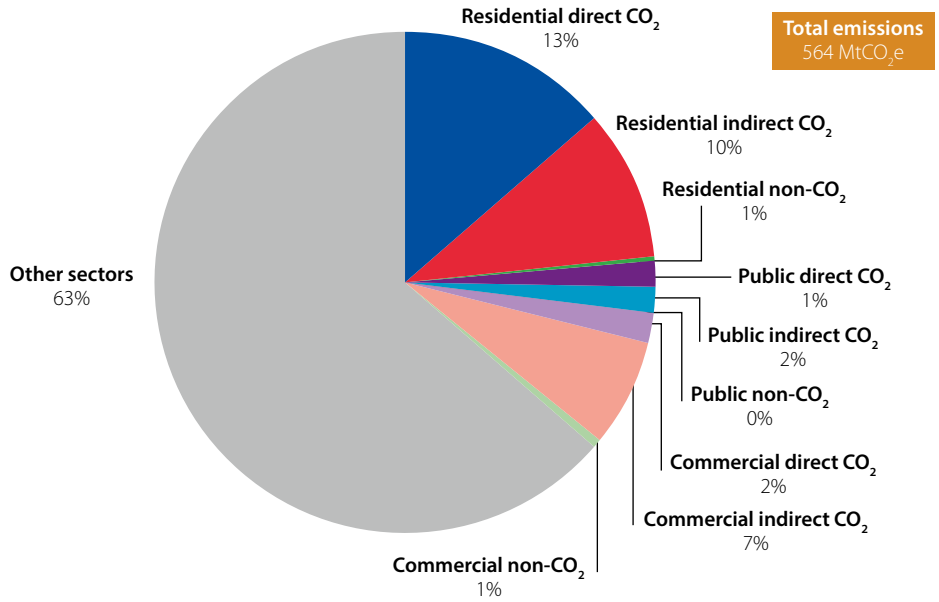
- **Strengthen the near-term framework for energy efficiency improvement in residential buildings**: increase ambition on insulating lofts and cavity walls while finalising the Energy Company Obligation (ECO) changes; by early-2015, maintain fiscal incentives to 2017; by end-2014, publish proposals for minimum energy performance standards for the private-rented sector.
- **Build on the existing approach to incentivising low-carbon heat in residential buildings**: commit funding for the Renewable Heat Incentive to 2020 and commit to extending this approach beyond 2020 unless and until an alternative mechanism is in place; extend the Green Deal to cover the upfront cost of low-carbon heat technologies funded under the RHI and consider using Government guarantees to lower the financing cost; develop measures to improve consumer confidence in renewable heat.
- **Consider future options for the focus of the ECO** (i.e. whether this should be on delivering more difficult efficiency improvements for the fuel poor or across all households). This consideration should reflect evidence on costs of solid wall insulation, costs of alternative options for reducing emissions and whether an alternative delivery mechanism could better tackle fuel poverty.
- **Develop additional measures to tackle fuel poverty** in England to supplement the Affordable Warmth element of the ECO, possibly including targeting of the RHI (by end of 2014).
- **Ensure that the Zero Carbon Homes standard requires investment in low-carbon heat** unless heating requirements are very low, and only grant exemptions where a clear economic rationale for these has been demonstrated.
- **In the commercial sector**: simplify and rationalise existing policies for energy efficiency improvement, with a view to strengthening incentives by the end of 2016, and publish proposals for minimum energy performance standards for the private-rented sector.
- By the end of 2014, **set carbon targets for central government** beyond 2015.

2. Buildings emission trends

(a) Overview

Emissions from buildings accounted for 7% (206 $MtCO_2e$) of all UK GHG emissions in 2013 (Figure 3.1). The residential sector accounts for 65% of these emissions, the commercial sector 26%, and the public sector 10%. Buildings CO_2 emissions are split broadly equally between direct (i.e. from burning fossil fuels) and indirect emissions (related to the burning of fossil fuels to generate electricity).

Figure 3.1: GHG Emissions from buildings in the context of total UK emissions (2013)



Source: NAEI (2014), DECC (2014), *Energy Trends, March 2014*, DECC (2013) *DUKES*; CCC calculations.
Notes: 2013 emission estimates are provisional. Commercial sector and non-CO_2 are based on CCC estimates.

Over the first carbon budget (2008-12), buildings CO_2 emissions declined by 4%. There were large fluctuations within this period, with emissions declining in 2009 due to the impact of the recession and rising fuel prices, and then increasing in 2010 and 2012 due to cold weather. For example, in 2010, cold weather at the start and end of the year produced an 8% increase in emissions on the previous year. In addition, the 12% increase in the emissions intensity of electricity consumed from the grid in 2012 had a significant impact on indirect emissions for that year.

The 4% reduction was less than the 6% reduction we had assumed for our indicator to meet carbon budgets. Emissions were, however, higher than they would otherwise have been because of colder than usual winter temperatures (see Chapter 1). Without this temperature effect, emissions would have been lower, decreasing by around 9%, to a level below our suggested level for 2012. In the context of rising energy prices and the economic crisis, this does not imply outperformance in terms of underlying progress in implementing measures.

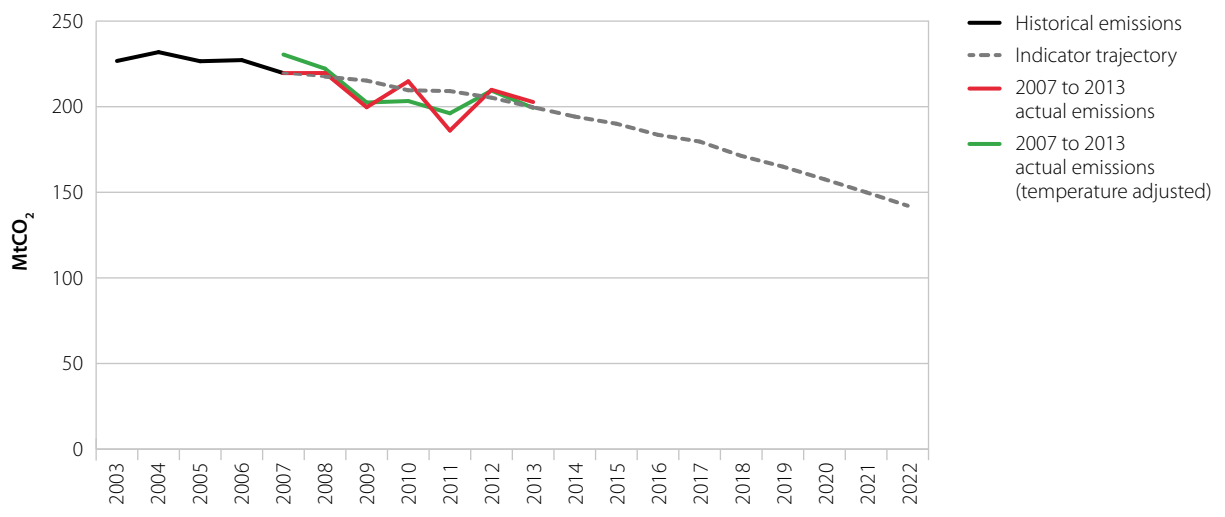
At the EU level, buildings CO_2 emissions stayed flat between 2007 and 2012 – both across the EU-28 countries and within the smaller EU-15 group. There were large annual fluctuations year-to-year, with a big increase in 2010 linked to colder temperatures, followed by a large fall in emissions in 2011 when temperatures were above average (replicating the trend seen at a UK level).

In 2013, buildings CO_2 emissions fell by 3% due to an 8% decrease in the emissions intensity of electricity consumed from the grid, whilst direct emissions rose:

- Emissions intensity of power from the grid fell 8% as the share of coal in the fuel mix declined, combined with the share of renewable energy increasing to a new high of 15% (see Chapter 2).
- With temperatures at the beginning of 2013 below the long-term average, there was a small increase in the number of heating days for the year. This contributed to an increase in direct emissions over the same period (up 3% on 2012 to 98 $MtCO_2$), reflecting rising gas consumption of 3%.

Rising direct emissions and declining indirect emissions in 2013 were observed across all three building sectors (Figure 3.2). However, removing the impact of the colder weather would have reduced emissions further to just below our suggested emissions level.

Figure 3.2: All buildings – historical emissions vs original indicator trajectory (2003-2022)



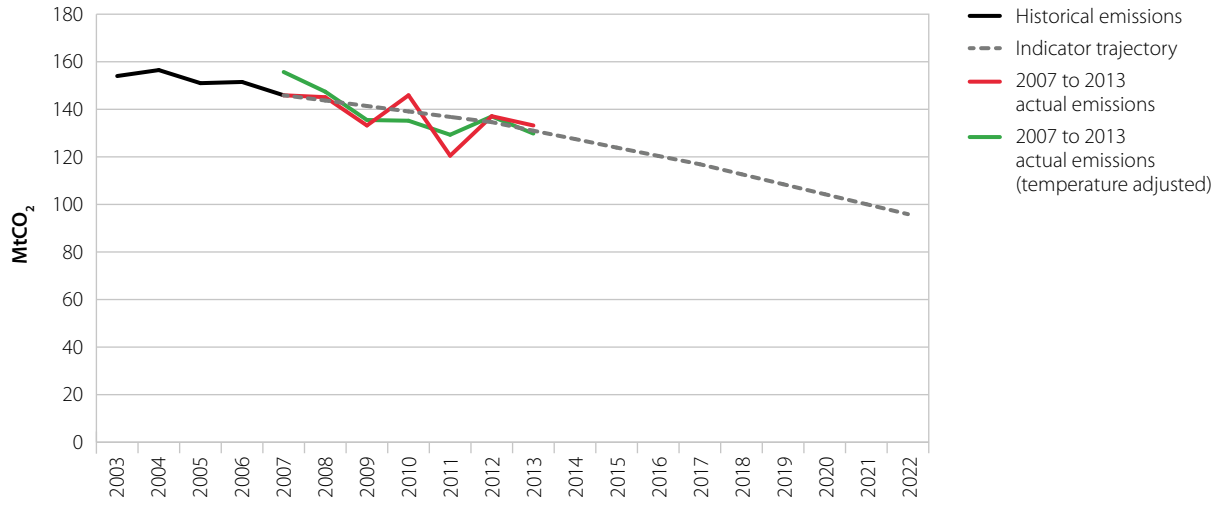
Source: NAEI (2014); DECC (2014), *Energy Trends*, *March 2014*; DECC (2013) *DUKES*; CCC calculations.
Notes: 2013 emission estimates are provisional. Temperature adjustment is based on CCC calculations.

(b) Residential buildings

Total residential CO_2 emissions from 2007 to 2012 decreased by 6%, with a further 3% decrease observed in 2013. The 2013 decrease is due to the 8% decline in the emissions intensity of grid electricity, which more than offset the 3% increase in direct emissions over the year:

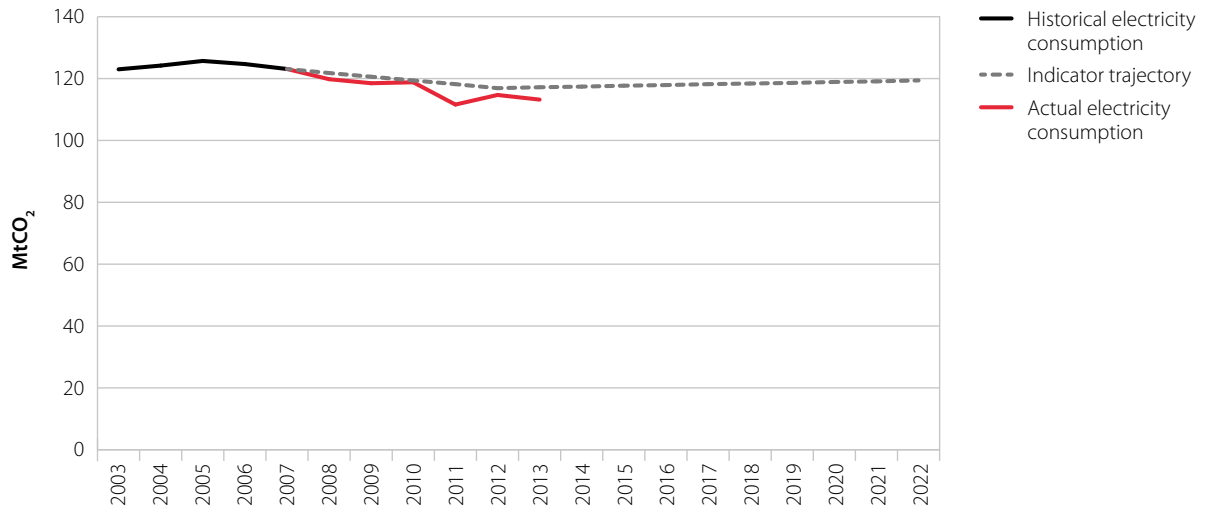
- Direct emissions account for just below 58% of total residential emissions. During the first carbon budget, direct emissions declined by 4%, while in 2013 direct emissions increased by 3% in line with fossil fuel energy consumption increasing (by 3%) in response to cooler temperatures. Adjusting for temperature effects, direct emissions declined by 5% in 2013.
- Indirect emissions fell by 8% during the first carbon budget period and by 10% in 2013, when they accounted for 42% of residential sector emissions. Electricity demand fell by 1%, continuing the trend reduction of 7% over the first carbon budget period, but the main contributing factor was the reduced carbon intensity of electricity generation. This enabled an outperformance against our indicators, and by 2013 electricity consumption was 3% below the indicator (Figure 3.3).

Figure 3.3: Residential sector – historical emissions vs original indicator trajectory (2003-2022)



Source: NAEI (2014); DECC (2014), *Energy Trends, March 2014*; DECC (2013) *DUKES*; CCC calculations.
Notes: 2013 emission estimates are provisional. Temperature adjustment is based on CCC calculations.

Figure 3.4: Residential – historical electricity consumption vs original indicator trajectory (2003-2022)



Source: NAEI (2014); DECC (2014), *Energy Trends, March 2014*; DECC (2013) *DUKES*; CCC calculations.
Notes: 2013 emission estimates are provisional.

Overall, residential emissions were above the level envisaged in our indicator, with only a 6% reduction versus the 8% implied in our scenarios. However, without the below average temperatures in 2012, emissions would have fallen 12%, or 2 Mt below the indicator (Figure 3.4).

In the EU-15, direct residential CO_2 emissions fell by under 2% over the period 2007 to 2012. However, this masks wide variations across the region. For example, there were large falls in emissions in Denmark, Finland and Sweden but increases in Germany and the Netherlands.[1]

(c) Commercial buildings

Commercial sector emissions are mostly indirect (79%). Overall progress has been slow in this sector, with little evidence of uptake of cost-effective abatement opportunities, particularly for reducing electricity consumption:

- Commercial sector electricity consumption increased by 1% over the first carbon budget period, and is up 3% in 2013 from 2007 levels. This may reflect some fuel switching to electricity over the period.
- There has been a small reduction in direct emissions, which fell from 11 $MtCO_2$ in 2007 to around 10 $MtCO_2$ in 2012 and 2013, both in actual terms and when adjusted for annual variation in weather.[2]

In 2013, total commercial sector CO_2 emissions fell by 5% to 49.8 $MtCO_2$, entirely due to the fall in power sector emissions intensity. This offset the impacts of a slight increase in electricity consumption along with a small increase in direct emissions.

- Direct emissions increased by 3% in 2013. This does not appear to be due to the colder weather, as emissions would only have been 0.3% lower when accounting for this temperature-effect.
- Indirect emissions decreased by 7% in 2013, with the 2% increase in electricity consumption offset by the fall in power sector emissions intensity of 8%.

The slow progress overall underlines the need for further effort to unlock cost-effective abatement opportunities within the sector.

(d) Public sector

As with commercial buildings, progress in reducing emissions from public sector buildings has been slow. Total emissions remained flat over the first budget period, before falling slightly by 3% in 2013 due to a fall in indirect emissions.

- Direct emissions rose by 3% in 2013, continuing the trend from 2007 which saw direct emissions increase by 9% to 2012. A large part of this increase is accounted for by fluctuations in temperature, with emissions remaining broadly flat otherwise.

1 Temperature-adjusted data is not available beyond 2011. However, the series to 2011 suggests that falls in Denmark, Finland and Sweden are largely not a function of a temperature- effect. On the same basis, increases in Germany and the Netherlands are likely to be at least partially a function of colder temperatures.

2 The change is more pronounced when adjusting for year-to-year variation in temperature, but rounds to the same figures.

- Indirect emissions account for a lower proportion of the total in public buildings, at 47% of total CO_2 emissions. These fell by 7% between 2007 and 2012, and then by a further 9% in 2013, mostly due to the fall in power sector emissions intensity.

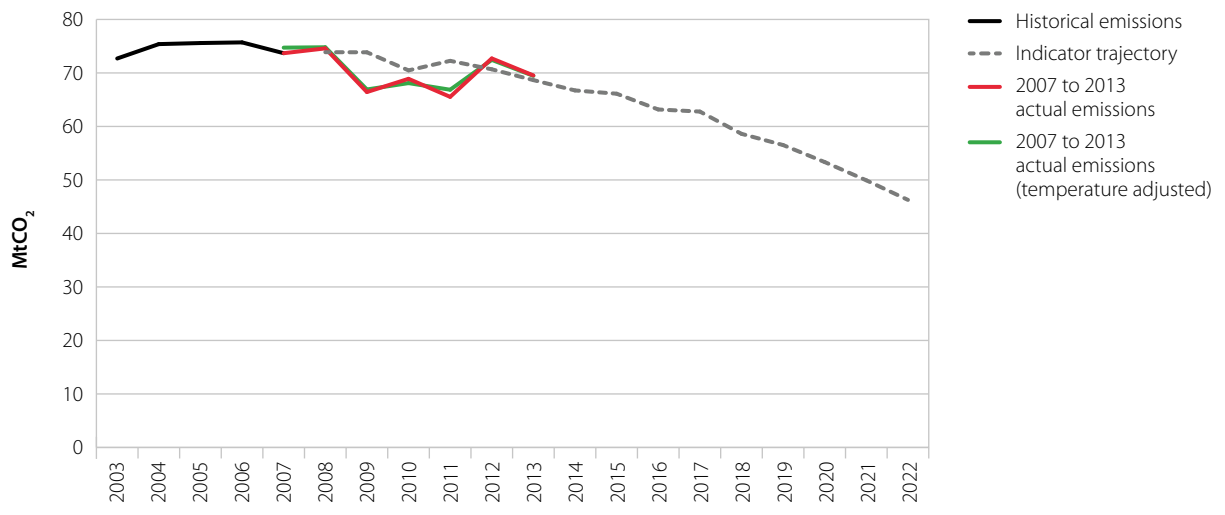
(e) All non-residential buildings

Across non-residential buildings, a combination of slow progress and the 2012 upturn in power sector emissions meant that total emissions fell by 1% over the first carbon budget period, against a 9% reduction assumed in our indicator (Figure 3.5). The poor performance in 2012 was partly a reflection of the colder temperatures, as weather-adjusted emissions fell by 3% over the period.

Compared to the rest of the EU-15, UK performance has been slightly better than the average of a 4% increase in non-residential buildings emissions between 2007 and 2012. With one exception (Belgium, where emissions fell by 5%), in the countries with the largest services sectors in emission terms (France, Germany, Italy, Netherlands, Spain), direct emissions either remained flat or increased over the period. However, as temperature-adjusted data to 2012 are not available, it is not possible to isolate the impact of temperature within these trends.

Further comparison of energy intensity and uptake of low-carbon heat are considered in sections 5 and 6.

Figure 3.5: Non-residential sector – historical emissions vs original indicator trajectory (2003 – 2022)



Source: NAEI (2014); DECC (2014), *Energy Trends, March 2014*; DECC (2013) *DUKES*; CCC calculations.
Notes: 2013 emission estimates are provisional. Temperature adjustment is based on CCC calculations.

3. The Committee's buildings indicator framework

We track progress against our detailed indicator framework, which we set out in our first progress report in 2009. The indicators are based on analysis which suggested scope for significant emissions reductions in buildings from a range of measures. We then developed a set of buildings indicators consistent with meeting carbon budgets.

Residential indicators

- Insulation of all remaining uninsulated lofts (10.5 million) and cavity walls (8.1 million) by 2015[3].
- Insulation of 2.3 million solid walls by 2022.
- Replacement of 12.6 million old inefficient boilers by 2022.
- 58% of the stock of wet appliances rated A+ or better and 45% of cold appliances rated A++ or better by 2022.

Non-residential indicators

- Implementation of all cost-effective measures to reduce emissions from lighting, appliances, heating and cooling in the public and commercial sector by 2018.

Low-carbon heat indicators

- Increasing investment in low-carbon heat to achieve a 12% penetration of total heat.

The indicator framework also includes policy milestones to support the implementation of measures, including new residential energy efficiency policies, the extension of energy performance labelling to all buildings, and accelerating the introduction of minimum standards for privately-rented residential and commercial properties.

In the next three sections, we assess progress during the first carbon budget and in 2013. We first look at the residential sector, where we consider implementation rates for measures such as energy efficiency improvement and look at key policy milestones. We then turn to developments in the non-residential sector, and finish by assessing progress towards increasing levels of low-carbon heat.

In section 7, we summarise progress against all the indicators and provide a 'traffic lights' assessment (see chapter 1 for a description of this approach). This rates performance against the main indicators. We also revise some of our indicators to reflect performance to date and new evidence. This will allow us to continue to effectively assess progress in future progress reports.

4. Residential buildings

(a) Implementation of insulation measures

Improving energy efficiency through better home insulation[4] is important for reducing emissions, energy bills and fuel poverty rates.

During the first carbon budget period, a large number of insulation measures were delivered through the Carbon Emissions Reduction Target (CERT) and the Community Energy Saving Programme (CESP). In 2013, the policy changed to the less ambitious Energy Company

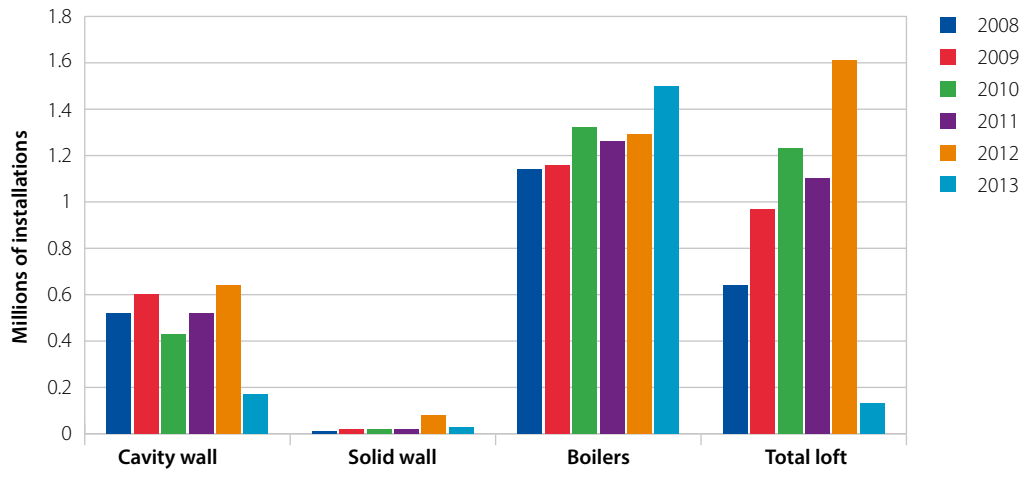
3 This was based on the previous government's commitment and we assumed that 90% of the remaining technical potential could be achieved.
4 Insulation also has implications for overheating in homes (for a more detailed discussion see Adaptation Sub-Committee 2014 Progress Report).

Obligation (ECO) and the market-based Green Deal, resulting in a sharp drop in building fabric insulation rates:[5]

- **Lofts.** Loft insulation rates fell by 92% on the previous year to just under 130,000 installations in 2013. This also compares unfavourably with the first carbon budget period when an average of around 1.1 million lofts were being treated each year. Almost all of the installations in 2013 were delivered under the ECO to low-income households, with the Green Deal and the cashback scheme only accounting for 140 and 277 installations respectively. The low uptake under the Green Deal reflects its failure to deliver these less costly measures as it was intended to do.
- **Cavity walls.** While the volume of cavity wall installations averaged around 0.5 million per year during the first carbon budget period, levels in 2013 only reached 170,000, down 73% on the previous year. As with lofts, ECO was the main mechanism for delivering the bulk of installations in 2013, although 79% of uptake under ECO was for the more expensive hard-to-treat installations.
- **Solid walls.** The ramp-up of activity in 2012 as energy suppliers strove to meet obligations in the final year of CERT and CESP was not continued into 2013, with numbers being insulated returning to levels seen before 2012 of less than 30,000.

The indicators for uptake of measures which we developed in 2009 were based on insulating all lofts and cavity walls by 2015 (where feasible – effectively 90%), and a ramp-up of solid wall insulation to 2 million households by 2020. However, uptake in 2013 was well below the rate needed to be on track with the indicators. Uptake was also below DECC's own estimated uptake levels, as set out in the ECO and the Green Deal Impact Assessment:

Figure 3.6: Installation of residential insulation measures (2008-2013)



Source: Ofgem (2013); DECC (2013) *Estimates of home insulation levels in Great Britain*; CESP data; CCC calculations.
Notes: 2013 data excludes uptake of 145 cavity walls, 2,666 lofts, and 17,421 solid walls due to CESP mitigation activity.

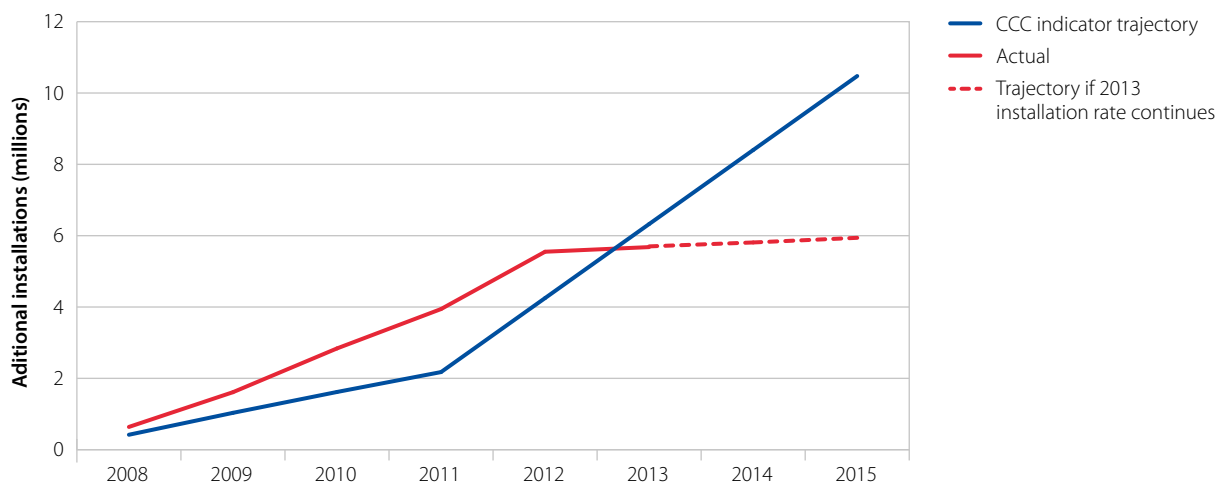
5 Additional activity was also carried out in 2013 as a result of some energy suppliers not meeting their CERT or CESP obligations by end 2012. Preliminary data indicates that a further 145 cavity walls, 2,666 lofts, and 17,421 solid walls were treated due to CESP mitigation activity.

- For this first time since 2008, the cumulative rate of loft insulation fell below our indicator with around 650,000 fewer installations delivered by 2013 than suggested in our indicator (over 2 million cumulative installations by 2013, Figure 3.7).
- While the actual uptake of cavity wall insulation has remained well below our indicator since 2008, the slump in activity in 2013 served to widen the gap with the cumulative level 45% below the indicator for 2013, equivalent to a shortfall of 2.4 million (Figure 3.8).
- With the uptake of solid wall insulation totalling around 170,000 by end 2013, levels are well below the 0.5 million we included in our indicator (Figure 3.9).

Given the performance to date, there remain a much larger number of lofts, cavity walls and solid walls left to insulate than we previously assumed. Since we developed the indicators in 2009, there has also been new evidence on different categories (and relative ease of insulation) of cavity walls, as well as estimates of lower energy savings. We therefore undertook a review[6] of the remaining technical potential and concluded that by end 2013:

- 4.5 million cavity walls remained left to insulate and would deliver carbon savings of almost 2 $MtCO_2$. This technical potential is split between 1.6 million cavity walls that are categorised as easy-to-treat, and the remaining 2.9 million as hard-to-treat (and much less cost-effective). There are an additional 0.84 million cavity walls which have been identified as having limited potential for insulation. However, DECC has identified a larger number of cavity walls with limited potential (1.4 million) and consequently fewer that are easy-to-treat (0.7 million) at the end of March 2014.

Figure 3.7: Loft insulation cumulative installations (2008-2015)

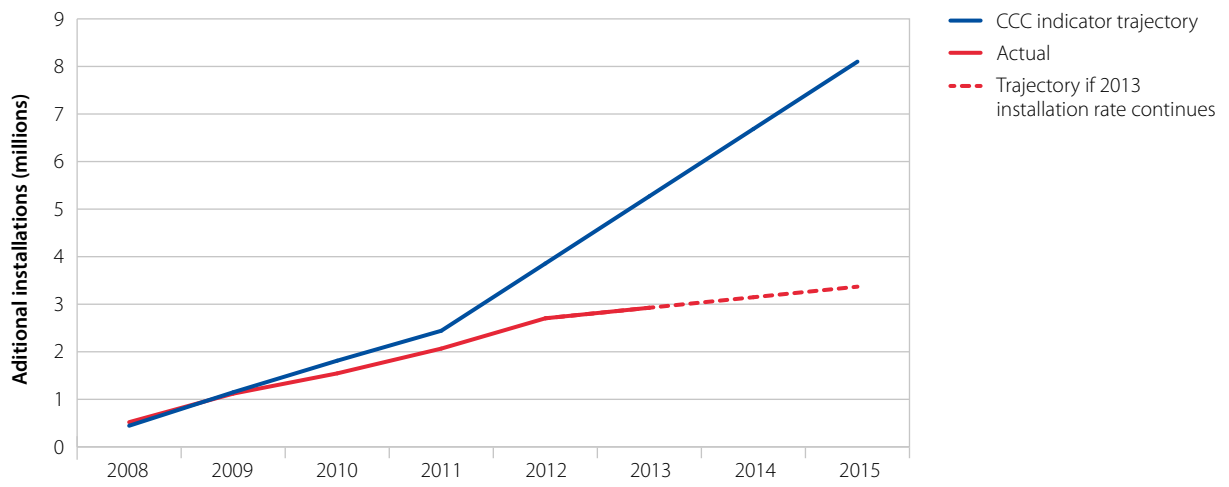


Source: Ofgem (2012 and 2013); DECC (2013); CCC calculations.

6 CCC (2013) *Fourth Carbon Budget Review 2013.*

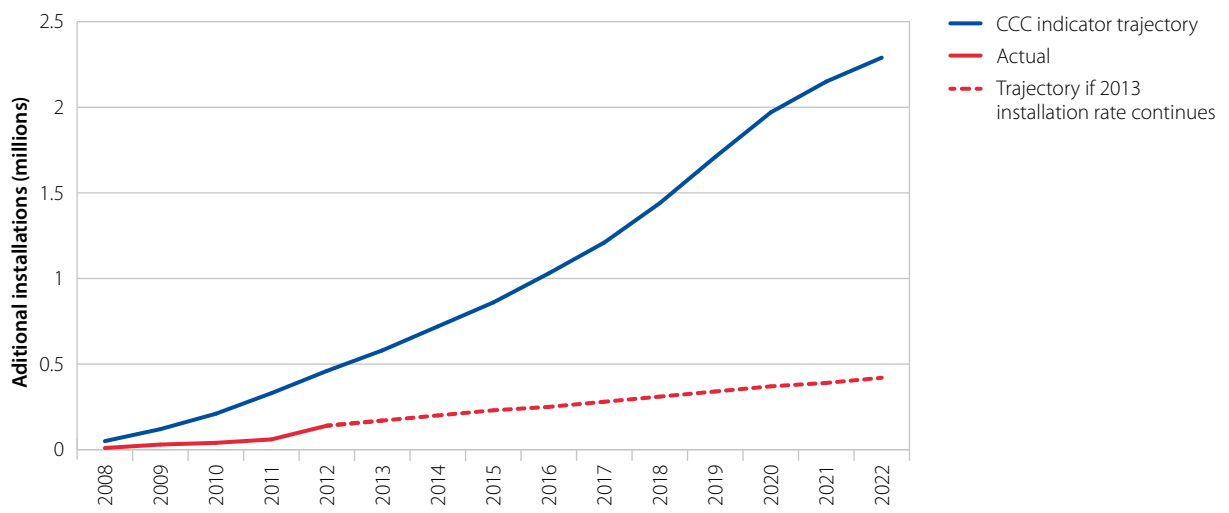
- There were no lofts without any insulation left, but over 10 million easy-to-treat lofts could benefit from additional top-up. We estimate that over 90% of the carbon savings potential reside with lofts requiring filling with an additional 50mm-125mm (to reach recommended levels of 250mm). These 9 million lofts could deliver emissions savings of 0.7 $MtCO_2$.
- There were more than 7 million solid walls without insulation, which could provide 5 $MtCO_2$ of savings.

Figure 3.8: Cavity wall insulation cumulative installations (2008-2015)



Source: Ofgem (2012 and 2013); DECC (2013); CCC calculations.

Figure 3.9: Solid wall insulation cumulative installations (2008-2022)



Source: Ofgem (2012 and 2013); DECC (2013); CCC calculations.

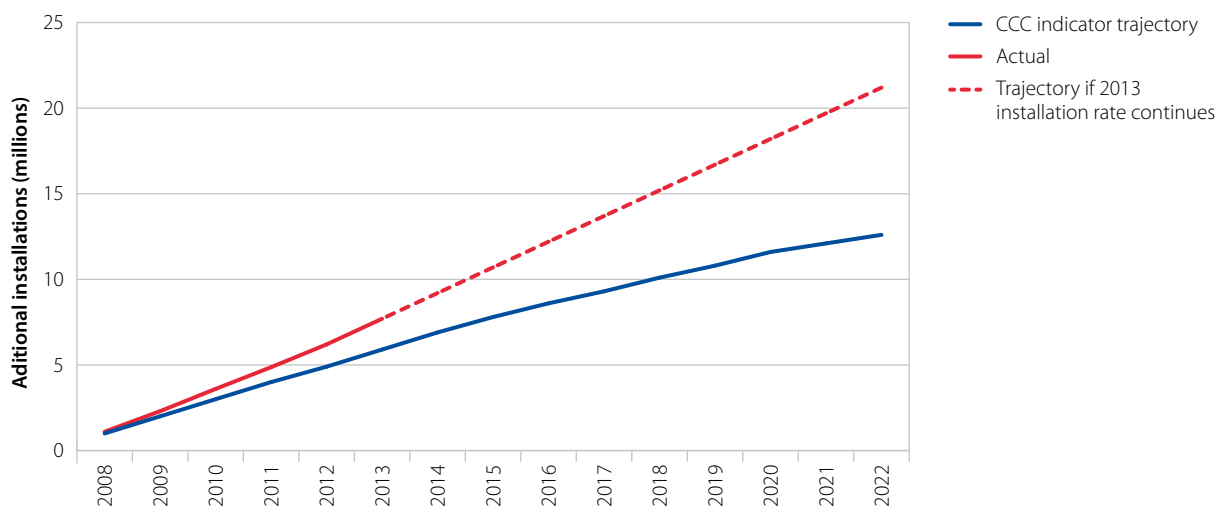
Based on this new evidence, as well as rates of delivery to date, meeting our original indicator (based on the Government's ambition at the time) for nearly all lofts and cavity walls to be insulated by 2015 is no longer feasible. We have therefore revised our indicators for loft and cavity wall insulation and assume that 90% of lofts, easy-to-treat and hard-to-treat cavity walls will be insulated by 2022. This delay can be accommodated within carbon budgets 2 and 3 at an economy-wide level, as the design of these did not fully anticipate the impact of the recession. We have yet not revised our solid wall insulation indicator as there is still considerable uncertainty over the cost-effectiveness of solid wall insulation. We expect the evidence base to further develop over the next year or so (section f, Box 3.3).

(b) Boiler replacement

Boiler replacement continued at a steady pace throughout the first carbon budget period, with an annual average of 1.6 million new efficient boilers installed from 2008 to 2012. In 2013, a further 1.5 million A-rated boilers were installed which means that cumulative uptake by 2013 was 1.8 million higher than our indicator (Figure 3.10).

222,000 of these boilers were installed under the ECO Affordable Warmth Obligation in low-income households. Under the Green Deal cashback scheme, almost 10,000 boiler installations were subsidised in the period up to the end of March 2014. However, the large number of boiler installations taking place every year suggests that no specific incentives are needed to promote new boilers in able-to-pay households (see section 3 (e) (i)).

Figure 3.10: A-rated boilers cumulative installations (2008-2022)



Source: Ofgem (2012 and 2013); DECC (2013) CCC calculations.

(c) Efficient appliances

Electricity demand in the residential sector declined by 7% from 2007 to 2012 and by a further 1% in 2013. While this is partially a recession impact, more efficient appliances and lighting have played a role.

In our last two progress reports, we commented on the lack of government monitoring of energy efficient appliances. The situation has improved and the DECC publication Energy Consumption in the UK now includes data on appliances uptake by energy rating up to 2012, so this is the first time since 2011 that we can report on stock penetration.

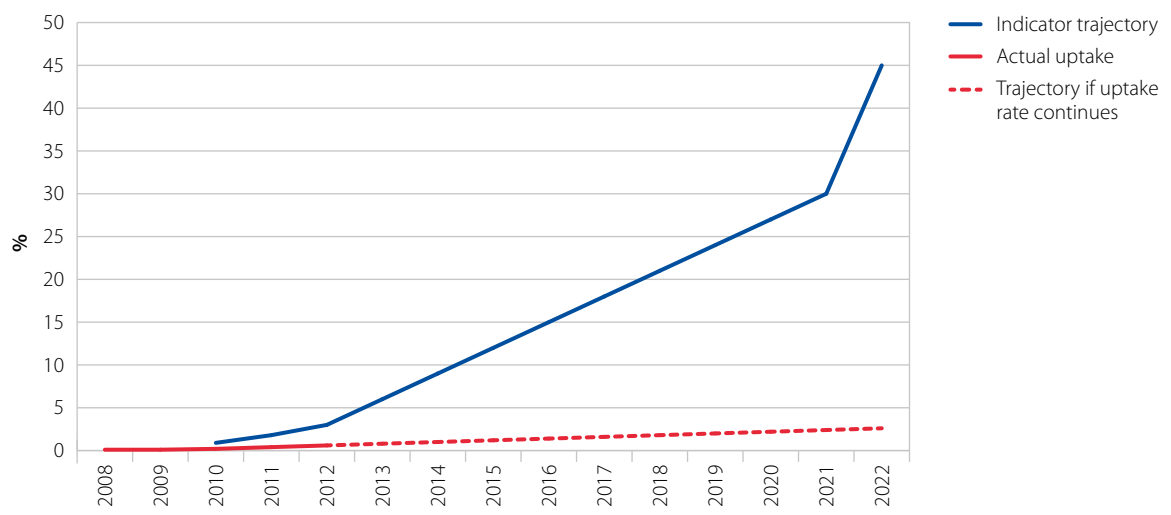
Since 2007, uptake of the most efficient appliances has increased but is still below our indicator:

- Cold appliances A++ or higher should have achieved a stock penetration of 3% but still only represent 1% of the stock (Figure 3.11).
- Wet appliances (A+ or better) have performed better with a 9% share of the stock. However, our indicator suggested that they should have achieved a 16% stock penetration by 2012 (Figure 3.12).

Cold and wet appliances together accounted for around a quarter of residential electricity consumption in 2012. While there was a 9% decrease in electricity use by the total stock of cold appliances, electricity consumption of all wet appliances increased by 10% from 2007 to 2012, with the latter driven by a 9% increase in the number of wet appliances over the period offsetting any efficiency gains in the stock.

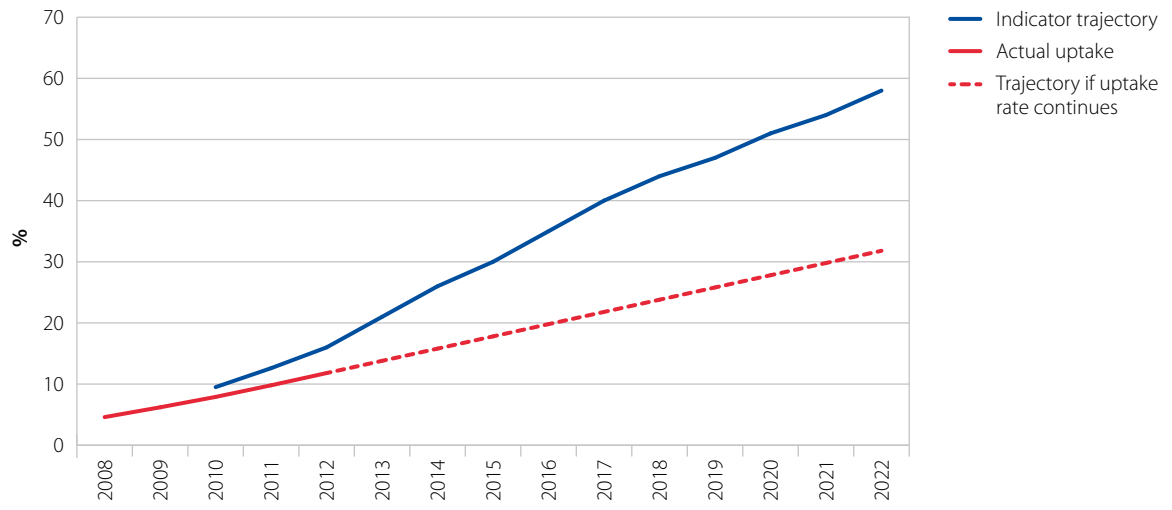
There is plenty of further potential for reducing emissions and energy bills through the use of more efficient appliances. In section 3 (e) (iii), we consider the effectiveness of the policy to achieve this.

Figure 3.11: Appliance uptake against trajectory (% of stock) – Cold A++ rated or higher (2008-2022)



Source: DECC (2013) *Energy Consumption in the UK 2013*; CCC calculations.

Figure 3.12: Appliance uptake against trajectory (% of stock) – Wet A+ rated or higher (2008-2022)



Source: DECC (2013) *Energy Consumption in the UK 2013*; CCC calculations.

(d) UK residential buildings performance versus the rest of the EU

Differences in climate and housing stock make it difficult to compare the performance of UK buildings with other EU countries. There is a paucity of comparative buildings data but some studies suggest that the UK's homes are some of the least efficient in Europe, both in terms of building fabric and the stock of appliances.

- In a comparison of U-values (a measure of the leakiness of walls) for single family dwellings across eight countries, the UK ranks worst[7].
- The UK has a higher percentage of older and single family homes than other EU countries, which tend to be less efficient than newer flats which are more common elsewhere in the EU.
- However, according to data on energy consumption per household and per m^2, performance of UK homes is fairly average.
- A recent study[8] on appliances suggests that in 2010, the average energy consumption of new appliances in the UK was almost 8% higher than the EU-wide average.

Over recent years, the energy performance of the UK housing stock has improved (e.g. between 2007 and 2011 the average SAP rating of a dwelling in England increased by 6 SAP[9] points from 51 to 57). However, there remains a considerable potential for further improvement which could to be realised through effective policy measures, as discussed below.

7 http://www.ukace.org/wp-content/uploads/2013/03/ACE-and-EBR-fact-file-2013-03-Cold-man-of-Europe.pdf
8 http://www.globalactionplan.org.uk/News/promoting-highly-efficient-electrical-appliances
9 The Standard Assessment Procedure (SAP) compares the energy performance of dwelling on a scale of 1 to 100, with 100 being the best performance.

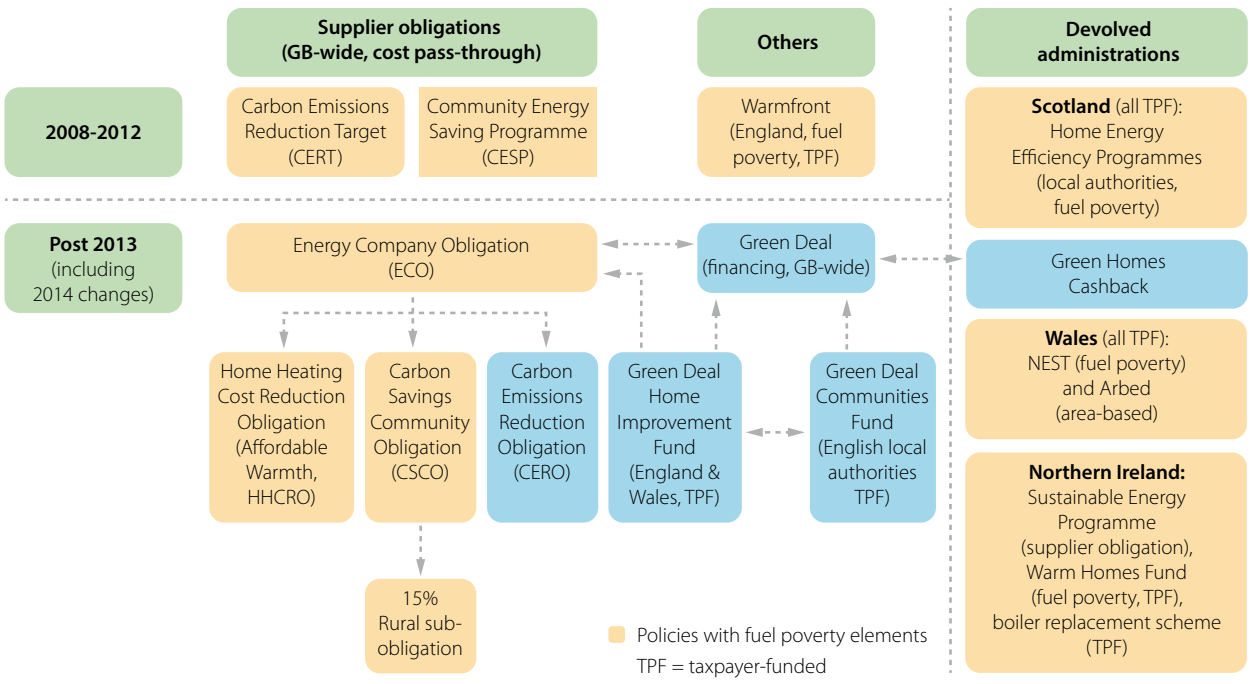
(e) Energy efficiency policy

While most energy efficiency measures are cost-saving, there exists a range of well-documented obstacles that prevent their uptake. The UK Government and the devolved administrations have therefore implemented policies that either incentivise (e.g. through grants and subsidies) or mandate (e.g. through the building regulations) energy efficiency improvement. The resulting policy landscape is complex, with different programmes available in different parts of the country (Figure 3.13).

These policies are particularly important for the alleviation of fuel poverty. The number of fuel poor households in the UK has increased from 4 million in 2007 to an estimated 5.6 million in 2013 (using the '10%' definition, see Box 3.2), mainly due to the increase in wholesale energy prices during this period. By 2020, we expect low-carbon measures (mainly electricity sector decarbonisation) to increase average bills by around 10%. Energy efficiency measures play an important role in ensuring that price rises from low-carbon policies are offset in energy bills and the most vulnerable households protected.

In this section, we assess progress in the key energy efficiency policy instruments – the Energy Company Obligation and the Green Deal, Building Regulations and Products Policy.

Figure 3.13: UK home energy efficiency programmes



(i) Energy Company Obligation and Green Deal

Progress under the new policy framework

The fall in the delivery of loft and cavity wall insulation in 2013 reflects a change in the focus of the majority of the energy supplier obligation, from low-cost measures (now limited to low-income households) to hard-to-treat cavity and solid wall insulation. However, progress with these measures was also limited, because they are expensive and difficult to deliver.

- Before 2013, energy suppliers were obligated under the Carbon Emissions Reduction Target (CERT) and the Community Energy Saving Programme (CESP). This required them to deliver emission reduction mainly through low-cost measures such as loft and cavity wall insulation, some of it focused on low-income households.
- The Energy Company Obligation (ECO), introduced in January 2013 (with targets to be achieved by March 2015) restricted the delivery of low-cost measures to low-income households only (called the Home Heating Cost Reduction Obligation or 'Affordable Warmth'), with solid wall and 'hard-to-treat' cavity wall insulation to be delivered in able-to-pay households (under the Carbon Emissions Reduction Obligation – CERO). It was envisaged by the Government that low-cost measures for these households would be delivered by the market under the Green Deal. Additionally, a Carbon Savings Community Obligation (CSCO) required suppliers to deliver insulation and district heating connections in low-income areas, with 15% of the measures to be delivered in rural areas.
- In practice, delivery on measures under the Affordable Warmth part of the ECO has progressed well, with suppliers having delivered almost 90% of their 2015 obligation by the end of April 2014, mainly through low-cost boiler replacements.
- However, the other elements of the ECO turned out to be expensive and difficult to deliver (e.g. 39% of CERO, 28% of CSCO and only 2% of the rural sub-obligation had been delivered by the end of April 2014).

In addition to the ECO, the Green Deal was intended to revolutionise energy efficiency and provide a market-based funding route for loft and cavity wall insulation. However, uptake has been disappointing with interest rates of around 7% contributing to making Green Deal plans unattractive, while an initial cashback scheme has been mainly supporting boilers:

- More than 200,000 Green Deal Assessments have been carried out but fewer than 2,500 Green Deal Finance plans have been signed. According to a recent survey for DECC[10], 60% of people who have had an assessment done have subsequently installed one or more recommended measures, mainly offered for free (i.e. under the ECO or local authority schemes). Some homeowners are also self-financing measures but overall installation numbers are still low compared to under the previous policy.

10 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/320656/green_deal_customer_journey_wave_2.pdf

- The Green Deal cashback scheme ran from January 2013 to June 2014 in England and Wales. £125 million was made available but only £6.4 million was claimed for around 13,000 measures, mainly supporting new boiler installations (84%). However, boiler replacement is proceeding well and does not need to be subsidised in able-to-pay households.
- In Scotland, the Green Homes cashback vouchers scheme has disbursed more funds, with less of a focus on boilers. It has paid out £7.8 million for just under 19,000 measures (November 2012 to May 2014). The largest number of vouchers covered LED lights (27%), followed by boilers (26%) and heating controls (18%).

In last year's progress report, we highlighted the need for supporting measures to incentivise Green Deal uptake (e.g. stamp duty relief), as well as the inclusion of cavity and loft insulation under the ECO.

ECO and Green Deal changes

In late 2012, following claims by energy suppliers that ECO costs were escalating, the Government announced a number of changes to the ECO. Detailed proposals for the redesigned ECO were published in March 2014, with the consultation response still outstanding.

The redesigned ECO includes some positive changes. In line with the Committee's advice, loft and cavity wall insulation are to be allowed under the CERO. However, a reduced carbon reduction ambition and changes so early into the operation of the policy have caused uncertainties for key players such as the supply chain and local authorities:

- The Affordable Warmth and CSCO elements of the obligation remain unchanged and are to be extended to March 2017, while the carbon target under the CERO has been reduced by 33% (from 20.9 $MtCO_2$ lifetime savings to 14 $MtCO_2$) and now includes low-cost measures.
- Additionally, suppliers are to be allowed more generous carry-over terms for over-delivery under CERT and CESP, as well as a very generous uplift (1.75) for early activity. This effectively means that the ambition is further reduced, leading to an overall reduction of 50% or more.
- The cost estimate has been reduced from the original £1.3 billion to around £900 million per year to achieve an average reduction in household energy bills of just over £30 on the annual bill for a typical household. Given that it is not transparent by how much bills have been reduced following the revised policy, it is not obvious why so much less funding should be available. Under the previous level of funding, considerably more could be achieved, for example almost all of the easy-to-treat cavity walls (constituting the majority of the low-cost abatement) could be insulated. The level of ambition is low also relative to the new funding envelope and the potential for insulation of lofts and cavity walls.
  - The latest ECO impact assessment suggests that the revised ECO will lead to the insulation of 438,000 lofts, 722,000 cavity walls (247,000 of which are easy-to-treat) and 85,000 solid walls between April 2014 and March 2017.

- According to DECC's latest insulation statistics, this would leave a further 2.9 million cavity walls (0.5 million easy-to-treat and 2.4 million hard-to-treat) and 9.7 million lofts to be insulated.
- Analysis by the Association for the Conservation of Energy[11] suggests that there is scope for increasing the ambition of the CERO (up to 50,000 loft, 100,000 cavity wall and 25,000 solid wall insulation measures) within the same funding envelope.

- A solid wall minimum of 100,000 installations, to be delivered by the end of March 2017, has been introduced. This appears low, given that in 2012, 82,000 solid walls were insulated under CESP and CESP, and that fuel poverty is particularly prevalent in solid wall homes (Box 3.3).
- A number of local authorities have announced that they have had to downscale their Green Deal/ECO schemes. New funding for local authorities has been introduced (Box 3.4) but there remains a lack of continuity and consistency making it difficult for local authorities to plan and maintain their level of involvement in the Green Deal and ECO delivery.

With the final details of the ECO changes still outstanding and the low level of ambition, insulation rates have seen a further marked fall in April 2014 after several months of higher installation rates (e.g. the number of measures installed under the ECO fell by 56%, in particular measures under the CERO which saw a 77% drop from March to April).

The Government announced that the ECO changes would be carbon neutral. This is to be achieved through new measures worth £540 million over three years. Subsequently, the Green Deal Home Improvement Fund started operating in June 2014. It provides the following incentives:

- Up to £1000 for two measures from a list of 12 measures (including boilers, double glazing, insulated doors, floor insulation, heat recovery etc);
- Up to £6000 (or 75% of the installation costs if less) for solid wall insulation;
- An extra £500 if the applicant has moved house over the last 12 months;
- Up to £100 refund for the cost of a Green Deal assessment;
- Householders are not required to take out Green Deal Finance.

However, the Government has so far only guaranteed rates for the first £50 million (£16.5 million of this were already claimed within the first three weeks of the fund operating). It is not clear how many measures will be supported (as no impact assessment has been produced) and whether these new measures will compensate for the lower carbon reduction ambition in the revised ECO.

11 http://www.ukace.org/wp-content/uploads/2014/04/ACE-Consultation-Response-2014-04-The-Future-of-the-Energy-Company-Obligation.pdf

Recommendations for strengthening incentives for near-term delivery

Given potential to go further on loft and cavity wall insulation, and the benefits that this would bring in terms of cost-effective emissions reduction and energy affordability, the Government should increase the ambition in the Energy Company Obligation to 2017.

The costs and risks associated with delivering increased ambition could be reduced through extending current financial incentives further out in time, and introducing minimum standards for the private rented sector.

- **Financial incentives.** As part of the redesigned ECO, new financial incentives were introduced in June 2014 through the Green Deal Home Improvement Fund. These have already stimulated consumer demand, and should be extended out to 2017. As we have previously recommended, there may also be a case for additional incentives such as stamp duty relief to ensure people maximise energy efficiency improvements when carrying out general refurbishments (e.g. on moving home).
- **Minimum standards.** In recognition of landlord-tenant split incentives (i.e. tenants receive the benefits of energy efficiency improvements but these are paid for by landlords), the Energy Act 2011 provides for the introduction of minimum standards for energy performance in the private rented sector, to be introduced from 2018. To provide certainty to landlords, the Government should set the minimum standards for 2018 now and a clear timetable for tightening these over time. Standards should require the implementation of cost-effective efficiency improvements such as loft and cavity wall insulation.

The above relates primarily to the part of ECO available to fund efficiency improvements in any household, accounting for around 60% of the total funding. There is also an element ('Affordable Warmth') specifically reserved to reduce heating costs for low-income households, including the fuel poor. Most of the initial target (which runs to March 2015) has already been met.

As a result, many eligible vulnerable households in England (the devolved administrations have additional fuel poverty programmes) have been left unable to access ECO funding at a time when the number of fuel-poor households has been rising (to an estimated 2.9 million in England in 2013). There is therefore a need to explore other instruments to ensure more widespread action on fuel poverty in the near term.

Post 2017 options for the ECO and Green Deal

There are a number of options for the design of the Energy Company Obligation beyond 2017 (i.e. the date to which the current policy applies). The focus could switch to solid wall insulation and other hard-to-treat measures across all households or the fuel poverty element of the ECO could be increased. If solid wall insulation turned out to be too expensive, the Government could reduce the scope of the ECO, although alternative fuel poverty measures would have to be implemented.

We identify three options:

Option 1: Focus on solid wall insulation and other hard-to-treat measures. As the majority of low-cost opportunities will have been taken up, it might then be justified to move the focus to more difficult measures such as solid wall insulation. However, considerable uncertainty remains over the potential costs of such a large-scale programme. If this option were pursued, safeguards may be appropriate to ensure that solid wall insulation is not installed in very expensive cases (e.g. a possible buy-out mechanism could be included in the Energy Company Obligation).

Option 2: Focus on fuel poverty. Currently, around half of the ECO is targeted at low-income households. The proportion targeted at the fuel poor could be increased to help achieve the Government's forthcoming fuel poverty target (which is likely to be based on achieving a minimum energy performance rating in fuel-poor homes).

Option 3: Reduce the scope of the ECO. If a wider solid wall insulation programme is shown to be prohibitively costly and if other ways are found to address fuel poverty (e.g. through taxpayer funding, using local authorities as the delivery vehicle as currently is done in Scotland) it might be appropriate to reduce the scope of the ECO. This would allow energy bill savings against the £55 currently paid for the ECO by the typical household. It would also raise questions about how future carbon budgets would be met, requiring additional actions in other sectors of the economy, and about how to roll out low-carbon heat for homes with solid walls (e.g. this would be more challenging for heat pumps, for which the economics are more favourable in well-insulated homes with lower peak heating requirements).

Further evidence on the cost of solid wall insulation and other measures for hard-to-treat properties is required before a choice between these options can be made; and any choice should be made in conjunction with the development of a broader strategy for addressing fuel poverty.

In addition, the Government needs to look at options to reduce the financing costs under the Green Deal. For example both Germany and France have energy efficiency improvement programmes with very low or even zero interest rates and much higher take-up than the Green Deal (Box 3.5) and there is scope for reducing interest rates for the Green Deal (e.g. through government guarantees, Box 3.6).

Box 3.2: Fuel poverty

Based on the most recent DECC statistics, the official number of households in the UK deemed to be fuel poor under the 10% definition[11] totalled 4.5 million in 2012. This equates to 17% of all UK households. While the level remains unchanged from 2011, there are 13% or 0.5 million more households living in fuel poverty compared to 2007, largely owing to the increase in energy bills during the period:

- Residential gas prices increased by 5% in real terms in 2013, and by 38% between 2007 and 2012.
- Residential electricity prices increased 5% in real terms in 2013, and 16% between 2007 and 2012, driven mainly by the rising gas price.

We also have more up to date estimates of fuel poverty based on work commissioned from the Centre for Sustainable Energy (CSE). This uses the National Household Model (NHM) which was developed by DECC. CSE's analysis suggests that under the 10% definition, the number of UK households in fuel poverty increased to around 5.6 million in 2013, with rising fuel prices explaining the large rise from the 2012 level.

The key differences in the approach used by CSE (using the NHM), DECC (for England) and each of the devolved administrations in modelling fuel poverty relate to housing stock data sources and energy efficiency of the stock, fuel prices, incomes and methodological assumptions around heating regimes and under-occupancy.

In 2013 England adopted a new definition for measuring fuel poverty based on the Low-Income/High-Cost (LIHC)[12] method. As the new definition effectively excludes low-income households with low energy costs in energy efficient homes, the numbers estimated to be in fuel poverty is much lower (2.3 million in 2012) when compared to the 10% definition (3.1 million in 2012). Using the LIHC definition:

- Fuel poverty numbers in England have fallen since 2007 from 2.4 million households to 2.3 million in 2012. The number is also down from the 2011 level (2.4 million).
- However, the average fuel poverty gap, which measures the severity or depth of fuel poverty[13] has widened from £395 to £443 (in real terms) over the same period.

Applying the LIHC definition, CSE estimates an increase in fuel poverty in England to 2.4 million in 2013. Their work also identified:

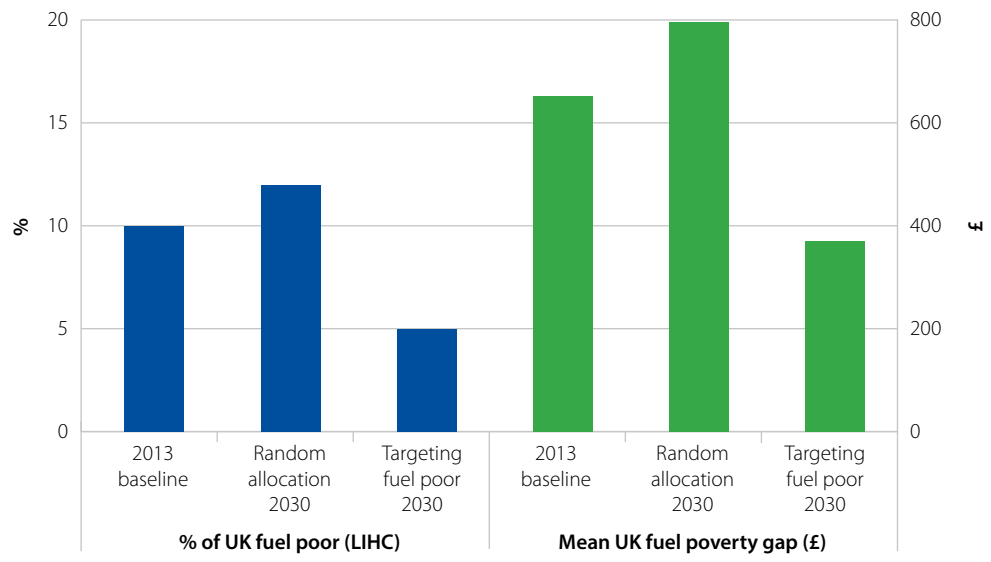
- A difference in the types of householders that make up the fuel poor between the two definitions, with fewer single adults over 60, and more adults of a younger age with children appearing in the LIHC definition compared to the 10% definition. Furthermore, while tenure was not a factor for fuel poverty under the 10% definition, fuel poverty rates were higher in the private rented sector under the LIHC definition.
- Targeting of energy efficiency and low-carbon heat measures to those in fuel poverty (compared to allocating them randomly across all households) can significantly reduce both fuel poverty numbers under the LIHC definition and the fuel poverty gap (Figure B3.1). This suggests that there is a requirement to go beyond the 'Affordable Warmth' element of the ECO, by specifically prioritising the installation of measures in fuel poor households.

We will publish more detailed results from this work later in the year.

12 A householder is fuel poor if 10% or more of the household income is spent on fuel to maintain an adequate level of warmth.
13 A householder is fuel poor if income is below the poverty line (taking into account their energy costs) and their energy costs are higher than is typical for their household type.
14 Defined as the fuel bill reduction required to take a householder out of fuel poverty.

Box 3.2: Fuel poverty

Figure B3.1: Impact of targeting energy efficiency and renewable low-carbon heat measures on fuel poverty



Source: CSE.
Notes: Compares random allocation of energy efficiency and renewable heat measures across the whole population to targeting of measures to those in fuel poverty first.

The Energy Act 2013 has put in place a new legal framework that requires the Government to set a new fuel poverty target in secondary legislation. The Government has indicated that this is likely to be based on a minimum energy performance standard for fuel poor homes. This will be consulted on in the summer.

Box 3.3: Solid wall insulation

Our most recent estimates for the cost-effective potential for solid wall insulation suggests a wide range of costs of -£62 to £1,200/tCO_2 for external insulation and -£166 to £494/tCO_2 for internal insulation.

- We estimate that there are around one million homes that are cost-effective (i.e. they would reduce emissions more cheaply than a carbon price rising to £70/tCO_2 by 2030) to treat with solid wall insulation.
- Almost half of this number is made up of large and medium-sized electrically heated homes, with the remainder heated by oil or coal.
- The least cost-effective opportunities for solid wall insulation are in small homes heated by gas or district heating.

Reducing the costs of installing solid wall insulation will increase cost-effectiveness and help drive higher uptake. This can achieved by deciding to insulate when undergoing general home renovation works (e.g. fixed costs for external solid wall insulation will be less if the scaffolding is already in place for other works such as a loft conversion and by installing measures at scale, such as a local authority-led programme of works. We estimate that a reduction in installation costs by a third could increase cost-effectiveness for a further 108,000 homes, although gas heated homes would still not be captured. Additionally, there are other benefits to insulating solid homes such as increased comfort.

Around 843,000 (30%) of fuel poor households (LIHC definition) in the UK live in uninsulated solid walled homes (e.g. pre-1919 homes), of which 400,000 are electrically-heated. We have previously highlighted the importance of targeting measures to electrically-heated households as these can expect particularly high future bill increases due to the costs of electricity sector decarbonisation.

Increasing the number of insulated solid wall homes is also important for rolling-out heat pumps as they can only perform optimally in a well-insulated building.

Box 3.4: Local authority involvement in the ECO and Green Deal

In our 2012 report on local authorities, we highlighted the need for extra funding for local authorities to become involved in the Green Deal and access ECO activity. The Government has since funded several schemes to support local authorities:

- In 2012, DECC provided £12 million to seven cities to run Green Deal 'Go Early' pilots. For example, Manchester delivered a £7.7 million programme of retrofit works to 608 homes across all ten Greater Manchester authorities. In addition to £2.7 million from DECC, the project leveraged a further £5 million match funding, including £2.5 million of ECO funding. Loan repayments (£800,000 over 20 years) are to be used to pay for energy efficiency works in fuel poor homes.
- This was followed by the £10 million Green Deal Pioneer Places scheme which supported 39 projects across 150 councils. The funding had to be spent in a very short time period (January to March 2013) and much was used to fund free Green Deal Assessments (e.g. Brighton and Hove Council funded 100 free assessments and then chose 10 households to fund £10,000 worth of energy efficiency improvements).
- In 2013, the Government announced a new £20 million Green Deal Communities Fund, the funding of which was subsequently quadrupled as part of the ECO changes announced in December 2013. £88 million was allocated in April 2014 to projects in 24 local authorities to provide improvements to up to 32,000 households, to be rolled out on a street-by-street basis.

While this funding has been important for individual councils, frequent changes and often short time scales for applying and delivery have made it difficult for councils to strategically plan their involvement. Furthermore, the changes to the ECO (and uncertainties around it) have resulted in a number of local authorities announcing that they are downscaling or putting on hold their Green Deal/ECO schemes:

- The Birmingham Energy Savers Scheme was going to be worth £1.6 billion between 2012 and 2020 but has reportedly been downscaled by £600 million as take-up has been slow and a number of partner authorities have dropped out.
- Leeds City Region (11 local authorities) announced in 2013 that it was tendering for one of the largest Green Deal schemes in the country, worth £100 million over 3 years, aimed at retrofitting 12,000 properties. However, it has since delayed the process citing uncertainties over the ECO. Furthermore, a Leeds City Council £1.2 million ECO-funded scheme for solid wall insulation that was due to start early in 2014 has been put on hold, due to the ECO changes. Leeds City Region has recently been awarded almost £5 million worth of Green Deal Communities funding but the bigger scheme remains on hold.

Going forward, there may be a case for a continuous funding stream to help Councils in their involvement in energy efficiency (e.g. making them responsible for the delivery of a tax-payer funded fuel poverty programme as in Scotland's Home Energy Efficiency Programmes).

Box 3.5: Energy efficiency financing in France and Germany

In contrast to the high interest rates under the Green Deal scheme, both France and Germany have low interest/zero interest loan programmes for energy efficiency measures. The German scheme has relatively high uptake numbers (almost 250,000 homes in 2012) and encourages deep retrofits, while the French scheme only reached 34,000 households in 2012. This experience suggests low interest rates alone are not sufficient to incentivise high uptake of energy efficiency measures. France is now relaunching its scheme with the aim of increasing uptake to 100,000 homes per year.

Germany: 'Energieeffizient Sanieren' (energy efficient refurbishment)

The government-owned KfW bank has been operating buildings energy efficiency refurbishment programmes since 2001. The 'Energieeffizient Sanieren' scheme was introduced in 2009 and offers cheap loans and subsidies for a range of measures (insulation, efficient boilers, renewable heat, new windows & doors):

- Cheap loans for up to 30 years with 10 years guaranteed at an interest rate of 1%, up to €75,000
- A further €50,000 loan is available for renewable heat at 2.25%
- Single measures or package of measures to achieve a certified efficiency standard (i.e. deep retrofit)
- Loan repayment subsidy of up to 17.5% (€13,125), linked to energy efficiency standard achieved
- Direct subsidies (not linked to loan) are also available (10% or up to €5,000 for single measures, up to 25% or €18,750 linked to achieving a certain efficiency standard achieved)

In 2012, almost 400,000 measures in 242,000 homes were funded, resulting in CO_2 savings of 0.6 $MtCO_2$.

France: 'Ecoprêts' interest free loan scheme and tax incentives

France has been offering zero interest loans (and other incentives such as tax relief) for home energy efficiency improvements for several years. However, despite attractive financing conditions only 34,000 households took out loans in 2012, leading to the installation of around 64,000 measures. With an estimated 20 million inadequately insulated homes, the French government has just announced that energy efficiency would be a priority in France's 'energy transition'.

The Ecoprêts scheme will be relaunched and simplified, with the aim of reaching 100,000 households per year. Loans will be underwritten by a new government-backed guarantee fund. In addition, more generous tax relief will be introduced from September 2014. Homeowners will be able to offset up to 30% of the cost of energy efficiency improvements (max. €16,000) against income tax.

Box 3.6: Reducing the cost of financing

Energy efficiency and low-carbon technologies typically face a range of financial and non-financial barriers. Many of these interventions have high up-front costs which can be recouped over time through lower running costs. When appraised at the social discount rate (3.5%, real) these investments can provide a cost-effective way of reducing carbon emissions. However, in many cases, the cost of finance available to households is significantly higher, reducing the prospects for take up of these technologies at socially optimal levels.

We commissioned Frontier Economics to research the cost of capital for household decisions to invest in heat pumps, electric vehicles and insulation.

Frontier reviewed the interest rates for a range of products that could be used for financing heat pumps, EVs and energy efficiency; determined how the overall rates are affected by their main components (cost of funds, transaction costs and expected cost of default); identified the factors affecting these components, and therefore driving different interest rates across financial products and low-carbon technologies; and identified measures to address any market failures relating to these components, so that the overall interest rate could be reduced to socially optimal levels.

Frontier found that there was scope for the Green Deal to become a more attractive financing instrument for energy efficiency and also for heat pumps (which we cover in section 6):

- **Energy Efficiency:** There is scope for Green Deal interest rates to be made more attractive. The Green Deal Finance Company (GDFC) is a new institution and has a very limited track record, and currently faces a very high cost of funds. However, Green Deal loans are repaid through energy bills, where default rates are extremely low, such that Green Deal loans should be a low-risk investment. A government guarantee of funding for the GDFC would reduce its cost of borrowing for an initial period, until it has built up a sufficient track record. Frontier estimate this could result in interest rates of around 3.5% per annum by 2020.
- **Heat pumps** could also be financed cost-effectively through the Green Deal with a change to the Golden Rule. The Golden Rule currently requires that expected financial savings must be equal to or greater than the loan repayments attached to the energy bills in the first year of the loan, but Renewable Heat Incentive payments for installing a heat pump do not count towards this calculation. Amending the Golden Rule to allow for RHI payments would in many cases allow heat pumps to qualify for a Green Deal loan, at the same interest rate of around 3.5% as energy efficiency improvements.

DECC has indicated that it is looking at options for making the Golden Rule more flexible.

(ii) Building regulations and zero-carbon homes

Building regulations are a key policy lever for achieving energy efficiency improvements and emission reductions in homes. Part L[15] of the Building Regulations sets energy efficiency standards for the building fabric for both new-built homes and building renovations. It applies to around 140,000 new homes that are currently built every year, as well as more than 200,000 extensions, loft and garage conversions. Window replacements, insulation measures and boiler installations also have to meet standards set by Part L.

For new-build homes, Part L has been tightened twice since 2010, as part of Government commitments to achieving a zero-carbon home standard[16] from 2016 in England and the devolved administrations, although further steps will be needed to achieve a zero-carbon standard:

- In 2010, a tightening of part L resulted in a 25% improvement in energy efficiency for both new-built and extensions compared to the 2006 Building Regulations.

15 Buildings regulations are devolved. In Northern Ireland, conservation and fuel of power is covered in Part F of the building regulations.
16 This will apply to regulated emissions only, i.e. those related to heating, hot water and fixed lighting but not appliances.

- A further tightening of Part L by between 8 and 26%[17] was proposed for 2013, as well as a requirement for consequential improvements for extensions and boiler and window replacements. However, this policy was delayed and watered down, in the end requiring only a 6% improvement in CO_2 emissions for new-built homes from April 2014, with no further improvements to extensions or windows and no requirement for consequential improvements.
- The Scottish government has gone further in its latest Part L announcement, with a 21% improvement over 2010, to be implemented in October 2015. Wales has adopted the English standards and Northern Ireland is making plans to follow.

The Government has announced that the final Zero Carbon Homes details for England will be published in the forthcoming Infrastructure Bill. This will include an 'allowable solutions' mechanism (on which the Government recently consulted), where developers can pay for off-site solutions for part of the carbon compliance.

Given that on-site zero carbon solutions can be expensive (and infeasible on some sites), the 'allowable solutions' mechanism may deliver a more cost-effective outcome but there is a risk that it will work against the installation of low-carbon heat options.

- Zero Carbon Hub estimates that with allowable solutions, additional construction and capital costs would be around £4000 above Part L 2013 for a three bed semi-detached house or just over £2200 for a low-rise apartment. These are expected to further fall by 2020[18].
- The cheapest compliance can be achieved with a gas boiler. As the Renewable Heat Incentive is not available for installations in new-build properties, there is a risk that 'allowable solutions' will disincentivise low-carbon heat options such as air-source heat pumps.
- Our heat analysis suggests that low-carbon options (especially heat pumps) are cost-effective in new-build properties. As they are more difficult and expensive to retrofit, a Zero Carbon Homes policy should encourage their uptake.

Applied to on-site electricity generation the 'allowable solutions' mechanism is sensible, given that large-scale off-site generation is often a cheaper way to provide low-carbon electricity. However, when applied to heat and efficiency measures it is problematic. For all new houses policy should require that either low-carbon heating is installed or efficiency is so high that heating requirements are minimal.

Additionally, the Government has announced that small developments (with the size affected to be consulted on) are to be exempt from part of the zero carbon requirement. There is a risk that a substantial number of homes could be affected. For example, in 2013, 37% of planning applications were for sites of 50 or fewer homes, and 12% for 10 or fewer homes (according to research from construction data firm Barbour ABI). As developers often split developments into

17 The higher rate was an absolute carbon target based on a different methodology to the 8% target reduction.
18 http://www.zerocarbonhub.org/sites/default/files/resources/reports/Cost_Analysis-Meeting_the_Zero_Carbon_Standard.pdf

several smaller phases, the exemption could affect a significant numbers of homes. This could ultimately raise the costs and risks of meeting future carbon budgets.

No rationale has been provided for the exemption for small developments. It is not clear why the economics of efficiency measures or low-carbon heating should significantly differ from larger developments. Therefore, this proposal should be dropped unless the Government can show clear evidence of its value.

While the tightening of buildings regulations is important for carbon budgets, the actual delivery of carbon savings is not necessarily assured. There has been increasing evidence of a significant gap between predicted performance and in-use performance, with new buildings rarely delivering the expected savings due to a variety of factors (e.g. poor design and installation).

Zero Carbon Hub, which supports the Government in delivering the Zero Carbon Homes policy, is currently carrying out a performance gap project to develop solutions. Given that by the mid-2010s, Part L and Zero Carbon Homes are expected to contribute some of the largest policy savings (6 $MtCO_2$ by 2030) per year, it is important that the Government continues to support the work of the Hub and implement solutions as they become apparent.

(iii) Products policy

Products policy refers to a number of policies aimed at improving the energy efficiency of home appliances (including lighting), primarily the EU Ecodesign for Energy-Using Products and the Energy Labelling Directives. The Government expects large savings from products policy (e.g. more than 5 $MtCO_2$ in 2020).

Under the Ecodesign Directive, minimum energy efficiency standards have been set for a range of domestic electrical and electronic appliances and these are being tightened over time. However, there continues to be a large difference between the highest and least efficient appliances on the market.

- For example, refrigeration minimum standards (for fridges, fridge-freezers and upright freezers) were first introduced in 2010 and have been tightened twice with the 2014 minimum standard being 24% more efficient than the 2010 standard.
- As of July 2014, only fridges and freezers labelled A+, A++ or A+++ can be sold.
- The best A+++ fridge freezer currently for sale in the UK uses only half the electricity of an average A+ fridge freezer.

Currently, around half of cold appliances and a third of wet appliances (washing machines, tumble driers, dishwashers) in the stock are B or worse, while stock penetration of the most efficient appliances is still very low. There remains scope for large energy savings from switching to the most efficient appliances (e.g. in our *Fourth Carbon Budget Review* we assume savings of 16 TWh from the main appliances and lighting).

There is some uncertainty over the achievability of these savings under current policy, due to weaknesses in the EU policy framework (both the Ecodesign process and the energy label) and a trend towards larger appliances potentially increasing consumption.

- A recent evaluation study for the European Commission[19] suggests that across product groups the ambition for implementing measures has been too compared to what is technically and economically feasible. The lengthy rule-making process under the Directive has been identified as a major problem, as well as issues such as weak enforcement.
- The energy label has become less effective as + classes have superseded the more straightforward A-G classes (e.g. for fridges, there are now only A+, A++ and A+++ appliances available and consumers perceive that there is no big difference between these).
- Furthermore, the study found that the trend to larger, but more efficient products (e.g. TVs, refrigerators), can lead to higher consumption thus potentially undermining projected savings.

Responsibility for Products Policy has recently moved from Defra to DECC, in recognition of the importance of the policy for carbon reductions. It is therefore important that DECC engages fully with EU partners to ensure that Products Policy delivers its full potential.

There may be a case for additional incentives (e.g. Scotland is covering LEDs under its Green Deal cashback scheme) to drive the uptake of certain appliances where justified from a carbon or fuel poverty perspective, but further analysis is needed on their effectiveness.

5. Non-residential buildings

(a) Tracking progress in commercial and public buildings

Over the first carbon budget in non-residential buildings, both energy and emissions have broadly remained flat. Because of a lack of data, our indicator framework for non-residential buildings includes high-level emissions, energy consumption and policy indicators, but does not include indicators for specific measures.

Difficulties stemming from the lack of data also affect the ability to accurately forecast the impact of policies, which implies that future savings attributed to existing policies are potentially at risk (Box 3.7).

19 http://www.energylabelevaluation.eu/tmce/Final_technical_report-Evaluation_ELD_ED_June_2014.pdf

Box 3.7: Uncertainty in projected savings from energy efficiency in non-domestic buildings

Because of the diversity of the non-residential building stock and a lack of comprehensive survey data, the evidence base on realisable savings from energy efficiency is weak.

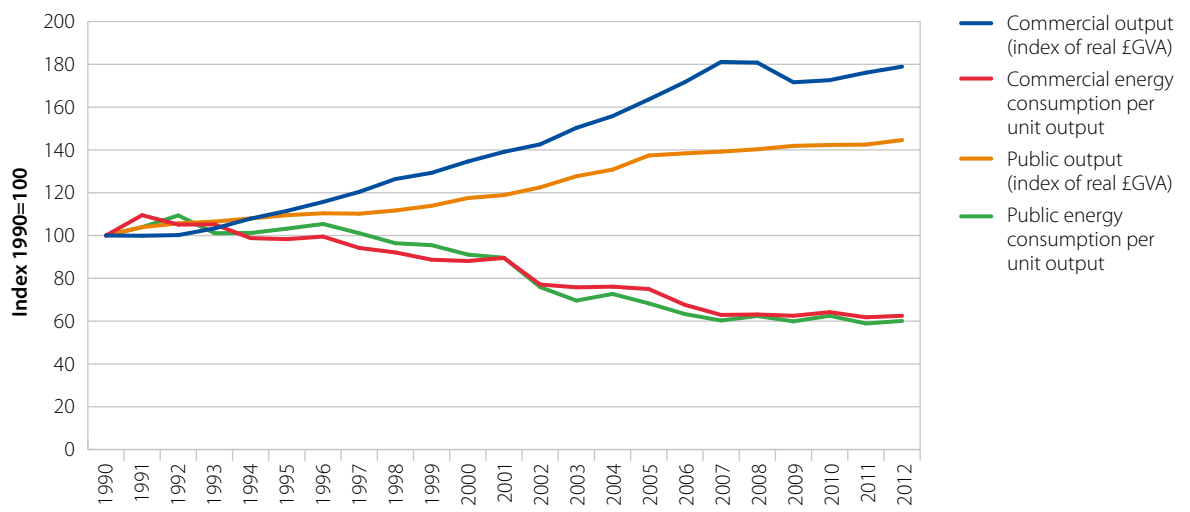
- We have commented previously on issues with the N-deem dataset which underpin our and DECC's carbon scenarios, along with the Government's assessment of carbon savings from policies such as the non-domestic Green Deal.
- There is growing evidence showing a performance gap between buildings as designed, as built, and in-use, reflecting similar issues with the building physics model (SBEM) which underpins DEC certificates and the estimates of savings from building regulations.
- Finally, forecast carbon emissions from non-domestic smart metering rely on evidence from a single study from the Carbon Trust to support estimated electricity savings of 2.8% and gas savings of 4% across the stock, in contrast to the large number of studies which look at the impact of smart meters in homes. This leads to greater uncertainty related to these savings, including how the impacts of smart metering interact with other policy impacts such as the CRC energy efficiency scheme. Work is planned to conduct research to improve the evidence base relating to the delivery of energy saving benefits to non-domestic users of smart metering.

Further research and analysis is underway which will help:

- DECC are currently conducting a large research project to address this by developing a new dataset on energy demand and efficiency potential in non-domestic buildings, with results scheduled on a rolling basis over the next two years.
- Our ability to estimate actual energy savings and the impacts of regulations should improve as further work is conducted, making use of new evidence such as energy bills data collated under the non-domestic NEED project. This may lead to revised estimates of policy savings from building regulations.

In the absence of indicators to track energy efficiency, trends in energy intensity in both commercial and public sector buildings (defined in terms of the amount of energy consumed per unit of real gross added value) show energy intensity falling since 1990 as output grew, before flattening out in 2007 (see Figure 3.14). This reflects decoupling of growth and energy consumption over the period to 2007, but also underlines the lack of progress over the first budget period in reducing energy consumption.

Figure 3.14: Index of output and energy intensity of services (1990 to 2012)



Source: DECC (2013) *Energy consumption in the UK.*

The fact that energy intensity has not fallen in line with the energy efficiency potential identified in our central scenario since 2007 suggests that more needs to be done.

Comparison with performance in other countries across Europe suggests stagnation in the UK's performance.

- Between 2000 and 2007, the UK ranked top out of EU-15 countries in terms of improvement to energy intensity in services[20].
- Since 2008 the UK has been in the middle of the pack (ranking 7th, or 9th on a temperature-adjusted basis).

Overall, there is not any strong evidence from other EU countries of success in driving energy efficiency.

It is not possible to demonstrate any impact from participating in the CRC Energy Efficiency Scheme (previously Carbon Reduction Commitment), due to changes to scope implemented in 2013 (Box 3.8). Pending more detailed evaluation this means that it is not possible to make a straightforward comparison between years.

Box 3.8: Evidence from the CRC energy efficiency scheme

The CRC Energy Efficiency Scheme is the main scheme driving energy efficiency in the non-residential sector, focused on large consumers of electricity and gas. It has been in place since 2010. Participants are required to report energy consumption and purchase permits to cover their carbon emissions on an annual basis.

There is no evidence of an overall decrease in emissions, despite a few market leaders showing good year-on-year improvement.

- One year of data in the Performance League Table shows individual improvements, but this has since been scrapped and replaced with emissions-only reporting.
- In 2013, electricity and gas consumption increased both in total and on average by participant.
- However, changes to the scope have led to differences both in the number and size of organisations covered, and the electricity and gas meters covered by the scheme. Equally, the removal of the requirement to report turnover means that it is not possible to compare energy consumed per unit of turnover, which means that increased consumption could also be due in part to increased output.

Therefore it is not possible to evidence any impact of the scheme to date, pending more detailed evaluation by the Government over the course of 2014-2015.

(i) Commercial sector

There is some evidence of action from carbon benchmarking initiatives such as the Carbon Disclosure Project, along with voluntary initiatives in some sectors such as the Better Retailing Climate Initiative. These suggest that high-profile individual businesses (particularly large companies with strong public profiles) are taking action to reduce energy and emissions. However, the lack of progress overall suggests that this is not matched across the rest of the sector, or is otherwise offset by growth in other areas.

20 Based on Odyssee data, with real output calculated on a Purchasing Power Parity-adjusted basis.

- **Carbon Disclosure Project.** Whilst the territorial scope of the top FTSE listed companies reporting under this scheme is global rather than UK limited, reported emissions indicate that a portion of the largest UK-operating companies are achieving year-on-year emission reductions. This is particularly true of the larger FTSE 100 companies, which report significantly higher emissions than the rest of the FTSE 350 listed firms (Box 3.9).
- **Retail sector.** Retail is the biggest consumer of energy within commercial buildings, currently covering around a fifth of total commercial energy consumption. Reporting from the voluntary sectoral agreement, the Better Retailing Climate initiative, shows larger companies are achieving some emission reductions despite significant expansion in recent years, but that this may not be being replicated in smaller firms (Box 3.10).

Box 3.9: Evidence from the Carbon Disclosure Project

The Carbon Disclosure Project reports annually on emissions from the Global 500 and FTSE 350. Companies are ranked on the basis of the disclosure of emissions, along with action taken in response to climate change, which include promoting mitigation, adaptation and transparency.

To achieve the top rank of 'A' for performance, companies must achieve a minimum level of GHG reductions due to emission reduction actions over the past year (of 4% or above in 2013) along with meeting a number of criteria.

The top performers for 2013 are set out in Table B3.9.

Table B3.9: Top companies by disclosure and performance

Company Name	Sector	Disclosure Score	Performance Score
Diageo	Consumer Staples	98	A
British Land	Financials	98	A
GlaxoSmithKline	Healthcare	98	A
HSBC	Financials	97	A
Anglo American	Materials	96	A
British Sky Broadcasting	Consumer Discretionary	95	A
BT	Telecommunication Services	93	A
Barclays	Financials	92	A
Morgan Advanced Materials	Industrials	92	A
Reed Elsevier	Consumer Discretionary	91	A
BG Group	Energy	89	A

The 2013 report compares reporting and performance between FTSE 100 (the 100 largest companies on the London Stock Exchange) and FTSE 350 companies (the 101st to 350th largest companies), and finds that FTSE 100 companies show a more sophisticated response to climate change, with higher levels of reporting and successful emission reductions.

- 94% of FTSE 100 companies and 56% of FTSE 350 companies responded to CDP in 2013.
- 61% of FTSE 100 companies reported a decrease in emissions since 2012 compared to only 34% of FTSE 350 companies.
- FTSE 100 companies emit substantially more emissions, with FTSE 350 companies reporting emitting just one tenth of the emissions emitted by FTSE 100 companies (FTSE 100 – 541 $MtCO_2e$ in total; FTSE 350 – 59 $MtCO_2e$ in total) (CDP, 2013).

Source: Carbon Disclosure Project (2013) *Are UK companies prepared for the international impacts of climate change? FTSE 350 Climate Change Report 2013.* Report prepared by PwC.

Box 3.10: Progress from the Better Retailing Climate initiative

Retail is the largest energy-consuming sector in commercial buildings, covering around a third of all commercial energy consumption.

The Better Retailing Climate is a voluntary initiative set up by the British Retail Consortium in 2008. Its signatories make up just over half of the retail sector (~52% sector turnover), and are dominated by the big players and household names. Its members have adopted a suite of environmental targets across energy consumption, carbon emissions, water and supply-chain sustainability.

Reporting in 2013 shows good progress by the largest retail firms in part offset by growth over the period.

- In 2013, the group reported on their progress towards the targets, including an 8% decrease in absolute CO_2 emissions between 2005 and 2013. These reductions were achieved despite a significant expansion over the period, which means that the consortium achieved a 30% reduction in emissions intensity over the same period.
- The group also report achieving absolute reductions of F-gas emissions from refrigeration of 40% over the period. This is significantly higher than with the sector-wide reduction in F-gas commercial refrigeration emissions of 8% between 2005 and 2012.

Along with anecdotal evidence, this suggests that this progress may not be mirrored more widely across retail, particularly in SMEs. This is likely to be a function both of lower resources (both financial and in terms of staff for monitoring and reporting), a lack of policy drivers and public scrutiny, and a lack of awareness of realisable cost savings.

The Retail Energy Efficiency Taskforce, an initiative set up by DECC, is seeking to redress this disparity by encouraging the big supermarket firms to share case studies of cost savings and build awareness across the sector.

(ii) Public sector

In last year's progress report, we noted the progress achieved by central government towards its 'greening government' targets, which were renewed in 2011. The targets include a 25% cut in GHG emissions from its estate and transport (against a 2009-10 baseline) along with other commitments covering water use, waste, and supply chain impacts. The latest year of performance data shows some progress, although it remains a challenging target to achieve.

- In 2012-13, a 14% reduction in GHG emissions was achieved, with eleven out of 21 departments exceeding the 2014-15 target early.
- The top three best performing departments were the Department of Communities and Local Government (-41%), the Office of National Statistics (-41%) and the Treasury (-36%).

Because of the value in setting a good example, it is crucial that efforts are redoubled for the departments still lagging behind, with funding committed to all cost-effective measures and best practice adopted in driving behaviour change. Furthermore, the Government needs to start preparing for new targets post-April 2015.

Some progress in public buildings more widely is in evidence from analysis of Display Energy Certificates (DECs), although issues remain around compliance. This suggests there is good potential for mandatory roll-out across all large non-residential buildings, provided work continues to ensure the benchmarking reflects the latest available evidence on the performance gap between designed, built and in-use energy demand.

- Since 2011, all public authorities have been required to display a Display Energy Certificate (DEC) in all buildings over 500m^2, ranking the building's operational performance against benchmarked energy consumption. DECs need to be updated on an annual basis.

- In our 2013 Progress Report, we examined data which showed a lack of progress overall in reducing energy consumption, along with compliance issues.
- Analysis prepared for the Chartered Institute of Building Service Engineers (CIBSE) in 2013 shows some improvements in 13 out of 14 sectors (including general office, schools and hospitals) and improvements in electricity consumption in 9 out of 14 sectors.[21] However, it also suggests that compliance is patchy, with just 12% of buildings in the dataset having complete records over the four-year period.

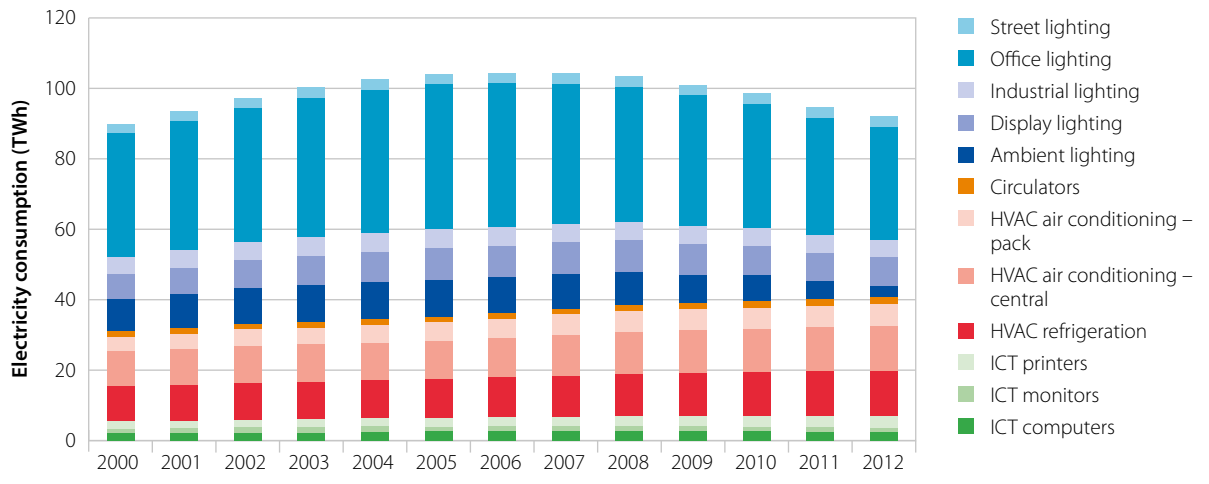
It is important that compliance with DECs is improved. Levels of compliance should be monitored on an ongoing basis by the Department for Communities and Local Government, and further action taken if issues persist.

(iii) Efficient appliances

As for domestic appliances, in 2013 DECC started reporting levels of uptake of energy-efficient appliances in public and commercial buildings. This shows an increase in a number of low-energy products, offset by increases in the number of appliances.

- Across non-residential buildings, electricity consumption from lighting and computing has fallen since 2007, whilst consumption from air conditioning and printers have both increased (Figure 3.15).
- Improvements in energy efficiency for appliances such as LCD monitors, laptops and low-energy lighting has been partially offset by growth in the levels of appliance ownership.

Figure 3.15: Electricity consumption in non-residential buildings (2000-2012)



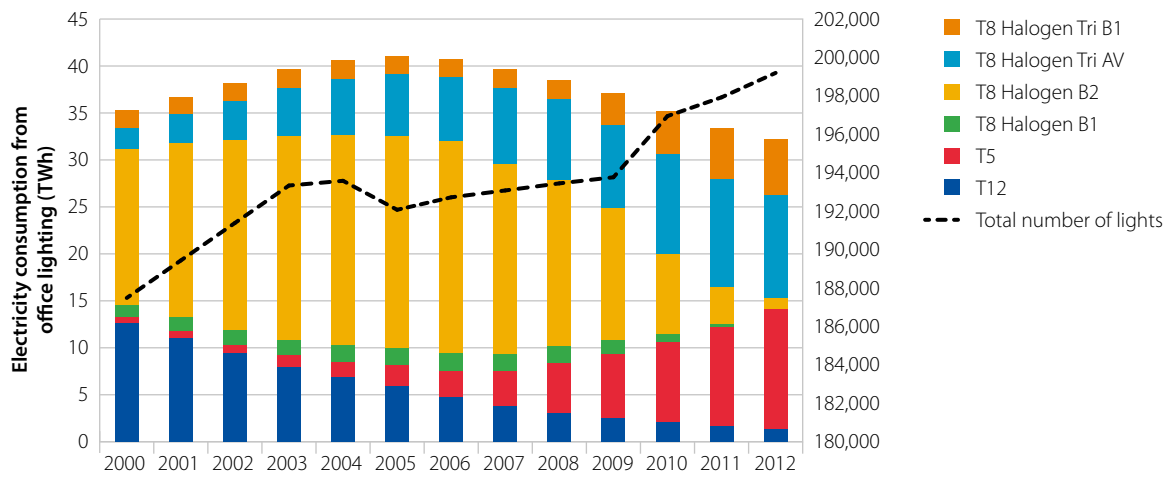
Source: DECC (2013) *Energy Consumption in the UK.*

21 CIBSE (2013) *An analysis of Display Energy Certificate for Public Buildings, 2008 to 2012.*

- The single largest source of electricity demand is office lighting, which makes up 35% of electricity demand in non-residential buildings (Figure 3.16). In the public sector, LED streetlights have grown by 250% between 2007 and 2012, although total penetration levels remain low at around 8% of stock.

Overall, this suggests that total electricity consumption from appliances would have increased over the period, but has been offset by uptake of energy-efficient appliances.

Figure 3.16: Electricity consumption from office lighting (2000-2012)



Source: DECC (2013) *Energy Consumption in the UK.*

(b) Policies to support energy efficiency improvement in the non-residential sector

Given the lack of progress to date, significant potential remains to improve energy efficiency in the non-residential sector. For example, our advice on the Carbon Reduction Commitment in 2010 identified the opportunity to reduce energy demand by around 30% to 2020 through implementation of cost-effective measures; our assessment above suggests that only a limited part of this potential has been addressed since then.

To address this will require clear information on available opportunities and strong incentives provided by policies.

The current policy framework

The current policy landscape is both administratively complex and uneven in the incentives it provides, with a multiplicity of carbon price instruments, information requirements, and regulations:

- **Information requirements.** There are currently a number of requirements to collect and provide information on energy consumption.
  - **Energy Performance Certificates.** These certificates rate buildings based on design energy efficiency and energy costs and are mandatory for all buildings when sold or leased. EPCs also identify cost-effective options for reducing energy spend and improving performance.
  - **Display Energy Certificates.** In contrast to EPCs, DECs rate buildings on operational energy consumption relative to performance benchmarks for buildings within the same class. These must be displayed in all public buildings over 500m^2.
  - **Information for the CRC Energy Efficiency Scheme.** This requires large electricity and gas consumers to report annually on electricity and gas consumption. The scheme and reporting requirements have been significantly watered down since its inception (Box 3.8).
  - **Mandatory reporting on greenhouse gas emissions.** Since October 2013, all companies listed on the London Stock Exchange must report annually on GHG emissions across all their operations (i.e. including those outside of the UK).
  - **Compulsory Energy Audits (known as Energy Savings Obligation Scheme, or ESOS).** These are required under the EU Energy Efficiency Directive, and extend to all 'large' enterprises (defined as having over 250 employees and/or are above the turnover and balance sheet thresholds). The implementation in the UK seeks to minimise administrative burden, given the considerable overlap for large organisations already covered by the CRC and/or mandatory GHG reporting. The first set of audits will need to take place by the end of 2015, with follow-ups every three years. The audits will identify cost-effective energy efficiency measures, but there is currently no proposed requirement to implement recommended measures.
  - **Non-domestic smart metering.** Smart meters are planned to be rolled-out across businesses by 2020, with government forecasts 1 Mt CO_2 savings a year in 2020 from businesses reducing energy consumption based on the information provided.
- **Carbon price instruments.** There are four policies which can impose a carbon price on organisations in the non-residential sector. They vary across different types of organisations, thus creating distortions across the economy (Box 3.11).
  - **EU ETS.** This EU policy increases the price of electricity by imposing a carbon price on fossil fuel generation. It impacts most energy consumption in the commercial sector which is dominated by electricity rather than direct burning of fossil fuels.
  - **Carbon price floor.** This tops up the EU ETS carbon price to a target level for electricity generation, and therefore further increases the electricity price.

- **Climate Change Levy.** The Climate Change Levy is a tax on energy consumption (i.e. electricity and fossil fuel) for the non-residential sector only loosely related to its carbon content; large consumers may face a reduced rate if they enter Climate Change Agreements with the Government to improve energy efficiency.
- **The CRC Energy Efficiency Scheme.** This covers large but not energy-intensive organisations, and requires them to pay a carbon tax on their energy consumption.

- **Regulations.** Energy efficiency is covered by buildings regulations, current and planned minimum standards.
  - **Buildings regulations.** These set minimum energy efficiency standards for newbuild and building renovations. In line with the tightening of standards for residential buildings, standards for non-residential buildings are currently being tightened every few years in successive stages towards the 'nearly-zero' energy standard which will apply to public buildings from 2018, and all buildings by 2019 (box 3.12).
  - **Minimum standards, buildings and appliances.** Minimum standards currently apply to a range of energy-consuming appliances under the Ecodesign directive (see section 4). The Government is currently committed to introducing a minimum EPC standard for all private-rented properties from 2018.
- **Finance.** The non-domestic Green Deal has been available to businesses since 2013, offering loans for energy efficiency at an interest rate of 7%. There has been little take-up to date, which supports the need for further incentives and regulation to drive demand.

Given this complex landscape, we have previously highlighted scope for rationalisation, and the need to fill gaps (e.g. for SMEs). This is echoed in a recent report for the Green Property Alliance which consulted with a large number of stakeholders. The report suggests that policies should provide a clear signal, that they should be stable over time, and that they should be designed as part of an integrated and mutually reinforcing package (Box 3.13).

Box 3.11: Implicit carbon prices

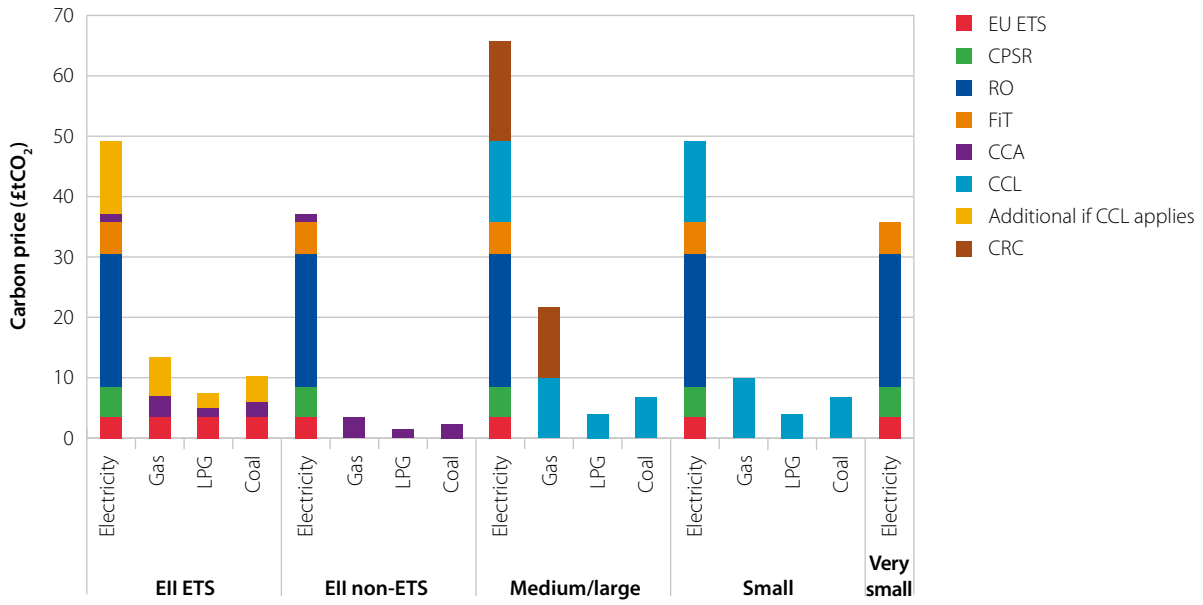
Variation in implicit carbon prices in the UK

The layering of energy and carbon policies over time has led to a large degree of variation in carbon prices across users and fuel types (Figure B3.2). This is set out in a joint report from the Institute for Fiscal Studies, Esmée Fairbarn Foundation, ESRC and the Centre for Climate Change Economics and Policy (2013), which looks at the implicit carbon prices that result from energy bills, energy taxes and the EU ETS.

- The implicit carbon price for electricity is much higher than for gas, due to both upstream policies (e.g. the EU ETS) and downstream (energy efficiency and fuel poverty policies).
- Non-energy intensive medium and large enterprises currently face the highest implicit prices on electricity and gas.
- There are no policies imposing a carbon price on gas use by households. Taking account of the reduced rate of VAT paid on household energy consumption (5%, down from the standard 20%) leads to a negative carbon price for gas.

Uneven prices create distortions across the economy and increase the overall cost of meeting carbon budgets. Whilst some level of differentiation may be justified (i.e. reduced rates for low-income households, technology innovation, or to address competitiveness impacts), the degree of variation is not optimal. In particular, there is a clear case for rationalisation in the commercial sector.

Figure B3.11: Uneven carbon prices for UK business sector, by type and size of business, and by fuel (2013)



Source: Bassi, S., Dechezleprêtre, A., Fankhauser, S. (2013), *Climate change policies and the UK business sector: overview, impacts and suggestions for reform, Policy paper, Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment.*

EU comparison

Similar patterns are evidenced from across the EU. The UK is second only to Greece in degree of variation in carbon prices throughout the economy.

The tax burden falls differently however between countries. In the UK, business faces higher prices (particularly medium/large enterprises) than households; in Italy, homes share more of the burden.

Sources: Advani, A., Bassi, S., Bowen, A., Fankhauser, S., Johnson, P., Leicester, A., Stoye, G. (2013) *Energy use policies and carbon pricing in the UK*; Vivid Economics (2012) *Carbon taxation and fiscal policy consolidation in Europe.*

Box 3.12: Recent updates to building regulations

All buildings will be need to be 'nearly-zero' carbon buildings by 2019 under the 2010 recast of the EC Energy Performance in Buildings directive. Progress on this has been slow, with questions remaining around the definition of 'nearly-zero'.

- Part L 2013 was finally introduced in April 2014, with non-residential improvement watered down from 20% to 9% improvement on Part L 2010 regulations – lower than the 'low' option in the consultation of 11%.
- Stronger targets have been proposed in Scotland of 43% on 2010 levels, to be introduced in 2015. Wales are also planning to adopt more stringent targets of 20% on 2010 levels.
- There is as yet no UK definition of 'nearly-zero' carbon, as required under the 2010 recast of the Energy Performance in Buildings directive.

There is some question around the realisable savings from existing regulation due to uncertainty around build rates and realisable savings (see box 3.7).

Box 3.13: Findings from the Green Property Alliance study on energy efficiency policies for commercial buildings

A recent review of the policy framework targeting energy efficiency in the commercial buildings has been prepared by Deloitte for a consortium of government and real estate bodies, including a large consultation of over 300 stakeholders.

The report suggests that the large number of policy instruments are unevenly distributed across the property lifecycle, but minimum standards for sales and lettings could help redress this balance.

- The current emphasis is strongly on operational carbon, and very limited attention on embodied carbon.
- There are few mechanisms targeting the buying/selling, renting and refurbishment stages of the buildings' lifecycle, suppressing demand for efficient buildings.
- Minimum standards for sales and lettings could be an effective mechanism for bridging the performance gap, particularly if linked to the Energy Savings Obligation Scheme.

The stakeholder responses reveal that the market is on the whole supportive of the principles behind the policy framework, but perceives the current framework to be complex and burdensome. However, there is a strong association between policy familiarity and perceived business benefit. Building codes, positive financial incentives and choice-editing instruments are seen to be more effective than broad impact price instruments or process-driven instruments (such as air conditioning inspections).

The reports calls for:

- Careful rationalisation with more effective bundling of policies (assessment, labelling, a clear target/trajectory, minimum standards and sanctions)
- Stronger incentives/penalties, and more effective enforcement
- Better arrangements for measuring and monitoring impact of policies; a new advisory stakeholder group on generating future legislation/re-steering existing legislative requirements.

Finally, it sets out a set of pre-conditions for policy effectiveness, including a clear target, direction of travel and bundling. The recommendation is that these should be adopted by policy-makers.

Recommendations for the commercial sector

Assessing the current policy framework against these principles suggests a number of options. Any redesigned policy framework should provide a combination of financial incentives, clear standardized information on energy performance and scope to improve this, and regulation to drive uptake.

- **Financial incentives: Rationalising carbon price instruments.** The carbon price signal should be uniform and consistent across firms and fuels. Therefore, the carbon price aspect of the Carbon Reduction Commitment should be abolished, and the Climate Change Levy increased, unless there is compelling evidence to suggest that this would undermine incentives (i.e. there is anecdotal evidence that the CRC payment mechanism raises the corporate profile of energy efficiency improvement).
- **Regulation.** Around 60% of space is rented in the commercial sector. As a result of the landlord-tenant split, therefore, even with strengthening of financial incentives and improvement in information, much unexploited potential for energy efficiency improvement is likely to remain. Regulation is required to address this. In particular, the Government should now introduce minimum standards consistent with take up of cost-effective abatement, as provided for under the Energy Act 2011. Given long refurbishment cycles, setting out a clear timetable for tightening standards over time would improve investor confidence and unlock additional abatement from retrofit.
- **Information.** It is essential that organisations understand their energy consumption, and scope to improve this, if they are to act on energy efficiency improvement. In principle, this requires only one, good source of information, rather than the multiple but often weak information sources currently in place. This one source could be the energy audits, although these would have to be significantly enhanced relative to the current design. Alternatively, DECs could be rolled out across the non-residential sector. Only if one of these were to be implemented would it be justified to drop the information requirements associated with the CRC.
  - **Energy Audits (ESOS scheme).** In their current proposed form, these are not a strong enough mechanism to replace reporting under the CRC. Audits are only required once every three years; they can be carried out by a member of staff; and there is no disclosure requirement or mechanism to drive uptake of the cost-effective measures identified. To be adequate as a single information and reporting mechanism, energy audits would need to be conducted by an external auditor, to accurately measure and benchmark performance, to identify opportunities to improve performance including routes to implementation and to include certification for public display.
  - **Display Energy Certificates.** Much of what could be achieved through energy audits could be achieved through a mandatory roll-out of DECs. These have the additional advantage of being visible to staff and visitors within buildings. However, for these to meet requirements under EU Energy Efficiency Directive and not to duplicate efforts, they would have to be part of a wider audit process.

Improving policies in the ways described above would strengthen incentives for organisations to implement measures which will save them money, put the economy on the cost-effective path to meeting longer term objectives, and reduce the administrative burden associated with current policies. It should therefore be a priority for the Government.

6. Low-carbon heat

(a) Progress against indicator

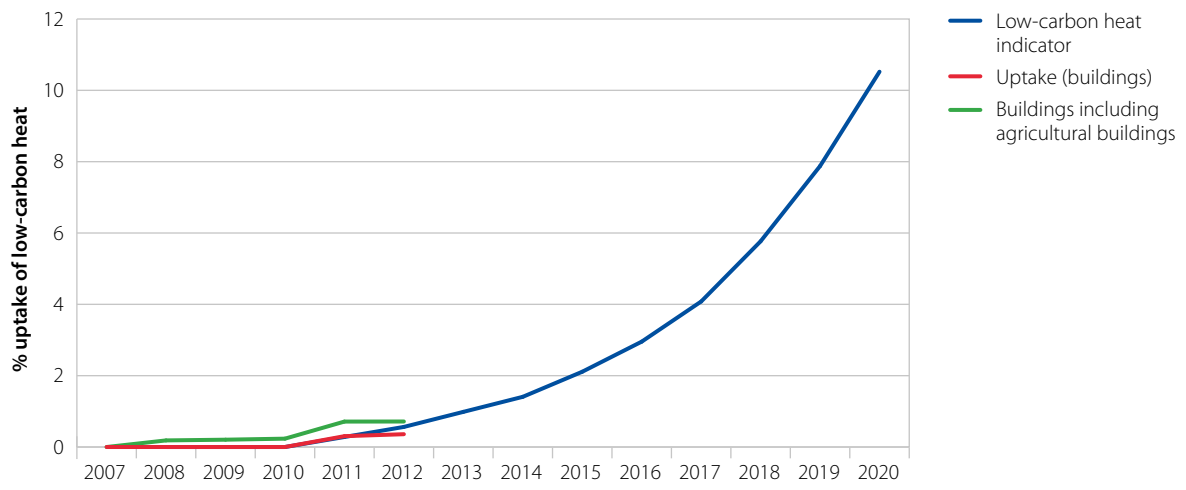
Progress on low-carbon heat over the first carbon budget has been slow. Whilst the economy-wide production of low-carbon heat was on track with our indicator in 2012, the rate of increase is unlikely to reach the Government ambition of 12% of heat demand in 2020. Much of the increase that has occurred has been was due to use of biomass boilers, with investment in heat pumps remaining particularly low:

- In 2012, low-carbon heat coming on line since 2007 was 0.8% of total heat demand in 2012, or 2.0% of demand overall. This is equivalent to 8 TWh/year additional low-carbon heat from 2007, on top of the 7 TWh/year already online in 2007.
- The UK is off-track in buildings, with only 0.3% of new low-carbon heat in 2012 coming online since 2007 (Figure 3.17).
- Overall, there was around 11 TWh of heat from bioenergy in 2012, and 3 TWh of low-carbon heat from other sources such as geothermal, waste, solar thermal and heat pumps.
- Around 5 TWh of low-carbon heat was produced in industrial sectors, and 2 TWh in farms and forestry, with the remainder in buildings, mainly domestic biomass and solar heating.

When we developed our individual indicators for low-carbon heat uptake in buildings and industry in 2012, we did not envisage substantial take-up of low-carbon heat in agricultural buildings (Chapter 6). However, even if we include this in the total for buildings, we are only just on-track, with 0.6%, equivalent to 5 TWh additional uptake from 2007.

At current rates of investment, low-carbon heat is unlikely to reach the Government's economy-wide ambition of 12% penetration by 2020; and is likely to be very far from the indicative 25% in 2030 suggested in our fourth carbon budget review, to be delivered in buildings mainly through heat pumps.

Figure 3.17: Uptake of low-carbon heat in buildings, and buildings and agriculture



Source: DECC (2013) *Digest of UK Energy Statistics 2013*; DECC (2013) *Energy Consumption in the UK*; CCC calculations.

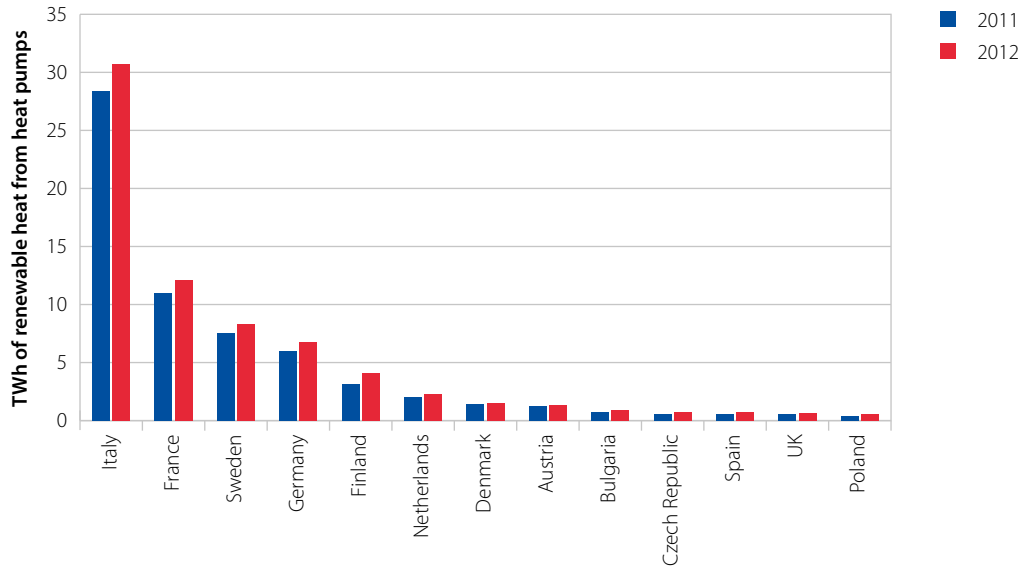
The UK lags behind in levels of heat pumps and bioenergy uptake in absolute terms compared to a number of EU countries, including France, Germany, Italy, Sweden and Finland. Heat networks also remain at very low levels, but better progress has been made in recent years in developing biogas resources.

- 11 out of 26 EU countries have higher uptake of heat pumps than UK, with Italy, France, Sweden and Germany all reporting heat pump output in 2012 over ten times the current level in the UK (see Figure 3.18)
- 16 EU countries have higher levels of heat from biomass than UK, with France and Germany reporting over 100 TWh/year of heat from solid biomass (see Figure 3.19)
- A number of countries have much more developed systems of heat networks, including Denmark (around 60% of the population connected), Finland (49%) and Austria (18%)[22]. This compares to around 2% of heat supplied through heat networks in the UK.
- However, UK investment in biomethane injected to grid compares favourably with other countries, with several new installations, together worth over £10 million in 2012 and 2013, which rank as some of the largest across Europe.

Clearly, historical levels of uptake of low-carbon heat in different countries reflect a range of different circumstances including demand for heat, population density, natural gas and bioenergy resources, and electricity prices. Nonetheless, there is evidence that regulation (Switzerland) can be a useful tool for driving uptake, along with innovative approach to supporting widespread district-scale heat (Denmark, see Box 3.12).

Communicating a clear ambition for the sector is important for creating the right climate for investment in training and supply-chains. France recently announced a target penetration by 2030 of 38% of heat from low-carbon sources, as part of their recently announced 'energy transition' package.

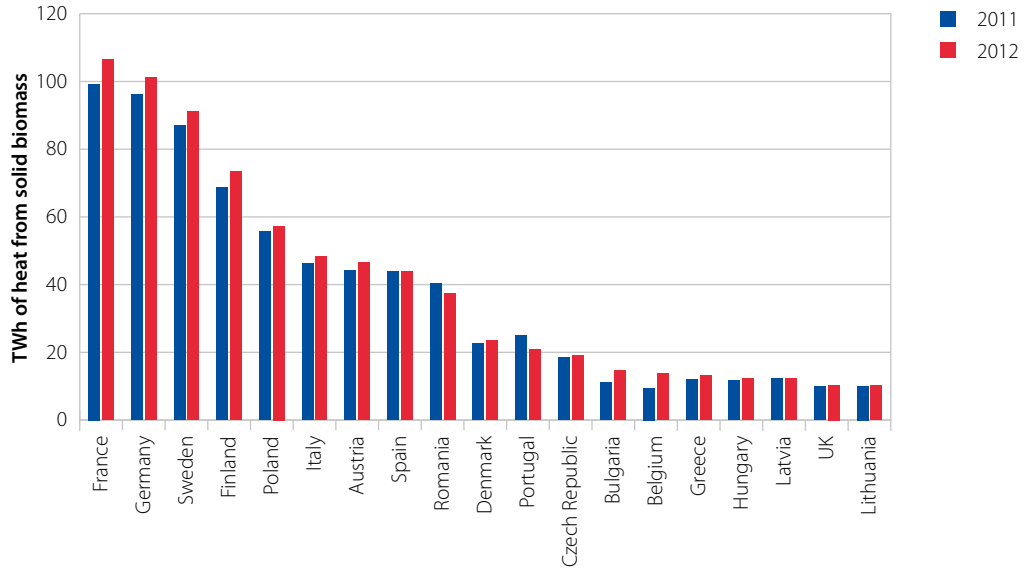
Figure 3.18: EU countries with the highest levels of heat pumps (2011 and 2012)



Source: Eur'Observer (2013) *The State of Renewable Energies in Europe, edition 2013.*

22 DECC (2013) *The Future of Heating: A strategic framework for low-carbon heat in the UK.*

Figure 3.19: EU countries with the highest levels of bioenergy for heat, 2011 and 2012



Source: Eur'Observer (2013) *The State of Renewable Energies in Europe*, edition 2013.

Box 3.14: Successful approaches to driving low-carbon heat in other European countries

Heat pumps

Heat pump uptake is favoured by low population density, abundant electricity and negligible gas reserves/infrastructure (e.g. Sweden, Switzerland), as well as architecture (e.g. provision of basements) but effective policies can drive uptake:

- Strong uptake of heat pumps in Netherlands and France has been driven by capital grants and tax rebates. There are a range of existing grant and tax rebate schemes across the EU, of up to 8,000 euros in France and 5,000 euros in Sweden.
- Renewable energy standards in buildings in Switzerland have been effective (similar to the UK Merton rule). The recast EC Energy Performance in Buildings directive requires consideration of heat pumps in all new-build properties and major renovations.
- Marketing campaigns proved very effective in stimulating uptake in Sweden, where a combination of a test and certification programme for new installations and marketing (consisting of information campaigns, brochures and articles) led to a doubling of sales between 1995 and 1996.

Heat networks

Denmark is one of the leading examples for a large-scale expansion of heat networks. A combination of municipal heat supply planning and the zoning of heat networks and new natural gas infrastructure have been key to Denmark's success in this area over the past thirty years.

- The 1979 Heat Supply Act set provisions for municipal heat supply planning, an approach to developing a new gas supply network and a shift from fossil fuel boilers to CHP and renewables.
- The decision to invest in either heat networks or a local gas network is based on economic appraisal.
- Connecting to the heat network was also made mandatory under the Act, which ultimately helped ensure low costs to consumers.

Across Europe, local authorities have played a central role in planning, owning and operating heat networks, including in Denmark, Sweden, Germany and Austria. Local authority involvement is now on the increase in the UK also, with support and funding from the Heat Networks Delivery Unit in DECC (Box 3.15 for further details of UK progress).

(b) Policy

(i) Domestic RHI and RHPP scheme

The major development in the residential sector has been the launch of the domestic Renewable Heat Incentive (RHI) scheme in April 2014, with tariffs for heat pumps, biomass boilers and solar thermal technology. The scheme is open to all households, but offers the best deal for houses which are not on the gas grid.

In the interim, the small-scale Renewable Heat Premium Payment (RHPP) scheme was extended to March 2014. The scheme has now run for three phases (Phases 1 & 2, and Phase 2 extension), with over 15,000 projects delivered in total, including 5,000 since April 2013.

- Uptake was low relative to projections, with uncertainty around the introduction of the RHI being a factor. More funds were made available to social landlord schemes in the Phase 2 extension, which ran from May 2012.
- The evaluation of RHPP Phase 1 found that most people taking up the scheme would have installed the technology anyway. Experience of technology installed was on the whole positive (DECC, 2013).
- Projects reflected a good mix of technologies, with 53% heat pumps, 31% solar thermal and 16% biomass boilers.

Although the delay in launching the domestic RHI scheme means that support to date has been very small-scale, progress has been made in the interim, particularly on quality assurance of installations and improving understanding of consumer attitudes to heat.

- DECC have developed standards and training for installers, including a new Microgeneration Certification Scheme standard for heat pumps.
- The RHPP scheme has also generated useful evidence on technology performance and consumer feedback.

These are critical to guaranteeing emissions and cost savings and boosting consumer confidence.

(ii) Non-domestic RHI

The non-domestic scheme has been operating since late 2011, supporting a total of around 0.8 TWh of heat to date – around a third of the low-carbon heat generated since 2011 in industry and agriculture (i.e. including potential legacy applications).[23] Although not all heat generated would qualify, the fact that only a portion of the low-carbon heat was supported may reflect the take-up of cost saving opportunities (i.e. finance typically may not factor in income from the RHI), combined with the complexity of the certification process acting as a deterrent to applying for subsidies.

23 Assuming the same level of heat generated in 2013 as in 2012. It is not possible to calculate an additional share generated in non-domestic buildings due to limitations in the data.

- Over 99% of heat generated to date in receipt of non-domestic RHI payments has been from bioenergy.
- There is a significant underspend on heat pumps, with only £530,000 spent to date out of a total spend to date of £65 million[24].
- Total installed capacity has been spread between agriculture, non-residential buildings and industry (Figure 3.20).

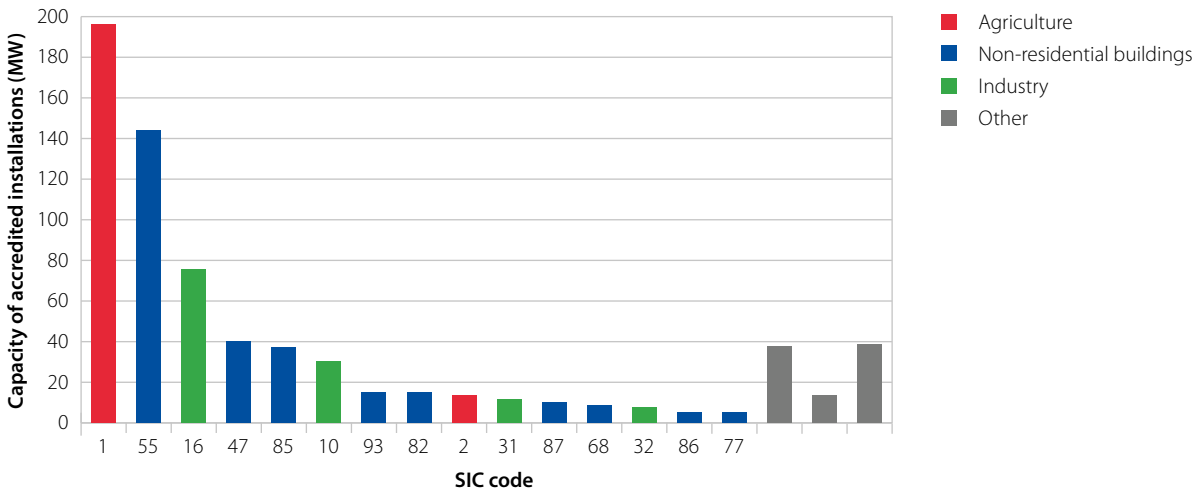
DECC responded to this under-delivery with recent increases to the ground-source heat pump tariff, and a new tariff for air-to-water heat pumps of 2.5p/kWh. Further tariff increases apply to CHP, large biomass boilers, biogas combustion, geothermal and solar thermal. There is a new tariff for energy from waste.

(iii) Future low-carbon heat policy compatible with carbon budgets

A very significant scaling up of investment in low-carbon heat is required to meet future carbon budgets, with an important role for heat pumps and low-carbon sourced district heating. Biomass should be applied mainly in industrial applications.

- **Heat pumps.** In particular, there is a major role for investment in heat pumps. For example, our analysis for the fourth carbon budget suggested that the aim should be to invest in around 4 million residential heat pumps by 2030, with an additional 26.5 TWh of heat pumps in the non-residential sector.

Figure 3.20: Non-domestic RHI delivery (MW capacity), by Standard Industrial Code (SIC)



1 Crop and animal production, hunting and related service activities
55 Accommodation
16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
47 Retail trade, except of motor vehicles and motorcycles
85 Education
10 Manufacture of food products
93 Sports activities and amusement and recreation activities
82 Office administrative, office support and other business support activities
2 Forestry and logging
31 Manufacture of furniture
87 Residential care activities
68 Real estate activities
32 Other manufacturing
86 Human health activities
77 Rental and leasing activities
Other non-residential buildings
Other industry
Other, not classified

Source: DECC (2014) *RHI and RHPP deployment data, 31 March 2014.*

24 Ofgem, *RHI Public Report*, generated on 8 July 2014.

- **District heating.** There should also be an important role for district heating, although further evidence is required on the technical feasibility and economic viability of district heating using low-carbon technology (particularly networks with large-scale heat pumps) along with addressing barriers on large-scale transmission infrastructure and securing heat demand. Good progress has been made in supporting local authorities to develop feasibility studies (see Box 3.15).
- **Biomass heat.** The role of bioenergy to provide heat in buildings is likely to be limited, given constraints on availability of sustainable biomass supply, which provides more value when used in other sectors of the economy (e.g. to provide high grade heat in industry). In our 2011 Bioenergy Review we assessed that, up to 80% of the UK's potential biomass resource for heat will be required in industry. Currently, only around 30% of the RHI uptake has been in industrial applications.

Box 3.15: Progress on developing low-carbon heat networks

Progress to date

The Heat Networks Delivery Unit within DECC has been operating now for just over a year, with £1.9 million spend to date on supporting local authorities in England and Wales to develop feasibility studies.

- There has been strong demand for this funding, with studies funded in 26 local authorities.
- The next step is to develop the commercial business case to secure funding.

Scotland has adopted a 2020 district heating target of 40,000 additional homes connected to networks in the 2013 Heat Policy Statement. A UK-wide target should be considered, as it could prove useful to signal government commitment and secure resources.

Promising developments include a new push on mapping water-source heat pump potential from DECC.

- This has good potential as a low-carbon source for heat networks, with a new scheme on the Thames currently being developed which will supply heat to around 150 homes and a large conference centre.
- Other examples of a high efficiency system using district-scale heat pump include a new scheme in Drammen, Norway (Star Energy), which delivers water at 90°C to 6,000 homes.

There is a potential role for the Green Investment Bank for large-scale innovative schemes, such as those using water-source heat pumps, geothermal and heat storage solutions.

Next steps

Poor quality installations and a lack of consumer protection issues are both risks which must be fully addressed before wide-scale roll-out of heat networks.

- Anecdotal evidence suggests that some poorly designed schemes have been built in recent years resulting in increased carbon emissions and higher costs to consumers and social landlords.
- A first step to addressing this has been taken, with the Combined Heat and Power Association and Which? working together to develop a voluntary code of practice.
- Next steps should include further work to address natural monopoly issues, including setting up a formal complaints process and looking at regulatory options.

Previously, we identified waste heat from thermal low-carbon power stations as a major cost-effective opportunity for district heating. Further work is required on addressing barriers on large-scale transmission infrastructure and securing heat demand.

With the expansion of both district-level and building-scale low-carbon heat solutions into the 2020s, there is also a growing risk of funding going towards competing solutions, leading to higher overall abatement costs. One solution is to look at the potential for zoning low-carbon heat at a local level, building on the Danish example (see box 3.14). We will return to this for our advice on the fifth carbon budget next year.

It is possible that alternative ways could be found to support investment in low-carbon heat (e.g. subjecting heat consumption to a carbon price/requiring low-carbon heat investment under buildings regulations). While these alternatives should be considered, they are unlikely to be technically or politically feasible in the near-to-medium term, implying that the RHI is the only realistic delivery mechanism for the foreseeable future.

Given that it is the only feasible mechanism, there is a need to reduce current uncertainty about the RHI by committing funding to 2020, and committing to its continued existence beyond 2020.

- **Committing funding to 2020.** Funding for the RHI has only been committed for the period to 2016. This undermines incentives for supply chain development and should be addressed as a matter of urgency through committing funding to 2020.
- **Committing to continued existence of the RHI in the 2020s.** A very significant ramp up of investment in low-carbon heat is needed to meet carbon budgets in the 2020s. The Government should commit to the continued existence of the RHI in the 2020s until and unless an adequate replacement is in place (see below for a discussion of alternative delivery mechanisms in the medium term).

Despite the fact that the RHI is generous, take-up to date has been low. The appropriate response is not to increase the subsidy. Rather it is to overcome the financial and non-financial barriers, which would otherwise result in funding costs for the RHI being prohibitive.

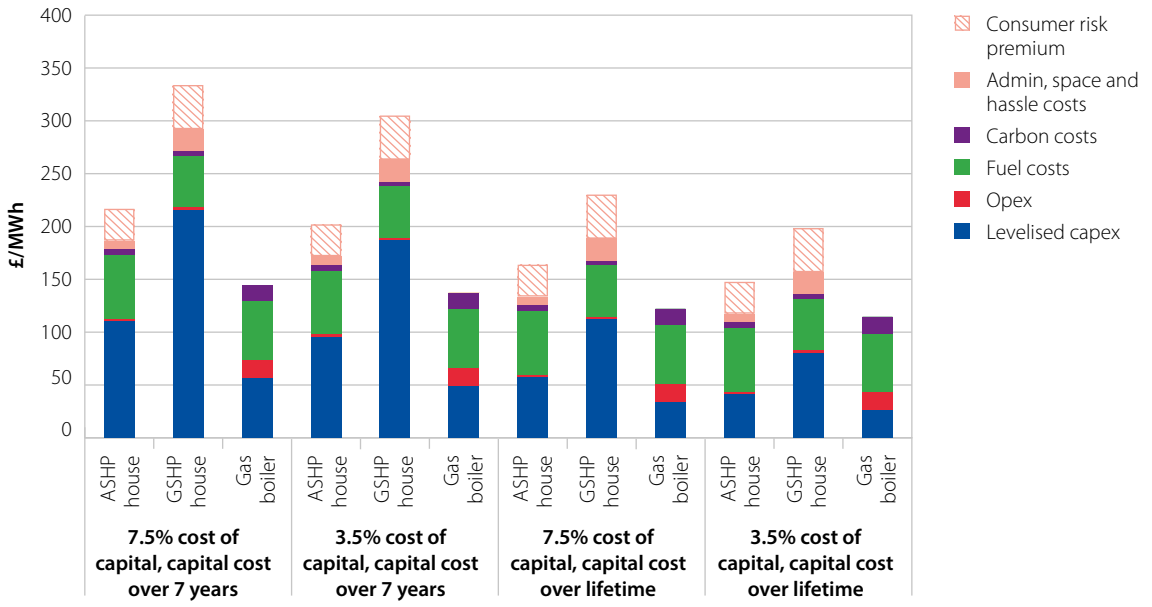
- **Reduce funding costs through addressing non-financial barriers.** The RHI is an operational subsidy paid quarterly to consumers and businesses, based on the additional upfront cost of low-carbon heat installations along with operating costs/savings. In the case of the domestic scheme, the net upfront cost is annuitised across a seven-year period. The tariff includes high barrier costs, calculated so as to give an overall return of 16% to consumers, and 12% to businesses. These very high returns are in part to overcome non-financial barriers to uptake. These barriers should be addressed through improved information and confidence-building.
  - Sustained large-scale marketing campaigns through multiple channels are required to raise the profile of low-carbon heat technologies and awareness of the finance available.
  - Consumer confidence could be improved through basic installer training for all heating engineers, along with support for consumers at initial set-up, plus follow-up, for those installing heat pumps.
  - Further work on ways to reduce disamenity costs (e.g. loss of space) would be useful.

- **Reduce funding costs by introducing new financing instruments.** The high return offered under the RHI also partly reflects the cost of finance to consumers. Therefore if the cost of finance could be reduced, the cost of funding the RHI could also be reduced. The annual funding cost could be further reduced by spreading payments over a longer time period. Extending the Green Deal to pay for investment in renewable heat offers the opportunity to reduce financing costs and spread these over longer term periods.
  - If the cost of finance for households could be reduced from 7.5% to 3.5% this would reduce the annual funding cost in 2025 by £300 million.
  - Spreading costs over the life of the heat pump, rather than seven years as under the RHI currently, could further reduce the required annual funding (i.e. by around £300 million in 2025).
  - There is scope to achieve this by extending the Green Deal to cover the full upfront cost of heat pumps. This assumes that the Green Deal interest rate falls from its currently high level, which should be possible as the instrument becomes established and could be facilitated by Government guarantee (see Box 3.16).

Box 3.16: Extending the Green Deal to support low-carbon heat

The RHI offsets the difference in costs between heat pumps and conventional alternative.

Figure B3.16: Levelised cost of heat pumps under different assumptions about financing costs and tenors



Source: Frontier Economics and Element Energy (2013) *Pathways to high penetration of heat pumps, report prepared for the CCC*; DECC (2013) *RHI consultation* and *energy price projections*; CCC calculations.

Box 3.16: Extending the Green Deal to support low-carbon heat

Therefore, funding for low-carbon heat can be reduced if the finance costs can be reduced. This could be worth several hundred million pounds annually by the mid-2020s.

- The cost per year to heat a standard home with an air source heat pump is around £2,180, under assumptions of capital cost financed at 7.5% and annuitised over 7 years.
- This comes down to a cost of around £2,000, if financed at 3.5% over 7 years.
- Based on a number of different property types and sizes, and uptake of 2 million heat pumps in 2025, this could give estimated savings of around £300 million.

The lack of access to low-cost and long term funding could be addressed by changing Green Deal to allow for finance of heat pumps in full.

- Unsecured funding is expensive. Limited numbers of consumers have the scope or inclination to extend their mortgage.
- The Green Deal is also currently expensive, but there is scope for reduced interest rates over time.
- Currently the Green Deal can only pay for a small part of heat pump investment due to the Golden Rule. This should be revised to cover the full upfront cost.

The Green Deal should therefore be changed so that it can be used to pay for investment in low-carbon heat. There may also be a case for additional subsidy, for example, through the Energy Company Obligation. There might be a role for the Green Investment Bank, either working through the Green Deal finance company or with other financial institutions.

Even with this package of measures in place, it is uncertain that the level of uptake required to meet carbon budgets and be on the cost-effective path to economy decarbonisation would be achieved. Alternative options to further strengthen incentives, and to reduce the burden on the taxpayer, would be to introduce a carbon price for heat, or to require investment in heat pumps through buildings regulations.

- **Carbon price.** Introducing a carbon price for heat in the residential sector would reduce the relative cost of heat pumps compared to conventional alternatives. This would stimulate demand for heat pumps, providing incentives for uptake where this is cost effective. Investment would be paid for by consumers rather than taxpayers. It would also make energy efficiency measures more cost-effective. The impact of this on consumers could be offset through reducing other taxes, although there would be distributional implications of such a move which would need to be addressed.
- **Buildings regulations.** This would again shift the burden of investment cost from taxpayers to consumers. If buildings regulations were chosen as the mechanism to support heat pump roll-out, these would have to be designed very carefully, given that heat pumps are suitable for some but not all homes. In particular, a progressive approach to tightening regulations, focussing first on off-gas segments could prove a sensible approach, if accompanied by low-cost finance[25].

These would be difficult to implement in the near term, for technical and political reasons, hence the need to commit to the continuation of the RHI in the 2020s unless and until an alternative mechanism is introduced.

25 For further discussion, see Frontier Economics and Element Energy (2013) *Pathways to a high penetration of heat pumps, report prepared for the CCC.*

As part of strengthening the approach to supporting investment in low-carbon heat, there may be scope to join this up with policy to reduce fuel poverty. In particular, there is a significant opportunity for cost-effective investment in low-carbon heat to replace inefficient heating systems in fuel-poor households. The Government should work to understand and address barriers to uptake of low-carbon heat in fuel-poor households. It should consider targeting part of the RHI to the fuel poor, which together with provision of low-cost finance may be sufficient to encourage uptake (Box 3.17). There may also be a case for additional subsidy, for example, through the Energy Company Obligation.

Box 3.17: Joining up low-carbon heat and fuel poverty policies

Many fuel poor have inefficient heating systems, with high numbers living in homes off the gas grid and facing above average heating costs.

- Around three quarters of people living in homes off the gas grid have higher incomes which take them above the income threshold defined in the Low-Income/High-Costs fuel poverty measure (see box 3.1 on fuel poverty).
- However, electric and oil-based systems are more expensive than gas-based heating, causing problems for low-income households – especially for those living in poorly insulated homes.
- In particular, those using the more expensive electrical systems have the highest probability of being fuel poor, around 2.5 times more than those with gas heating systems (DECC, 2013).

It is cost-effective to replace inefficient heating systems with heat pumps or other low-carbon options.

- Air source heat pumps replacing electric heating in houses are a key segment for uptake of low-carbon heat off the gas grid, where the levelised cost of the heat pump is around £90/MWh, compared to running costs of over £180/MWh for resistive electric heating. Smaller savings are also possible compared to running electric storage heaters with a time-of-use tariff.
- The fuel poverty marginal alleviation cost curve analysis undertaken by DECC in 2013 also identified both air source and ground source heat pumps in off-gas homes as two of the highest measures in the merit order for tackling fuel poverty in some of the most severely fuel poor homes.

In order that fuel poor households invest in heat pumps, there needs to be a mechanism to pay for upfront cost (e.g. low cost-finance through the Green Deal).

Beyond this, the Government should consider targeting part of the Renewable Heat Incentive to the fuel poor, which together with the provision of low-cost finance may be sufficient to encourage uptake. Options include ring-fencing part of the budget towards capital subsidies, or making funds available through third parties, building on the Scottish Warm Homes fund example. There may also be a case for additional subsidy, for example, through the Energy Company Obligation.

Source: DECC (2013) *Fuel Poverty: a Framework for Future Action – Analytical Annex.*

(c) New heat indicator trajectories

We are not updating our central scenario trajectory in buildings this year to include savings from low-carbon heat and to reflect the latest analysis from our review of the fourth carbon budget last year. This is because of new evidence on costs and feasibility along with delays in implementing low-carbon heat policy, which together mean that it is unlikely that we will achieve the uptake to 2020 included in our central emissions scenario.

We intend to review this in detail in 2015 as part of our advice for the fifth carbon budget.

We will continue to track progress in take-up of low-carbon heat across the economy and in buildings to 2020. From 2015, we will also look at the total number of heat pumps installed in homes since 2007, and track progress towards a new indicator for domestic heat pumps in 2020.

- Our previous analysis undertaken on bioenergy suggests that total sustainable biomass resource available for heat could be limited to around 50 TWh in 2020, of which up to 40 TWh is likely to be required in industry where options are limited due to the need for high-temperature process heat.
- Therefore, other technologies such as heat pumps are crucial for meeting the carbon budgets. DECC's central forecast for the domestic RHI scheme features heat pumps as one of the primary low-carbon heating technologies in homes to 2020.
- In the supporting analysis for the fourth carbon budget in 2013, we presented a critical path uptake for heat pumps to 2050, based on modelling by Frontier Economics and Element Energy (2013). This shows that a minimum of 116,000 heat pumps in homes is required in 2020, in order to leave options open for decarbonising heat in buildings by 2050.[26]
- It is clear on this basis that we cannot rely on heat from biomass to meet the 2020 EU Renewables directive target, and that we need to build up the UK market in order to meet future carbon budgets.

To this end, we will track progress towards uptake of 600,000 heat pumps in homes in 2020 (see box 3.18 Approach to deriving 2020 heat pumps indicator).

Box 3.18: Approach to deriving the 2020 heat pumps indicator

The central trajectory under the RHI is based on 490,000 new heat pumps in homes by 2020/21. This compares to a total of 600,000 in 2020 in our central scenario for meeting the fourth carbon budget.

Modelling looking at uptake under the domestic RHI by Frontier Economics and Element Energy (2013) gave a range of 450,000-1,000,000 residential heat pumps in 2020, corresponding to low and high fossil fuel price scenarios. The central estimate is for 650,000 domestic heat pumps in 2020, or over 900,000 if including hybrid air source heat pumps.

We have therefore adopted a central value of 600,000 heat pumps in homes in 2020.

We are not proposing an equivalent target for non-residential heat pumps at this point in time.

- There remains a good deal of uncertainty around the level of ambition required from non-residential buildings to meet the EU Renewables directive target and the feasible level of deployment under the non-domestic RHI. DECC RHI estimates range from 13-39 TWh of low-carbon heat in 2020-21, with similar uncertainty in heat pump uptake.
- Equally, critical path analysis by Frontier Economics and Element Energy[23] for uptake of heat pumps in non-residential buildings is not binding in 2020 in the same way as in the residential sector (with a minimum of less than 0.5 TWh of uptake required in 2020, and 6 TWh in 2030). This suggests that there is a lower risk to meeting the 2050 target than in residential buildings.

However, heat pumps remain a cost-effective technology for meeting the fourth carbon budget in non-residential buildings, with 26.5 TWh in 2030 in our central cost-effective pathway. We will therefore continue to monitor uptake closely and return to this in 2015 when we review our low-carbon heat scenarios for our advice on the fifth carbon budget.

26 Based on a 2050 decarbonisation pathway with 31 million heat pumps in homes in 2050. The critical path is calculated based on a natural stock replacement rate, without scrapping boilers early.

27 Frontier Economics and Element Energy (2013), *Pathways to a high penetration of heat pumps, report prepared for the CCC.*

7. Summary of progress and revised progress indicators

(a) Summary – past progress

In this chapter we have considered progress against indicators in buildings and low-carbon heat. We summarise this below in the form of traffic light ratings for a set of our key indicators.

For each key indicator, we compare the outturn data over 2007-12 to our indicators, and to assign it a colour of red, amber or green where (broadly):

- Green signifies on-track performance or outperformance (e.g. in terms of lower emissions, higher deployment, or policy that is either in place earlier than we recommended, or more comprehensive).
- Amber signifies slight underperformance against our indicator (e.g. policy implementation delays)
- Red signifies significant underperformance or rejection of certain policies and/or measures.

For buildings, only one indicator (uptake of boilers) has a green rating, with all the other indicators either red or amber (Table 3.1). This reflects our assessment that in most policy areas (residential energy efficiency, non-residential energy efficiency, low-carbon heat) progress has been slow and in several cases, policy changes have significantly undermined the delivery of measures.

Table 3.1: Buildings traffic lights		
Indicator	**Traffic light**	**Comment**
Residential energy efficiency		
Uptake of solid wall insulation	Red	Very low uptake numbers (170,000 cumulatively by the end of 2013, compared to 500,000 in our indicator). Some success during 2012 (final year of the Community Energy Saving Programme) but uptake numbers have fallen under the Energy Company Obligation (ECO).
Uptake of loft insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. A cumulative 5.7 million lofts were insulated by end 2013, below our indicator of 6.3 million.
Uptake of cavity wall insulation	Amber	Progress good until 2012 but very low in 2013 following change in policy framework. A cumulative 2.9 cavity walls were insulated by end 2013, significantly below our indicator of 5 million.
Uptake of boilers	Green	High uptake of new efficient boilers. A cumulative 7.7 million cavity walls were insulated by end 2013, against our indicator of 5 million.
Uptake of energy efficient appliances	Amber	Stock penetration for the most efficient appliances is low (Wet appliances A+ or better are 9% of the stock versus 16% in the indicator). However, overall efficiency of the appliances on the market has improved significantly.
New energy efficiency financing mechanism	Red	Green Deal introduced in 2013 but unattractive interest rates and very low uptake. Scope for currently unattractive interest rates to fall in future as Green Deal lending is scaled up.
Post-CERT delivery framework	Amber	ECO started in 2013 but several changes proposed which lower ambition significantly.
Accelerate introduction of minimum standards for privately rented homes	Amber	Commitment in 2011 Energy Act but actual proposals still outstanding.
Non-residential energy efficiency		
Develop low-carbon policy for SMEs	Red	No progress, except non-domestic Green Deal but no uptake.
Government decision on roll out of DECs to non-public buildings	Red	Ruled out by Secretary of State for Communities and Local Government.
Low-carbon heat		
Penetration of low-carbon heat (%)	Red	Progress in buildings is off-track against low levels of projected uptake (i.e. only an additional 0.3% of new low-carbon heat in 2012 against 2007 levels against 0.6% in our indicator trajectory).
Domestic Renewable Heat Incentive in operation	Amber	Delays to RHI launch, but some progress made in setting standards and improving evidence base.
Non-domestic Renewable Heat Incentive in operation	Amber	Scheme up and running since 2011, but low uptake apart from biomass. Work ongoing on improving the policy (e.g. recent tariff review, 2014 evaluation).
Source: CCC analysis		

(b) Summary – future policies

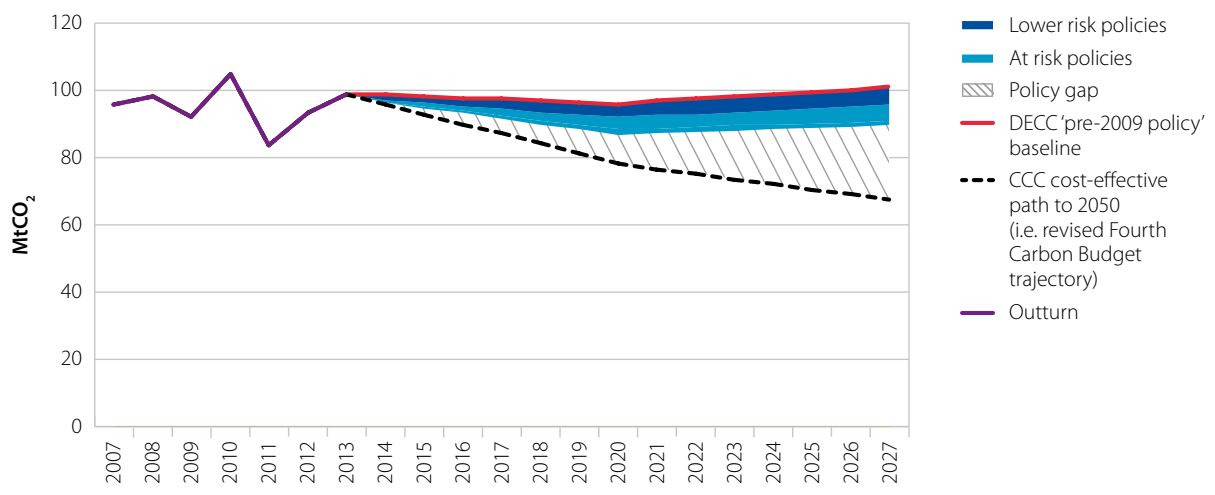
In our Fourth Carbon Budget Review we suggested that non-traded buildings emissions would need to fall to 68 $MtCO_2$ by 2027 to meet carbon budgets. According to DECC's updated energy projections (UEP), non-traded buildings emissions in the absence of policy would be 101 $MtCO_2$ in 2027, falling to 89 $MtCO_2$ when estimated savings of current and planned government policies are included (Figure 3.21).

This leaves a gap of 20 $MtCO_2$ in 2025 to be addressed in order to meet carbon budgets. Most of the gap is due low-carbon heat, making up 19 $MtCO_2$ out of the total. This is due both to lower ambition to 2020 and a lack of policy post-2020 to drive low-carbon heat uptake.

- Residential sector: the gap is 13 $MtCO_2$, with low-carbon heat accounting for 11 $MtCO_2$ (Figure 3.22)
- Non-residential sector: the gap is 7 $MtCO_2$, which is all from low-carbon heat (Figure 3.23)

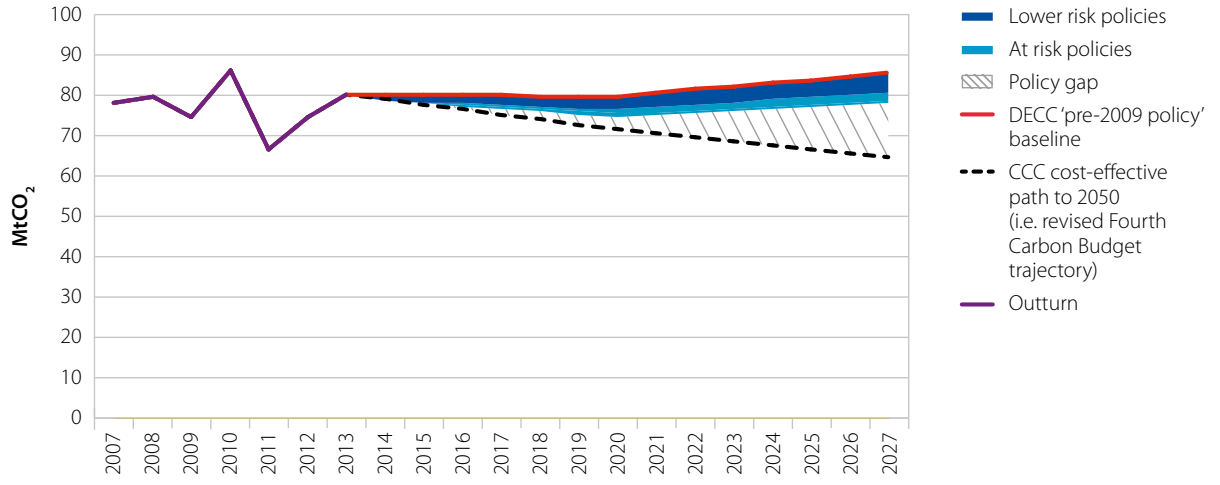
Furthermore, not all policy savings are assured. We have made an assessment of the risk associated with the policies listed in UEP, based on the policy discussion in earlier sections of this chapter. While 3 $MtCO_2$ are to be delivered by low risk policies, by 2025, 6 $MtCO_2$ are dependent on policies with design/delivery problems or are unfunded or even missing (Table 3.2). The biggest gap is the RHI post-2016.

Figure 3.21: Assessment of planned policies against future targets – all buildings (non-traded)



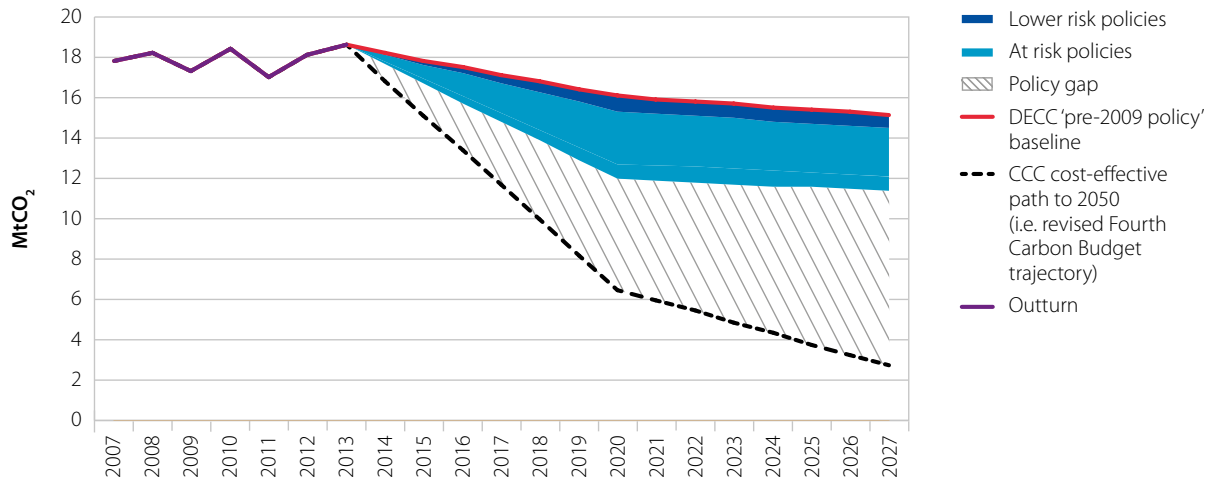
Source: DECC (2013) *Updated emissions projections*; CCC analysis.

Figure 3.22: Assessment of planned policies against future targets – residential (non-traded)



Source: DECC (2013) *Updated emissions projections*; CCC analysis.

Figure 3.23: Assessment of planned policies against future targets – non-residential (non-traded)



Source: DECC (2013) Updated emissions projections; CCC analysis.

Table 3.2: Buildings policy evaluation	
Policy	**Comment**
Lower risk policies	
Buildings (residential)	
Real time displays/ smart meters;	Energy suppliers have a licence obligation to deliver full roll-out by 2020. A central delivery body has been set up to promote behaviour change via consumer engagement activities in order to achieve energy demand reduction.
CERT (2009-12)	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 (2008-12)	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.
EU Products Policy Tranche 1	The Ecodesign Directive sets minimum standards for appliances which ratchet up over time. Energy labelling helps overcome consumer awareness barriers. Most of tranche 1 standards are now in place. Some questions remain over rate of stock replacement and number of consumers choosing the most efficient appliances.
Buildings Regulation Part L 2010	Long-standing effective policy, 2010 tightening of standards significant, provided level of compliance and future build rates are adequate.
RHI to April 2016	Despite delays to its introduction, the policy was put in place in 2014 and targets the financial barriers. Incentivises the right mix of low-carbon technologies. Provided issues around low awareness and consumer confidence are addressed, it should stimulate the market in key off-gas segments and in social housing, although landlord-tenant issues remain an issue in the private-rented sector. Incentives broadly at the right level. Funding has been committed until April 2016.
Buildings (non-res)	
Non-Domestic Smart Metering	As in the residential sector, smart metering addresses a key information gap, with roll-out driven by the requirement on energy suppliers. However, the estimated savings for businesses are only based on one study from the Carbon Trust, in contrast with smart metering in homes, where there is better evidence of the impact on energy savings
RHI to April 2016	Right mix of technologies is targeted. Policy savings have been revised downwards based on market forecasts, and are now reasonably cautious. Although uptake to date has been mainly biomass, government has responded with recent changes to the scheme including new tariffs, which are now broadly at the right level. Funding has been committed until April 2016.

Table 3.2: Buildings policy evaluation	
Policy	**Comment**
Policies with design/delivery problems	
Buildings (residential)	
ECO and domestic Green Deal	While it is aiming to target the right measures and customer types (e.g. fuel poor, hard- to-treat homes and rural households), uptake to date has been very low due to low ambition and poor design, and carbon saving targets are off track. Furthermore, current proposals to amend the ECO are creating a lot of uncertainty. No commitment post-2017. Additional incentives available through the Home Improvement Fund but this is only funded for one year.
EU Products Policy Tranche 2	As above for tranche 1 but question marks over implementation as significant process delays. Estimate of savings in UEP is high – it is not clear how robust the model on which these are based is.
Zero Carbon Homes	Policy to be introduced from 2016 but Government has proposed exemptions for small developments. Scale of exemptions to be consulted on but could be significant.
Buildings (non-residential)	
EU Products Policy tranche 1	As with domestic products, minimum standards for products are set under the Ecodesign directive and ratcheted up over time. Realised savings are at risk due to delays to implementation and uncertainty around stock replacement rates. Assumptions underpinning modelled savings are unclear and under review. Overall, the risks are greater than with tranche 1 domestic appliances due to a less developed evidence-base.
EU Products Policy tranche 2	Shares same risks as tranche 1, with additional risks due to delays to implementation process.
Non-domestic Green Deal	Whilst the policy tackles a gap around finance for energy efficiency in SMEs, demand for the finance at the currently high interest rates is low. Pay-as-you-save model from the domestic sector is less well adapted to complex landlord-tenant relationships in the commercial sector.
CRC energy efficiency scheme	The scheme is targeting energy use not covered by existing policies, incentivising energy efficiency and addressing an information barrier. However, its credibility has been weakened due to the changes to the scheme, including the loss of the reputational lever of the performance league table. It is now a modest carbon tax which is hampered by the original trading scheme design architecture.
Building Regulations part L 2010	Focuses on the right barrier by regulating that developers meet certain CO_2 reducing standards compared to previous 2006 regulations. There are however some questions around the modelled savings based on the SBEM model, which are being reviewed in light of new bills data. This leads to uncertainty around compliance and the 'performance gap' between buildings as designed, built and in-use.
Unfunded Policies	
RHI from April 2016	No committed RHI funding after the 2015-16 financial year.
Missing Policies	
Residential energy efficiency post-2017	The ECO is currently proposed to be in place until 2017 but a large potential for energy efficiency will remain (e.g. 2.6 million cavity walls and 7-8 million solid walls could benefit from insulation measures). Further measures will be needed either through an extended ECO or other approaches (e.g. local authority-led area-based energy efficiency programmes).
Low-carbon heat policies	No proposed policies to drive low-carbon heat beyond 2020. The RHI should be extended until and unless there is an alternative framework in place. Financing costs need to be reduced and non-financial barriers addressed. Further abatement opportunities exist in new-build properties, which could be unlocked through the planning framework.

(c) Revised indicators to 2030

Going forward, we will continue to monitor progress in the buildings sector against a range of indicators. Reflecting our analysis for the fourth carbon budget review (including revised baseline projections), new evidence, and the recommendations in this report, we have revised our indicator framework for the second and third carbon budgets, and extended it to cover the fourth carbon budget period (Table 3.3).

- We have updated our electricity demand indicator. DECC's projections assume a lower level of demand of electricity demand compared to our cost-effective pathway to 2030. We will monitor progress in electricity demand savings against our pathway. However, we note that there are uncertainties[28] which emphasise the importance of monitoring uptake of energy efficient appliances and low-carbon heat, which is contingent on having reliable and robust data.
- In the future we will monitor progress against our direct emissions and electricity demand indicators. We no longer have an indirect emissions indicator as these emissions are monitored under the power sector.
- We have updated our indicators for loft and cavity wall insulation, boilers and appliances. Due to continuing uncertainties over costs and savings from solid wall insulation, we have not updated our solid wall indicator but note that the current indicator (3.5 million) is likely to be very challenging and expensive to achieve. We will revisit this indicator in future analysis.
- We have not updated our appliance indicators, due to weaknesses in the current evidence base. We expect to revisit this in our fifth budget advice. However, we have set a new LED indicator.
- We have revised our policy indicators for the residential sector, reflecting our recommendations on the ECO, Green Deal, fuel poverty, minimum standards and Zero Carbon Homes.
- We have added a new indicator for the non-residential sector to conduct a full review of non-residential low-carbon policies.
- We will continue to track progress in uptake of low-carbon heat towards 12% penetration in 2020. We also have set a new indicator for residential heat pumps in 2020.

We have not updated our central scenario trajectory in buildings this year to include savings from low-carbon heat and to reflect the latest analysis from our review of the fourth carbon budget last year. This is because of new evidence on costs and feasibility along with delays in implementing low-carbon heat policy, which together mean that it is unlikely that we will achieve the uptake to 2020 included in our central emissions scenario. We intend to review this in detail in 2015 as part of our advice for the fifth carbon budget.

28 Projections of electricity consumption are uncertain due to the difficulty in estimating the uptake of energy efficiency measures and improvements in efficiency. In addition, while energy efficiency measures will decrease electricity consumption, the uptake of low-carbon heat measures will increase demand, both of which are important.

Key findings

- Buildings CO_2 emissions fell **by 8% between 2007 and 2013** due to a mix of energy efficiency improvement, the recession and changes in the electricity sector.
- After good progress with home insulation during the first carbon budgets, **insulation rates have dropped sharply since early 2013** with the introduction of the Energy Company Obligation and the Green Deal.
- Given potential to go further on loft and cavity wall insulation, and the benefits that this would bring in terms of cost-effective emissions reduction and energy affordability, the Government **should increase the ambition** in the Energy Company Obligation to 2017 and introduce additional measures for fuel poor households. Beyond 2017, there are three options for the ECO: focus on delivering more difficult options for all households; focus on the fuel poor; reduce its scope and develop an alternative approach to fuel poverty.
- For **Zero Carbon Homes** to meet their full emission-reduction potential, the policy should incentivise the uptake of low-carbon heat options and grant exemptions only where there is a clear economic rationale.
- There remains **significant potential** to improve energy efficiency in the non-residential sector. The current policy framework is overly complex and should be redesigned to provide one instrument for each of information provision, financial incentives and regulation.
- Low-carbon heat accounts for **just 2%** of heat demand. Funding under the Renewable Heat Incentive should be committed to 2020 and measures introduced to reduce funding costs and delivery risk. Some funding should be targeted at fuel poor households.

Table 3.1: The Committee's buildings indicators

BUILDINGS		Budget 2	Budget 3	Budget 4	2013 trajectory	2013 outturn
All buildings						
Headline indicators						
Direct CO_2 emissions (% change on 2007)*	direct	-10%	-14%	-11%	-4%	0%
Final energy consumption (% change on 2007)*	electricity	4%	11%	14%	1%	-4%
Residential buildings						
Headline indicators						
Direct CO_2 emissions (% change on 2007)*	direct	-4%	-5%	-1%	-2%	-3%
Final energy consumption (% change on 2007)*	electricity	4%	11%	14%	1%	-8%
Supporting indicators						
Uptake of solid wall insulation (million homes, total additional installations compared to 2007 levels)		1.2	2.3	3.5	0.6	0.17
Uptake of loft insulation (top up of between 50- 200 mm) (million homes, total additional installations compared to 2007 levels)		5.6	9.2	9.2	6.3	5.7
Uptake of cavity wall insulation (million homes, total additional installations compared to 2007 levels)		4.0	6.3	7.2	5.3	2.9
Uptake of energy efficient boilers (million homes, total additional installations compared to 2007 levels)		9.3	12.6		5.9	7.7
Uptake of energy efficient appliances – cold A++ rated (% of stock)		18%	45%		3% (2012)	0.6% (2012)
Uptake of energy efficient appliances – wet A+ rated (% of stock)		40%	58%		16% (2012)	12% (2012)
Uptake of LEDs (replacing halogens with LEDs)		87 million	169 million	250 million	n/a	(new indicator from 2014)
ECO: Increase ambition on lofts and cavities to 2017		Now, as changes to ECO are finalised				
ECO/Green Deal: Maintain financial incentives until 2017		Ongoing to March 2017				
ECO: Decide on focus for future of ECO, in particular the role of solid wall insulation		By mid-2016				
Green Deal: Achieve reduction of Green Deal interest rate (e.g. through government guarantees)		By end-2015				

Table 3.1: The Committee's buildings indicators

BUILDINGS		Budget 2	Budget 3	Budget 4	2013 trajectory	2013 outturn
Fuel poverty: develop additional measures for England to supplement Affordable Warmth under the ECO		By end 2014				
Private-rented sector: Publish proposals for minimum energy performance standards (with a timetable for a progressive tightening of standards)		By end 2014				2011 Energy Act requires introduction by 2018 but proposals still outstanding
Zero Carbon Homes: Ensure that the Zero Carbon Homes standard requires investment in low-carbon heat unless this is prohibitively expensive. No exemptions for small developments should be given unless there is a clear economic justification.		For 2016 start				
Other drivers						
Average SAP rating, implementation of behavioural measures, population (by age), number of households (by type – building and occupants), household disposable income, electricity and gas prices, appliance ownership, weather.						
Non-residential buildings						
Headline indicators						
Direct CO_2 emissions (% change on 2007)*	direct	-33%	-50%	-52%	-12%	4%
Final energy consumption (% change on 2007)*	electricity	-6%	0%	10%	-4%	1%
Supporting indicators						
Accelerate the introduction of minimum standards for privately rented non-residential properties			By 2016			Energy Act proposes introduction by 2018
Government decision on the following recommendations for EPCs and DECs:			By 2016			
– All non-residential buildings to have an EPC			By 2017			No commitment to do this
– All non-residential buildings to have a minimum EPC rating of F or higher				By 2020		No commitment to do this
– Roll out of DECs to non-public buildings			by 2017			No commitment to do this
Conduct a full review of non-residential low-carbon policies to evaluate options for strengthening and rationalising incentives, regulation and information requirements, and implement recommendations		By 2016				Ongoing

Table 3.1: The Committee's buildings indicators					
BUILDINGS	Budget 2	Budget 3	Budget 4	2013 trajectory	2013 outturn
Other drivers					
Emissions and fuel consumption by subsector, electricity and gas prices.					
Renewable heat					
Headline indicators					
Low-carbon heat penetration (% of heat demand from renewables) – total buildings and industry	5%	12% in 2020		0.6%**	0.8%**
Low-carbon heat penetration (% of heat demand)	4%	11% in 2020		0.6%**	0.3%**
Other drivers					
Uptake and costs of low-carbon heat technologies in buildings – Biomass boilers, Solar thermal, GSHP/ASHP, District heating.					

* These figures exclude low-carbon heat.
** 2012 figures – no data available for 2013. Figures are based on additional low-carbon heat, relative to a 2007 baseline.

Note: Numbers indicate amount in last year of budget period i.e. 2017, 2022, 2027.

Key: Headline indicators Supporting indicators Other drivers

Chapter 4

Chapter 4: Progress reducing emissions from industry

1. Introduction and key messages

This chapter covers emissions from industrial activity including manufacturing, construction, extraction of fossil fuels and refining.

Emissions from industry accounted for around a third of UK greenhouse gas emissions in 2013 (around 170 $MtCO_2e$), of which around 90% are CO_2. Industry CO_2 emissions are around 74% direct emissions (of which 92% are from the combustion of fossil fuels and 8% are from chemical processes) and 26% indirect emissions (i.e. electricity-related).

In this chapter we assess industrial emissions and energy consumption over the first budget period (2008-2012), preliminary 2013 data on industry emissions, as well as progress against policy milestones.

The key messages in the chapter are:

- There have been large reductions in industrial CO_2 emissions since 2007. These falls have been in line with our indicators for CO_2 reduction, although evidence suggests they are mainly a result of the recession rather than specific abatement activities:
  - Between 2007 and 2012, CO_2 emissions fell by 20%. However, this reduction did not ensue because the potential that we identified for energy efficiency improvement was unlocked. Rather, the large fall in emissions was due to output reducing by 9% as a result of the economic recession, which had a disproportionate impact on the more carbon-intensive sectors (e.g. iron and steel).
  - In 2013, CO_2 emissions fell by a further 2% due to continued decarbonisation of electricity. There was a 3% rise in direct CO_2 emissions from manufacturing, despite a fall in output of 1%. This rise in CO_2 emissions was due to a rise in more carbon-intensive production, including steel production from the reopening of Teesside steelworks.
- Non-CO_2 emissions fell by 14% between 2007 and 2012, and fell 1% in 2013, reflecting the introduction of technologies to abate N_2O emissions in industrial processes and reduced methane emissions from the gas distribution network and coal mines.
- Significant improvements in industrial energy efficiency are possible, and are needed to meet the fourth carbon budget. However, there is no clear evidence to date of energy efficiency improvement sufficient to reduce the emissions intensity of production taken place on the aggregate level. Going forward, there is unlikely to be sufficient progress to meet the fourth carbon budget, due to high barriers and weak policy incentives. In particular, the EU ETS carbon price remains low, as does ambition in the Climate Change Agreements.

- In order to improve progress towards a low-carbon industry sector, the Government should include the full range of cost-effective abatement options in the sectoral decarbonisation roadmaps currently being developed jointly by the Department of Energy and Climate Change (DECC) and Department for Business, Innovation and Skills (BIS). These should include options highlighted in the fourth carbon budget review such as increased electric-arc steel production, clinker substitution in cement and optimisation of refineries. In developing roadmaps, the risk is that these remain high level, and do not result in required investment. To mitigate this risk, it is important that they include key milestones together with policies to ensure they are met in practice, noting that policies are likely to go beyond reliance on the carbon price in the EU ETS, even if this is strengthened significantly.
- Carbon Capture and Storage (CCS) in industry is a key option to meet the 2050 target. We have repeatedly recommended that the Government should publish an approach to demonstration and commercialisation of industrial CCS compatible with deployment in the 2020s, by when CCS should be approaching commercialisation. This is now urgent, given the timeline to deployment, and the opportunity for substantial CCS abatement if deployed alongside expected industrial plant refurbishments from the late 2020s. Failure to address industrial CCS now will result in missing opportunities in plants' refurbishment cycles, raising the costs and risks of industrial decarbonisation.
- There are potential competitiveness risks for electro-intensive industries, which are also subject to international competition and face higher energy costs relative to competitor countries. We have previously recommended that at-risk sectors are compensated for these additional costs, and that the Government should aim to provide greater long-term certainty. In principle, with State Aid approval, the recent compensation announcements are enough to offset carbon policy impacts to 2020.

Overall, the impact of policy is not on track with our indicators for monitoring progress with reductions in emissions and energy consumption mainly due to recession impacts, rather than underlying progress. This implies a risk for meeting future budgets and we have set new energy, emission and policy indicators to monitor future progress. Our policy recommendations are summarised in Box 4.1.

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

- Industry emission trends
- Opportunities and challenges in reducing industry emissions
- Policy progress in the industry sector
- Managing competitiveness risks
- Summary of progress in decarbonising industry

Box 4.1: Policy recommendations – Industry

- Use the **"2050 decarbonisation roadmaps"**, planned for spring 2015, to identify and set out the opportunities for reducing emissions in industry, then by 2017 publish a strategy for delivering abatement in the 2020s, including milestones to monitor progress against.
- By the end of 2016, **set an approach to deploying initial industrial CCS projects** compatible with widespread deployment from the second half of the 2020s, and joined up with the approach to CCS commercialisation in the power sector.
- **Review policies for compensating at-risk industries for costs of low-carbon policies**, by the end of 2016.
- Work with industry and the EU to **improve knowledge sharing within industry and R&D** into opportunities to reduce emissions at low cost.
- Investigate options to **overcome barriers to capital investment.**

2. Industry emission trends

(a) Overview

Industrial activity includes manufacturing industries[1], refining of petroleum products and other energy supply (extraction and production of oil, gas and solid fuels).

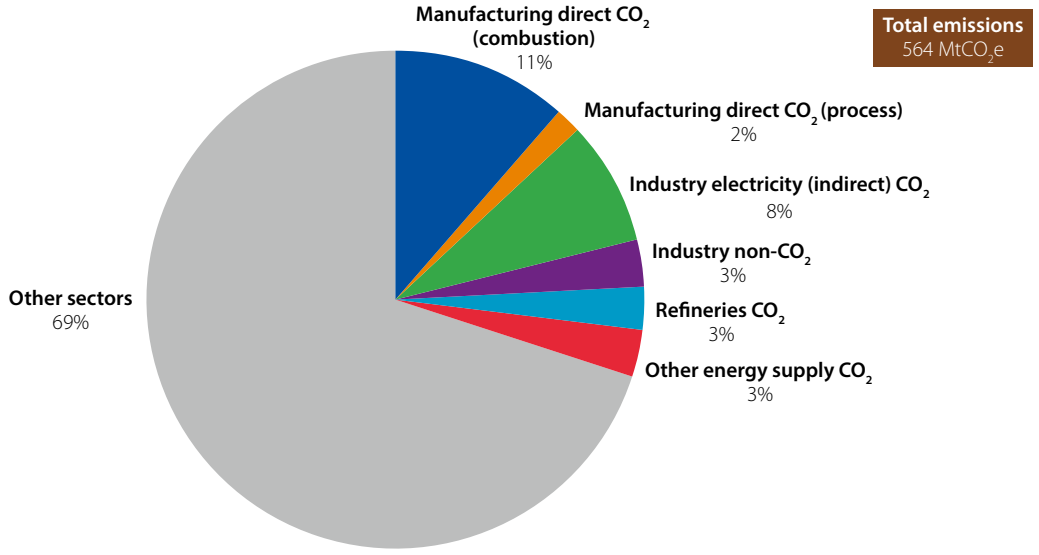
Emissions from industry accounted for around a third of UK greenhouse gas emissions in 2013 (around 170 $MtCO_2e$), of which around 90% are CO_2 (Figure 4.1). Industry CO_2 emissions are 74% direct emissions (of which 92% are from the combustion of fossil fuels and 8% are from chemical processes) and 26% indirect emissions (i.e. electricity-related).

Within the manufacturing and refining sectors, around 80% of all CO_2 emissions and energy consumption is accounted for by the six most energy-intensive industries[2] i.e. these make up almost 20% of UK GHG emissions (Figure 4.2). There are diverse industrial processes and products beneath these sectors, for instance minerals contain the production of glass, cement, ceramics, lime and concrete, but a focus on these six sectors will maximise the potential CO_2 abatement going forward.

Between 1990 and 2007 CO_2 emissions fell by 14%, despite an 8% rise in output. The fall in emissions intensity of production is likely to be a consequence of significant improvements in energy efficiency and decarbonisation of electricity, which more than offset the rise in output.

1 Manufacturing of products from steel, minerals, chemicals, paper, food & drink etc. This category also includes some emissions from the construction sector.
2 Refineries, iron & steel, mineral products, chemicals, food & drink, paper, pulp and publishing sectors.

Figure 4.1: GHG emissions from industry in the context of total UK emissions (2013)



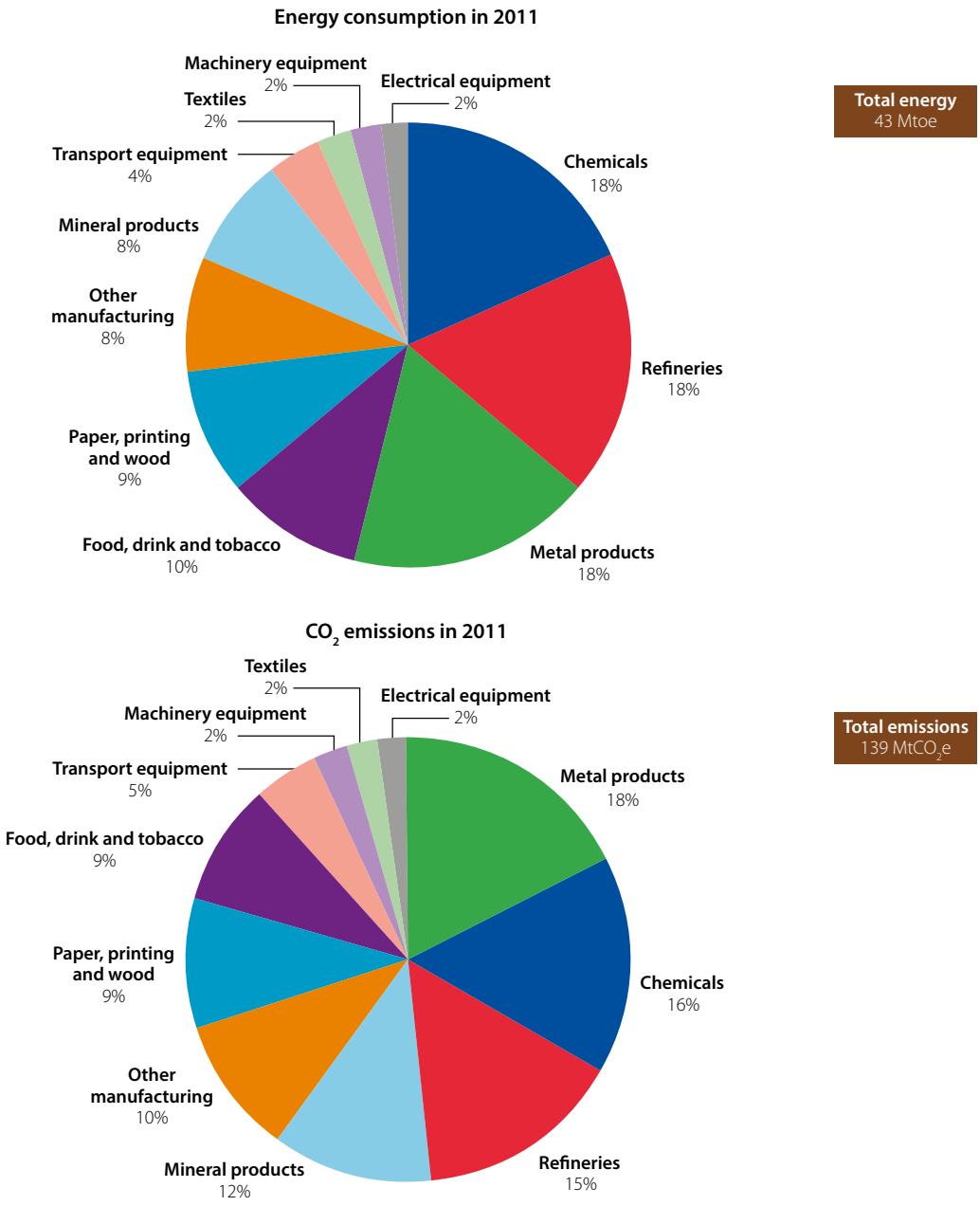
Source: National Atmospheric Emissions Inventory (NAEI).
Notes: 2013 emission estimates are provisional. Percentage figures may not add up to 100% due to rounding.

During the first carbon budget period (2008-2012), reduced UK output as a result of the recession that disproportionately hit the more carbon-intensive sectors, caused total industry GHG emissions to fall by 19% (Figure 4.3 and Table 4.1).

- Industry direct CO_2 emissions fell by 23% between 2007 and 2012.
  - Direct CO_2 emissions from manufacturing fell by 26%. These emissions come from combustion of fossil fuel and chemical reactions in the production process.
    - Combustion emissions from fossil fuels fell 23% due to a proportional fall in fuel consumption.
    - Process emissions fell 40%. Process emissions come from chemical reactions in the production process, notably in the production of clinker for cement, production of steel and chemicals. Over this period, there was significant reduction in clinker production in line with the fall in production of cement, and steel blast furnace gas flaring from Teesside steelworks.
  - Manufacturing output overall fell 9%. However, this fall in production was uneven, with output for some of the more carbon-intensive sectors falling much further. For example UK production of paper fell by over 10%, chemicals by over 20%, and production of steel and cement both fell by over 30% between 2007 and 2012.
  - Refinery CO_2 emissions fell by 12% in line with a fall in throughput of oil, due to the closure of Teesside and Coryton, and reduced running of the continuing refineries. CO_2 emissions from other energy supply fell by 19%.

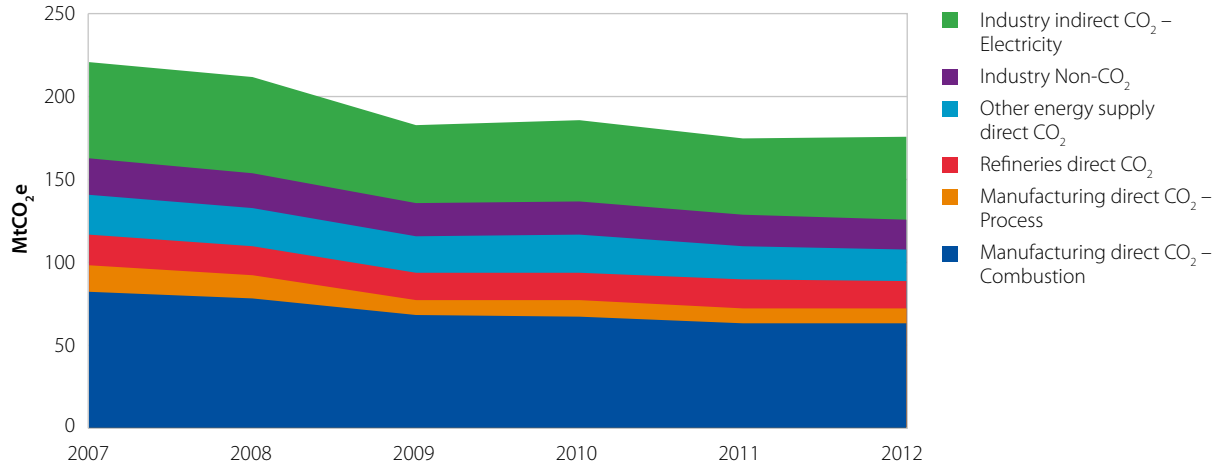
- Industry indirect CO_2 emissions fell by 13%, due to a 11% reduction in electricity consumption and 2% fall in grid electricity carbon intensity.
- Industry non-CO_2 emissions fell by 14%.

Figure 4.2: Split of manufacturing and refining total CO_2 and energy consumption (2011)



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

Figure 4.3: GHG emissions from industry (2007-2012)



Source: NAEI.

Table 4.1: GHG emissions from industry (2007-2012)

$MtCO_2e$	2007	2012	2007-2012	2007-2012 %
Manufacturing Direct CO_2 – Combustion	82	63	-19	-23%
Manufacturing Direct CO_2 – Process	16	9	-6	-40%
Refineries Direct CO_2	18	16	-2	-12%
Other energy supply Direct CO_2	24	19	-5	-19%
Industry Non-CO_2	22	18	-3	-14%
Industry Indirect CO_2 – Electricity	58	50	-7	-13%
Total Industrial GHG emissions	218	176	-42	-19%

Source: NAEI and CCC analysis
Note: 2007-2012 change and percentage figures may appear wrong due to rounding.

In 2013, overall industry GHG emissions fell by 2%, due to continued decarbonisation of grid-supplied produced electricity (Table 4.2). Without this, emissions from industry would have risen, despite production continuing to fall, due to a shift towards more carbon-intensive output with the reopening of Teesside steelworks.

- Direct CO_2 emissions rose by 1%.
  - Direct CO_2 emissions in manufacturing increased by 3%, with combustion and process emissions rising by 3% and 6% respectively. As manufacturing output fell 1% in 2013, this rise can be accounted for by a shift towards more carbon-intensive sectors, specifically the reopening of Teesside steelworks.
  - Refineries and other energy supply CO_2 emissions fell by 4%,
- Indirect CO_2 emissions fell by 8% due to a slight reduction in electricity consumption, but mainly from an 8% fall in grid carbon intensity,
- Non-CO_2 emissions fell by 1% in line with output.

Therefore during the first carbon budget period and in 2013, the impacts of the recession caused the majority of the reduction in emissions, rather than improvements in energy efficiency. This is supported by results from our new decomposition analysis (Box 4.2).

Falling investment in new plant and equipment[3] may also suggest continued use of older, less-efficient plant. Investment in new plant and equipment fell by 1% in 2013, and by an average of 3% in the six years since the recession, compared with an average annual increase of 5% in the six years prior to the recession.

Table 4.2: GHG emissions from industry (2012-2013)

$MtCO_2e$	2012	2013	2012-2013	2012-2013 %
Manufacturing Direct CO_2 – Combustion	63	65	+2	+3%
Manufacturing Direct CO_2 – Process	9	10	+1	+6%
Refineries Direct CO_2	16	15	-1	-4%
Other energy supply Direct CO_2	19	18	-1	-4%
Industry Non-CO_2	18	18	0	-1%
Industry Indirect CO_2 – Electricity	50	46	-4	-8%
Total Industrial GHG emissions	176	173	-3	-2%

Source: NAEI and CCC analysis

Box 4.2: Manufacturing and refining industries energy and CO_2 emission decomposition analysis

Falls in industrial CO_2 emissions 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),
- **Fuel switching** to lower-carbon fuels (e.g. coal to gas).
- **Fuel carbon intensity** (e.g. decarbonisation of grid electricity).
- **Energy intensity** (e.g. improvements in energy efficiency, changes in product mix or plant utilisation).

In our 2013 progress report, we presented results from analysis conducted by Hammond and Norman (2012). They found that between 1990 and 2007 the primary reason for the fall in emissions was an improvement in energy intensity, with emissions reduction due to changes in industrial structure and grid decarbonisation offsetting output increases and fuel switching to more carbon-intensive fuels.

This year we commissioned Ricardo-AEA to produce a decomposition model for energy and emissions in the UK manufacturing and refining sectors, so that we could analyse the factors causing a change in emissions for manufacturing and refining industries as a whole, and each manufacturing sector. After a review of available data and methods for carrying out a top-down disaggregation the analysis used a Log Mean Divisia Index (LMDI) approach.

This analysis found that between 1992 and 2007 improvement in energy intensity was the largest contributor to the reduction in CO_2 emissions in the manufacturing and refining sectors. Energy intensity improvement averaged around 1.3% per annum over this period, which is similar to the results found in Hammond and Norman (2012).

3 Gross fixed capital formation: plant and machinery CVM SA £m (DWLO), ONS (2013) National Accounts, available at http://www.ons.gov.uk/ons/datasets-and-tables/data-selector.html?table-id=F&dataset=qna

Box 4.2: Manufacturing and refining industries energy and CO_2 emission decomposition analysis

Between 2007 and 2011, however, the main reason for the fall in CO_2 emissions was reduced output from the recession, which disproportionately hit the more carbon-intensive sectors. Therefore there was a structural movement towards less carbon-intensive sectors in the overall mix of industrial output. In fact the analysis found that there was a fall in energy intensity over this period.

There are distinct differences in the results between the major industrial sectors, and after discussion with sector representatives it is possible to see groups of sectors where the experience since 2007 has been similar:

- **Output down, energy intensity higher** – in the chemicals, refineries and ceramics & glass sectors, there have been significant falls in output, while at the same time energy intensity has increased since 2007. In all of these sectors there has been under-utilisation of plant during the recession, as operators have either been unable or unwilling to rationalise, and this has been the main cause of the increased energy intensity. In all cases there are now signs of recovery.
- **Output down, energy intensity little changed** – in the steel, paper and motor industries there has been a fall in output but energy intensity has not changed by a large amount. In these cases the output fall has totally dominated emissions changes.
- **Output down, energy intensity down** – in the cement and lime sector, both output and energy intensity have fallen. The energy intensity has been affected by a product-mix change towards less intensive cement production.
- **Output up, energy intensity down** – the food and drink sector is unique among the major sectors in showing an increase in output from 2007 to 2011 (although output did fall early in the recession). In this sector there has been considerable rationalisation of plant, which will have reduced energy intensity and improved utilisation.

Continuing this analysis into the future will allow comparison of the contribution of the energy intensity driver to emissions changes. This will give some indication as to whether industrial energy efficiency is improving sufficiently. However, energy intensity is only a proxy for technical energy efficiency and it also includes the effects of changing product mix and utilisation of plant and equipment. We will also continue our dialogue with industry sectors to understand what changes to capacity utilisation and product mix are taking place.

Source: Hammond, G. P. and Norman, J. B. (2012) Decomposition analysis of energy-related carbon emissions from UK manufacturing. Energy, 41 (1). pp. 220-227

(b) Trends compared to the Committee's industry indicator framework

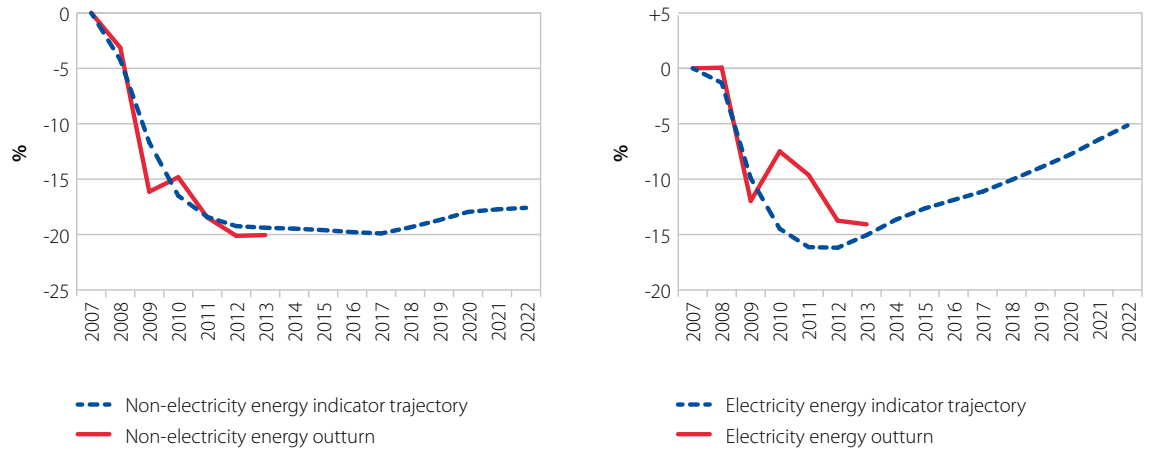
We have previously set out an indicator framework for monitoring progress in industry towards meeting the first three carbon budgets, this includes: industrial direct/indirect CO_2 emissions, energy consumption and intensity for manufacturing. Progress to date has been mixed.

- Our emissions indicator trajectory reflects scope for energy efficiency improvement, and reflects a 19% reduction in non-electricity energy between 2007 and 2013. Outturn non-electricity energy consumption fell 20% to 2013. Electricity energy consumption in manufacturing sectors fell 14% from 2007 to 2013 in line with our indicator (Figure 4.4).
- Our indicator trajectory for non-electricity intensity in manufacturing reflects an 8% reduction between 2007 and 2013. Outturn non-electricity energy intensity fell 12% to 2013 (Figure 4.5). As discussed above, the majority of this fall in energy intensity can be explained through shifts towards less carbon-intensive sectors.
- Our direct CO_2 emission indicator trajectory reflects a 14% reduction between 2007 and 2013. Outturn direct CO_2 emissions fell 22% to 2013 (Figure 4.6). The reduction in direct emissions was far greater than that in our trajectory and in manufacturing direct energy consumption, partly due to shifts to less carbon-intensive sectors, together with a 40% fall in manufacturing process emissions.

- Our indirect (electricity) CO_2 emission indicator trajectory reflects a 14% reduction between 2007 and 2013. The outturn was a 20% reduction (Figure 4.6). This over performance largely reflects that there was a 10% reduction in the carbon intensity of the electricity grid, as well as a reduction in electricity consumption in line with reduced output due to the recession, rather than additional indirect energy saving.

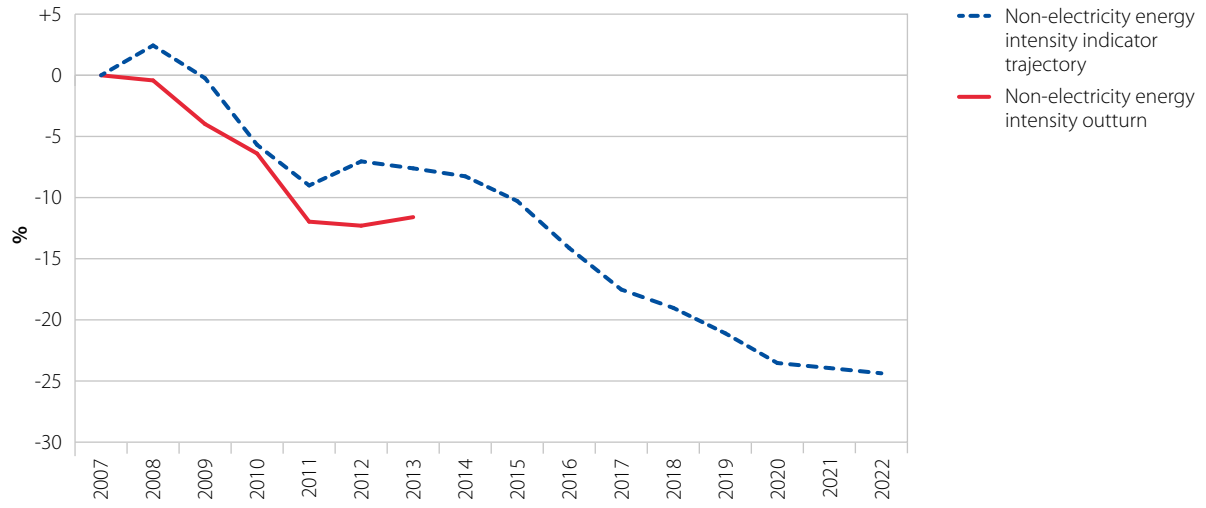
Overall, while industry's energy consumption and emissions are on track with our indicators, this has mainly been due to the impact of the economic recession rather than policy or investment in abatement technologies. It is quite possible therefore, that savings may be short-lived. There is a range of opportunities to reduce emissions further in industry at low cost if barriers can be overcome, as we set out in section 3.

Figure 4.4: Manufacturing non-electricity and electricity energy and indicator trajectory (2007-2022)



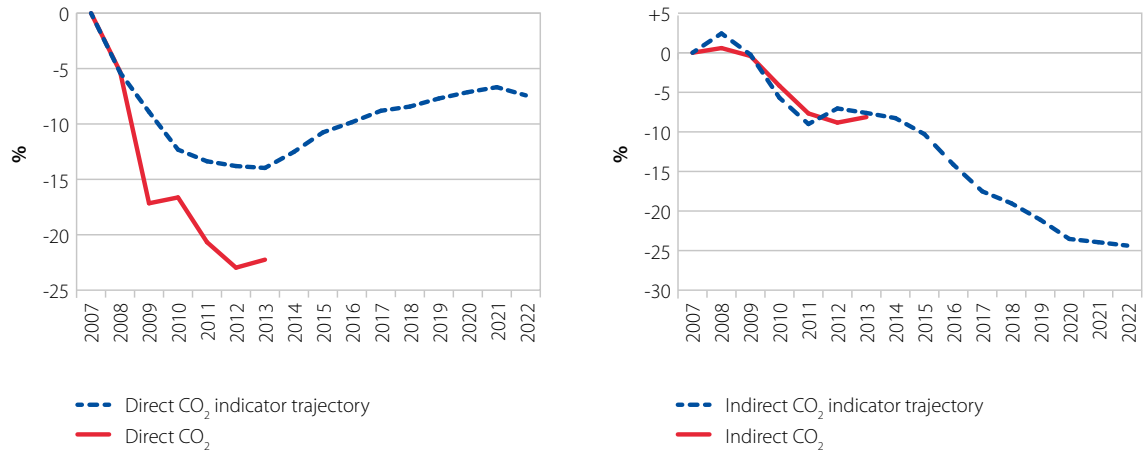
Source: DUKES and CCC analysis.
Notes: Does not include refineries or other energy supply.

Figure 4.5: Manufacturing non-electricity energy intensity and indicator trajectory (2007-2022)



Source: CCC analysis, DUKES and Index of Production (ONS).
Notes: Does not include refineries or other energy supply.

Figure 4.6: Manufacturing direct and indirect emissions and indicator trajectory (2007-2022)



Source: NAEI and CCC analysis.
Notes: Does not include refineries or other energy supply.

(c) Trends in UK energy intensity compared to the EU

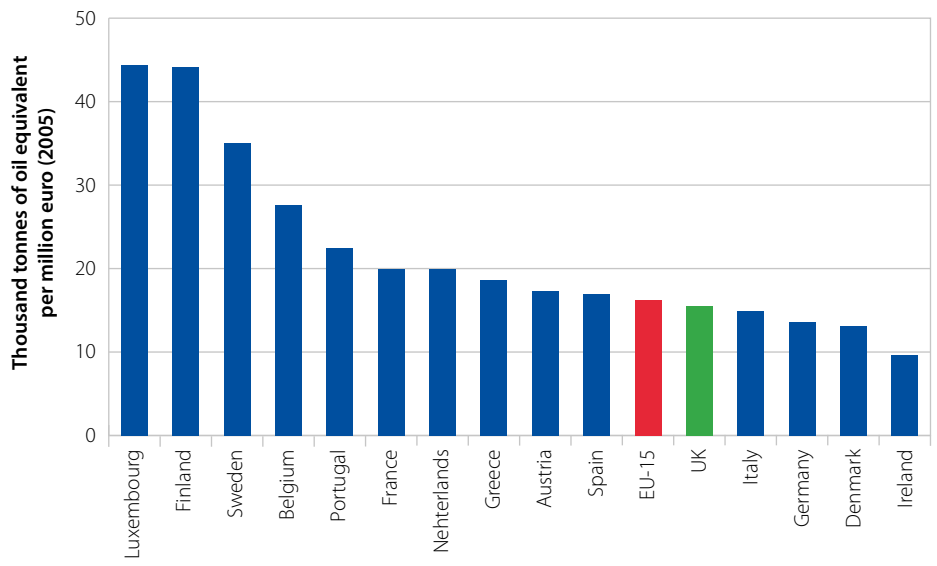
Industrial energy efficiency is the key factor in the potential to drive down emissions from this sector. A comparison between UK and EU energy intensity shows that UK manufacturing may be less energy-intensive than the EU on average and improved further since 2007. However, there are difficulties in assessing energy intensity (Box 4.2), especially when comparing data between countries.

- In 2010 the UK manufacturing sector used less energy than the EU-15 average per unit of gross value added (GVA) (Figure 4.7). Between 2007 and 2011, the UK's manufacturing energy efficiency[4] improved faster than the EU-27 (Figure 4.8).
- There are many reasons for improvement in energy efficiency across the entire manufacturing sector, including shifts in production between differing energy-intensive sectors or sub-sectors. Therefore, we have also compared the recent energy efficiency improvement of individual industrial sectors. From this analysis it appears that some UK manufacturing sectors have become more energy efficient compared to the EU-27 average and others less.
- However, the UK data used here does not directly compare to that used in our decomposition analysis. It is also difficult to make comparisons of an individual sectors energy intensity between countries because of different products that may be produced through different industrial processes. For example, in the steel sector the UK has a higher proportion of basic oxygen arc furnaces that use iron ore, rather than electric arc furnaces that use recycled steel which are more prevalent in other European countries.

4 The change in consumption of energy over the change in production

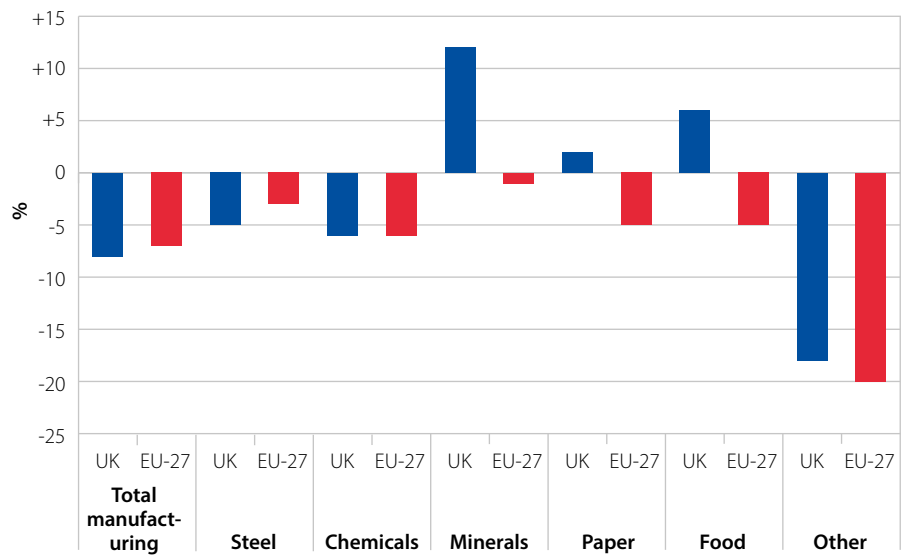
While this analysis provides some comparison between the UK and the EU, for a truly comparable measure we would need to compare the energy intensity change between comparable products and industrial processes.

Figure 4.7: Manufacturing energy consumption per unit of GVA – PPP adjusted (2010)



Source: Odyssee.

Figure 4.8: UK and EU-27 change in manufacturing sector energy intensity (2007-2011)



Source: Odyssee, CCC analysis.

3. Opportunities and challenges in reducing industry emissions

(a) Opportunities to reduce emissions

The *Fourth Carbon Budget Review* published in December 2013 updated our view on the scope for reducing direct emissions in industry from around 140 $MtCO_2$ in 2007 to around 80 $MtCO_2$ in 2030 (Figure 4.9).

- **Energy efficiency improvement**. There is significant but uncertain potential. Our best estimate comes from the ENUSIM model that suggests scope for reducing direct industry emissions by around 3 $MtCO_2$ per year in the period to 2020 through energy efficiency measures[5].
- **Options in energy-intensive industry**. Further cost-effective options for energy-intensive industry could provide up to around 9 $MtCO_2$ per year abatement by 2030. These include increased electric-arc steel production, clinker substitution in cement and optimisation of refineries.[6]
- **Low-carbon heat and use of bioenergy**. Modelling conducted by NERA for the Committee suggests the potential to reduce direct industry emissions by 13 $MtCO_2$ per year by 2030. This is primarily through use of biomass and biogas within sustainability limits, with smaller contributions from heat pumps and combined heat and power (CHP).[7]
- **Industrial carbon capture and storage (CCS).** CCS could be feasible and cost-effective for deployment in a range of industrial sectors during the 2020s, reducing emissions by 5 $MtCO_2$ per year by 2030. By 2050 industrial CCS could contribute to cost-effective reductions of around 33 $MtCO_2$ per year.

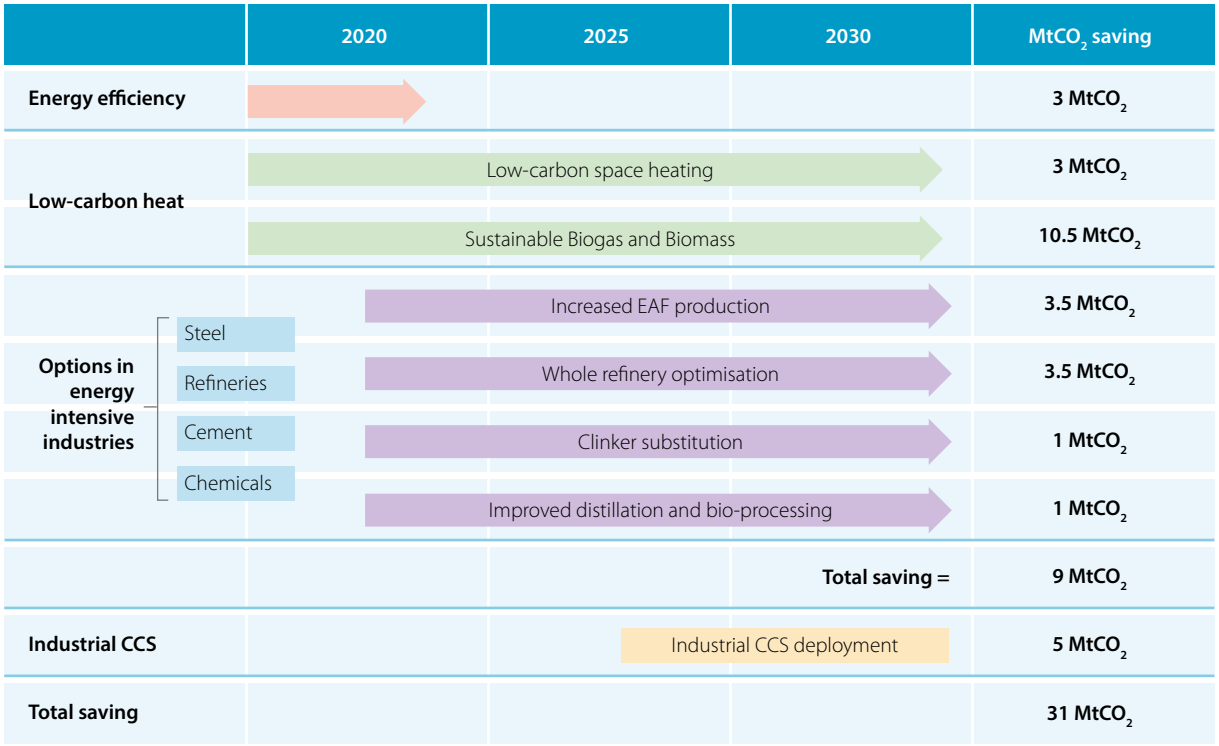
(b) Revised energy and emission indicators to 2030

The *Fourth Carbon Budget Review* updated our view on options for reducing emissions in industry up to the fourth budget period. Based on this, we have updated our indicator trajectories for emissions and energy through to 2030.

We have also included new energy efficiency and emission intensity indicators for the manufacturing and refineries sectors that we will monitor using our decomposition analysis discussed above (Table 4.3). We will report on what proportion of the energy and emission intensities are due to long-term energy efficiency improvements and switching to low-carbon fuels, rather than short-term movements to less carbon-intensive sectors as we have seen during and since the recession.

5 The Energy End-Use Simulation Model (ENUSIM) is a technology based, bottom-up industrial energy end-use simulation model which projects the uptake of energy-saving and/or fuel-switching technologies taking into account the cost effectiveness of technology options under future carbon and fossil fuel prices.
6 Ricardo-AEA (2013) Updating and extending carbon budget trajectories: A review of the evidence. Available at: http://www.theccc.org.uk
7 NERA (2010), Updating Decarbonising Heat: Low -Carbon Heat scenarios for the 2020s, Available at: http://www.theccc.org.uk

Figure 4.9: Milestones to meet the *Fourth Carbon Budget Review* cost-effective trajectory in industry



Source: CCC analysis.
Notes: Figures may not sum correctly due to rounding.

Table 4.3: The Committee's industry indicators (% change from 2007)

		Budget 2	Budget 3	Budget 4
CO_2 emissions	Direct (non-electricity)	-25%	-32%	-41%
Final energy consumption	Total	-18%	-18%	-20%
	Non-electricity	-20%	-20%	-22%
	Grid-supplied electricity	-11%	-10%	-9%
Manufacturing and refining emission intensity	Direct (non-electricity)	-17%	-29%	-42%
Manufacturing and refining energy intensity	Total	-10%	-14%	-19%
	Non-electricity	-12%	-16%	-22%
	Grid-supplied electricity	-1%	-6%	-9%

Source: CCC analysis

(c) Challenges to reduce emissions

These indicators are very challenging. It will be important to plan for investment in low-carbon measures given long project lead times, and the need to synchronise investment with the refurbishment cycles of the capital stock.

- **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 early for abatement in line with refurbishment cycles. For example, blast furnaces have around 15-20 years between refurbishments, which involve significant disruption. This leads to a risk that these infrequent opportunities for major improvements are missed, and high-carbon infrastructure is locked in.
- **Capital constraints.** Many of the cost-effective opportunities in energy-intensive industry have substantial upfront requirements for capital and longer payback periods. Following the economic recession and with competition for capital, a short-term view of investment can prevent necessary investment that would bring long-term benefits. 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 to ensure that this investment is prioritised in a capital-constrained world.
- **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. In order for firms to take advantage of these further abatement opportunities, there needs to be intervention or co-ordination for these critical infrastructure and markets.

Government policy has to address these challenges in order to maximise carbon abatement opportunities. The next section assesses progress to date against our policy indicators.

4. Policy progress in the industry sector

(a) Current government policy

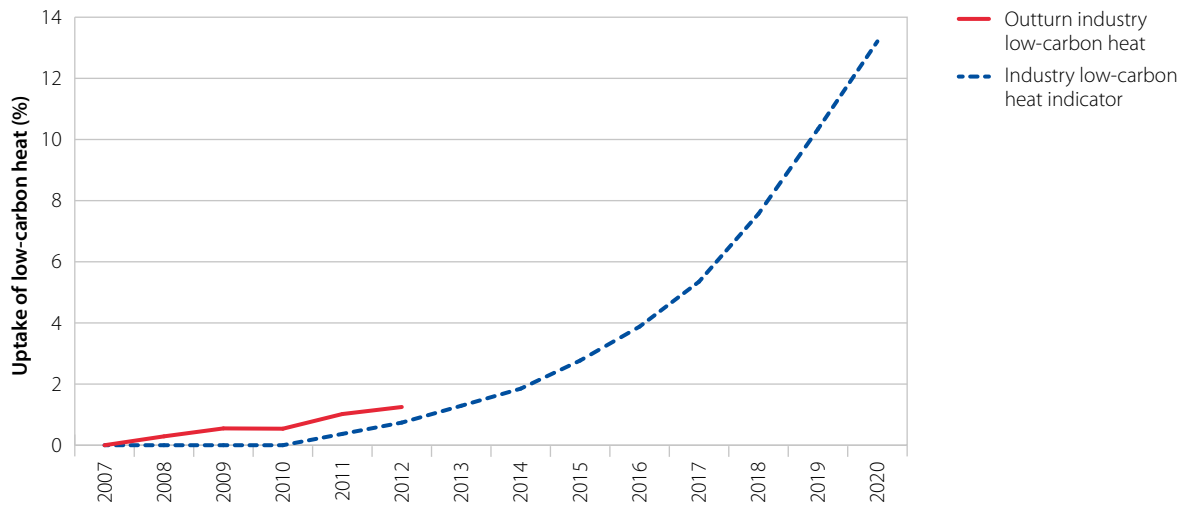
In order for firms to plan and finance abatement opportunities, policies will have to be put in place that offer a premium to low-carbon investment, and ensure that this is prioritised in a capital-constrained world. Progress in 2013 on key policy areas was slow, with a continuing low carbon price in EU ETS, and limited ambition in the new Climate Change Agreement (CCA) targets. There was continued progress on low-carbon heat uptake in industry, but no progress on how to ensure uptake of expensive measures for energy-intensive sectors in the 2020s including deployment of industrial CCS.[8]

8 This section considers the main policies, the sector is also partially covered by other policies such as the CRC and building regulations, see chapter 3.

- **EU ETS.** Verified emissions in the EU ETS have been consistently below the allocation of allowances (see Chapter 1), largely because of the recession. Given the combination of a limited carbon price signal, and uncertainty over the EU ETS in the 2020s, this weakens incentives for energy-intensive industries to prepare for and make long-term investments in line with the fourth carbon budget.
- **Climate Change Agreements (CCAs).** CCAs are voluntary agreements that allow eligible energy-intensive sectors to receive up to 90% reduction in the Climate Change Levy[9] (CCL) if they sign up to government-agreed absolute or relative energy efficiency targets. A total of 53 industrial sectors across more than 9,000 sites have signed up to targets.
  - In 2013, a new set of simplified CCAs targets through to 2020 came into operation, which now only cover emissions from energy consumption outside the EU ETS (previously they covered both the EU ETS and non-EU ETS), resulting in around a 60% reduction in emissions covered compared with the previous design. However, energy consumption both within and outside the EU ETS will remain eligible for the CCL discount. This implies weakened incentives for reducing direct emissions in industry.
  - As part of a project to update our indicator trajectories for the *Fourth Carbon Budget Review*, Ricardo-AEA analysed the potential impact of the new CCA targets on energy consumption to 2020. The CCA's overall target is estimated to be a reduction in energy consumption of 12%. We have estimated that, if the targets are met, the overall impact on total manufacturing energy consumption will be a reduction of around 3% by 2020, which is less than the 5% reduction potential to 2020 highlighted within our cost-effective trajectory.
- **Renewable Heat Incentive (RHI).** Industrial uptake of low-carbon heat technologies was on track with our indicators and has mainly come from biomass (Figure 4.10). Chapter 3 gives an overview of economy-wide progress on uptake of low-carbon heat across buildings, industry and agriculture.
  - Given the limited availability of sustainable biomass, we have identified the use of biomass in large industrial installations as a priority because of the lack of other low-carbon alternatives, and recommended that the Government sets out an approach to encourage uptake in this market segment. In May 2013, the Government announced increased tariffs (from 1.0 to 2.0 p/kWh) for large-scale biomass. Close monitoring is now required to ensure that this additional incentive improves uptake for large biomass projects.
  - Additionally, as discussed in Chapter 3, uncertainty about RHI funding beyond 2016 needs to be resolved as soon as possible in order to achieve supply-chain growth to deliver the increased uptake consistent with meeting carbon budgets.

9 A tax on energy delivered to non-domestic users.

Figure 4.10: Industry low-carbon heat uptake and trajectory (2007-2020)



Source: CCC analysis.
Notes: Previous progress reports had monitored industrial and agricultural building renewable heat uptake, we now have estimated just industry uptake.

- **Electricity Demand Reduction**. A pilot scheme introduced in June 2014, with at least £20 million of funding, will auction financial incentives for equipment that offer lasting electricity savings as an alternative to electricity generation in the forthcoming Capacity Market (see Chapter 2). The scheme aims to provide incentives to overcome the capital constraints barrier. The scheme will not be open to electricity consumption already covered by CCAs or measures to switch to another energy source (e.g. to on-site electricity generation). If the pilot is taken forward, the Government should consider opening the scheme up to organisations covered by CCAs, provided that the CCA targets are strengthened in line with successful bids.
- **Enhanced Capital Allowances (ECAs).** Companies can write off 100% of the cost of new energy-saving plant or machinery against the business taxable profits in the financial year the purchase was made. For this tax incentive to have an impact, there need to be taxable profits, so this will probably have had a relatively weak impact over the last few years.
- **Combined Heat and Power (CHP)**. Both fossil fuel and low-carbon CHP plant may qualify for support from CCL and business rate exemptions and ECAs. Renewable fuel CHP may also qualify for incentives under the Renewables Obligation, Renewable Heat Incentive and Feed-in tariff. Fossil fuel CHP may qualify for Hydrocarbon Oil Duty Relief. In Budget 2014 it was announced that fuel used in CHP for electricity generated to supply manufacturing firms would be exempt from the Carbon Price Floor. This has increased the incentive for CHP, which had previously been significantly reduced with the removal of an exemption from the CCL on all electricity exported from CHP plants.

- **Industrial carbon capture and storage (CCS).** CCS in industry is a key option to meet the 2050 target. CCS is also likely to be a key abatement option globally, with significant spillovers from the UK contribution to commercialisation to international action to reduce emissions.
  - The development of CCS infrastructure in the power sector provides an opportunity for co-located industrial plant to be included in a CCS commercialisation strategy across both the power and industrial sectors.
  - In our 2012 progress report we set out an indicator that in light of the outcome of the CCS competition, the UK Government should by the end of 2013, set out an approach for industrial demonstrations compatible with deployment in the late 2020s.
  - In 2013 there has been limited progress apart from funding for one feasibility project and a DECC/BIS study to update potential abatement and cost to 2025 of industrial deployment.
  - Given that CCS is a key option in this sector, Government needs to develop a joined-up approach for CCS development beyond the initial two power projects, including initial industrial projects compatible with widespread deployment in the second half of the 2020s, together with a strategy for CO_2 infrastructure development and CCS deployment in the power sector through the 2020s.

Overall, UK policy towards industrial decarbonisation through measures to improve energy efficiency are similar to those employed by other EU member states (Box 4.3). Based on this assessment, the Government needs to closely monitor low-cost measures, commit to long-term funding of existing measures (e.g. RHI) and strengthen incentives for more expensive measures that could significantly decarbonise industrial sectors to 2030.

Box 4.3: EU industrial energy efficiency policy

The UK is similar to many other EU member states in which most of the emphasis on energy efficiency in industry has so far been with targets set under voluntary agreements.

In addition many of the Member States have introduced energy efficient products policies, funds for research and innovation on energy saving technologies, grants or loans for implementation of energy saving measures and regular energy audits.

Going forward, all EU member states with energy-intensive industries will have to go further, beyond these voluntary agreements and piecemeal efficiency gains.

Industrial low-carbon strategy

We previously recommended that the Government should publish an industry strategy, including detail and milestones for meeting carbon budgets, incentives and mechanisms for overcoming barriers by the end of 2013.

While this deadline has not been met, DECC and BIS have begun to work with industry to develop a series of 'Industrial Sector 2050 Decarbonisation Roadmaps'. These roadmaps are investigating the potential carbon abatement options, barriers to deployment and enabling activities that firms, sectors and government can undertake for eight energy-intensive sectors (iron & steel, paper & pulp, chemicals, glass, ceramics, cement, refineries and food & drink). The roadmaps project is due to be completed by spring 2015.

- Our analysis suggests some key milestones that could be included in decarbonising industry further through the 2020s. These were detailed in our *Fourth Carbon Budget Review* and include increased electric-arc steel production, clinker substitution in cement and optimisation of refineries. Other analysis such as the INDEMAND project (Box 4.4) may raise further abatement potential through increased industrial material efficiency.
- We recommend that the roadmaps consider all abatement opportunities including the low-carbon heat and energy efficiency opportunities we highlighted in our decarbonisation pathway to 2030 for the fourth carbon budget. Industrial CCS could also play a significant role in industry decarbonisation after 2030.
- After these roadmaps are published, the UK Government then needs to build on this evidence base by consulting with sectors to develop decarbonisation strategies, including milestones, supported by incentives and mechanisms to ensure delivery. This provides an opportunity to set out how gaps in the current policy framework can be filled, and give more confidence over the implementation of the measures required to meet carbon budgets.

The Government needs to complement roadmaps with long-term financial instruments that align incentives for abatement and overcome barriers to uptake of measures in the industrial sector. Financial support may be most appropriate for projects that have large capital cost requirements and long payback periods, but for which the abatement costs are below the expected carbon price. These could potentially be explored by linking opportunities set out in the roadmaps to financing from the Green Investment Bank.

Box 4.4: UK INDEMAND – Industrial material efficiency project

The key materials we use to support modern lifestyles – steel, cement, plastic, paper and aluminium in particular – are the main 'carriers' of industrial energy. To make a big reduction in industrial energy use demand for these materials must be reduced.

The UK INDEMAND Centre comprises around 30 full-time researchers working across four universities: the University of Cambridge, the University of Leeds, Nottingham Trent University and the University of Bath. Its aim is to enable delivery of significant reductions in the use of both energy and energy-intensive materials in the industries that supply the UK's physical needs, through strategies that will lead to a step-change reduction in UK demand for materials, and the policy and business conditions under which these strategies would become attractive.

The planned outputs of the UK INDEMAND Centre include technical innovations to deliver material savings in production and design, demonstrations of the business case for material efficiency accounting for purchasing preferences, policy recommendations based on business, sector and trade analysis, and information tools to support well-informed decision making.

Examples of this might be through engineering areas such as:

- **Redesign:** Reconsidering construction processes to ensure that the minimum amount of material is wasted.
- **Reuse:** For example, constructing a new building entirely out of the components of an old building through deconstructing rather than demolishing the old building.
- **Reduce:** If products are kept for longer, that would slow down the rate of replacement and hence reduce the need for new energy-intensive materials.

The project has over £5 million of committed funding, including support for at least 30 PhD students to work with the Centre and connect its work to the specific interests of consortium partners. The project is also strongly supported by four key government departments, the Committee on Climate Change and a wide network of smaller organisations whose interests overlap with the proposed Centre, and who wish to collaborate to ensure rich engagement in policy and delivery processes.

As part of the Committee's involvement in the project, we will monitor progress and draw out key conclusions on how material efficiency could be used to further decarbonise the UK and help meet future carbon budgets.

(b) Revised indicators to 2030

In monitoring progress on reducing industry emissions in future, we introduce new indicators given the need to strengthen incentives and overcome non-financial barriers if measures are to be effective in reducing emissions (Table 4.4).

Table 4.4: The Committee's industry policy indicators

Sector	Indicator	Budget 2	Budget 3	Budget 4
Industrial CCS	DECC/BIS to set out approach to deploying initial industrial CCS projects compatible with widespread deployment from the second half of the 2020s	End 2016		
Low-carbon heat	Industry low-carbon heat penetration	5%	13% in 2020*	
Industrial decarbonisation	Publish industrial sector 2050 decarbonisation Roadmaps	End 2015		
	Publish industry strategy setting out milestones, incentives and mechanisms for meeting carbon budgets	End 2017		
Effectiveness review	Publish evaluation of effectiveness of compensation package to date	End 2016		

Source: CCC analysis
Note: * we will return and update the low-carbon heat indicator in light of our advice for the fifth carbon budget.

(c) EU Benchmarking – policy progress

The UK is similar to many of the other EU member states in which most of the emphasis on energy efficiency in industry has so far been with targets set under voluntary agreements between industrial sectors and the government.

A number of Member States, including Germany and France, have introduced different funds for research and innovation on energy saving technologies and implementation of energy saving measures. Spain has introduced a grant scheme for energy saving measures and improvements in equipment and processes for industrial companies have been set up.

5. Managing competitiveness risks

In our 2013 report on competitiveness risks of carbon budgets, we noted that there are potential competitiveness risks for electro-intensive industries that are also subject to international competition and facing higher relative energy costs. These firms could see a squeeze on profits which could potentially drive output and jobs overseas, if compensating support is not available.

It is important to ensure that increased energy costs resulting from low-carbon policies do not result in offshoring of UK industry. Output moving abroad would not have any benefits for the UK's overall carbon footprint (i.e. including consumption emissions) and therefore global emission reductions, and would not be desirable from a wider economic perspective. The Committee's assessment in 2013 concluded that there has been no significant industry relocation to date as a result of low-carbon policies and there is no reason to expect this in future, given current and planned policies to limit competitiveness risks.

The UK Government has recognised these risks and either put in place support arrangements or plans to:

- **Offset EU ETS/CPF**[10] impact of rising electricity prices for electro-intense industries (e.g. iron/steel) to 2015.
- **Offset impact of Electricity Market Reform** on electricity prices.
- **Exemptions from CCL** for metallurgical and mineralogical process sectors.

In addition, Budget 2014 announced changes:

- **Carbon Price Support (CPS) cap** – the CPS top-up to the EU ETS price applying to the electricity sector has now been capped at £18/tCO_2 through to 2019-20.
- **Extended compensation of EU ETS/CPF** cost for energy-intensives through to 2019-20.
- **Offset renewables obligation and small-scale feed-in tariff** energy bill cost impacts from 2016-17.

Other EU member states already have some form of compensation or protection from the extra costs of renewable energy policy. For example, Germany and France compensate the extra costs from renewable energy policy for energy-intensive sectors through a reduction in the surcharge or tax used to fund renewables. However, over the last year the Commission has opened State Aid investigations into both of these countries' policies

Government plans to introduce a new compensation scheme to help energy-intensive sectors with higher electricity costs resulting from renewable energy schemes from 2016-17 are due to be consulted on shortly. Revisions to EU Energy and Environment Aid guidelines (EEAG) published in April 2014 extended the list of sectors that could potentially be eligible for help from this scheme. In principle, the combined funding available from these announced compensation measures, with State Aid approval, is in line with our previous estimates of support needed to address competitiveness risks of energy intensive sectors in 2020.

Our previous analysis demonstrated the largest impacts occur due to electricity price increases to 2020; incremental impacts from higher electricity prices in the 2020s are relatively small. It is important that competitiveness impacts in this period are closely monitored to ensure there is appropriate support for specific sectors at risk. As part of this, the Government should review the impact of the compensation packages to date.

10 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.

6. Summary of progress in decarbonising industry

(a) Summary – past policy

In this chapter we have considered progress against indicators in industry. We summarise this below in the form of 'traffic light' ratings as outlined in Chapter 1 for a set of our key indicators.

For each key indicator, we compare the outturn data over 2008-13 to our indicators, and assign it a value of red, amber or green where (broadly):

- Green signifies on-track performance or outperformance (e.g. in terms of lower emissions, higher deployment, or policy that is either in place earlier than we recommended, or is more comprehensive).
- Amber signifies slight underperformance against our indicator (e.g. policy implementation delays).
- Red signifies significant underperformance or rejection of certain policies and/or measures.

Industry emissions and energy indicators were met for the first carbon budget (2008-12). However, these reductions were a result of the economic recession reducing output and disproportionately hitting the more carbon-intensive sectors (e.g. iron and steel) rather than actual low-carbon abatement being unlocked.

For industry, only one indicator (low-carbon heat penetration) has a green rating, with two other indicators as red (Table 4.5). This reflects our assessment that progress has been slow in development of industrial CCS and further abatement from energy-intensive sectors for the 2020s.

Table 4.5: Traffic light assessment of CCC indicators

Indicator	Traffic light	Comment
Industry low-carbon heat penetration	Green	1.25% uptake compared to 1% in trajectory
In light of outcome of CCS competition, set out an approach for industrial demonstrations compatible with deployment in the late 2020s	Red	No project in competition or strategy. Techno-eco study published and funding for feasibility study
Publish industry strategy setting out milestones, incentives and mechanisms for meeting carbon budgets	Red	No strategy to meet carbon budgets, but 2050 Roadmaps underway

Source: CCC analysis

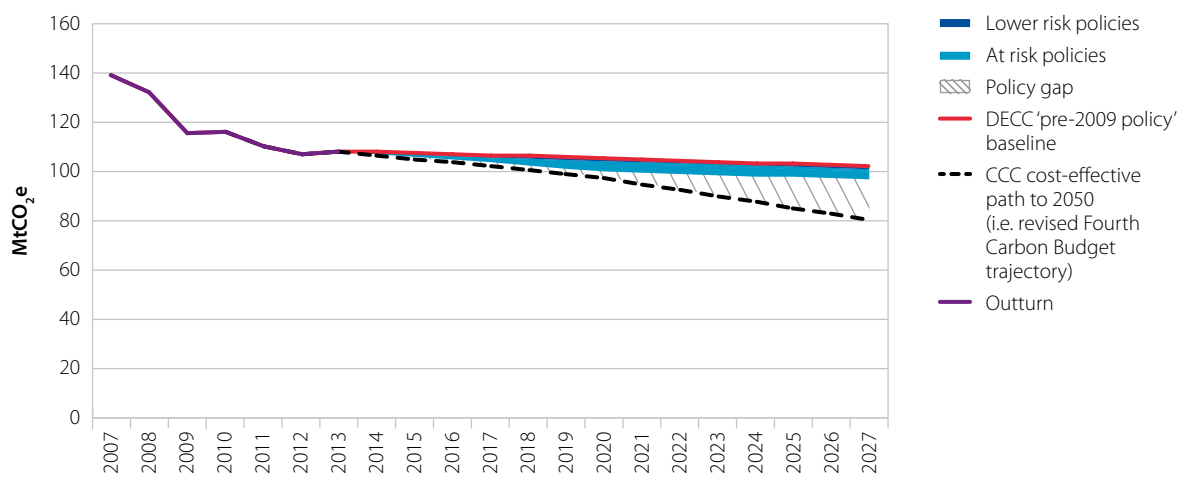
(b) Summary – future policy

In our fourth carbon budget review we suggested that direct industry emissions could fall to 85 $MtCO_2$ in 2025 to meet carbon budgets. According to DECC's updated energy projections (UEP), industry emissions in the absence of policy would be 103 $MtCO_2$ in 2025, falling to 97 $MtCO_2$ when estimated savings of current and planned government policies are included (Figure 4.11).

This leaves a gap of around 13 $MtCO_2$ in 2025 to be addressed to stay on the cost-effective path we have identified to meet carbon budgets. Most of the gap comprises further options for energy efficiency in energy-intensive sectors (5 $MtCO_2$) and low-carbon heat (5 $MtCO_2$).

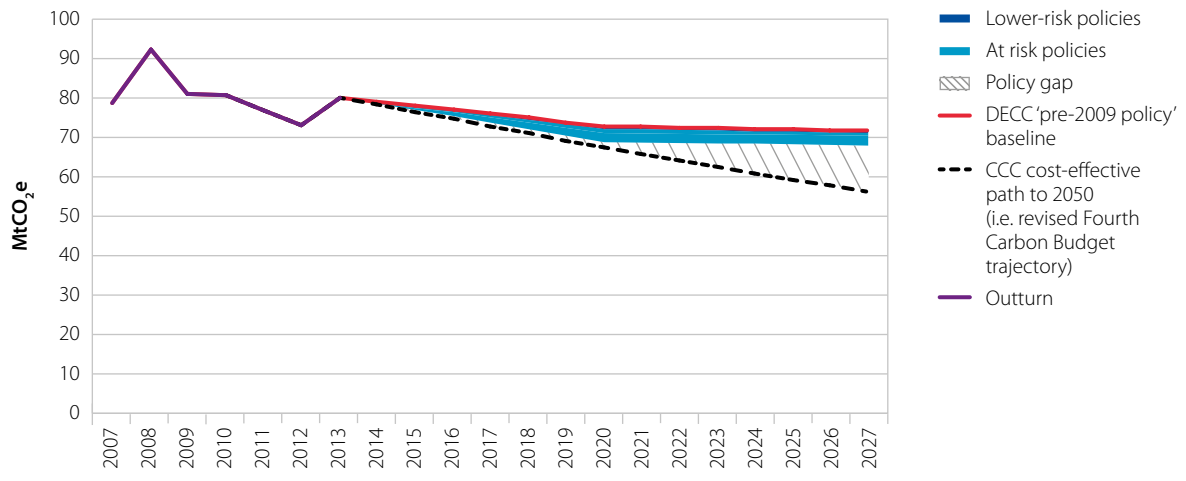
- Traded sector: the gap is almost 9 $MtCO_2$, with options in energy-intensives accounting for 5 $MtCO_2$, low carbon heat 2 $MtCO_2$, conventional energy efficiency 2 $MtCO_2$ and CCS 1 $MtCO_2$ (Figure 4.12).
- Non-traded sector: the gap is almost 4 $MtCO_2$, with low-carbon heat accounting for 3 $MtCO_2$ and conventional energy efficiency 1 $MtCO_2$ (Figure 4.13).

Figure 4.11: DECC Industry emission projection risk assessment (2007-2027)



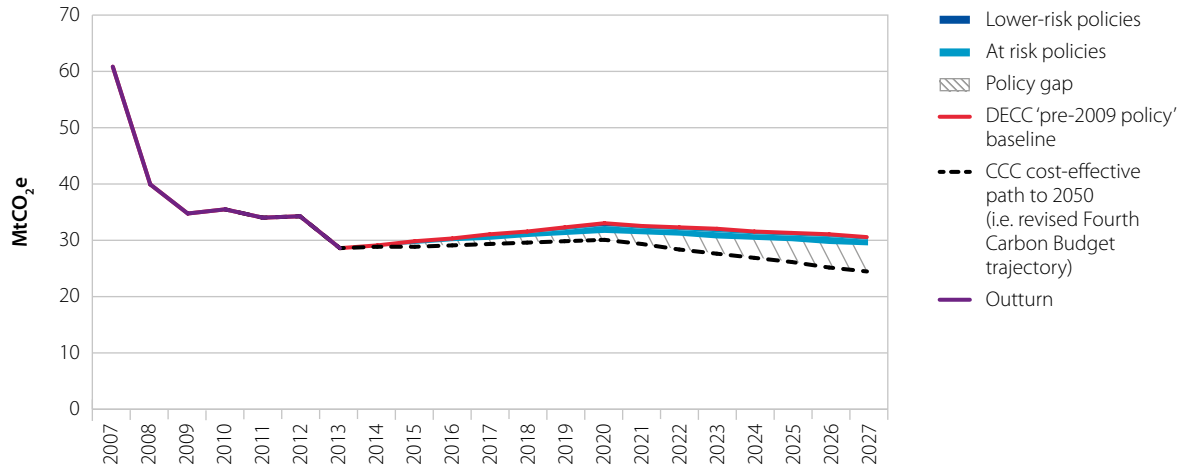
Source: CCC analysis.

Figure 4.12: DECC Industry traded emission projection risk assessment (2007-2027)



Source: CCC analysis.

Figure 4.13: DECC Industry non-traded emission projection risk assessment (2007-2027)



Source: CCC analysis.

Furthermore, not all policy savings are necessarily assured. We have made an assessment of the risk associated with the policies in DECC's projections, based on the policy discussion in earlier sections of this chapter. While 1 $MtCO_2$ is to be delivered by lower-risk policies, 4 $MtCO_2$ savings are dependent on policies with design/delivery problems or are currently underfunded (Table 4.6).

There still remains a gap and effort needed to overcome barriers to unlock full cost-effective abatement potential. In order to reduce this gap we have made a series of policy recommendations (Box 4.1).

Table 4.6: Assessment of DECC energy model policy savings	
Policy	**Comment**
Lower-risk policies	
RHI to April 2016	Right mix of technologies are targeted. Policy savings have been revised downwards based on market forecasts, and are now reasonably cautious. Although uptake to date has been mainly biomass, government has responded with recent changes to the scheme including new tariffs, which are now broadly at the right level. Funding has been committed until April 2016.
Policies with delivery at risk	
EU Products Policy tranche 1	As with domestic products, minimum standards for products are set under the Ecodesign directive and ratcheted up over time. Realised savings are at risk due to delays to implementation and uncertainty around stock replacement rates. There is also uncertainty around the current modelling of uptake, which is under review. Overall, the risks are greater than with tranche 1 domestic appliances due to a less developed evidence-base.
EU Products Policy tranche 2	As with tranche 1, but with greater risks relating to delays to implementation.
Building Regulations part L 2010	Focuses on the right barrier by regulating that developers meet certain CO_2 reducing standards compared to previous 2006 regulations. There are however some questions around the modelled savings based on the SBEM model, which are being reviewed in light of new bills data. This leads to uncertainty around compliance and the 'performance gap' between buildings as designed, built and in-use. There is also some uncertainty around build-rates.
RHI from April 2016	No committed RHI funding after the 2015-16 financial year.
Missing Policies	
Low-carbon heat policies	The bulk of the remaining abatement potential occurs after 2020 where there are currently no proposed policies to drive low-carbon heat. The RHI should be extended until and unless there is an alternative framework in place. Further abatement opportunities exist in new build properties, which could be unlocked through the planning framework.
Energy efficiency	Additional 2 $MtCO_2$ potential abatement from cost-effective conventional energy efficiency in industry to 2020. After 2020, a further 9 $MtCO_2$ cost-effective abatement potential from energy intensive sectors. The forthcoming "2050 decarbonisation roadmaps" should be used to identify these opportunities and then further mechanisms set out for delivering this abatement.
Industrial CCS	Potential 5 $MtCO_2$ abatement by 2030, an approach to deploying initial industrial CCS projects needs to be set out, compatible with widespread deployment from the second half of the 2020s.

Revised indicator trajectories & policy indicators

Going forward, we will continue to monitor progress in the industry sector against a range of indicators. New evidence, as well as revised estimates for baseline emissions and policy delivery, have led us to revise some of the indicators for the second and third carbon budgets. Additionally, we have extended our indicators to cover the fourth carbon budget (Table 4.7).

Key findings

- Total industry CO_2 emissions fell 2% in 2013 and are now **22% below 2007** due to the recession reducing output, especially for the more carbon-intensive sectors, and decarbonisation of the electricity grid.
- Substantial **improvements in industrial energy efficiency** are possible, and are needed to meet the fourth carbon budget. However, there is no clear evidence to date of significant energy efficiency improvement and there is unlikely to be sufficient progress to meet the fourth carbon budget, due to high barriers and weak policy incentives.
- The Government should include the full range of cost-effective abatement options in the **industry sector decarbonisation roadmaps** currently being developed. It is important that these roadmaps lead to key milestones together with policies to ensure they are met in practice, noting that policies are likely to go beyond reliance on the carbon price in the EU ETS, even if this is strengthened significantly.
- Given the timeline for industrial **Carbon Capture and Storage (CCS)** deployment action on this is now urgent. Failure to address industrial CCS now will result in missing substantial abatement opportunities with plants' refurbishment cycles in the late 2020's, raising the costs and risks of industrial decarbonisation.
- There are potential **competitiveness risks for electro-intensive industries** which are subject to international competition and face higher energy costs relative to competitor countries. In principle, given State Aid approval, the recent compensation announcements are enough to offset carbon policy impacts through to 2020.

Table 4.7: The Committee's industry indicators

INDUSTRY		Budget 2	Budget 3	Budget 4	2013 Outturn
Headline indicators					
CO_2 emissions	Direct (non-electricity)	-25%	-32%	-41%	-22%
Final energy consumption	Total	-18%	-18%	-20%	-16%
	Non-electricity	-20%	-20%	-22%	-17%
	Grid-supplied electricity	-11%	-10%	-9%	-11%
Manufacturing and refining emission intensity	Direct (non-electricity)	-17%	-29%	-42%	-14%
Manufacturing and refining energy intensity	Total	-10%	-14%	-19%	-7%
	Non-electricity	-12%	-16%	-22%	-8%
	Grid-supplied electricity	-1%	-6%	-9%	-2%
Supporting indicators					
Industrial CCS	DECC/BIS to set out approach to deploying initial industrial CCS projects compatible with widespread deployment from the second half of the 2020s	End 2016			
Low-carbon heat	Industry low-carbon heat penetration	5%	13% in 2020*		1.25%
Industrial decarbonisation	Publish industrial sector 2050 decarbonisation Roadmaps	End 2015			
	Publish industry strategy setting out milestones, incentives and mechanisms for meeting carbon budgets	End 2017			
Effectiveness reviews	Publish evaluation of effectiveness of compensation package to date	End 2016			

Source: CCC analysis.
Note: Energy and emission intensity here is different to that described in Box 4.2. In this table intensity is change in energy or emissions over the change in output. Therefore it does not take into account structural, fuel switching or fuel carbon intensity effects.

* We will return and update the low-carbon heat indicator in light of our advice for the fifth carbon budget.

Key: Headline indicators Supporting indicators Other drivers

Chapter 5

Chapter 5: Progress reducing transport emissions

1. Introduction and key messages

Domestic transport accounted for 25% of total UK CO_2 emissions, and just over 20% of greenhouse gas emissions, in 2013. There is significant potential for emissions reductions through fuel efficiency improvements in conventional vehicles, switching to alternatively fuelled vehicles, and from changing behaviour (reducing unnecessary travel, driving more efficiently and choosing more sustainable ways to travel).

In this chapter, we examine transport emissions trends and drivers over the first carbon budget period (2008-2012), together with preliminary data for 2013. We assess progress in policy development and delivery, and consider the prospects for future emissions reductions.

The key messages in this chapter are:

- **Emission trends:** Domestic transport CO_2 emissions fell 11.9% between 2007 and 2012, and a further 0.2% in 2013. This was a result of efficiency improvements for cars and vans and increased penetration of biofuels, with some reduction in demand due largely to the impact of the recession and rising fuel costs. Reductions in road transport emissions outperformed our indicator trajectory.
- **New vehicle CO_2:** There has been good progress in reducing new car and van CO_2, largely by manufacturers striving to meet EU legislation, with limited contribution from consumer purchase behaviour. It is important that stretching EU targets which account for the role of electric and other ultra-low emissions vehicles, are now set for 2030. Targets for HGVs should also be set as soon as possible. Fiscal levers provide an important tool to encourage the shift away from high emission vehicles. These should be aligned to new EU targets over time, and should provide additional incentives for uptake of lower emission vehicles.
- **Electric vehicles:** The market for electric vehicles is developing with many new models available. However uptake has been slow to date. The allocation by the Office for Low Emission Vehicles (OLEV) of a £500 million funding package for 2015-2020 is positive and includes a range of measures proven to be successful in promoting uptake (e.g. rapid charging infrastructure, softer measures such as access to bus lanes and preferential parking). Nevertheless, new financing and marketing approaches are required to address cost and attitudinal barriers, together with infrastructure investment to provide access to charging for people without off-street parking.

- **Biofuels:** While biofuel supply was on track with our indicator for most of the first carbon budget period, it fell slightly short of our indicator in 2012 and 2013. Importantly, this reflects a move to more sustainable feedstocks, driven by double-counting of waste-derived biofuels and residues introduced in the Road Transport Fuel Obligation (RTFO) in 2012. Recent EU developments suggest some progress towards an agreement on how to minimise the carbon impacts of biofuels, which paves the way for the Government to resolve remaining uncertainty in this area.
- **Travel demand:** There has been some progress in changing travel behaviour, and advances in technology provide the opportunity to support more efficient fuel consumption in the future. Further interventions may be required to increase the reach and sustain the effectiveness of current action.
- **Forward look:** Our assessment suggests that existing and planned policies will go some way to deliver the measures needed to meet future carbon budgets but that a significant gap remains and needs to be addressed in order to meet carbon budgets cost-effectively.

Key measures to bridge this gap are summarised in our policy recommendations below (Box 5.1).

Box 5.1: Policy Recommendations – Transport

- **Push for stretching EU targets for emissions of new cars and vans for** 2030 in the context of negotiations around the overall 2030 EU emissions reduction package; these should take account of the scope for improving efficiency of conventional vehicles and the need to achieve greater take-up of electric vehicles (EVs) and other ultra-low emissions vehicles (ULEVs).
- Work with partner organisations (e.g. industry, local authorities, the Green Investment Bank) to **tackle financial and non-financial barriers to electric vehicle uptake** by providing: new, low-cost approaches to financing; on-street residential charge points and a national network of rapid charge points; softer time-limited measures such as access to bus lanes and parking spaces.
- With agreement of a strong EU target and/or tackling of financial and non-financial barriers there would be scope to phase out the existing capital subsidy for electric vehicles. The Government should **consider how to phase out EV subsidy and whether there is any benefit in announcing this in advance** (e.g. in stimulating manufacturers to develop financing packages).
- Over time, adjust **fiscal levers** (i.e. Vehicle Excise Duty, Company Car Tax and Enhanced Capital Allowances) to align to new vehicle CO_2 targets and provide additional incentives for ULEVs.
- Push for a swift conclusion to current EU work on **standards for HGVs** and press for new vehicle standards as soon as practical (e.g. soon after 2015).
- Ensure **demand-side opportunities** are realised: continue progress reducing car travel once the current Local Sustainable Travel Fund ends in 2015; encourage adoption of complementary technologies to support eco-driving, including pushing for fuel consumption meters to be reconsidered in future EU negotiations; monitor existing voluntary action in the freight sector aimed at improving fuel consumption and consider stronger levers as required, including ways to address barriers for smaller operators.
- **Fully evaluate the carbon implications of use of natural gas in vehicles** before any nationwide roll-out of gas infrastructure and support.
- When considering future **airport expansion**, plan on the basis of 2050 emissions at around 2005 levels, implying an increase in demand – provided aircraft efficiency continues to improve significantly – of around 60% on 2005 levels by 2050.

We set out the analysis that underpins these conclusions in five sections:

- Trends in transport emissions
- Progress in decarbonising transport
- Progress in changing travel behaviour
- Progress in reducing emissions from aviation and shipping
- Summary and next steps

2. Trends in transport emissions

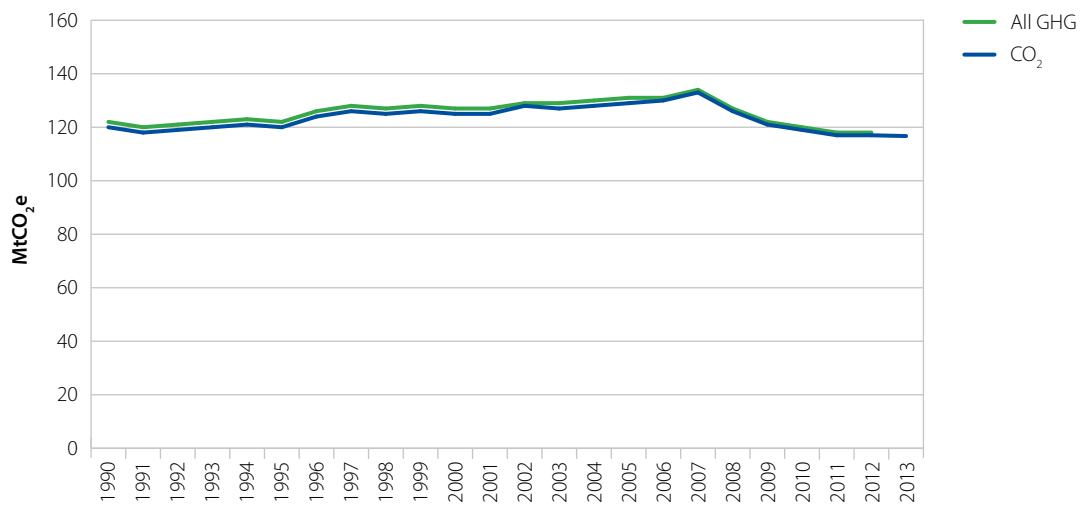
Total UK domestic transport CO_2 emissions are provisionally estimated at 116.7 $MtCO_2$ (25.1% of UK CO_2 emissions) in 2013.

More detailed data are available for 2012, when total UK domestic transport CO_2 emissions were 116.9 $MtCO_2$ (24.7% of UK CO_2 emissions), and total GHG emissions from domestic transport were 118 $MtCO_2e$ (20.5% of total UK GHG emissions). Trends in non-CO_2 emissions closely track those in CO_2 (Figure 5.1). Given the relatively low levels of non-CO_2 emissions from domestic transport, the rest of this chapter will focus on CO_2 emissions.

Total UK domestic transport CO_2 emissions fell by 11.9% from 2007 to 2012, and a further 0.2% in 2013.

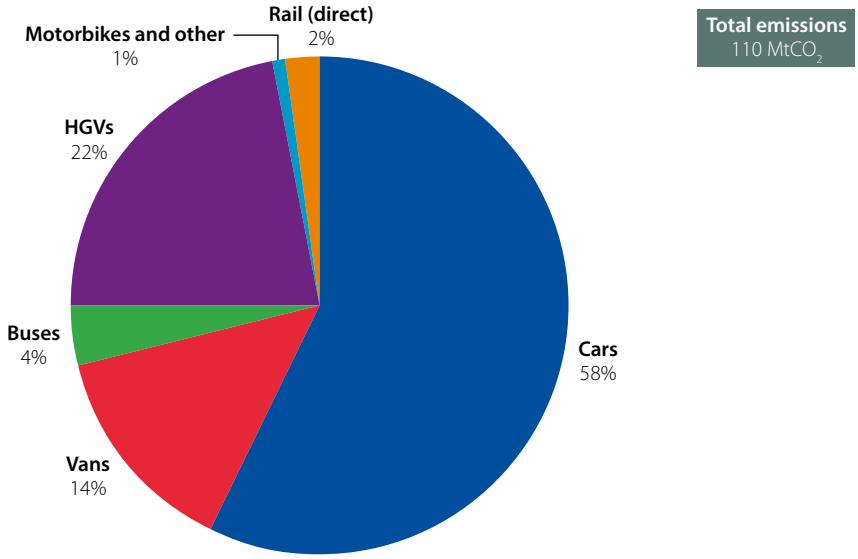
Surface transport CO_2 emissions account for the vast majority of domestic transport emissions with domestic aviation and shipping accounting for 3%. The majority (96%) of surface transport emissions are from road transport and within this, the biggest contributors are cars (58%), vans (14%) and HGVs (22%) (Figure 5.2).

Figure 5.1: Transport CO_2 and non-CO_2 emissions (1990-2013)



Source: NAEI (2014), DECC provisional emissions.

Figure 5.2: Breakdown of surface transport CO_2 emissions by mode (2012)



Source: NAEI (2014).
Notes: 'Other' includes motorcycles and mopeds, liquefied petroleum gas emissions (all vehicles), aircraft support vehicles and other road vehicle engines.

In this section we present outturn data covering the entire first carbon budget period and compare this with the trajectory the Committee set in 2009 for emissions reductions over this period. Data for 2013 are also presented where available. We consider in turn:

(i) Emissions from surface transport

(ii) Emissions from aviation and shipping

(i) Emissions from surface transport

Economic Context

Our 2009 progress report set out a cost-effective path for meeting carbon budgets – reflected in our indicator trajectory for transport emissions, which was based on the latest projections for key economic drivers (GDP, fuel prices etc.) at that time.

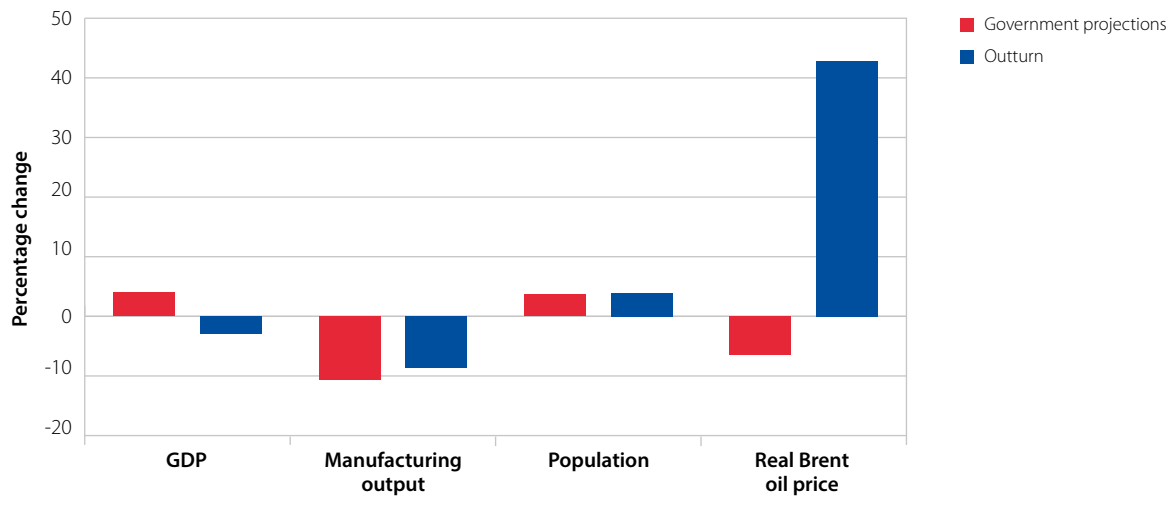
Comparing outturn data for these key drivers over the first carbon budget period with projections from 2009 (just after the onset of the recession) shows GDP growth was lower, and the oil price significantly higher than had been expected, although manufacturing output growth was slightly higher (Figure 5.3).

- Real GDP fell by 3% between 2007 and 2012, compared to a projected increase of 4%.
- Given that changes in population were in line with projections, per capita GDP followed the same trend as total GDP falling more rapidly than our projections. By the end of 2012 GDP per capita had fallen by 6.6% from 2007 levels, compared with a projected increase of 0.3%.

- Manufacturing output, although accounting for only around 9% of GDP is a key driver of HGV demand. The onset of the recession was accompanied by a disproportionately large contraction in manufacturing output, which fell by 10.1% between 2008 and 2009. The recovery since 2009 means that the outturn over the whole budget period was slightly higher than had been expected.
- Oil prices fell sharply in 2009, before rebounding rapidly in the following two years. By the end of 2012 real Brent oil prices were 37% higher than in 2007, contrasting sharply with a projected decline of 6.5%.

The combined impact of these differences in outturn versus projected values would be to reduce emissions relative to our indicator trajectory, other things equal. It is therefore possible that economic drivers, rather than measures to reduce emissions, have led to outperformance of our indicator trajectory for transport emissions, to which we now turn.

Figure 5.3: Outturn vs projections for key economic indicators (2007-2012)



Source: CCC calculations based on Office of National Statistics and IEA Data.

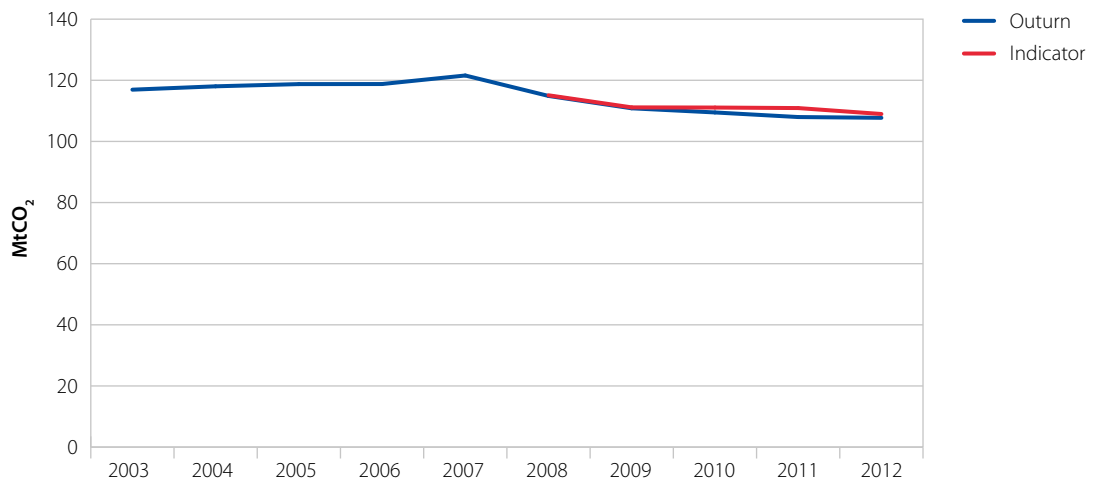
Emissions trends

According to the National Atmospheric Emissions Inventory (NAEI), surface transport emissions decreased by 11.0% over the first carbon budget period, to 110 $MtCO_2$ in 2012. Road transport emissions recorded a similar reduction (11.4%). This represents a slightly greater reduction than our indicator trajectory (Figure 5.4).

While official data for surface transport emissions for 2013 are not yet available it is possible to estimate road transport emissions on the basis of petrol and diesel sales. Trends in this measure have historically closely tracked NAEI estimates, and would suggest that in 2013 emissions fell by approximately 0.7% from the previous year.

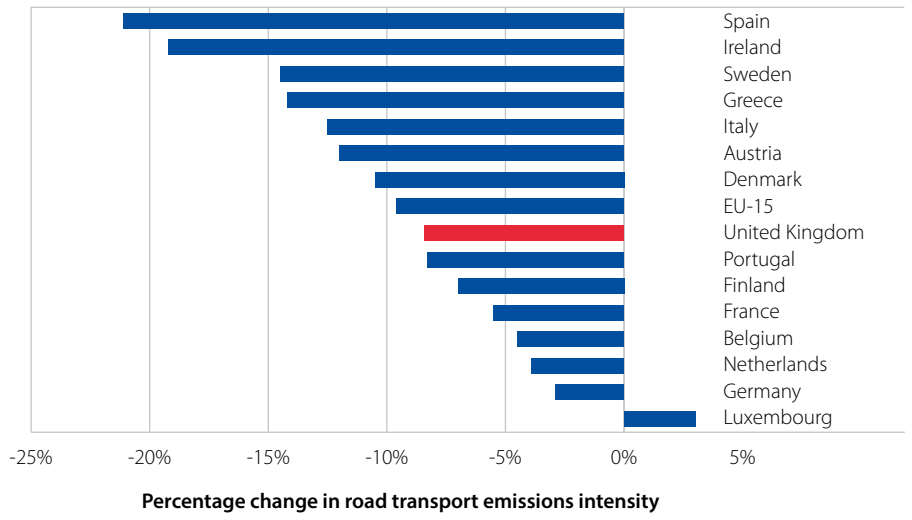
Emissions trends in EU-15 member states were broadly similar to the UK. Between 2007 and 2012 EU-15 average surface transport emissions fell by 10.9%, marginally lower than the UK reduction. The decrease in emissions outweighed the reduction in GDP, such that emissions intensity improved by 9.6% in EU-15 countries as a whole and by 8.4% in the UK. Spain had the biggest improvement in emissions intensity over this period (–21.1%), while in Sweden, Austria and Belgium emissions fell at the same time as output increased (Figure 5.5).

Figure 5.4: Road transport CO_2 emissions, outturn and indicator trajectory (2003-2012)



Source: NAEI (2014), CCC modelling.

Figure 5.5: Road transport emissions intensity in EU15 member states (change 2007-2012)



Source: Eurostat, CCC calculations.

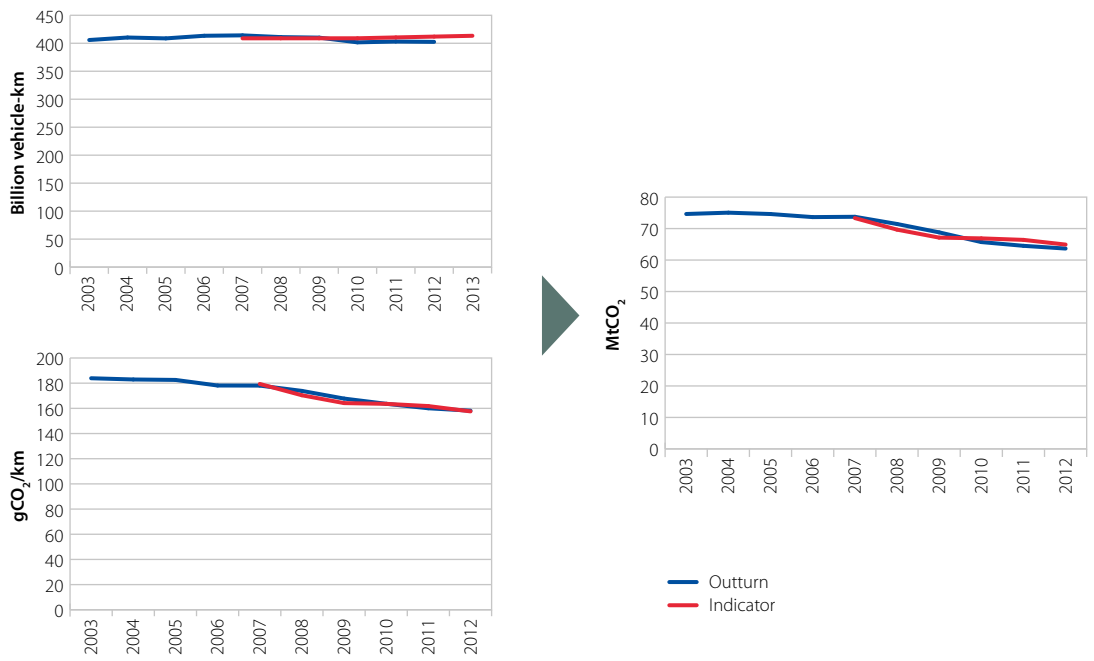
Car emissions

NAEI data show that car emissions decreased by 13.7% between 2007 and 2012, compared to a reduction of 11.5% in our indicator trajectory. Despite being above our trajectory in early years, by 2010 car emissions had fallen below the trajectory and remained there through to 2012. This may, in part, reflect under-prediction of recession impacts when our trajectory was set.

The key components of falling emissions were a slight decrease in distance travelled, combined with an implied 11.2% reduction in the average CO_2 intensity of the car fleet as a whole. (Figure 5.6).

- Total car distance travelled fell by 2.8% over the first carbon budget period (compared to a rise of 0.8% envisaged in our indicator trajectory), before increasing 0.9% in 2013. This is likely to have been due to economic factors, although observed changes do not fully conform to previously established relationships between demand and key drivers (Box 5.2).
  - Given outturn data for population, real GDP per capita, real car motoring costs per kilometre, and using elasticities in the DfT's National Transport Model, we would expect a reduction in km of 4.8% over the first carbon budget period.
  - The actual reduction in car km is therefore lower than expected. Given modelling uncertainty, the observed decrease could be within the margin of error in model estimates.
  - It is also possible that consumer demand for car travel has become less responsive to these drivers over time.

Figure 5.6: Historical trends of vehicle km, $MtCO_2$ and gCO_2/km for cars (2003-2012)



Source: NAEI (2013), DfT (2013) *Transport Statistics Great Britain 2012.*

- Given data on emissions and car km, the implication is that average CO_2 intensity of the car fleet fell by 11.2% over the first carbon budget period. This can be attributed to increased blending of biofuels and better fuel efficiency of the fleet as a result of stock turnover and improvements in new car efficiency. However, the reduction was less than the 12.2% envisaged in our indicator trajectory, partly as a result of slower stock turnover during the recession.
  - Biofuel penetration for cars increased from 0.7% to 2.7% (by energy) over the first carbon budget period, accounting for around 2 percentage points (pp) of the reduction in car emissions.
  - Stripping out the effect of increased biofuels the data imply that fuel efficiency of the fleet improved by 9.3%, accounting for the remaining c.9 pp reduction in emissions. Just over half of this was due to stock turnover, with the rest due to new car efficiency improvements.
    - Stock turnover accounted for around 5 pp of the improvement in fleet fuel efficiency, as older, less efficient cars were replaced by newer, more efficient ones – even with no improvement in new car CO_2 over the period.
    - New car efficiency improved by 19.3% over the period, accounting for around 4 pp of the improvement in fuel efficiency.
    - A slowdown in new car sales/stock turnover rates during the recession meant that the average age of the fleet increased from 6.8 years in 2007 to 7.7 years in 2012; had turnover rates remained at 2007 levels, CO_2 intensity of the fleet might have fallen by an additional 1.4 pp.

Data for car emissions in 2013 are not yet available. However, we can make an estimate based on the provisional data for distance travelled, data for biofuels penetration and new car CO_2:

- We noted above that car passenger demand increased by 0.9% in 2013.
- Biofuel penetration in the car fleet increased from 2.7% to 3.0% by energy.
- Stock turnover, together with a 3.6% improvement in new car efficiency, implies the average efficiency of the fleet improved by around 2%.

Together these data suggest that car emissions are likely to have fallen between 2012 and 2013, though this should be treated with caution given uncertainties in the data.

Box 5.2: Drivers of travel demand

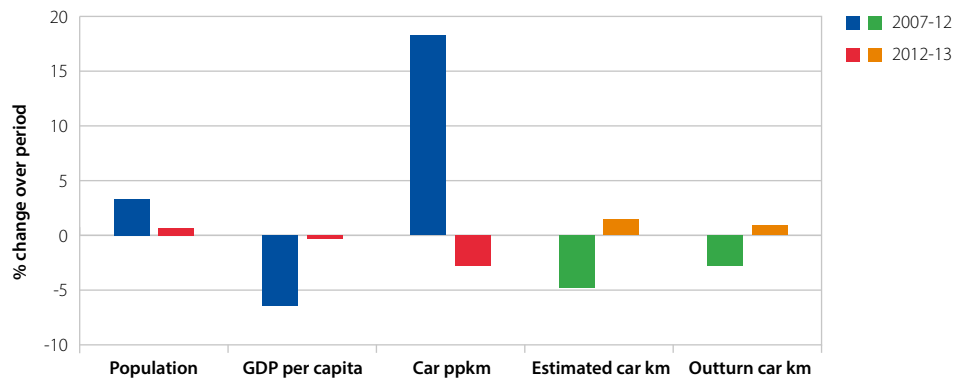
While travel demand fell over the first carbon budget period, for car and van travel the change was less than would have been expected given key changes in economic indicators including population, fuel costs and income. As the economy grows it is important that key drivers of travel demand are closely monitored, given their importance in determining overall emissions and progress against our indicator trajectory.

The charts below show both how key drivers have changed over the first carbon budget period, as well as the estimated impact of these changes on vehicle kilometres, based on elasticities used in the NTM.

Cars

Over the first budget period population rose, real GDP fell and motoring costs rose sharply as fuel cost rises outweighed the improvement in car efficiency. Given this combination of factors, car travel would have been expected to fall by around 5%, compared with the observed reduction of 3%. A reduction in fuel costs and a slowing down of the rate of contraction of GDP per capita suggest that car travel would be expected to increase slightly in 2012-13 and this did occur, but less than would be expected given the key drivers. Given that annual changes are subject to more fluctuation, too much weight should not be attached to this recent change.

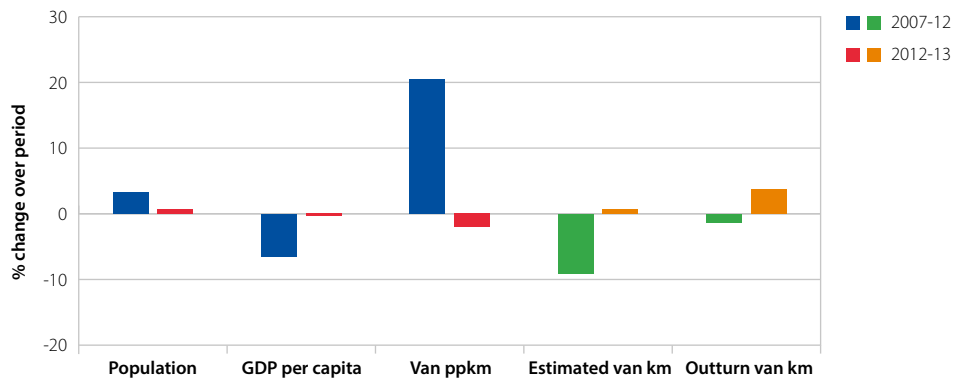
Figure B5.2.1: Drivers of car demand



Vans

As with car travel, van travel fell less than would have been expected in the first carbon budget period given falling GDP and rising motoring costs. Similarly, during 2013 where growth recovered and motoring costs actually fell, travel demand rose much more than these drivers predict. Given the relative strong continuing demand for van travel, it is thought that other factors could be at play. (see Box 5.3)

Figure B5.2.2: Drivers of van demand

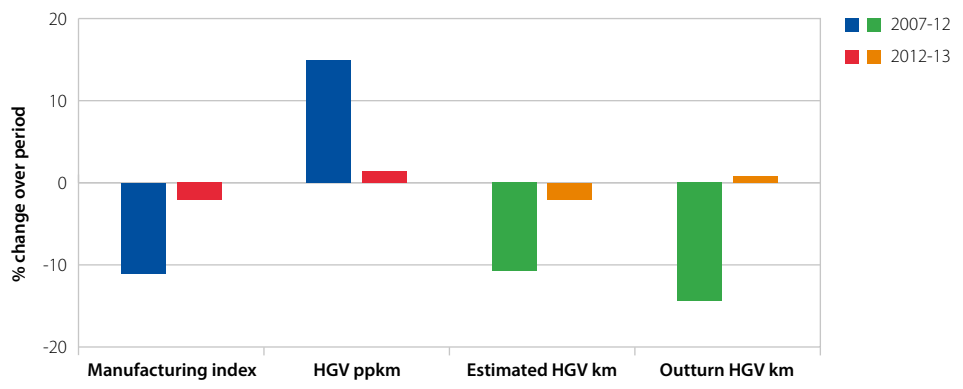


Box 5.2: Drivers of travel demand

HGVs

The sharp decline in UK manufacturing during the recession, combined with higher running costs, appears to explain a large proportion of the 14% reduction in HGV km over the first carbon budget period.

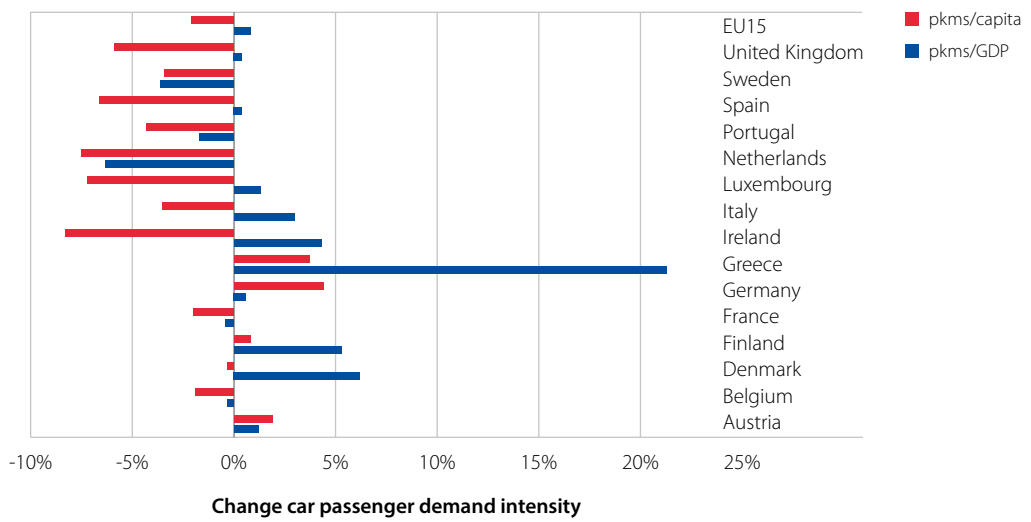
Figure B5.2.3: Drivers of HGV demand



Source: CCC calculations based on Office of National Statistics and Department of Transport data.
Note: Data is displayed over the first budget period in green, and for 2013 compared to 2012 in orange.

Car travel in EU-15 member states also decreased, but by less than in the UK. In the period from 2007-2011 (the latest year for which data are available), car travel fell by 0.3% on average across EU-15 countries, and by 2.9% in the UK. The key drivers of demand for which comparative data are available are GDP and population. While car travel relative to GDP rose on average across the EU-15 countries, travel per person declined (Figure 5.7).

Figure 5.7: Car passenger demand intensity in EU-15 member states (2007-2011)



Source: Eurostat, CCC calculations.

- Car travel relative to GDP rose by 0.8% on average across the EU-15, compared to a 0.4% increase in the UK. In most countries this was due to recessionary impacts, with economic activity falling faster than car kms between 2007 and 2009. More recently, car travel has risen at a slower rate than output, in line with historical trends.
- Between 2007 and 2011, car travel per inhabitant declined by an average of 2.1% in EU-15 countries, and by 5.9% in the UK, as passenger demand fell and population increased.
- The Netherlands was the only EU-15 member state which had an expanding population and growing GDP but where car passenger demand fell (5.8% – the fastest among the EU-15 member states). This is partly a result of continuous investment in cycling infrastructure and, in some provinces, financial incentives for commuters to switch to bikes.

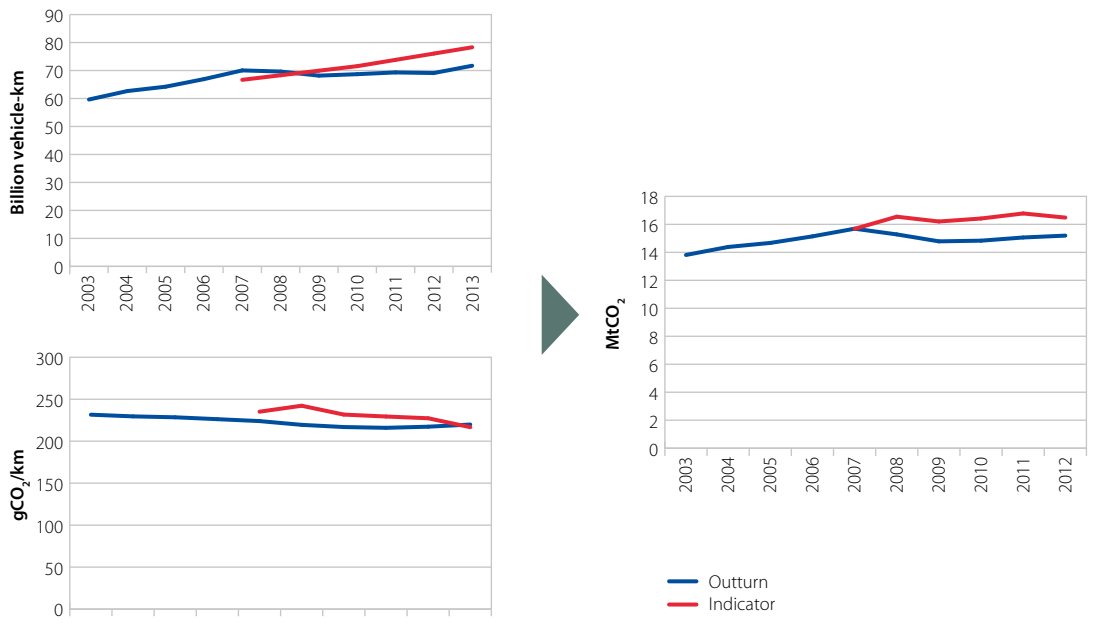
Van emissions

Emissions from vans fell by 2% between 2007 and 2012, compared to an anticipated increase of 5.1% when our indicator trajectory was set. This was largely a result of a slight fall in van demand during the recession, combined with an implied fall in average CO_2 intensity of the fleet as a whole (Figure 5.8).

- Van travel fell by 1.3% between 2007 and 2012, before increasing by 3.8% in 2013. The net increase is significantly higher than would be expected based on outturn economic data and elasticities from the NTM – possibly as a result of structural changes in demand for vans (Box 5.3).
- The implication of data on emissions and van travel demand is that average carbon intensity of the van fleet decreased by 1.8% over the first carbon budget period. As with cars, this can be attributed to increased blending of biofuels and better fuel efficiency of the fleet. However, the reduction was less than the 7.8% envisaged in our indicator trajectory, partly as a result of slower stock turnover during the recession.
  - Biofuel penetration for vans increased from 1.3% to 2.4% (by energy) between 2007 and 2012, accounting for an estimated 1.1 pp of the reduction in van emissions.
  - Stripping out the effect of increased biofuels implies that fuel efficiency of the fleet improved by 0.7%, accounting for the remaining 0.7 pp of the reduction in emissions.
    - Stock turnover will have improved the efficiency of the fleet as new efficient vans replaced older less efficient models[1].
    - New van efficiency improved by 7% over the period (a smaller reduction than for cars, reflecting later introduction of EU regulations; see section 3 below).
    - As for cars, the recession saw a slow-down in new van sales which fell by 44% between 2007 and 2009 and by 2012 had recovered to only 72% of 2007 levels. This contributed to an increase in the average age of the van fleet from 6.6 years in 2007 to 7.8 years in 2012. Had stock turnover rates remained at 2007 levels, CO_2 intensity of the fleet might have fallen further.

1 We do not have sufficient historic data on new van efficiency to estimate the precise contribution of efficiency improvements compared to stock turnover over the first carbon budget period.

Figure 5.8: Historical trends of vehicle km, $MtCO_2$ and gCO_2/km for vans (2003-2012)



Source: NAEI (2013), DfT (2013) *Transport Statistics Great Britain 2012.*

We do not have data for van emissions in 2013, but can make an estimate based on data for distance travelled, biofuels penetration and new van CO_2:

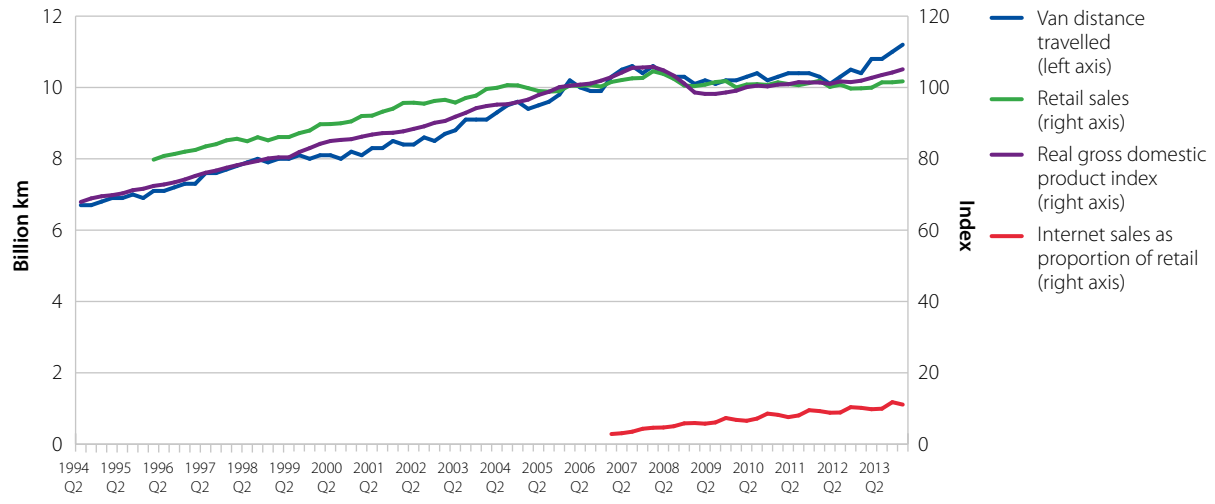
- As noted above van travel increased by 3.8% in 2013.
- Biofuel penetration for vans increased from 2.4% to 2.8% by energy.
- Stock turnover, together with a 1.4% improvement in new van efficiency, implies the average efficiency of the fleet improved by 1.2%.

These suggest that emissions are likely to have increased between 2012 and 2013, though this should be treated with caution given uncertainties in the data.

Box 5.3: Van Demand and Online Shopping

In our previous progress reports, we have noted the large increase in van traffic, particularly when compared with relatively modest growth in passenger car travel and HGVs. Since 1993 van travel has increased by 66% whilst car and HGV traffic have grown by 15% and 4% respectively. One possible explanation for this is the recent expansion of online shopping and associated changes in the distribution of goods away from larger retail outlets, using larger trucks, to smaller localised distribution through vans. An initial analysis of the trends in van travel and online sales suggest these are closely related.

Figure B5.3: Van Demand and retail sales



Source: ONS (2014) Retail Sales, DfT (2014).

However, more detailed modelling[2] suggests that online sales growth does not explain this rise. The study found a large and significant impact from overall GVA but no additional impact of online sales. This may be because, despite their recent rapid growth, online sales still constitute a small proportion of overall retail sales (11% of all retailing in April 2014). The elasticity of van travel to GVA was greater than 1, suggesting that this variable captures both changes in the size and composition of GVA

However, the work did point to an interesting relationship between HGV and van travel.

- In the short-run there is a positive correlation between HGVs and van travel demand – suggesting an increase in freight demand is met by both modes. However, there is a negative relationship between HGV and van demand in the long-run – suggesting vans can be substitutes for HGVs.
- More stringent HGV operating and licensing conditions introduced in September 2009, made it both more difficult and costly to operate HGVs, and appear to have contributed to this substitution effect.
- The analysis has important implications for carbon budgets and transport policy more generally. More vans trips are required to carry the same weight of goods that a single HGV can carry, but whether they are more or less carbon intensive depends on a number of factors such as distance travelled, lading factors, empty running and driving conditions – types of roads used and congestion. We are working with DfT to better understand these interactions and will use the analysis to inform the future design of carbon budgets.

A recent study, carried out by the Campaign for Integrated Transport[3] found the most likely drivers of recent growth were: less regulation on vans compared to HGVs; changes in delivery approach (e.g. 'Just in Time' and centralised stock holding); communication equipment servicing and installation; and economic and household growth.

2 Townsend (2014) *What has been driving the recent rise in van traffic?*
3 Campaign for Integrated Transport (2010) *Vans and the economy.*

HGV emissions

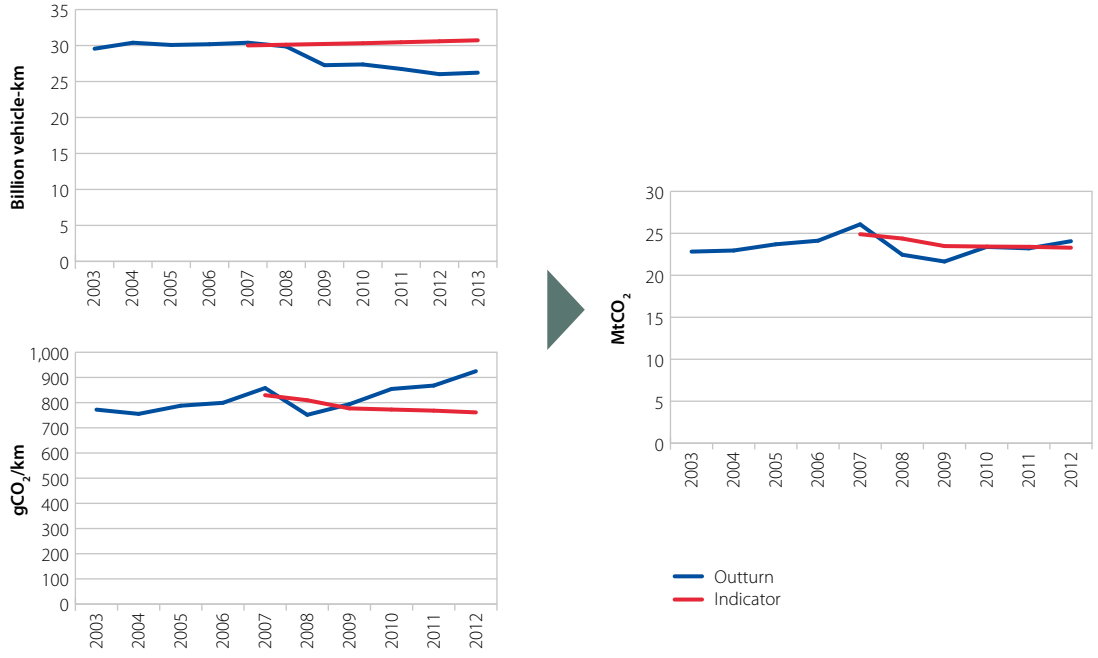
Emissions from HGVs, as recorded by the NAEI, declined by 7.7% between 2007 and 2012 – slightly more than the 6.5% in our indicator trajectory. Sharp falls during the economic downturn have been partly offset in recent years, explained by changes in HGV travel demand, while implied average emissions intensity of the HGV fleet rose (Figure 5.9).

- HGV km fell by 14.4% between 2007 and 2012. This was greater than the reduction that would have been expected given falling manufacturing output and rising HGV fuel costs over this period. (Box 5.2) Other than modelling uncertainty, possible explanations for this include a move to heavier HGVs and changes to utilisation rates (Box 5.4)
- The much smaller percentage reduction in emissions than HGV travel suggests average emissions intensity (emissions per vehicle km) of the HGV fleet rose by 7.8% over the period, compared to a reduction of 8.2% in our indicator trajectory. This increase in emissions intensity was despite increased penetration of biofuels – implying a worsening of fuel efficiency as measured per vehicle km.
  - Biofuel penetration for HGVs increased from 1.3% to 2.4% (by energy) over the first carbon budget period, implying a reduction in average fleet emissions intensity of 1 percentage point.
  - This implies that the average fuel efficiency of the fleet (as measured per vehicle km) worsened by almost 9% over the period.
  - Issues with the NAEI estimation methodology for HGVs which we have previously highlighted mean that this estimate should be treated with caution (Box 5.5).
  - Nevertheless, a rise in fuel consumption per vehicle km across the fleet is not surprising given the following factors:
    - There has been a continuing trend towards heavier HGVs (Box 5.4), which other things equal, would increase fuel consumption per vehicle km – though this may mask improvements in fuel intensity per tonne km; this is considered below.
    - There was reduced HGV stock turnover during the economic downturn, which led to an increase of 1.2 years in the average age of the fleet between 2007 and 2012.
    - Unlike for cars and vans, there is no EU regulation of new HGV CO_2 emissions (see section 3 below).

We do not have data for HGV emissions in 2013. However there are provisional data on distance travelled and biofuels penetration.

- As noted above HGV km rose by 0.8% in 2013.
- Biofuel penetration increased from 2.4% to 2.8%.
- We do not have data on fuel efficiency of the new HGV fleet and cannot estimate the fleet average.

Figure 5.9: Historical trends of vehicle km, $MtCO_2$ and gCO_2/km for HGVs (2003-2012)



Source: NAEI (2013), DfT (2013) *Transport Statistics Great Britain 2012.*

If fuel efficiency had remained constant between 2012 and 2013, it seems likely that there would have been a small rise in emissions last year.

The trends in vehicle size and utilisation discussed in Box 5.4 highlight that the number and emissions intensity of vehicle kms are only part of the story for HGV emissions – consideration must also be given to tonne km, which ultimately is the most important measure in freight.

Data on HGV tonne kms are currently available to 2010 only. The trend in emissions per tonne km followed that of emissions per vehicle km until 2008 (Figure 5.10). In 2009, lighter loads carried per vehicle – probably due to recession impacts – led to a sharper increase in gCO_2/t-km than in gCO_2/v-km. While the series reconverged as demand for goods transport bounced back in 2010, the divergence during the recession demonstrates the limitations of gCO_2/v-km as the only measure of emissions intensity. Going forward, we will monitor emissions intensity on the basis of both vehicle km and tonne km, and explore the possibility of setting out an indicator trajectory for gCO_2/-v-km.

Box 5.4: Move to heavier HGVs

There is evidence that goods are increasingly being carried in heavier HGVs. The greater empty weight of these vehicles, together with the fact that they tend to be operated with higher lading factors than smaller HGVs, would tend to increase emissions intensity of HGV travel per km. However, more trips are also run empty in heavier HGVs compared to their smaller counterparts, which would have the opposite effect on intensity per km.

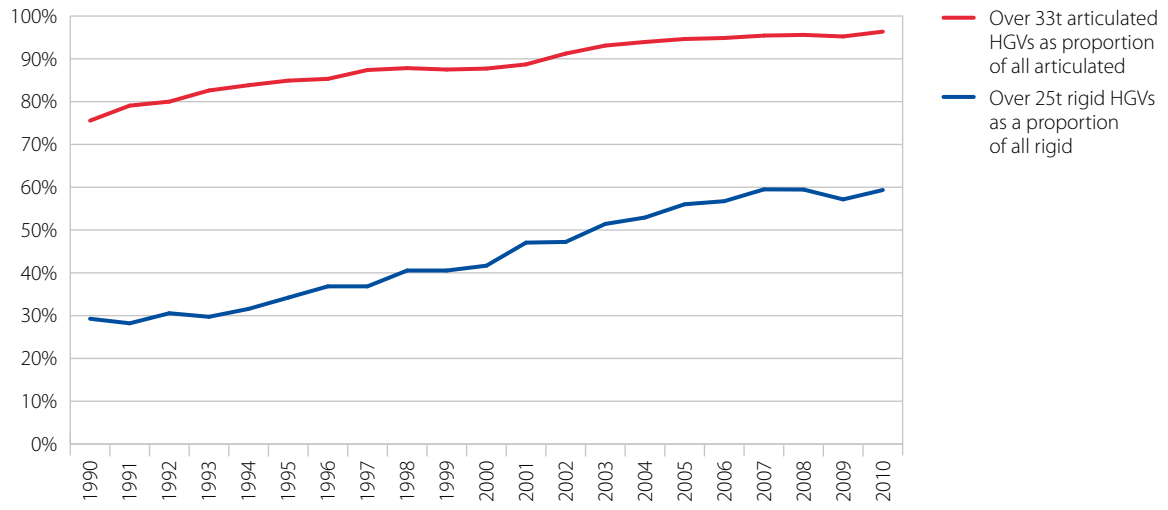
Data from the Continuing Survey of Road Goods Transport (CSRGT) show that the proportion of total goods carried by articulated lorries weighing over 33t rose from 72% to 75% between 2003 and 2010 (the latest year for which data are available) at the expense of smaller articulated vehicles, with similar trends observed for rigid HGVs (Figure B5.4). There has been a corresponding rise in the share of km travelled by heavier vehicles, from 85.7% to 92.5% for articulated HGVs over 33t and from 23.1% to 30.7% for rigid HGVs over 25t. Other things equal these changes would have the effect of reducing HGV km and increasing emissions intensity of HGV travel (gCO_2/v-km).

An increase in average lading factor, which grew by 3.5% between 2003 and 2010, may have been partly attributable to a shift from smaller lorries as heavier HGVs are typically better utilised in terms of loading than those in lower weight categories. Other things equal, increased lading factor would also have the effect of reducing HGV km and increasing emissions intensity (gCO_2/v-km).

Offsetting these effects, was an 8.3% increase in empty running over the same period. Empty running is independent of the lading factor as the latter is only calculated when goods are carried.

While the move towards heavier HGVs may give the impression of increasing emissions intensity when measured per km, this issue does not arise when measuring by tonne km – an indicator of goods movement rather than vehicles movement.

Figure B5.4: Proportion of tonne kms moved by the heaviest rigid and articulated HGVs (1990-2010)



Source: NAEI (2013), DfT (2013) *Transport Statistics Great Britain 2012.*

Box 5.5: NAEI estimation methodology

The National Atmospheric Emissions Inventory (NAEI) includes estimates of road transport CO_2 emissions by mode. CO_2 emissions from each mode are estimated with the following steps:

- Fuel consumption factors are defined for petrol and diesel vehicles, for each type of road.
- Total petrol and diesel consumption is estimated based on fuel consumption factors and vehicle km travelled on each type of road.
- Estimated petrol and diesel consumption is adjusted so that total consumption equals official statistics on total petrol and diesel sales in the UK.

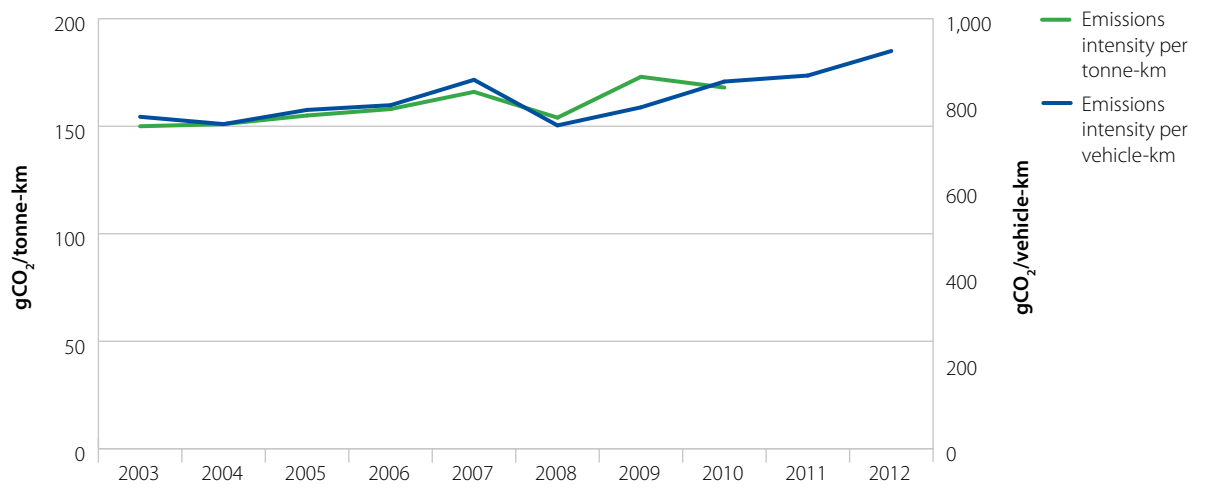
In previous progress reports, we highlighted two problems with this methodology:

- While bus and HGV fuel consumption factors reflect real-world survey data, car and van factors are assumptions based on speed-emissions curves which do not reflect reductions in gCO_2/km arising from the latest EU new car and van CO_2 regulations. Car and van emissions are therefore likely to be overestimated.
- For petrol, any discrepancy between estimated consumption and total sales is allocated proportionally across petrol consuming modes, but for diesel it is allocated entirely to HGVs. This can lead to large year-on-year changes in implied HGV fleet efficiency, raising questions over the robustness of the estimates.

The implication of this issue is that estimates of HGV fleet efficiency, particularly year-on-year changes, should be treated with caution.

Alternative estimates are available from the Continuing Survey of Road Goods Transport (CSRGT), though currently data are available only to 2010. According to these estimates, fuel efficiency worsened by 1.6% between 2007 and 2010, compared to an estimate of 6.5% based on the NAEI.

Figure 5.10: Historical emissions intensity for HGVs (2003-2012)



Source: NAEI (2013), DfT (2013) *Transport Statistics Great Britain 2012.*

Across the EU there was a reduction in HGV road freight demand (tonne km) relative to economic activity between 2008 and 2012, a continuation of longer term trends.

- The manufacturing component of GDP fell by nearly 5% and HGV tonne kms fell by more than 11% on average across EU-15 member states, resulting in a de-coupling of freight movements from GDP over this period. This was also the case in the UK, though the scale of the impact was lower.
- The reasons for this are unclear, though operational efficiency improvements – better routing and vehicle utilisation – as well as a switch of some goods movement to rail in some EU member states are likely to have played a part.

Public transport emissions

Emissions from buses, coach and rail represent 5.5% of surface transport emissions. Over the first carbon budget period these emissions fell by 11.4%.

Trips by public transport (including local and non-local buses, trains and London Underground), as recorded by the National Travel Survey, fell by 3.5% over the first carbon budget period, though its share in total trips remained broadly flat at around 9.5%. However this masked a 13% increase in rail trips (the share of which in public transport trips rose from 19% to 22%), which were offset by a 7% fall in bus trips (the share of which fell from 72% to 69%).

Other modes

Whilst cycling remains a small proportion of all travel, its share of trips rose from 1.6% to 1.9% between 2007 and 2012, while distance per trip rose by 13%.

(ii) Emissions from aviation and shipping

Aviation

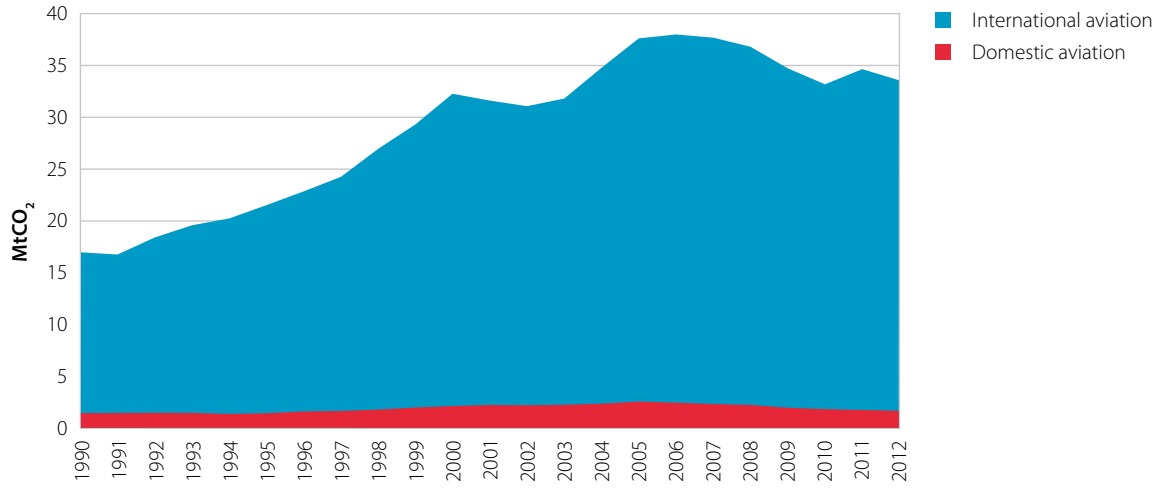
In 2012, at the end of the first carbon budget period, UK aviation emissions were 33.6 $MtCO_2$. This represents a fall of 11% between 2007 and 2012 and a fall of 3% in the year ending 2012 (Figure 5.11). Both domestic and international emissions fell:

- Domestic aviation emissions fell by 4.4% in 2012 from 1.7 $MtCO_2$ to 1.6 $MtCO_2$. Over the first carbon budget period they fell 28%.
- International aviation emissions (which are not included in carbon budgets) fell by 2.7% in 2012 from 32.8 $MtCO_2$ to 32.0 $MtCO_2$. Over the first carbon budget period they fell 10%.

This reflects changes on both demand and supply sides:

- Demand for aviation fell substantially during the recession, and in 2012 was 8% lower than in 2007.

Figure 5.11: UK aviation CO_2 emissions (1990-2012)



Source: DECC (2014).

- On the supply side, airlines reacted to falling demand by reducing the number of flights (which fell by around 15% over the budget period) and by increasing the occupancy rate of aircraft. Available data suggests fuel efficiency therefore improved (e.g. by an average of 1.6% per year over the first budget period[4]).

EU aviation emissions also fell over the first carbon budget period, by an average of 7% across both the EU-28 and EU-15. While UK emissions fell more, they remain the highest in Europe. This reflects the fact that UK passenger demand is the highest in Europe, as well as the UK's role as an international long-haul hub.

Shipping

In 2012 at the end of the first carbon budget period UK shipping emissions were 10.9 $MtCO_2$. This represents a fall of 10% over the budget as a whole and a fall of 13% in the year ending 2012 (Figure 5.12). Both domestic and international emissions fell:

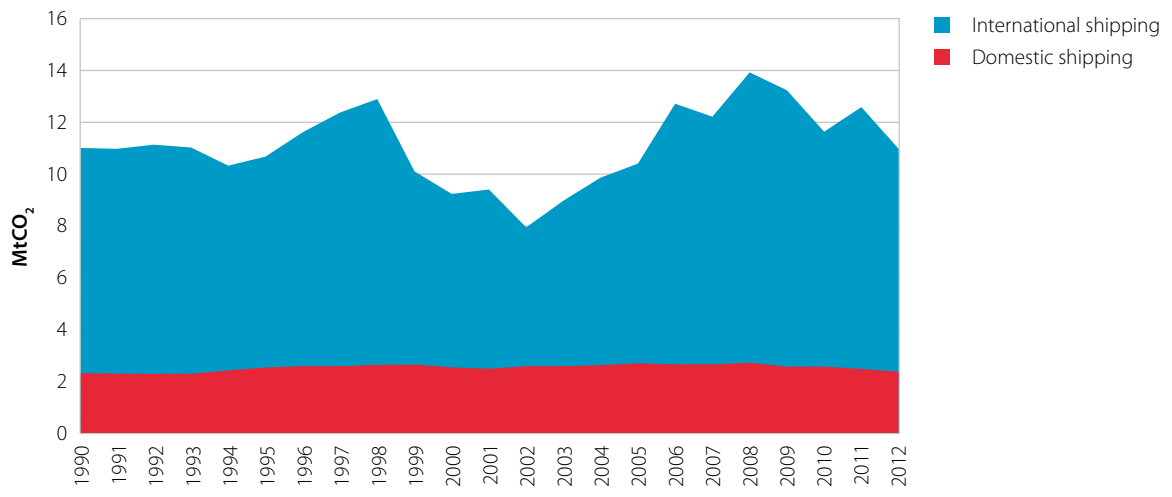
- Domestic shipping emissions fell by 4.1% in 2012 from 2.5 $MtCO_2$ to 2.4 $MtCO_2$. Over the first carbon budget period they fell 11%.
- International shipping emissions (which are not included in carbon budgets) fell by 15.0% in 2012 from 10.1 $MtCO_2$ to 8.6 $MtCO_2$. Over the first carbon budget period they fell 10%.

This reflects changes on both the demand and supply sides:

- Demand for shipping fell substantially during the recession, as global trade volumes fell. In 2012 UK shipping demand was 11% lower than at the start of the first budget period.

4 Data from Sustainable Aviation Progress Report 2013. This covers emissions from all Sustainable Aviation partner airlines, including for their non-UK flights. It can therefore only be considered indicative of changes in UK aviation fuel efficiency.

Figure 5.12: UK shipping CO_2 emissions (1990-2012)



Source: DECC (2014).

- On the supply side, in response to falling demand and a significant over-supply of new ships, a key response of shipping firms has been to reduce speeds. Reducing speed can significantly reduce emissions (e.g. a 10% reduction in speed can reduce emissions by up to around 20%).

EU shipping emissions also fell over the first carbon budget, by an average of 18% across both the EU28 and EU15. This was larger than the fall in UK emissions, reflecting other EU countries' roles as international maritime trade and fuel supply hubs rather than the UK.

3. Progress in decarbonising transport

(i) New vehicle emissions intensity

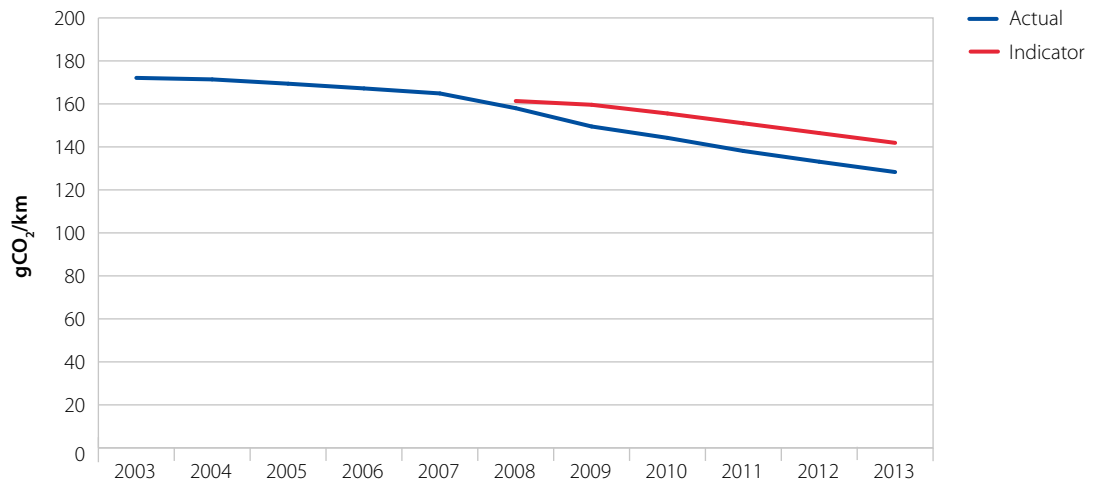
(a) Cars and vans – progress to date

New car test cycle emissions

EU regulation of average new car CO_2 has been in place formally since 2009, following initial announcement in 2007, with targets set for 2015 and 2020. Following lengthy negotiations, final details around the 2020 target were recently agreed and reflected in the legislation (Box 5.6).

To date the EU regulations have been very effective at delivering test cycle emissions reductions. Average test cycle new car emissions intensity in the UK fell by 19.3% over the first carbon budget period, from 164.9 gCO_2/km in 2007 to 133.1 gCO_2/km in 2012. This trend continued in 2013, when new car CO_2 fell to 128.3 g/km – below our indicator value of 141.9 gCO_2/km and meeting the EU 2015 target of 130 gCO_2km two years early (Figure 5.13). The average annual percentage reduction in new car CO_2 in the six years since EU regulations were initially announced has therefore been 4.1%, compared to 1.2% in the six year period prior to this.

Figure 5.13: New car CO_2 vs indicator

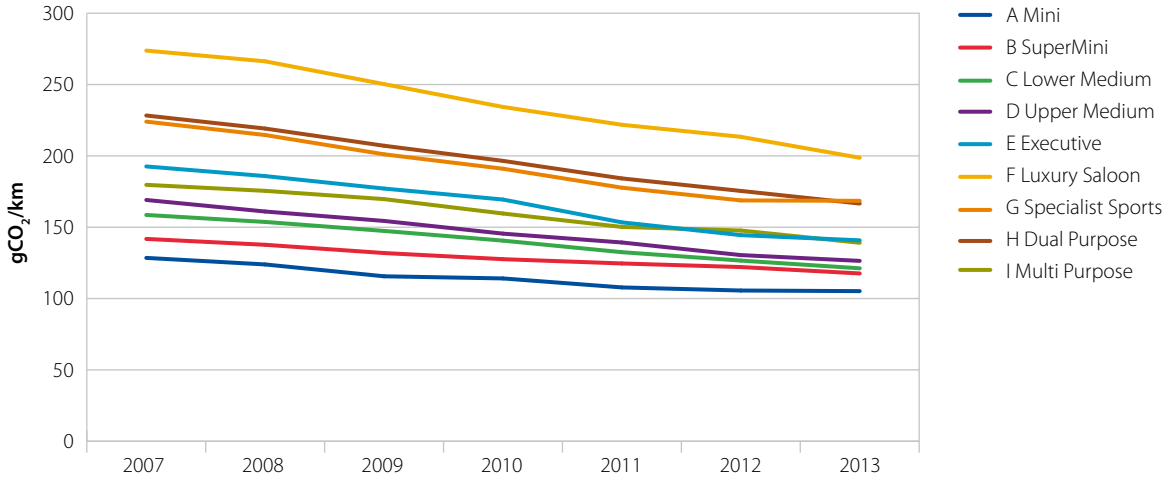


Source: SMMT (2014), CCC modelling.

Evidence suggests reductions have been driven largely by the supply side as manufacturers strive to meet EU targets, while consumer purchase decisions have changed in a way that is broadly neutral.

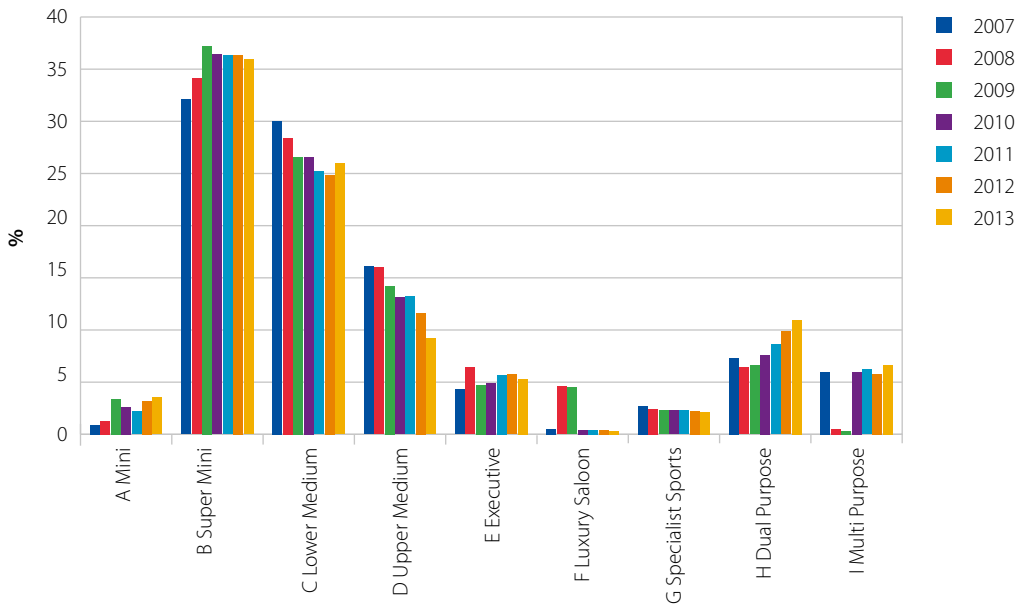
- There have been reductions in average gCO_2/km of new cars offered in all vehicle classes, driven in particular by reductions in the maxima for each class. The biggest improvements have generally been seen in the larger vehicle classes, due to greater scope for reduction through, for example, light-weighting (Figure 5.14).
- Evidence on the contribution of consumer purchase decisions is mixed, with some polarisation in class choice, and limited change in best-in-class purchase behaviour, but with increasing purchase of diesel vehicles.
  - While the share of sales in the smaller class sizes grew from 33.0% to 39.5% over the first carbon budget period, the market share of larger cars, particularly Multi Purpose Vehicles (MPVs), also increased, from 20.8% to 24.0%. This trend continued in 2013 (Figure 5.15).
  - The proportion of buyers choosing cars in the lowest quartile of gCO_2/km within each class remained broadly stable between 2007 and 2012. However, 2013 did see an increase in buyers choosing best-in-class, from 34% to 41% (Figure 5.16).
  - The proportion of diesel sales increased in all vehicle segments over the first carbon budget period, particularly medium segments where the average share of diesel grew from 50.6% to 68.7%. However, this trend was reversed in 2013, with a slight fall in diesel sales in most segments, particularly MPVs where the diesel share fell by 5.9 percentage points to 64.8%.

Figure 5.14: New car CO_2 by segment (2007-2013)



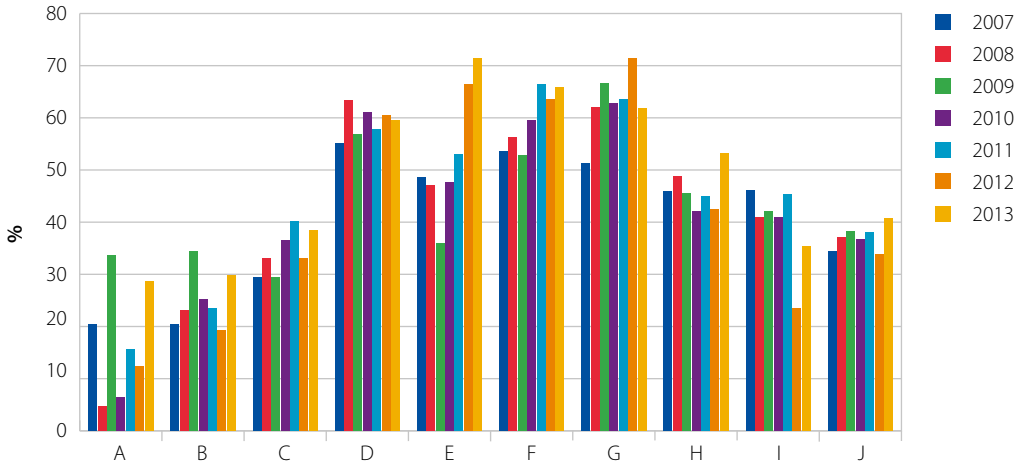
Source: SMMT (2014).

Figure 5.15: Share of new car sales by segment



Source: SMMT (2014).

Figure 5.16: Share of car sales in best quartile for gCO_2/km, by class



Source: SMMT (2014).

Box 5.6: Agreement on EU targets

Cars

In 2009, the EU set legally-binding targets for new cars to emit 130 gCO_2/km by 2015 and 95g in 2020. In July 2012, the European Commission put forward a proposal on how the 2020 target should be met.

The Environment Committee of the European Parliament voted in favour of this proposal in April 2013, and in June 2013 a provisional agreement was reached on the final text. However the agreement was narrowly rejected in a final vote, leading to further negotiations.

A new deal was struck in December 2013, slightly revising the previous agreement such that the regulation will be phased in over one year, with 95% of sales counting towards the target in 2020, before rising to 100% in 2021. This deal was approved by the Council and accepted by the Parliament in February 2014, and is now reflected in the legislation.

Manufacturers' emissions targets apply to the fleet average of all new cars sold in the respective year and take into account vehicle weight, with heavier cars being allowed higher emissions, and the opposite for light vehicles, according to a 'limit value curve'.

In order to stimulate the uptake of Ultra Low Emissions Vehicles which produce less than 50 gCO_2/km, the legislation provides for the use of super credits. When calculating fleet average emissions, each ULEV counted as 3.5 cars in 2012 and 2013, 2.5 cars in 2014, and will count as 1.5 cars in 2015. From 2016 to 2019, there will be a hiatus, but between 2020 and 2022, each ULEV will again count as multiple cars (2 cars in 2020, 1.67 in 2021 and 1.33 in 2022), though their contribution will be capped at a maximum of 7.5 gCO_2/km over the three years.

In addition, manufacturers can be granted emissions credits – up to 7 gCO_2/km per year – for 'eco-innovations': innovative technologies that improve vehicle efficiency in real-world driving but not on the test cycle (e.g. efficient air conditioning).

Vans

Similar targets were set for vans in 2011, when regulation was passed requiring new vans to emit on average no more than 175 gCO_2/km in 2017 and (provisionally) 147 gCO_2/km in 2020. In July 2012, following a review of the 2020 target, the European Commission made a proposal to confirm the 147 gCO_2/km value, which was accepted by the European Parliament and member states in 2013.

The 2017 target is being phased in from 2014, when 70% of sales will be counted, rising to 100% in 2017. However the 2020 target will have immediate effect.

As with cars, the use of super credits for vehicles with emissions below 50 gCO_2/km will be allowed. For vans, these credits enable ULEVs to count as 3.5 vehicles in 2014 and 2015, 2.5 vehicles in 2016 and 1.5 vehicles in 2017, up to a maximum of 25,000 vans over the period.

Source: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0333&from=EN

Real world versus test cycle emissions

While reductions in test cycle emissions are positive, there is evidence of a growing gap between test cycle emissions and those achieved in real-world conditions, implying smaller reductions in gCO_2/km on the road.

- A recent study[5] for the European Commission attributed the increasing gap between real world and test cycle emissions to a number of factors including:
  - Increasing use of technologies with greater benefit in the test cycle than under real world conditions (e.g. stop start technology).
  - Increasing use of accessories such as air conditioning, heated seats, navigation and media systems, which are not switched on during the test procedure.
  - Increasing exploitation of flexibilities in the test procedure.
- A report by the International Council on Clean Transportation[6] suggested that in the UK, the gap may have increased from around 16% in 2007 to around 27% in 2011. This would suggest real-world new car gCO_2/km fell by around 8% between 2007 and 2011 (versus a fall of 16% in test cycle emissions).
- With no further increase in the gap to 2013, it would suggest real-world emissions fell by around 15% between 2007 and 2013 (versus a fall of 22% in test cycle emissions) – broadly in line with the 14% reduction in our indicator trajectory, rather than significantly outperforming it. If in practice the gap increased between 2011 and 2013, it its possible real-world reduction underperformed against our indicator trajectory.

In order that future emissions reductions are achieved, it is important that improvements in fuel efficiency measured in test conditions are delivered on the road. We consider this further below.

New van emissions

EU limits for average new van CO_2 were established in 2011, including targets of 175 gCO_2/km in 2017 and (provisionally) 147 gCO_2/km in 2020. The 2020 target was recently confirmed and reflected in EU legislation (Box 5.6).

The EU regulations have to date been effective in reducing new van emissions, though improvements have been slower than for cars. This partly reflects the later date of introduction of targets but potentially also a lower level of ambition (see below).

Estimates of new van CO_2 have been available from the Society of Motor Manufacturers and Traders (SMMT) since 2009. SMMT estimate that new van CO_2 intensity fell on average by 2.6% per year, from 204 g/CO_2/km in 2009 to 188 gCO_2/km in 2012. Intensity continued to fall in 2013, albeit at a slower rate of 1.2%, to 186 gCO_2/km – below our indicator value of 192 gCO_2/km and on track to the EU 2017 target of 175 gCO_2km. (Figure 5.17).

5 TNO (2012) *Supporting Analysis regarding Test Procedure Flexibilities and Technology Deployment for Review of the Light Duty Vehicle CO_2 Regulations*
6 ICCT (2013) *From laboratory to road*

Reductions in average gCO_2/km came despite a shift in van sales towards heavier, higher-emitting vans, which offer greater flexibility of use and increased payload efficiency.

- Between 2009 and 2012, the share in new van sales of light vans up to 2 tonnes fell (by 1.3 percentage points), while the share of light vans between 2 and 2.5 tonnes grew (by 0.8 pp).
- Over the same period, the share of medium vans between 2.5 and 2.8 tonnes fell (by 3.8 pp) while the share of medium vans between 2.8 and 3.5 tonnes grew (by 2.2 pp), as did the share of van over 3.5 tonnes (by 1.9 pp).
- Meanwhile the share of pick-ups was broadly unchanged overall[7].

This implies that the shift towards heavier vehicles was outweighed by improvements in average CO_2 intensity within-class, driven by technology-driven improvements in CO_2 intensity within each class and/or a shift in purchase behaviour towards best-in-class vehicles.

For most vehicle classes these trends continued in 2013. However there was a drop in the share of the heaviest vehicles (3.5 tonnes and over), which fell from 26.4% to 24.8%, and will have contributed to the fall in average new van CO_2.

In future, if the recent (albeit somewhat interrupted in 2013) trend towards heavier vans continues, it will be important that technology improvements continue to be delivered and that that purchasers choose the least carbon-intense options within-class. Policies to encourage this are considered below.

(b) Cars and vans – forward look

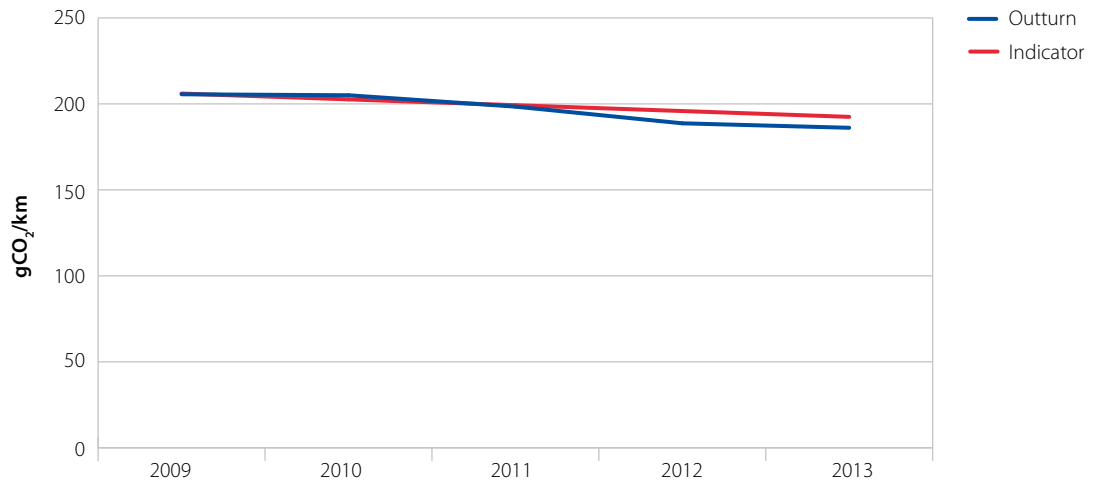
2020 targets

EU legislation governing new car and van CO_2 has to date been very effective at delivering test cycle emissions reductions and evidence suggests this is likely to continue to be the case until 2020.

- Progress to date is ahead of schedule, with both new car and new van CO_2 outperforming expected trajectories, though in part this may reflect a lack of ambition in the targets, particularly for vans: the figure of 203 gCO_2/km for average new van emissions across Europe in 2007, which was used at the time the targets were adopted, is likely to have been an overestimate, as by 2010 estimated average European new van emissions stood at a much lower 181 gCO_2/km.
- There are stiff penalties for failure to comply with the targets[8], while additional manufacturing costs associated with meeting them are thought to be lower than previously estimated, particularly for vans where estimates have come down from c.€2000-€3000[9] to c.€600[10] per vehicle.

7 The share of light 4x4 utility vehicles grew by 0.3 pp, but still accounted for only 3% of sales in 2012.
8 Currently €5 for the first g/km of exceedance, €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 of exceedance onwards.
9 Relative to 2007 baseline.
10 Relative to 2010 baseline.

Figure 5.17: New van CO_2 vs trajectory



Source: SMMT (2014), CCC modelling.

Improving the test cycle

Meanwhile, introduction of new test procedures (the Worldwide harmonized Light vehicles Test Procedures or WLTP), which better reflect real world driving conditions, should help ensure that test cycle reductions are reflected on the road.

- Alongside agreement on the 2020 targets (Box 5.6), there was also an agreement to move to the WLTP 'as soon as possible'.
- The WLTP will feature a more representative driving cycle, more precise road-load testing (to measure rolling and aerodynamic resistance), as well as generate improvements to the test procedure. Existing tolerances and flexibilities will be reduced, and more realistic CO_2 emission test results are expected.

While this is positive, it is also important that the move to the WLTP does not lead to protracted renegotiation of the 2020 targets or delays to the agreement of future targets.

2030 targets

While the above gives confidence that targets to 2020 are likely to be achieved for both cars and vans, and that emissions reductions similar to those measured by the test cycle will be delivered on the road, there are currently no targets post-2020.

It is likely that emissions reductions to 2020 will be delivered mainly through continuing efficiency improvements in conventional vehicles. However, there will remain potential for further efficiency improvements beyond 2020, together with emissions reductions from take up of electric and other ultra-low emission vehicles.

- Our analysis for the fourth carbon budget identified scope to reduce emissions intensity in 2030 to 80 gCO_2/km for conventional cars, and 120 gCO_2/km for conventional vans.
- Our analysis for the fourth carbon budget review showed that these conventional efficiency improvements together with penetration of electric vehicles, could result in average test cycle emissions in 2030 of 50 g/km for new cars and 60 g/km for new vans.

In order that this further progress is achieved, and given the European nature of the car industry, it is important that strong EU targets for new car emissions in 2030 are set as part of a broader package for European emissions reductions; this is something that the UK should push for in the context of negotiations about this package.

Moreover, in deciding what level of target to support, it is important to recognise not only the scope for efficiency improvement in conventional vehicles, but also the need to achieve increasing penetration of electric and other ultra-low emission vehicles through the 2020s.

Fiscal levers to meet targets

Achieving stretching EU targets will require action by industry and by member states to bring forward supply of more efficient models, to support EVs (discussed below) and to influence purchase decisions. There is evidence that member states with strong national policies to complement the EU regulations achieve greater improvements in average vehicle efficiency (Box 5.7).

There are currently a range of fiscal policies in the UK aimed at encouraging purchase of more efficient vehicles:

- **Vehicle Excise Duty.** VED rates have been graduated according to CO_2 bands since 2001, with special first-year rates introduced in 2010, and provide some incentive to buyers of both new and second hand cars. However, it is questionable whether the sums involved are sufficient to significantly affect choices; consumer research suggests VED is not an important factor in purchase decisions. Moreover, the lack of differentiation below 100 g/km, together with the large size of other bands, would need to be addressed in order to promote uptake of ultra-low emissions cars and to help bring average new car CO_2 to 95 g/km.
- **Company Car Tax.** CCT has been graduated according to emissions since 2002, with a gradual tightening of thresholds over time, affecting annual costs for both employers and employees. The sums involved are likely to have an impact on purchase decisions[11]; the reaction to around plans (later reverted) to scrap preferential sub-75 g/km rates suggests that CCT is an important consideration. Preferential rates for ULEV should therefore be continued (as is currently planned to 2019), and possible further tightening of thresholds considered in order to maintain progress on average new car CO_2.

11 E.g. currently, a £20k car emitting no more than 75 g/km saves around £660 for employers (£960-1920 for employees) in CTT over four years compared to one emitting 76 g/km, while zero emissions cars attract a 0% tax rate – though from next year the 0% rate will no longer apply.

- **Enhanced Capital Allowance.** Until 2018, firms are able to claim an ECA on low emissions vehicles bought for business activities. Currently, cars emitting up to 95 g/km are eligible for a 100% allowance in the first year; from March 2015, this threshold will reduce to 75 g/km, providing an incentive for purchase of very low emissions cars. For economically rational fleet buyers, the sums involved are likely to have an impact on purchase decisions[12]. However, the policy no longer applies to rental and hire companies (including car clubs); also it only applies to new cars. In both cases this misses an opportunity to support uptake of EVs, through consumer exposure and through supporting the second hand market.

For these policies to be effective in helping to ensure EU new vehicle CO_2 targets are met within the UK, it is important that they are closely aligned with these targets, with commensurate tightening of CO_2 thresholds over time. They should also provide additional incentives for EVs.

Box 5.7: Comparison of new car CO_2 improvements and national policies in other EU Member States

New car CO_2 has fallen faster in the UK than in the EU as whole, partly due a closing of the gap between UK diesel penetration and EU average. Compared to the EU15, however, the UK ranks mid-table in terms of new car CO_2 reductions (Figure B5.7).

Member States with the greatest reductions between 2007 and 2012 were those with strong fiscal policies in place to encourage purchase of low-emitting vehicles:

- In the Netherlands, registration tax is strongly graduated according to emissions performance, while very low emissions are also exempt from circulation tax and taxation of 'benefit in kind' payments for company cars is differentiated based on gCO_2/km.
- In Denmark, vehicle purchase tax was restructured in 2007 to be much more strongly based on CO_2, while annual circulation taxes are also graduated according to fuel efficiency.
- In Sweden, annual vehicle tax has been based on CO_2 emissions since 2005, and since 2009, cars emitting less than 120 g/km have enjoyed a five-year exemption. A new 'super green premium' for electric vehicles was also introduced in 2012.

Conversely, those Member States with poor performance in terms of new car CO_2 reduction have weak policies.

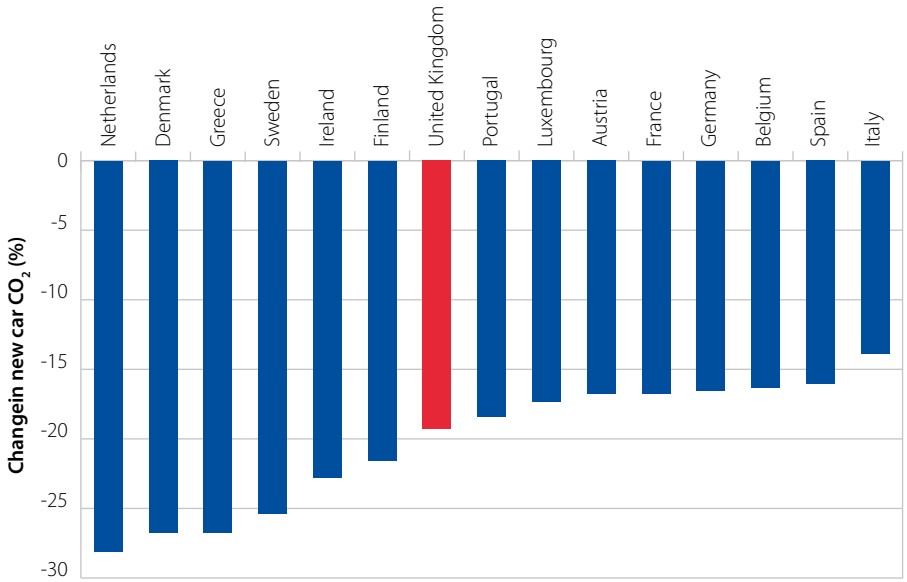
- In Italy, neither vehicle purchase or ownership taxes are graduated according to CO_2 emissions or fuel efficiency
- In Germany, there is no significant car registration tax, while the graduation of annual circulation taxes according to CO_2 is very weak (€2/g/km above a given threshold)

This demonstrates the potentially important role for complementary national policies in supporting EU targets for new vehicle emissions, with a growing evidence base for the effectiveness of purchase, registration and circulation taxes, if set at the right level, in influencing consumer decisions to buy low emissions vehicles.

12 E.g. reducing the 4-year cost of ownership of a £20k car by around £2000.

Box 5.7: Comparison of new car CO_2 improvements and national policies in other EU Member States

Figure B.5.7: Reductions in new car CO_2 in EU15 Member States (2007-2012)



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In summary, our overall assessment is that EU legislation is effective in reducing new car and van CO_2 and targets to 2020 are likely to be met. However, to achieve further progress beyond 2020, it is important that targets are now agreed for 2030, which take account of the role of EVs and other ULEVs. Current UK fiscal policies are likely to have influenced some consumers to purchase more efficient vehicles. Going forward, it is important these policies are fully aligned with the EU targets and that they encourage uptake of ULEVs.

(c) HGVs – progress to date

On the supply side, while Euro standards place mandatory limits on air pollutants from new HGVs, CO_2 emissions are not currently subject to EU regulation.

Fuel economy of new vehicles is believed to have remained broadly flat over the past decade, as tightening of NOx and PM legislation has tied up engineering resource, and provided some tension with fuel efficiency[13].

On the demand side, policy in the UK to date has been focussed on industry-led action, including voluntary schemes such as the Freight Transport Association's Logistics Carbon Reduction Scheme – though this is aimed at reducing carbon intensity of operations overall, not necessarily fuel economy of new vehicles. Demand side progress is discussed in more detail in section 4 below.

13 In some cases measures to improve air quality performance can reduce fuel efficiency, other things equal.

(d) HGVs – forward look

Opportunities

On the supply side, with stringent air quality standards now in place, attention is turning to reducing CO_2 emissions. Studies suggest there is remaining 'low hanging fruit' to be exploited in terms of fuel efficiency, in the form of cost effective – sometimes cost saving – improvements, for example in powering auxiliary devices.

The scenario we set out in our fourth carbon budget review assumes that emissions intensity of new HGVs (per vehicle km) falls by c.30% by 2030 relative to 2010, on a sales weighted basis.

Improvements in vehicle efficiency can be complemented with cost-effective emissions reductions through demand-side activity; these are discussed in section 4 below.

Current policy

Minimum standards for rolling resistance will be mandatory for new vehicle tyres from November 2014, and for replacement tyres from 2019 (currently replacement tyres must display labelling rating their performance). Tightening of minimum standards is expected to continue with tougher rolling standards for new vehicle tyres from November 2018 and for aftermarket tyres from 2023. Given the regulatory nature of the policy, it is likely that expected emission reductions, which are built in to the Government's emissions projections, will be delivered. However they are relatively small (between 2.6% and 5.4% per vehicle).

Going beyond current policy

Further savings will require more comprehensive policy. The European Commission recently published a strategy for addressing CO_2 emissions from heavy duty vehicles (HDVs), including HGVs, and helping deliver the EU 2030 climate and energy package. This set out a range of short term actions focussed on measuring, certifying and reporting HDV emissions.

- Direct measurement of whole-vehicle emissions (as is done for cars and vans) is not appropriate for HDVs, due to the diversity of models and trip patterns. Instead, the Commission have developed a simulation tool (VECTO) to calculate emissions of complete vehicles using test data for individual components. VECTO is expected to be operational in May 2014 for at least three HDV categories, together accounting for over 50% of HDV CO_2 across Europe, with other categories to be added in future.
- Subject to legislative changes, values provided by VECTO for each newly registered HDV could be certified, reported and monitored. Certification will require amendments to type approval legislation to include the methodology for determining values, while reporting will require adoption of new legislation paralleling that for cars and vans. The Commission is planning to make legislative proposals to this end in 2015.

- While not directly reducing emissions, reporting of new vehicle CO_2 will address some of the current market barriers by increasing transparency, thus stimulating competition among manufacturers and end-user awareness. As a result it should lead to the production and purchase of more fuel efficient HGVs emitting less CO_2.

The strategy states that, once these short-term actions are implemented, and based on the findings of further analytical work, medium term policy options, including mandatory new vehicle CO_2 targets, could be considered, though no dates are provided.

- Further work is needed to confirm the technological potential, to gain a broader understanding of market barriers hindering technology uptake, and to re-assess the costs and benefits of HDV CO_2 abatement as well as the underlying incentive structure for more energy efficient HDVs.
- As well as setting of mandatory CO_2 emission limits for new HDVs, policy options cited include infrastructure for alternatively fuelled HDVs, smarter pricing on infrastructure usage, use of vehicle taxation by Member States and other market based mechanisms. An impact assessment will be carried out to identify the most cost-effective option(s).

The Commission has invited the Council and the European Parliament to endorse the strategy and to help to deliver the outlined actions.

The UK Government should push for actions to progress swiftly so that targets for new HGV CO_2 are set as soon as possible to drive improvements in vehicle efficiency.

Use of methane in HGVs

In the UK, methane has been identified as a potential option for reducing g/km from HGVs. In March 2014, the Low Emission HGV Task Force published a set of recommendations on the use of methane and biomethane in HGVs[14], which fell into three categories: removing financial and legislative barriers; facilitating implementation and delivery; and improving the evidence base. Further, in April 2014, OLEV announced £4 million of funding for gas infrastructure for HGVs as part of its £500 million funding package for low carbon vehicles between 2015 and 2020.

While use of biomethane, particularly from waste sources, has potential to deliver CO_2 benefits on a lifecycle basis relative to diesel, the supply of biomethane is likely to be limited relative to overall demand for gas across the economy. There would therefore need to be a clear reason for using biomethane in HGVs versus other sectors in the longer term, particularly where there may be potential to use it in combination with carbon capture and storage to deliver 'negative' emissions.

Meanwhile, there is still work to be done to prove the lifecycle CO_2 benefits of using methane from fossil sources in HGVs, which will be very dependent on the gas supply pathway and that of the diesel it is replacing. Even where benefits relative to diesel can be proven, there may exist alternative technologies (e.g. hybrid electric) with the potential to offer much greater emission reductions in the given application, and investment in methane should not crowd out investment in these technologies in the longer term.

14 Low Emission HGV Task Force (2014) *Recommendations on use of methane and biomethane in HGVs.*

It is therefore important that the Government strengthen the evidence base in relation to these issues before long-term, large-scale commitment is made.

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Overall, our assessment is that progress reducing the emissions intensity of HGVs has been limited, reflecting the lack of a comprehensive policy framework. Given the effectiveness of EU regulations in reducing emissions from new cars and vans, it is important that actions progress swiftly to enable the setting of similar targets for HGVs. Use of methane in HGVs could offer a route to reducing emissions, given gas supply pathways which ensure well to wheel benefits and which are not at the expense of potentially greater savings in other areas; the Government should strengthen the evidence base in this area before long-term, large-scale commitment is made.

(e) Reducing emissions from buses

Low carbon buses are defined as those which deliver lifecycle greenhouse gas emissions at 30%, or more below the level of a standard Euro 3 bus. According to statistics from the LCVP there are currently (May 2014) 1,465 low carbon buses on the road in the UK.

Uptake of low carbon buses to date has been funded through two principle schemes, the Green Bus fund and the Bus Services Operators Grant (BSOG). The DfT-operated Green Bus Fund has provided over £88 million in funding towards purchase costs, over four rounds from 2009 to 2013[15], contributing to 1,238 of the low carbon buses currently on the road. In addition to this upfront cost subsidy, the bus services operators grant adds a further ongoing payment of 6p per km travelled.

An additional £30 million of funding is planned from 2015 as part of OLEV's £500 million package and could put over 1000 new low emission buses on roads, taking the total to 6% of the bus fleet, each delivering savings of around 25 tCO_2 annually. OLEV is also currently working with the Green Investment Bank to explore additional financing options, with further details to be published in late 2014. New approaches are likely to be needed to deliver the levels of uptake assumed within Government emissions projections, whereby the entire bus fleet is low carbon by 2031.

(f) Reducing emissions from rail

Electrification of rail has the potential to reduce emissions relative to equivalent diesel trains, with further benefits in increasing train capacity, and decreasing operating and maintenance costs.

In 2009, DfT set out a programme for increasing rail electrification, committing to an initial £1.1 billion of investment on lines in the North of England and on the Great Western Mainline. In 2009, only 33% of the UK rail network was electrified, one of the lowest figures in Europe, and compared with over 50% in France, Germany and Italy.

15 £88 million was allocated over rounds 1-4 of the fund. Increased requirements for local contributions impacted on uptake in the fourth round, resulting in not all available funding being used.

Electrification is currently on-going. The first of the Northern programmes, running from Manchester to Liverpool and Huyton to Wigan is on schedule for completion by December 2014; Preston to Blackpool is due to be electrified by May 2016; and Manchester to Preston by December of the same year. Electrification on the Great Western Mainline is due to be completed by 2017.

Other funded electrifications include Oxenholme to Windemere and Wigan to Lostock, where an initial assessment of required alterations is being carried out; as well as Manchester to Leeds and York where modification of bridges has begun.

Together, this will deliver emissions savings of around 2.2 $MtCO_2$ over the fourth carbon budget period according to government estimates.

(ii) Developing electric vehicle markets

(a) Progress to date

Electric car sales in 2013 were 60% higher than in 2012, at 3,584 vehicles. Nevertheless, this represented only 0.16% of total new car sales in 2013 and electric vehicle penetration remains low in the UK, with cumulative sales to date of around 9,800.

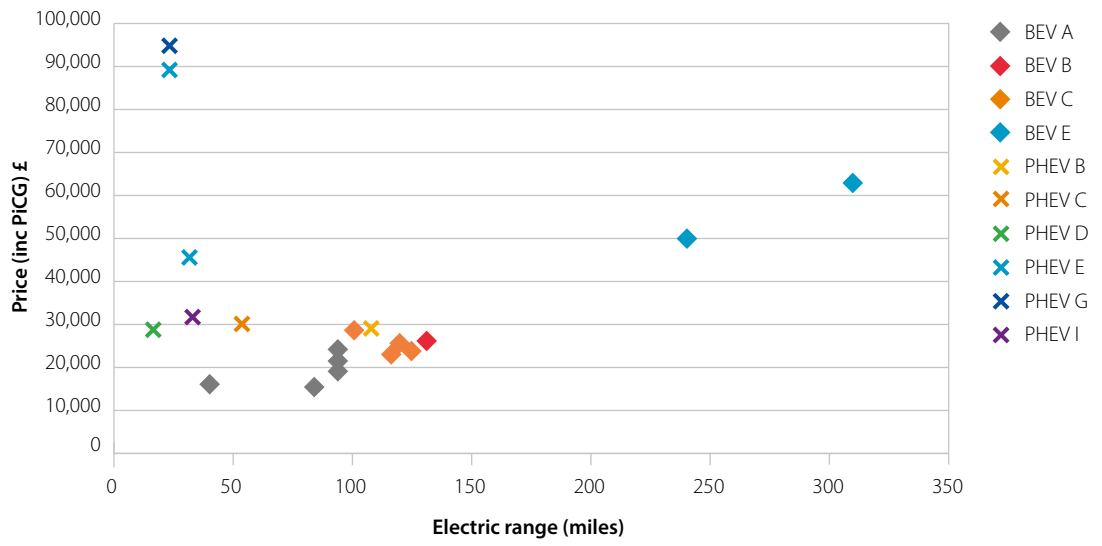
The fact that electric (and other ultra-low emission) vehicles play a potentially major role in moving to a low-carbon economy therefore poses a challenge (e.g. our analysis for the fourth carbon budget review assumes around 10.7 million electric cars, and 1.9 million electric vans, on the road in 2030).

However, there are a number of promising developments which provide confidence that this challenge can be addressed.

- The Government has committed funding of £500 million between 2015 and 2020. High-level allocation of this funding was announced in April 2014 and includes £200 million for continuation of the existing Plug-in Car Grant (to 2017 or 50,000 vehicles, whichever is sooner), £30 million for other ULEV types including vans, £20 million to support uptake of ULEV taxis, £35 million for a new city scheme competition to support EV uptake, £32 million for charging infrastructure including rapid chargers, £100 million for ULEV-specific research and development, as well as £30 million for low emissions buses and £4 million for HGV gas refuelling infrastructure.
- Progress has been made putting charging infrastructure in place. OLEV estimate that by the end of June 2014, over 6,300 charge points (CPs) had been provided through the Plugged-in Places (PiP) programme (which provided £30 million of match funding to public-private consortia), of which around 65% were publically accessible, while non-PiP organisations may have also installed about 5,000 CPs nationwide. The majority of these were normal (3-7kW) chargers. Further funding for CPs was announced in February 2013, including rapid and on-street chargers and CPs at train stations, as well as domestic chargers.

- A number of electric vehicle models are now available in the UK, with a range of price-quality characteristics, such that these could penetrate different market segments (Figure 5.18).
- Electric vehicle markets are developing rapidly in some countries. For example, in Norway, EVs represented 6.1% of all new car sales in 2013, almost double 2012's 3.3%, while the Tesla Model S was the biggest selling model, regardless of powertrain, in March 2014. EV market share also virtually doubled in California, from 2.2% to 4.0% of new car sales, contributing to a rise for the US as a whole from 0.8% in 2012 to 1.3% in 2013. Meanwhile, a sharp increase in plug-in hybrid sales in the Netherlands led to growth in EV market share from 1.0% to 5.6% of new car sales in 2013. However, this may have been spurred by a reduction in incentives for plug-in hybrids at the start of 2014, with a subsequent fall in sales.
- Sales of a number of battery (BEV) and plug-in hybrid (PHEV) models over the first three years since introduction have been comparable to those of non-plug-in hybrid electric vehicles, which have subsequently increased rapidly.

Figure 5.18: Availability of EV models in the UK



Source: SMMT data, nextgreencar.com, manufacturer websites.

(b) Forward look

Analysis for our fourth carbon review confirmed that electric vehicles (BEVs and PHEVs) are cost-effective means for meeting carbon budgets. It suggested that EV sales of 60% of new cars by 2030 was achievable, but with a slightly slower ramp-up than our previous assumption. We reflect this in our updated indicator trajectory, with EV sales reaching 9% of new cars in 2020.

However there are both financial and non-financial barriers to achieving significant growth in electric vehicle uptake, which need to be addressed:

- Without subsidy, electric vehicles are currently not competitive with conventional alternatives from a consumer perspective, given heavy discounting of the operating cost savings from EVs. If not addressed, this would present significant and possibly prohibitive economic and political challenges to mass roll out of electric vehicles.
- There is also a set of non-financial barriers which, if unaddressed, would limit growth of the electric vehicle market. These include access to charging, charging time, range constraints (real and perceived), awareness and acceptance, and brand and model availability.
  - **Access to charging**. The majority (around 70%) of new car buyers have access to off-street parking overnight, where the majority of EV charging could take place. Nevertheless, buyers value access to public charging to alleviate range anxiety.
  - **Charging time**. While this is less of a concern for regular overnight charging (using a 'normal' 3-7 kW charge point), buyers value being able to charge quickly if required (e.g. on long journeys).
  - **Range constraints (for BEVs)**. Despite current ranges being more than sufficient for the vast majority of trips, buyers value having the option to complete longer trips if desired. This can be partly addressed by access to public charging facilities. PHEVs do not face the same barrier.
  - **Awareness, acceptance and attitudes**. Awareness and acceptance of EVs is currently low, with only 20% of UK drivers very familiar with their attributes and capabilities[16]. To tackle this, the Government and industry have worked together to develop the 'Go Ultra Low' website and campaign to increase consumer understanding of the EV 'offer', although visibility of the campaign could be improved.
  - **Brand and model availability**. A choice of brands and models is important for achieving high uptake of EVs, given different consumer requirements and preferences, together with typically strong brand loyalty, The supply outlook for the UK is good, with the top ten brands due to be represented by 2015. However, supply varies across vehicle segments and EV types: the outlook for BEVs is better than for PHEVs and better for cars than for vans.

Evidence from other countries suggests that addressing both financial and non-financial barriers can be successful in driving uptake (Box 5.8).

16 European Commission Joint Research Centre (2012) *Attitude of European car drivers to electric vehicles: a survey.*

Box 5.8: EV support in leading markets

Norway and the Netherlands are the leading countries for market share of EVs, at 6.1% and 5.6% respectively.

In both cases, purchase incentives have been complemented with non-financial support for EVs (which also benefit the used car market).

In Norway, in addition to purchase cost incentives for BEVs, which reduce the premium compared to ICE vehicles to around €1,000, non-financial benefits that translate into daily cost or time savings are highly valued (e.g. the ability to access bus lanes and exemptions from paying road and ferry tolls). Awareness and acceptance have been raised by the Norwegian Electric Vehicle Association, a strong and active group in place for over 20 years, while government commitment to EVs is signalled through public procurement activity: the City of Oslo's procurement framework only allows for replacement of municipal vehicles with electric vehicles.

In the Netherlands, EVs enjoy access to a fully interoperable national charging system as well as a comprehensive range of support. This includes non-financial benefits, such as preferential allocation of parking permits, in addition to long-term purchase tax incentives (available until 2018); incentives directed at the company and lease car markets have been particularly effective. The Netherlands has also been innovative in its approach to awareness-raising: in Rotterdam, the Centre for EVs provides members of the public with information and opportunities to test drive vehicles.

Other areas with relatively high EV market shares similarly offer a comprehensive package of support including financial incentives, daily perks and infrastructure provision.

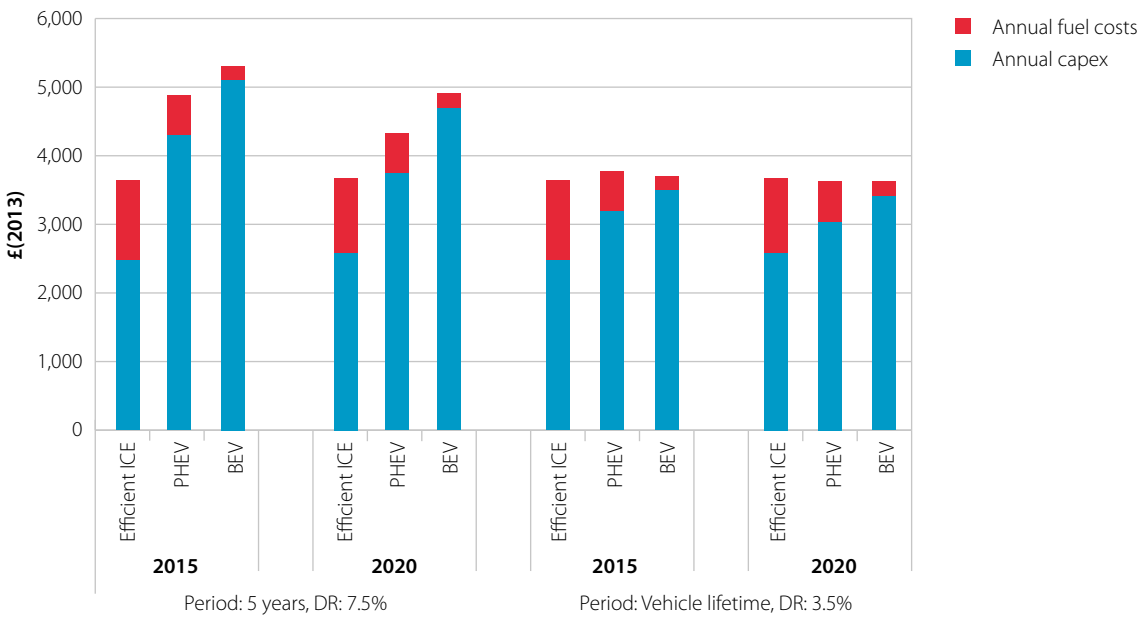
	Market share (%)	Capital incentive (£)	Annual tax exemption	Parking benefits	Zone/road charge exemption	Other benefits	Charge points (Normal + Fast)
Norway	2.86	12,200	✓	✓	✓		4000 + 130
Netherlands	0.77	5,500	✓	✓			4500 + 90
Japan	0.47	6,700					4000 + 1400
USA (state specific)	0.36	3,180		✓		Insurance benefits	14000 + 200
Sweden	0.34	3,900	✓	✓	Stockholm		280
Denmark	0.31	35,000	✓				1100
France	0.3	5,900	✓				1600
Ireland	0.17	5,650	✓				640
Germany	0.12	8,500	✓				2000
UK	0.11	5,000	✓		London		8500

Source: Element Energy et al (2013) Pathways to high penetration of electric vehicles, ICCT (2014) Driving electrification A global comparison of fiscal incentive policy for electric vehicles.

The key to addressing financial barriers is to close the gap between private discount rates/ cost of capital and the social cost of capital/risk free rate. If this gap can be closed, and finance extended over long periods, then subsidy for purchase of electric vehicles could be phased out by the early 2020s.

- The average annual cost to consumers of electric vehicles is relatively high compared to that of conventional vehicles if battery costs are spread over short time periods with high finance costs; but comparable with conventional vehicles when spread over longer time periods with lower finance costs (Figure 5.19).
- This suggests that if ways can be found to reduce the cost of battery finance and spread this out over longer time periods; battery costs fall as expected; and non-financial barriers to uptake are addressed (see below), then subsidy may not be needed beyond 2020.
- There is the opportunity to reduce the cost of finance and spread this over longer time periods (Box 5.9).

Figure 5.19: Average annual costs to consumers of EVs vs conventional cars



Source: CCC estimates based on modelling by Element Energy and Ricardo-AEA.
Notes: 'Period' is period over which battery costs are annuitised; 'DR' is discount rate used for battery. In all cases, the remaining vehicle cost is annuitised over the life of the vehicle using a discount rate of 7.5%. Estimates are for a medium car.

Box 5.9: Reducing EV costs through innovative financing

EVs are cost effective from a societal perspective

- Previous analysis (e.g. for our fourth carbon budget advice) has shown that EVs are a cost-effective option to reduce emissions from a societal perspective. By 2030, total costs for EVs over their lifetime, using a social discount rate of 3.5%, are expected to be lower than those for conventional vehicles when the cost of carbon is included at projected levels. However, the high upfront cost of EVs is likely to remain a barrier to uptake given the way consumers approach purchase decisions.

Capital cost is a potential barrier to EV uptake

- Consumer research consistently shows that car buyers attach more weight to purchase cost than to running costs when choosing a car. This means that the high upfront cost of EVs relative to conventional vehicles (where the additional cost is due mainly to the battery) is set against heavily discounted running cost savings, with most buyers demanding a payback period of five years or less for any additional investment.
- This can be illustrated by comparing the perceived average annual cost of EVs and conventional vehicles. With additional EV (i.e. battery) costs spread over five years (other capital costs spread over vehicle lifetimes) perceived annual costs of EVs are higher than those of conventional alternatives.
- For this reason, there is currently a need for purchase subsidy to reduce the upfront costs of EVs relative to conventional vehicles.

This can be addressed by spreading upfront costs of batteries over longer periods, and to do this through low-cost finance.

- In this situation, the perceived annual costs of EVs would be lower than those of conventional vehicles, as lower running costs of EVs are taken into account over a longer period, removing the need for purchase subsidy

Current finance is short-term and high-cost

- The majority of new cars bought by private consumers are purchased through a Personal Contract Plan (PCP) (similar to a hire purchase agreement but with the option at the end of the contract to pay a final lump sum to purchase the vehicle, or return it), while leasing is the most common financing mechanism for fleets. We commissioned Frontier Economics to investigate financing costs for households (see Box 3.5 in Chapter 3).
- Current PCP finance periods for conventional cars are typically three to five years, with finance rates of around 5-12% APR (real). Directly comparable packages for EVs are very limited[17] but high observed EV depreciation rates suggest that finance costs are likely to be higher than for conventional cars (due to impacts on the expected costs of default).
- An alternative EV ownership model is offered by Nissan and Renault. The car (excluding battery) can be bought or financed through a PCP, while the battery is leased separately, with minimum performance guarantees. Maximum battery lease terms are 72 months; monthly lease rates start at £70. However, information on factors implicit within these rates (battery costs, residual values and lifetimes, as well as interest rates) is not available.

17 Nissan and Toyota currently offer PCP finance for their EV models over 3-4 years at the lower end of the range (4.9%) – the same packages as offered for their other conventional models. However, it is difficult to draw robust conclusions from current examples which are likely to be affected by the availability of the Plug-In Car Grant.

Box 5.9: Reducing EV costs through innovative financing

However, there is scope to change this

- In both cases there is scope to reduce costs, by ensuring finance providers spread battery costs over long periods (e.g. towards vehicle lifetimes) and do this at as low a rate of interest as possible.
- Long-term battery guarantees from manufacturers could allow battery costs to be spread over vehicle lifetimes. Battery warranties are already a feature of the EV market (the Plug-In Car Grant is conditional on minimum performance guarantees), but warranty periods are currently less than vehicle lifetimes.
- Frontier Economics found that interest rates are expected to fall over time as the EV market matures, but there may be case for intervention in the near term
  - Over time, as both real technology risks and the misperception of technology risks reduce with increasing experience, EVs should be available at rates at least comparable to those for conventional vehicles. (Long term battery guarantees could aid this by transferring performance risks to manufacturers, who often have a better understanding of these risks and, in some cases, are better-placed to manage them than finance providers.)
  - There is a case that EVs could be made available at lower rates than those for conventional vehicles, given batteries may be expected to depreciate more slowly.
  - For those people choosing to buy the car (excluding battery) outright, there could be further scope to reduce battery finance costs by using the car as additional collateral.
  - However, there may be a case for intervention in the short term, if misperception of the technology risks and the immaturity of the EV market are observed to drive up the cost of capital

Government and industry should therefore work together to stimulate/develop finance packages which address current market failures around both the length of finance periods and the cost of capital. This might include a possible role for the Green Investment Bank. The Government should recognise this and consider how to phase out EV subsidy and whether there is any benefit in announcing this in advance (e.g. in stimulating manufacturers to develop financing packages).

The potential also exists to reduce finance costs further by stimulating the secondary market for batteries, e.g. through developing the market for stationary energy storage applications and providing clarity over battery residual values.

Finally, it is important to acknowledge that battery leasing represents a change in the way people pay for vehicles, especially in the second hand market and may therefore face barriers to uptake which would need to be addressed in order for finance packages involving such changes to be successful. Such barriers could be addressed through marketing and information strategies and developing consumer trust over innovative payment options. This could apply to other ownership models beyond battery leasing.

There are a number of options for addressing non-financial barriers, including further investment in charging infrastructure; developing approaches to large scale charging on-street; providing incentives for car manufacturers to heavily market electric vehicles and thereby change consumer perceptions, and offer packages which address range constraints; and supporting softer measures which can compensate for any remaining real or perceived barriers.

- **Infrastructure investment.** While overnight home/workplace charging is the most cost-effective solution for EVs, there is still a need for a public charging infrastructure to alleviate barriers associated with range and charge time on longer journeys.
  - Analysis for our fourth carbon budget review suggested this could be most efficiently provided through a relatively limited network of rapid chargers, rolled out between from an initial seeding in urban areas and connecting trunk roads, and reaching 500 sites (1000 CPs) by 2020 and c.2000 sites (20,000 CPs) by 2030. The network to 2020 could be achieved within currently committed spending (i.e. the £32 million announced by OLEV as part of its £500 million package, combined with existing and planned installations to March 2015[18]).
  - Public investment in rapid charging infrastructure is appropriate while EV penetration remains low. Further, it offers a lever to ensure that rapid CPs are strategically located to maximise range-extending benefits, and that they are easy to use, easy to find, and offer easy access and payment options. To enable this, Government and industry should work together to develop a common rapid charger data platform. For the longer term, as EV uptake grows, Government should support the private sector in developing new business models/service providers to deliver rapid charging services.
- **Widespread on-street residential charging.** It will be very hard to achieve required levels of market development if this is restricted only to household with off-street parking. For example, if 60% of all vehicles purchased in 2030 are to be electric, and around 70% of households have off-street parking, then nearly every household with off-street parking would have to buy an electric vehicle. Therefore it is important to develop approaches which would allow charging for households without off-street parking; these approaches should be for slow, overnight charging, so as to contain costs and demands on the power system. For example, Local Authorities could be incentivised to provide dedicated parking spaces on-street next to charging posts.
- **Providing incentives for car manufacturers.** A large element of the current non-financial barriers to electric vehicles relate to consumer perceptions These are changeable through marketing, subject to the product being marketed having at least comparable quality to alternatives already in the market; and through putting together packages which address range constraints for pure Battery Electric Vehicles (as opposed to Plug-in Hybrids), for example, through offering car club membership which could be used for longer journeys. Car manufacturers are best placed to lead on these types of activities, but need stronger incentives. The strongest lever for incentivising vehicle manufacturers to push electric vehicles at scale would be an EU target for new car emissions that requires significant market penetration of electric vehicles. For example, our analysis suggests that an EU target to reduce new car emissions to 60 g/km by 2030 would reflect required electric vehicle market development together with scope for further efficiency improvement in conventional vehicles.

18 There will be a rapid chargepoint at every motorway service station in the UK by the end of 2014 and a network of over 500 rapid chargers across the country by March 2015 if planned installations are delivered.

- **Softer measures.** Evidence from other countries has shown that electric vehicle uptake can be cost-effectively supported through time-limited non-financial measures which are valued by consumers, such as free/preferential access to parking and bus lanes. Non-financial measures also have the advantage of playing a role in supporting the used EV market. The £35 million city scheme competition announced as part of OLEV's funding package for 2015 to 2020 is therefore welcome in encouraging cities to provide such measures and leading the way for other areas of the country. The allocation of £20 million to support ultra -low emissions taxis is also positive, as a means of increasing exposure to EVs for a potentially large number of people; trials have shown consistently positive responses from people given direct experience of EVs. There is also an opportunity to help raise awareness and acceptance of EVs through public procurement. As significant fleet buyers, local and national government can, through their procurement, materially impact the number of EVs visible on the roads, as well as leading by example for other fleet buyers.

If financial and non-financial barriers can be addressed, then very significant growth of electric vehicle (car and van) markets can potentially be achieved. For example, cumulative sales of over 11 million by 2030 would be feasible given an increasing range of availability of models, longer range and falling costs in line with our modelling, together with the measures above.

Given the importance of electric and other ultra-low emission vehicles in the context of wider economy decarbonisation, the Government should:

- **Push for stretching EU targets for emissions of new cars and vans for** 2030 in the context of negotiations around the overall 2030 EU emissions reduction package; these should take account of the scope for improving efficiency of conventional vehicles and the need to achieve greater take-up of electric vehicles (EVs) and other ultra-low emissions vehicles (ULEVs).
- Work with partner organisations (e.g. industry, local authorities, the Green Investment Bank) to **tackle financial and non-financial barriers to electric vehicle uptake** by providing: new, low-cost approaches to financing; on-street residential charge points and a national network of rapid charge points; softer time-limited measures such as access to bus lanes and parking spaces.
- If a strong EU target is agreed and/or if financial and non-financial barriers are tackled there would be scope to phase out the existing capital subsidy for electric vehicles. The Government should **consider how to phase out EV subsidy and whether there is any benefit in announcing this in advance** (e.g. in stimulating manufacturers to develop financing packages).

While a failure to develop electric and other ultra-low emission vehicle markets would raise costs and risks of meeting carbon budgets, this set of actions would allow carbon budgets to be met in a cost-effective way.

(iii) Progress on hydrogen fuel cell vehicles

Hydrogen fuel cell electric vehicles (FCEVs) are not yet commercially available. However, models are expected to be introduced to the market from 2015 and could offer a useful complement to BEVs and PHEVs, particularly for more demanding duty cycles, including vans.

In addition to hydrogen vehicles, a hydrogen transport system requires production capacity and infrastructure for distribution and fuelling. We have previously identified the need for a coordinated approach to provide confidence in the parallel development of these elements, thereby reducing risks to investors, and ensuring that sufficient incentives are in place for research and development.

UKH2Mobility, a joint Government-industry project evaluating the potential of hydrogen as a transport fuel in the UK, aims to provide this coordinated approach. Findings from Phase 1 of the project were published in April 2013.

- Based on industry cost and supply data, together with consumer preference research, they suggested that annual sales of 300,000 per year (c. 10% market share) could be achieved by 2030 as vehicles become cost-competitive and the hydrogen refuelling network develops.
- An initial network of 65 hydrogen refuelling stations across the UK, covering major population centres and the connecting roads, could provide sufficient coverage for the early market in 2015, rising to 1,150 stations by 2030.

Subsequently, the Government's strategy for ultra-low emission vehicles[19], published in September 2013, committed to exploring options for grant funding to support industry's investments in the initial refuelling network, as well as working with industry to identify and resolve outstanding practical issues around the refuelling and use of hydrogen FCEVs (e.g. the quality assurance process for hydrogen). These have been the subjects of Phases 2 and 3 of UKH2Moblity. Phase 2, focussed on business case development, reached its conclusion early in 2014, while Phase 3, focussed on implementation planning, is underway.

As part of its recent announcement on the £500 million funding package for ULEVs, the Government has committed to set out, no later than autumn 2014, the actions that both Government and industry stakeholders will take to position the UK as a lead market for the introduction of hydrogen fuel cell vehicles. It also confirmed that the Plug-in Car Grant would continue to be technology-neutral and therefore available for FCEVs alongside other vehicles with ultra-low emissions.

While our scenario for meeting carbon budgets does not specifically include hydrogen fuel cell cars and vans, it is important that this option is kept open as part of a package of solutions for reducing transport emissions.

19 OLEV (2013) *Driving the Future Today A strategy for ultra-low emission vehicles in the UK.*

(iv) Biofuels in surface transport

(a) Progress to date

Despite being on track with our indicator for most of the first carbon budget period, biofuel penetration fell below our indicator in 2012 and 2013, largely as a result of changes in the accounting rules for more sustainable biofuels

- In 2013 biofuel penetration reached 3.5% by volume, 1.5 percentage points short of our indicator. This reflected double-counting of waste-derived biofuels, residues and advanced biofuels introduced in the RTFO in 2012, following an EU move to encourage feedstocks with a lower risk of indirect impacts, and the fuel duty differential for used cooking oil (UCO) and waste-derived biodiesel which was in place from April 2010 to April 2012.
- There has been a move towards more sustainable feedstocks from oil seed rape, soy and sugar to used cooking oil (UCO) and corn. This resulted in a shift in the fuel of choice from biodiesel to bioethanol, from 18% to 59% over the carbon budget period, and higher estimated GHG savings delivered – from -6% in 2008/9 to 56% in 2012/13 including estimated indirect land use change (ILUC) impacts.
- The additional incentive provided by double-certification of second generation biofuels has had little impact on investment in advanced biofuel production capacity in the UK.

The growth in biofuels has been the main driver of the increasing share of renewable energy in transport across the EU. Between 2007 and 2011, this grew slightly faster in the UK than the EU-28 average, but this was from a lower base, and deployment remains lower than the EU average. Sweden stands out among EU countries – its share of renewable energy is twice as high as any other member state and it has seen the fastest growth, driven by a target for 100% clean vehicles by 2030; a major research programme for second generation biofuels; tax exemption for green cars; and subsides for filling stations that dispensed biofuels.

An Ecofys[20] (2010) report suggests that the vast majority – over 90% – of biofuels deployed in the EU in 2010 were compliant with EU sustainability criteria (which currently exclude ILUC impacts). It estimates that the GHG savings from EU biofuel use is 53-60% compared with the fossil fuel equivalent. This is in line with the UK estimate for that period – nearly 60%.

In last year's progress report, we highlighted the uncertainty being caused by failure to reach EU agreement on how the biofuels target can be met and how ILUC impacts should be addressed. There has been some recent progress in this area, making it more likely that an agreement can be reached this year (Box 5.10). The primary concern for biofuels is that they are sourced from sustainable feedstocks, and the proposal for suppliers to report on ILUC impacts should be seen as a first step towards their full inclusion in EU sustainability criteria.

20 Ecofys (2010) *Renewable energy progress and biofuels sustainability* http://ec.europa.eu/energy/renewables/reports/doc/2013_renewable_energy_progress.pdf

Box 5.10: Changes in the EU policy climate since last progress report

In our 2013 Progress Report, we reported on European Commission proposals to minimise the carbon impacts of biofuels. These included a limit on the amount of food and crop-based biofuels; the inclusion of ILUC factors when calculating GHG savings from biofuels counted under the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD); and incentives for biofuels with no or low indirect land use change emissions, in particular advanced biofuels produced from feedstocks that do not create additional demand for land.

Towards the end of last year, the European Council failed to reach agreement on these issues. More recently in June this year, the Council of Ministers agreed an EC proposal to limit to 7% the contribution of biofuels made from food crops towards the 10% RED transport sub-target. The agreement also requires countries to set an advanced biofuels sub-target with 0.5% as a 'reference value', although governments can also set a lower target if they can explain why according to specified criteria. Double-counting of advanced feedstocks and renewable electricity from road and rail was also extended to the RED target but not to the FQD. The provisional agreement does not propose to take account of indirect land use change impacts – a key factor in assessing biofuels' sustainability. Instead, the proposal mandates only their reporting.

The new EU Parliament now has four months to consider the proposal and to put forward any amendments, after which the proposals will be adopted.

(b) Forward look

The RTFO obligation level remains at 4.75% (by volume) from 2013/14 onwards, pending conclusion of the EU negotiations. Many respondents to the recent government consultation on the post-implementation review of the RTFO[21] highlighted the hiatus in investment in this sector given the on-going uncertainty around the EU negotiations. Given recent indications that EU agreement could soon be reached, the Government should act swiftly to set out the future direction of policy in this area, including additional measures to meet carbon budgets should these be required.

Investment in advanced biofuel facilities requires a longer term certainty and confidence and we welcome the £25 million of capital funding for demonstration-scale advanced biofuel plant announced last year, and options to incentivise advanced biofuels once EU policy framework resolved. These include an additional support mechanism for advanced and more sustainable fuels and options to provide more certainty to suppliers such as a price floor for RTFO certificates.

4. Progress in changing travel behaviour

(i) Smarter Choices

(a) Progress to date

Smarter Choices aim to influence our choices of transport mode, with the goal of reducing car travel. They include: travel plans (e.g. workplace, school, residential), information to support public transport services, promotion of cycling and walking, car sharing schemes, teleworking, cycle training and marketing events. Measures are mostly delivered through local authorities.

21 DfT (2014) *Post-implementation review of the Renewable Transport Fuels Obligation: summary of responses and government response.*

Between 2007 and 2013, Smarter Choice options have been promoted through a range of schemes. These include the Sustainable Travel Towns pilot (which ran in 3 areas between 2004 and 2009) and Local Authorities' own initiatives such as those to promote car sharing, and raise awareness of alternative travel choices.

The largest initiative to promote Smarter Choices nationally is the Local Sustainable Travel Fund (LSTF). This pools central and local government funds to promote and evaluate sustainable travel measures, including infrastructure development, and is due to run until 2015/16.

- The LSTF is providing £600 million in funding, matched by £535 million from Local Authorities (LAs). Around 60% of funding is allocated to behavioural measures with the rest allocated to capital measures such as creation of cycle corridors and cycle storage or the upgrading of bus station facilities.
- Although precise comparisons are difficult, we estimate that average funding under the LSTF, including local contributions and capital funding, is around £10 per head per year (2013 prices). This is slightly lower than funding in the 'Sustainable Travel Towns' pilot scheme of around £12 per capita, per annum (2013 prices), but still significant.
- Currently 77 LAs are involved, accounting for around 70% of the population in England. DfT estimate that around 95% of the population of England is reached in some way through interventions. Projects cover both rural and urban areas.
- Local Authorities are required to produce annual reports from all schemes. However, only the twelve largest schemes (over £5m) are required to submit outcome reports which include details on progress towards reducing emissions; in-depth evaluation is limited to a small number of case studies.

Evidence of the effectiveness of these measures is patchy. The Sustainable Travel Towns pilot led to a reduction in short distance (<50km) car trips of 5-7%, though it is unclear if this was sustained over time. Smarter Choices measures delivered through LA's own initiatives were generally perceived to be effective but there is little information on overall coverage, extent and lasting impacts of measures. It is too early to evaluate LSTF schemes.

Evidence from other countries suggests measures such as those being funded through the LSTF can have an impact. In the Netherlands for example, 28% of all trips in 2012 were made by bicycle, with 17% in Denmark and less than 2% in the UK. Cycling in Holland and Denmark has been encouraged through the provision of safe and convenient cycling routes alongside developments of cycling rights of way, bike parking, traffic education, public events and integration with public transport. Concurrent measures to discourage car travel such as low car speed limits in cities, reducing road and parking capacity, placing higher taxes on car use and introducing strict land-use policies may also have helped.

(b) Forward look

Our scenario for the fourth carbon budget assumes nationwide roll-out of Smarter Choices measures by the third budget period, delivering a 5% reduction in total car-km compared to a business as usual scenario.

The LSTF is expected to remain the main policy targeting delivery of Smarter Choices measures in England up until 2015, with the Local Growth fund scheduled to provide funding in 2015-16. A variety of complementary projects also exist, a number of which are set out in DfT's Door to Door strategy and are also expected to contribute to reducing personal vehicle travel/encouraging modal shift from road.

- Bidding has recently closed to the Local Growth Fund which will provide £100 million in capital funding and £78.5 million in revenue funding towards sustainable travel initiatives in 2015/16. As with the LSTF this is expected to leverage Local Authority contributions (set at a minimum of 10% for revenue-only schemes and 30% for capital and revenue schemes).
- The Door to Door strategy published by DfT in 2013 brings together a variety of policies aimed at encouraging sustainable travel over a number of legs from journey start to final destination. It aims to tackle perceptions of inconvenience and high cost of public transport through provision of better information, better transport facilities, convenient connections and tickets covering all modes in a journey.

Government emissions projections assume that the LSTF contributes a 2% reduction in UK emissions in 2015, with savings declining over time after the scheme ends. This assumption appears sensible given the available evidence, notwithstanding uncertainties.

However, it also emphasises the potential need for additional and continued funding to achieve the reductions in car travel assumed in our scenario for meeting carbon budgets. Given further evidence from monitoring and evaluation of the LTSF, a decision on extending funding, both in time and coverage, should be taken as soon as possible. In the event that the LTSF is found to be less effective than anticipated and/or additional funding not provided, alternative measures for reducing emissions will need to be found.

(ii) Eco-driving

(a) Progress to date

Eco-driving can help drivers maximise fuel efficiency, through a range of techniques such as smooth acceleration, appropriate use of gears and speed, anticipating traffic conditions, using engine braking, and turning off the engine when stationary. Our indicator framework includes a trajectory for the number of drivers trained in eco-driving, reaching 2.8 million car drivers and 100% of all HGV drivers in the second carbon budget period. Evidence suggests current training levels are well below this trajectory.

- The Energy Saving Trust offers a key eco-driving training route for car and van drivers. 29,810 car and van drivers were trained under EST's programme between 2009 and 2012, compared to our indicator of 1.66 million over the same period. A further 3,056 drivers were trained in 2013 (compared to our indicator of 341,000) – a fall on the previous year.
- Other training routes do exist (e.g. through the Royal Society for the Prevention of Accidents), and a number of eco-driving techniques are taught to new learner drivers, but overall numbers are likely to be well below our indicator.
- Uptake amongst HGV drivers is higher, with eco-driving training contributing to drivers' mandatory Certificate of Professional Competence (CPC) requirement. Data from the Driving Standards Agency (DSA) suggests that a minimum of 37,000 eco-driving type courses were completed by HGV and PCV drivers in 2013/14. Approximately 60% of operators in the Logistics Carbon Reduction Scheme (LCRS) reported they regularly provide eco-driving training to their HGV drivers, with over 70% actively involved in monitoring fuel consumption.

A recent study by the RAC Foundation[22] suggests fuel consumption savings of 5-10% can be achieved through such training, but that benefits from eco-driving training decline over time unless they are reinforced.

Eco-driving behaviour can be encouraged through the use of technologies.

- Gear Shift Indicators (GSIs) have been mandatory for new models of cars sold in the EU since November 2012 and will be mandatory for all new cars from November 2014. The European Commission[23] estimate fuel savings of around 7% per vehicle from use of GSIs if they are actively used, with 1.5% savings across the fleet as a whole, given some drivers will not use them, and others may return to previous driving habits with time.
- Fuel Consumption Meters (FCMs) can also be effective in encouraging efficient driving. However a recent proposal to mandate their installation in new cars was rejected by the EC, despite a recent impact assessment produced by the Commission recommending their implementation (Box 5.11).

22 RAC (2012) *Easy on the Gas The effectiveness of eco-driving.*

23 EC (2014) *COMMISSION STAFF WORKING PAPER IMPACT ASSESSMENT Accompanying the document Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulations (EC) No 715/2007 and (EC) No 595/2009 as regards the reduction of pollutant emissions from road vehicles.*

- Telematics systems in passenger cars are increasingly being used by insurance companies to monitor driving styles. While the main focus of these is safety, systems typically record metrics which affect fuel consumption (e.g. speed, sharpness of acceleration and braking), which are presented to the driver, often with advice on how to improve their driving. The British Insurance Broker's Association estimate that by the end of 2013 there were 296,000 insurance policies with a telematics element in the UK, up from only 12,000 in 2009.
- In the freight sector monitoring technologies such as telematics are increasingly used to provide feedback to the driver and fleet managers on driving style. In 2004, 4% of HGV drivers had Fleet Management Systems compared with 11% in 2010[24].

Box 5.11: EC Impact Assessment on Complementary Measures

An EC report[25] released this year assessed the efficacy and costs of Gear Shift Indicators (GSI) and Fuel Consumption Meters (FCM). This estimated fuel savings per vehicle of 7% for GSI and between 1.5–5% for FCMs, based on results of a TNO study. Estimated savings for the fleet were lower -1.5% for GSIs and 0.3 – 1.1% for FCMs – taking account of drop-off rates over time. This assumed that 30% of drivers adapt their behaviour in response to these aids, and 75% of these drivers continue to do so long term.

Upfront costs of these technologies relate mainly to the need to redesign the dashboard, with costs per vehicle estimated at €0–€10 for FCMs and €0–€7 for GSIs in the long term, although in the short term costs could be up to twice this. Even under cautious assumptions, these measures would be cost effective for drivers.

The Impact Assessment identified two preferred options:

- The introduction of mandatory fuel consumptions meters for light duty vehicles; and
- Extending the mandatory installation of gearshift indicators from passenger cars to all light duty vehicles

Despite this a decision was taken by the EC in early 2014 not to mandate fuel consumption meters in new cars.

(b) Forward look

The EST's training programme remains the main formal training route for car drivers. While planned changes to marketing and delivery may lead to increased uptake, this is still likely to fall short of our indicator trajectory given that funding is available for just 8,500 course places.

Technology is expected to play an important role in delivering future savings from efficient driving, with the implementation of mandatory GSIs in new vehicles contributing to this. There also remains potential for emissions reductions from FCMs; the Government should push for these to be reconsidered as part of negotiations around the EU's 2030 package and within this new car CO_2 targets for 2030.

In the freight sector, commercial pressures are likely to remain the key incentive to encourage fuel efficient driving. Technology based solutions, which are growing in sophistication (for example systems can advise on appropriate speeds given road gradients tailored to specific HGVs) have the potential to support good practice. Take-up of these technologies should be closely monitored to ensure this sector is taking up opportunities to deliver efficiency and carbon savings.

24 Numbers reflect positive responses only. Non responses and negative responses cannot be distinguished.
25 See footnote 23.

(iii) Enforcing the speed limit

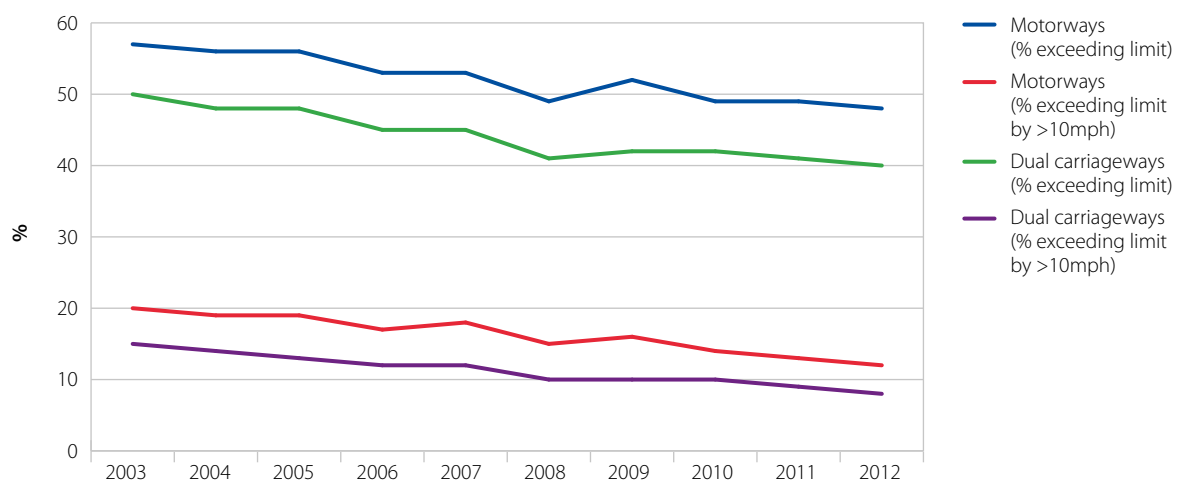
(a) Progress to date

Lower air resistance associated with travelling at 70 mph vs. 80 mph can reduce car emissions by 10-20%, given increases in fuel consumption above certain speeds. There was a reduction in speeding over the first carbon budget period, albeit from a high base, a trend which continued in 2013 (Figure 5.20).

- Between 2007 and 2012, the proportion of car drivers exceeding the 70 mph speed limit during free-flow conditions[26] fell from 53% to 48% on motorways and from 45% to 40% on dual carriageways. Speeding by van drivers also fell, from 51% to 49% on motorways and from 45% to 42% on dual carriageways.
- Speeding by car drivers continued to fall in 2013, declining to 47% on motorways (39% on dual carriageways), while speeding by van drivers fell to 48% on motorways (41% on dual carriageways).

However, the factors behind this are not clear: there do not appear to have been significant changes in the enforcement of speed limits (e.g. the number of operational fixed speed cameras actually declined slightly between 2010 and 2012), while concurrent falls in speeding on 30 and 40 mph roads over the first carbon budget period suggest limited concerns over fuel efficiency (below around 50 mph, fuel efficiency declines again with reducing speed)[27].

Figure 5.20: Speeding rates on motorways and dual carriageways (2003-2012)



Source: DfT Free flow vehicle speed statistics.

26 Located away from junctions, hills, sharp bends and speed enforcement cameras.
27 See footnote 22.

(b) Forward look

Our scenario for meeting carbon budgets assumes that there is no breaking of the 70 mph speed limit from 2013.[28]

Future speeding trends are likely to be influenced by speed limit enforcement as well as congestion, fuel costs, and societal attitudes towards those breaking the speed limit. However, the precise impacts of these factors on future levels of speeding are difficult to estimate, especially as recent historical reductions in speeding are not well understood.

If the average annual percentage reduction in speeding observed over the first budget period is simply extrapolated, this suggests that elimination of speeding would take much longer than our scenario assumes and could add emissions of around 1.5 $MtCO_2$ in 2020 – falling to 1 $MtCO_2$ in 2030 as efficiency of vehicles improves and uptake of EVs increases.

This would be made worse by any decision to increase speed limits which should not be done unless there is clear evidence of economic benefit when accounting for carbon and other costs.

(iv) Freight logistics

(a) Progress to date

HGV operators currently have a strong incentive for efficient fuel consumption given fuel costs make up between 20-24% operators' annual costs, with the highest percentages observed for heavier HGVs[29]. Rising diesel prices, which were almost 40% higher in real terms in 2012 than at the end of 2007, provide a further push for freight companies to reduce their fuel consumption.

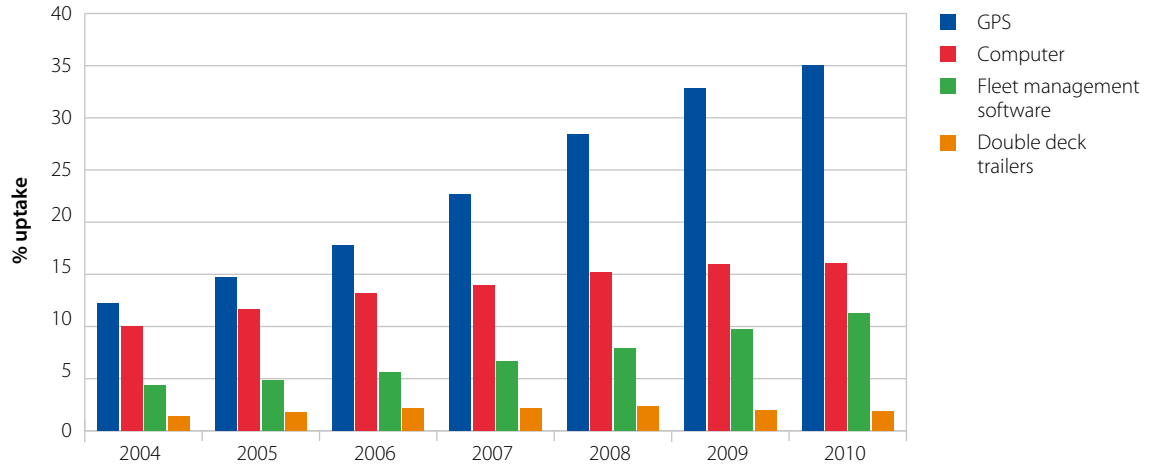
Fuel consumption can be reduced by increasing the efficiency of freight operations – reducing distance travelled (while moving the same goods between the same origins and destinations) and/or increasing the fuel efficiency of vehicles used.

Measures which have the potential to reduce distance travelled by road include measures to improve routing, improve vehicle fill, and the shift of freight from road to rail or water. There is evidence of an increasing use of these measures amongst operators:

- **Improving routing**. Evidence[30] suggests that between 2003 and 2010 the proportion of vehicles fitted with on-board computer systems, GPS systems and/or telematics in the freight sector grew sharply, increasing year on year for all measures in all years (Figure 5.21).

28 Whilst it is recognised that zero speeding is unenforceable, speeding rates should be reduced to as low rates as practicable.
29 http://www.fta.co.uk/policy_and_compliance/fuel_prices_and_economy/fuel_prices/fuel_fractions.html (accessed June 2014).
30 DfT (2012) *Continuing Survey of Road Goods Transport (CSRGT).*

Figure 5.21: Use of technology measures in freight logistics (2004-2010)



Source: (DfT) Continuing survey of road goods transport.

- **Improving vehicle fill.** Vehicle lading can be increased through, for example, use of double deck trailers, back-loading of deliveries, use of consolidation centres, and horizontal collaboration between operators. Data show that uptake of double deck trailers amongst articulated vehicles increased between 2004 and 2010, from 2.7% of vehicles to 4.1%. Over the same period, empty running increased by 7.1% while average lading factors simultaneously grew by 3.5%. Within the voluntary Low Carbon Reduction Scheme, over 70% of members have taken action to improve vehicle fill on laden trips, over 50% have made greater use of double deck/high cube vehicles, and just under 40% have consolidated loads on longer and/or heavier vehicles[31].
- **Modal shift.** Over the first carbon budget period, the proportion of total freight moved by rail increased by one percentage point to 12.1% while road freight's share fell by a corresponding amount. Despite the growing share in t-km, freight train movements fell by 17% between 2007/08 and 2012/13, suggesting a move towards longer and heavier trains.

One driver of progress in improving freight logistics has been the industry-led Logistics Carbon Reduction Scheme (Box 5.12), which has a target to reduce emissions intensity of operations by 8% between 2010 and 2015. To date progress against this target has been strong, with reductions in both unnecessary distance travelled, and average emissions intensity per vehicle km:

- In 2011, around 2% vehicle kms were saved, with reduction in empty running cited as accounting for the greatest amount of avoided km, followed by use of telematics to optimise vehicle routing, and relocation of distribution centres.
- Average gCO_2/v-km fell 7% between 2007 and 2012. Measured using this metric, the scheme is on track to deliver its emissions intensity target in 2014, one year ahead of schedule.

31 LCRS (2013) *Logistics Carbon Review.*

In their 'Freight Carbon Review' published in 2013, DfT committed to maintaining a voluntary approach to emissions reductions in the freight sector, whilst ensuring that *'all parts of the industry are taking the actions that we know to be effective in reducing emissions'*.

With regard to modal shift, in recent years, there has been investment in upgrading the quality of rail freight services, by Network Rail and operators, including through improving geographic coverage, goods tracking and temperature conditioning, which are often cited as barriers to shift from road to rail freight.

Box 5.12: The Logistics Carbon Reduction Scheme (LCRS)

The LCRS is a voluntary carbon reporting scheme run by the Freight Transport Association (FTA). Formed in July 2010, it had an initial complement of 37 members representing around 37,000 commercial vehicles. By July 2014 it had grown to 100 members (c. 0.1% of operators) covering over 66,000 commercial vehicles, of which approximately 70% were HGVs (c 10% of HGVs).

The LCRS has a collective target to reduce emissions intensity by 8% between 2010 and 2015; this compares to 5% adopted by government for the sector as a whole. The target was initially set based on estimates of abatement potential from the Logistic Industry Survey 2011, which surveyed FTA members, in addition to a parallel survey of LCRS members. Work on a post-2015 target for LCRS members is expected to commence at the end of this year.

Whilst all scheme members are expected to implement measures to reduce their emissions, the LCRS target is based on the scheme average and is not binding on individual members. Within the scheme, CO_2 intensity is recorded in a number of different ways (per GVA, per FTE, per member, per vehicle km). In their 2014 annual report the LCRS state that on an emissions per vehicle kilometre basis they expect to meet their emissions reduction target for 2015 one year early.

(b) Forward look

Our scenario for meeting carbon budgets includes a 6.5% reduction (relative to a business as usual scenario) in HGV km by 2030.

The LCRS is likely to remain a driver of progress, but with uncertainty around its reach, particularly amongst smaller operators.

- The existing LCRS target ends in 2015, but consultations are planned on extending the target. Strong progress to date gives some confidence that future targets will be met amongst members.
- However, the LCRS covers only a proportion of the sector (0.1% of operators and 10% of HGVs), and its membership is not representative of the sector as a whole. Current membership is skewed towards larger operators with an average fleet size of around 500 vehicles, compared to an average of 5-6 across the sector.

Beyond the LCRS there are a number of initiatives in place which could help operators reduce fuel consumption and emissions.

- Network Rail are investing £206 million between 2014 and 2019 towards rail freight expansion in England and Wales, while a £31 million allocation for Strategic Freight Enhancements has been announced in Scotland. The development of High Speed Two is expected to reduce passenger demand on the West Coast Mainline, leading to capacity for running an extra 80-85 freight trains per day between London and Rugby.
- OLEV, through the Low Carbon Vehicle Partnership, are currently working with industry to set up a scheme for accreditation of technologies which have the potential to reduce HGV fuel consumption[32]. This aims to address the informational barrier to uptake, and may be particularly useful for smaller operators without the resources to carry out in-depth research or trial prospective technologies.

It is important that the Government continues to monitor and appraise the success of the current voluntary industry-led approach to reducing emissions within the freight sector. Scope for additional intervention should be considered if necessary, particularly in encouraging engagement amongst sections of the industry which face greater barriers to reducing emissions (e.g. smaller operators).

(v) Other policy developments

National networks

In December 2013 government set out its vision of future policy on significant transport infrastructure projects under its National Policy Statement for National Road and Rail Networks (NN NPS). The focus of the consultation is on strategic infrastructure projects as defined under the Planning Act and relates mainly to motorways, main roads and important rail infrastructure (freight interchanges, and rail network excluding High Speed Rail 2). A final NPS will be published by the end of the year.

It is important that the transport business case to be included in the application for development of road and rail networks takes full account of carbon impacts; decisions to proceed with these should be based on an economic assessment that fully values the impact of carbon emissions.

32 http://www.lowcvp.org.uk/projects/commercial-vehicle-working-group/hgv-accreditation-scheme.htm

5. Progress in reducing emissions from aviation and shipping

Recent developments in aviation and shipping policy at the international, EU and UK levels reflect a continuation of approaches developed over the first carbon budget period:

- **International** – In October 2013 the International Civil Aviation Organisation (ICAO) agreed a roadmap at their General Assembly for a market-based measure to control global aviation emissions, to be decided at their 2016 General Assembly and to come into force in 2020. The International Maritime Organisation (IMO) continues to support implementation of the Energy Efficiency Design Index, agreed in 2011 and which entered into force in 2013.
- **EU** – In April 2014, following the ICAO's agreement at their General Assembly, the EU agreed to extend the "stop-the-clock" period for aviation in the EU ETS. This means that the exemption of non-EU flights will continue until 2016 (i.e. only intra-EU flights are covered). In June 2013 the European Commission proposed a new strategy for addressing shipping emissions. The first stage proposes monitoring, reporting and verification of shipping emissions from 2018 for ships using EU ports. This will help build a baseline for future stages, with reduction targets and market mechanisms envisaged in the medium to long-term.
- **UK** – In December 2013 the UK Airports Commission released their Interim Report on future UK airport capacity. This recommended the need for an additional runway in the south east by 2030. This approach can be compatible with long-term objectives, if aviation demand growth is limited to around 60% above 2005 levels and provided that there are significant improvements in carbon intensity of flying (e.g. of around one-third by 2050) (Box 5.13).

In future both aviation and shipping emissions are projected to continue to rise absent further measures but can be reduced through a combination of fuel efficiency improvements, use of biofuels, and, in aviation, demand moderation to around 60% market growth by 2050. In our 2012 advice on inclusion of international aviation and shipping in carbon budgets, we agreed that appropriate planning assumptions for 2050 were for aviation emissions to be at around 2005 levels and for shipping emissions to be around one-third lower than 2010 levels. More ambitious international policies, beyond those already agreed, will therefore be required to unlock the full range of abatement potential required.

To monitor annual progress, including towards these long-term objectives, we have developed – mirroring our approach for other sectors – a set of indicators for aviation and shipping. These summarise changes in aviation and shipping emissions, and the key drivers of these changes including demand and efficiency (Tables 5.4 and 5.5). We would welcome feedback on these indicators and will be further developing the evidence base underpinning them over the next year.

Box 5.13: The Airports Commission and future UK airport capacity

In September 2012 the Government established the Airports Commission to advise on future need for airport capacity in the UK. The Commission was asked to provide an interim report by the end of 2013 and final advice by summer 2015.

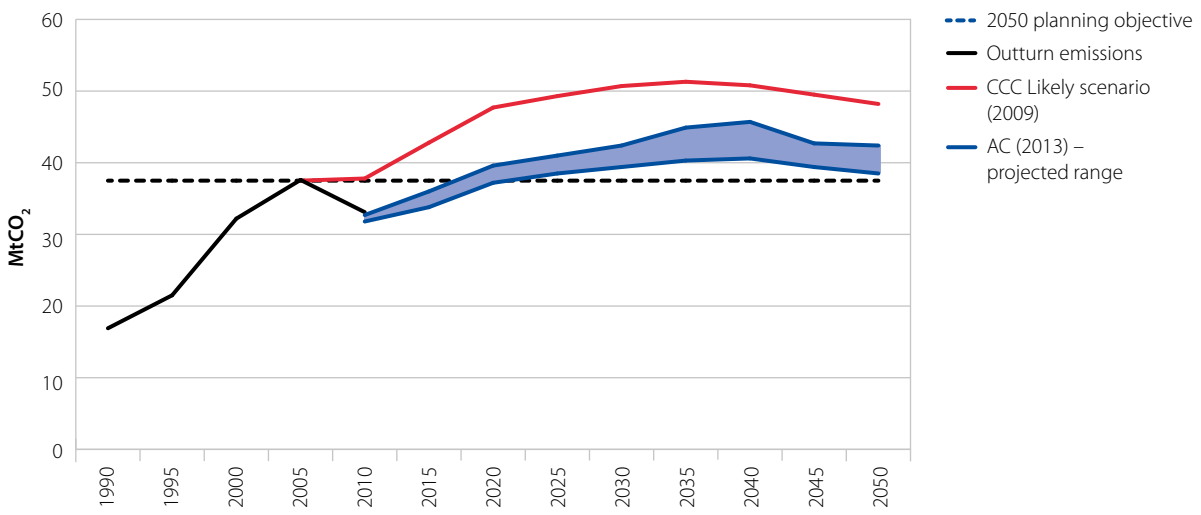
The Committee on Climate Change (CCC) wrote to the Commission in July 2013[33], highlighting that:

- Aviation emissions are included in the target to reduce economy-wide emissions by at least 80% in 2050 on 1990 levels, as set in the Climate Change Act.
- CCC analysis has illustrated how an 80% reduction could be achieved by returning aviation emissions to around 2005 levels in 2050, and reducing emissions in other sectors by 85% on 1990 levels.
- Returning aviation emissions to around 2005 levels in 2050 is possible through a combination of limiting demand growth to around 60% on 2005 levels, and significant reductions in carbon intensity[34].
- Given the need to limit aviation demand growth in a carbon constrained world, this should be reflected in economic analysis of infrastructure investments. For example, these should assess whether investments still make sense where demand growth is limited to around 60%.

In December 2013 the Airports Commission released their interim report[35], which:

- Recommended the need for an additional runway in the south east by 2030 and suggested a number of options for siting this. Its analysis also suggested there could be a case for a second additional runway by 2050.
- Re-examined the level of aviation demand growth compatible with 2050 objectives. The analysis found an increase in demand of 67% would be compatible with returning aviation emissions to 2005 levels by 2050, very close to our previous conclusions.
- Concluded that the need for an additional runway by 2030 was valid across a range of future scenarios, including where demand growth was limited to around 60-70% by 2050.

Figure B5.13: CCC and Airports Commission aviation CO_2 projections to 2050



Source: DECC (2014) *2012 UK GHG emissions*, CCC (2009) *Meeting the UK aviation target*, Airports Commission (2013) *Interim Report*.
Notes: Airports Commission projections are not fitted to 2010 outturn data. Assuming the same profile of emissions trajectory, this implies the lower end of the range would be slightly higher out to 2050.

33 http://www.theccc.org.uk/publication/letter-to-aviation-commission
34 http://www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050
35 https://www.gov.uk/government/publications/airports-commission-interim-report

Box 5.13: The Airports Commission and future UK airport capacity

The Airports Commission's emission projections are broadly similar in profile to previous CCC analysis. Both show emissions which rise over time before flattening off. However, the Airports Commission's projections are lower in absolute terms and show aviation emissions closer to 2005 levels in 2050 (Figure B5.13). This largely reflects a lower starting point due to the recession, lower forecasts of future economic growth and changes in Government policy on capacity expansion[36].

Both Airports Commission and CCC analysis suggest an additional runway by 2030 can be compatible with returning aviation emissions to around 2005 levels by 2050, provided that aviation demand growth is limited to around 60% above 2005 levels and that there are significant improvements in carbon intensity of aviation (e.g. of around one-third by 2050).

This approach should continue to be the basis for government policy unless and until technology improvements allow higher passenger demand growth – and associated infrastructure investment – to be demonstrated compatible with the 2050 target.

The Airports Commission is now undertaking analysis to feed into their final report due in summer 2015, including investment and emissions appraisal of the runway options identified in their interim report. In their final report, the Commission should update their UK emission projections for each proposal to allow the long-term implications for 2050 to be accurately assessed.

We will continue to monitor trends in aviation emissions and key policy developments in the context of our annual progress reports to Parliament. We will also revisit aviation emissions and their inclusion in carbon budgets as part of our statutory advice on the fifth carbon budget, due by end-2015.

36 The higher end of the Airports Commission's scenario range reflects unconstrained airport capacity. The lower end of the range reflects current Government policy for no new airport capacity. In contrast, CCC analysis was based on the then current policy of the 2003 Air Transport White Paper which assumed three additional runways by 2030 (at Heathrow, Stansted and Edinburgh).

6. Summary and next steps

Progress to date

In this chapter we have considered progress against our indicator framework for transport. We summarise this assessment below, in the form of traffic light ratings for a set of our key indicators (Table 5.1).

As described in Chapter 1, for each key indicator, we assign a rating of red, amber or green based on progress to 2013, where broadly:

- Green signifies on-track performance or outperformance against our indicator.
- Amber signifies slight underperformance or policy delay.
- Red signifies significant underperformance or rejection of certain policies and/or measures.

For transport, the majority of indicators have been assigned an amber rating, with one green rating (for new car CO_2) and two red ratings (for eco-driving and EV uptake).

Table 5.1: Progress to date against indicators in transport: traffic light assessment

Indicator	Traffic Light	Comments
New car CO_2	Green	Outperforming our indicator trajectory. Evidence of a growing gap between real world and test cycle emissions suggest real world improvements were smaller; however likely still to have met trajectory.
Fleet average gCO_2/v-km – vans	Amber	Emissions intensity of van travel is better than our indicator in absolute terms as data issues meant our indicator was overestimated; however the rate of reduction has been less than expected
Fleet average gCO_2v-/km – HGVs	Amber	Not meeting indicator trajectory: emissions intensity actually rose. However this may be due to a move to larger trucks which could reduce vehicle km. Data quality is an issue.
EV car sales	Red	Uptake well below our indicatory trajectory, although market developments (e.g. availability of a range of models) have been positive, and in hindsight uptake in the proposed trajectory was too high over the first carbon budget period.
Biofuel policy	Amber	Biofuel penetration was in line with our trajectory to 2011; it has fallen short of our indicator in the past two years but with improvements in sustainability.
Smarter Choices policy	Amber	The Local Sustainable Travel Fund is funding a number of projects across England; however the framework for evaluating carbon savings is not comprehensive
Eco-driving training	Red	While there has been good progress in the freight sector, uptake of training by car and van drivers is well short of indicator trajectory with no concerted effort to promote address this.

Forward look

In our fourth carbon budget review we suggested that domestic transport emissions could fall to around 80 $MtCO_2$ in 2025 as part of the cost-effective path for meeting carbon budgets, given improvements in conventional vehicle efficiency, uptake of electric vehicles, penetration of biofuels and measures to change personal travel behaviour and improve freight logistics.

We have considered the extent to which existing and planned policies will deliver the measures required to meet carbon budgets cost-effectively. Our assessment is that current policies and policy plans will go some but not all of the way to delivering these measures.

- According to DECC's updated emissions projections (UEP), emissions in the absence of policy would be 124 $MtCO_2$ in 2025, falling to 104 $MtCO_2$ when estimated policy savings are included.
- This leaves a significant gap to be addressed in order to meet carbon budgets cost-effectively. This gap comprises further conventional vehicle efficiency beyond EU 2020 targets, penetration of electric vehicles in line with our scenario, some further use of sustainable biofuels, together with ongoing demand-side measures in the passenger and freight sectors.
- In addition, we can have limited confidence in the savings that will be delivered by current and planned policies (Table 5.2). If only those savings from low-risk policies are delivered, transport emissions would be higher in 2030, leaving an additional gap to be addressed (Figure 5.22).

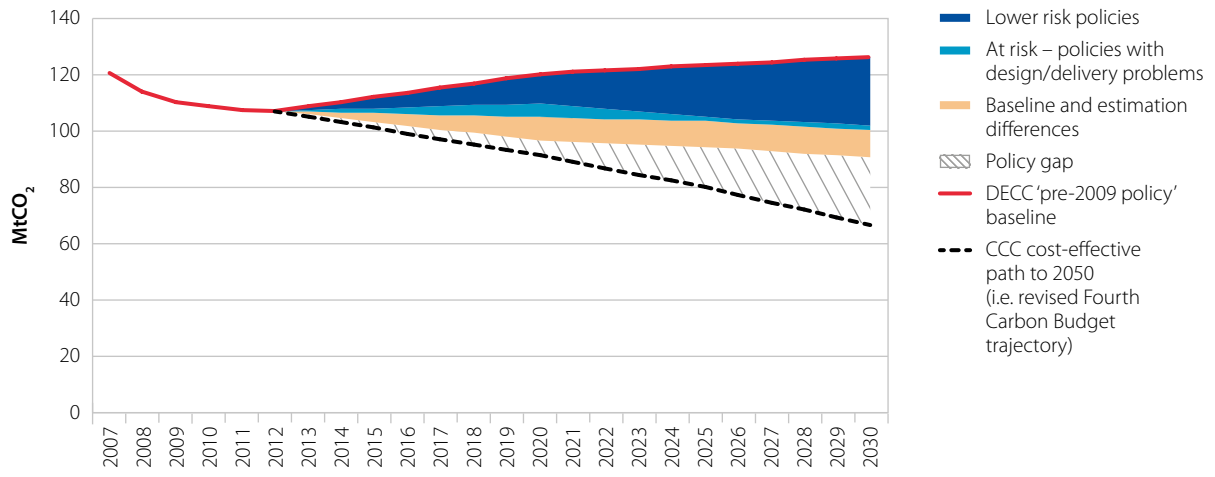
In order to deliver necessary reductions in transport emissions, it is therefore important that new policy approaches are developed; our key recommendations around these are summarised in Box 5.1.

Going forward, we will continue to monitor progress in the transport sector against a range of indicators. Reflecting our analysis for the fourth carbon budget review (including revised baseline projections), new evidence on progress to date, and the recommendations in this report, we have revised our indicator framework for the second and third carbon budgets, and extended it to cover the fourth carbon budget period (Table 5.3).

- We have updated our trajectory to 2020 for new car CO_2 to reflect latest outturn, and added an indicator for new van CO_2
- We have revised our trajectory to 2030 for uptake of EVs, and added a number of policy milestones for market development
- We have updated our policy indicators for Smarter Choices and added a policy indicator for freight logistics; we have also added a policy indicator around use of methane in trucks
- We have updated our trajectories for emissions and emissions intensity to reflect new baseline projections as well as the updates above

We will return to approaches for reducing transport emissions as part of our advice on the fifth carbon budget in 2015.

Figure 5.22: Assessment of emissions savings from current and planned policy against the cost-effective path in transport



Source: DECC (2013) Updated emissions projections, CCC analysis.

Table 5.2: Assessment of transport emissions savings from current policies and policy plans	
Policy	**Comment**
Lower risk policies	
New car & van CO_2 (EU regulations)	Regulation with stiff penalties for non-compliance, supported by UK fiscal policies. Targets legislated to 2020. More representative test cycle due to be introduced.
EVs to 2020	Funding package tackles all major barriers with combination of measures shown to be effective in leading markets. £500 million overall, inc. min £200 million for PiCG to 2017 or 50,000 cars; £32 million for infrastructure; £35 million for city schemes & £20 million for taxis; £100 million for R&D. Plug-in Car Grant of up to £5,000 per car is about right in the near term.
Smarter Choices (LSTF)	£600 million of DfT funding to 2015 (62.5% revenue, 37.5% capital), plus £535 million from LAs, for measures to tackle information and organisational barriers (e.g. school & workplace travel plans) and complementary infrastructure investment (e.g. cycle lanes). Level of funding per head broadly comparable to successful Sustainable Travel Towns pilot projects. Local Growth Fund providing funding in 2015/16.
HGV Low Rolling Resistance Tyres/Gear Shift Indicators	Mandated by EU regulation.
Low Carbon Buses	£30 million funding provided by OLEV from 2015-2020 to stimulate uptake of 1,000 Low Carbon buses. Funding will be provided on a declining basis as the cost differential between these and conventional buses narrows. DfT is working with the Green Investment Bank to assist potential buyers with financing.
Rail Electrification	Work is currently ongoing to electrify a number of lines in the North of England, as well as the Great Western Mainline. Electrification is at varying levels of completion, however progress is currently on-track.
Policies with design/ delivery problems	
Biofuels (RTFO)	RTFO currently flat-lined at 4.75% (by vol) pending EU decision on limiting 1G biofuels, ILUC and role of 2G – insufficient to deliver levels assumed to 2020 (penetration assumed to revert to current level post-2020).
HGV industry led action	Schemes such as LCRS encourage voluntary action, help members share best practice, provide CSR benefits; LCRS has emissions intensity target for 2015. But dominated by larger operators; no policy addressing financial barriers for smaller operators.
Unfunded Policies	
Low Carbon Buses	Uptake projected by OLEV appears optimistic given experience with Green Bus Fund round 4. Even if the full 1,000 buses are achieved this remains below the necessary uptake to 2030 to be consistent with UEP projections.
Missing Policies	
BEVS/ PHEVS	No policy to address upfront cost barrier post-2020
Biofuels	No trajectory post-2020 at UK or EU level
Passenger Demand Reduction	No policy beyond 2015-2016. Important that measures are sustained in order to sustain changes in travel behaviour.
HGV Demand Side Action	Demand side action expected to be led by the LCRS; currently no LCRS target beyond 2015; membership is limited.

Key findings

- Domestic transport emissions fell **11.9%** over the first carbon budget.
- Road transport emissions **outperformed our indicator trajectory** and likely to have fallen further in 2013.
- … Falls in car, van and HGV emissions over first carbon budget.
- EU new car and van CO_2 regulations have been instrumental in driving efficiency improvements.
- … Important that **stretching new EU targets** agreed for 2025 and beyond and introduced for HGVs.
- Market for **electric vehicles developing**…many new models across range classes
- … But take-up still low. Funding in place to enable market to develop but **new financing approaches, infrastructure investment** and **innovative marketing** still needed.
- Progress on **changing travel behaviours mixed**. Efforts to encourage people to switch to sustainable travel choices and action to improve freight operations may need strengthening.
- **Existing and planned policies** go some way to deliver the measures needed to meet future carbon budgets but **a gap** remains.

Table 5.3 The Committee's transport indicators

ROAD TRANSPORT		Budget 2	Budget 3	Budget 4	2013 outturn
Headline indicators					
Emissions (% change on 2007)	Road Transport	-24%	-36%	-46%	-11.4% (2012)
Vehicle km (billion)	Car	413	428	452	406
	Van	76	84	93	72
	HGV	26	27	27	26
Supporting indicators					
Vehicle technology					
New vehicle gCO_2/km	Car	111	95 (by 2020)	57	128.3
	Van	164	147 (by 2020)	89	186.1
New electric vehicles (cars and vans) registered each year		35,000	525,000	1,470,000	3,584
Stock of electric vehicles (cars and vans) in fleet		75,000	1,340,000	6,645,000	7,442*
Review of financial mechanisms for addressing up-front costs to EVs		2017			
Roll-out of strategic rapid charging network			2020		
Strategy for development of residential off-street charging points		2015			
Action plan for engaging local authorities in providing measures to support EV uptake		2015			
Full evaluation of GHG implications of methane trucks		2015			
Biofuels					
Penetration of biofuels (by energy)		5.9%	8.4%	9.9%	2.9%
Develop trajectory for RTFO to meet EU 2020 target following EU agreement		2015/16			
Demand side measures					
Evaluate effectiveness of LSTF and commit to further funding if appropriate		2016			
Nationwide rollout of Smarter Choices if appropriate			Complete		LSTF funding Smarter Choices projects in 77 Local Authorities in England
Review effectiveness of voluntary industry approach to reduce emissions in freight sector		2016			

Table 5.3 The Committee's transport indicators
Other drivers
Contextual
GDP and manufacturing output
Population
Car ownership
Cost of car travel vs. cost public transport
Trends
Petrol/diesel consumption
Modal split
New vehicle CO_2
New car sales that are best in class
Proportion of s/m/l cars
EU targets for new HGV CO_2
Post-2020 EU targets for new car and van CO_2
ULEVs
EV and H2 vehicle models on market
Battery costs
Biofuels
EU agreement on how to meet the 10% biofuel target
Demand side
Funding allocated to and population covered by Smarter Choices
Proportion of drivers exceeding 70mph
HGVs
gCO_2/tonne km
Uptake of freight logistics improvement measures (e.g. fleet management software, eco-driving)

Note: Numbers indicate amount in last year of budget period i.e. 2017, 2022, 2027.

* Excluding quadricycles.

Key: Headline indicators Supporting indicators Other drivers

Table 5.4 The Committee's aviation indicators

AVIATION	Domestic		International*		Total		CCC 2050 planning assumption	2050 forecast range**
	2005	2012	2005	2012	2005	2012	vs. 2005	
Headline indicators								
CO_2 emissions (million tonnes)	2.5	-35%	35.0	-9%	37.6	-11%	~0%	+3% to +13%
Passenger demand (million)***	50.0	-25%	177.4	+3%	227.4	-3%	~+60%	+76% to +98%
Supporting indicators								
Passenger composition								
Proportion of passengers travelling for business	46%	-6pp	22%	-2pp	27%	-5pp	n/a	
Airline utilisation								
Load factor****	n/a				79%	+4pp	n/a	
Wider monitoring								
Non-CO_2 climate science, international/EU policy (e.g. ICAO, EU ETS, SESAR programme), UK policy (e.g. Airports Commission), technology developments (e.g. biofuels, airframe/engines)								

* International emissions are not currently covered by carbon budgets, but are included in the 2050 target
** Airports Commission Interim Report (2013)
*** 2005 total passenger demand has been revised downwards in CAA statistics but domestic/international split is only available on old basis. We scale domestic and international demand downwards in proportion to revision to total passenger demand.
**** Only covers UK registered airlines and includes their worldwide activity

This is an initial framework for aviation and we will revisit it for 2015. We would welcome any feedback on this table and how it could be developed, including for a wider range of data sources.

Key: Headline indicators Supporting indicators Other drivers

Table 5.5 The Committee's shipping indicators

SHIPPING	Domestic		International*		Total	
	2011	2012	2011	2012	2011	2012
Headline indicators						
CO_2 emissions (million tonnes)**	2.5	-4%	10.1	-15%	12.6	-13%
Tonne-km (billion)***	40	-18%	1,220	-7%	1,260	-7%
Supporting indicators						
Demand						
Cargo carried (million tonnes)***	74	-12%	254	0%	328	-3%
Fleet						
Ship movements (thousands)***	n/a				146	-2%
Average ship size (thousand deadweight tonnes per ship)***	n/a				10.1	0%
Wider monitoring						
Non-CO_2 climate science, international/EU policy (e.g. IMO), industry/market factors (e.g. vessel speeds, relative prices of bunker fuels in UK/non-UK ports), alternative fuels (e.g. biofuels/LNG), technology developments						

* International emissions are not currently covered by carbon budgets, but are included in the 2050 target
** Total emissions measured on the basis of bunker fuel sales
*** Reflects imports/arriving ship movements

This is an initial framework for shipping. We will be undertaking further research on the key drivers of UK shipping emissions, with the aim of updating this table where relevant in 2015. We would welcome any feedback on this table.

Key: Headline indicators Supporting indicators Other drivers

Chapter 6

Chapter 6: Progress reducing emissions from agriculture

1. Introduction and key messages

In this chapter we present the latest evidence on emissions in agriculture, which accounted for around 10% (56.6 $MtCO_2e$) of UK greenhouse gas (GHG) emissions in 2012, and how they have changed during the first carbon budget (2008-12). We also consider the land use, land use change and forestry (LULUCF) sector, which continued to be a net carbon sink of 7 $MtCO_2e$ in 2012.

Our key messages are:

- In 2012 agricultural emissions were 56.6 $MtCO_2e$. This represented a 1% decline on the previous year, and a reduction of 3% over the first carbon budget period. It is consistent with a long-term decline in emissions since 1990 and more recently since 2003.
- However, there is no confidence that changes in farming practice have driven emissions reductions. In particular, efficiency of inorganic fertiliser use for crops does not appear to have improved and it is unclear whether productivity improvements in livestock output have resulted in reduced emissions per unit of output.
- It is essential therefore that there is a better evidence base to assess both the level of emissions and key drivers. This should come from the roll-out of the Smart Inventory next year, and the on-going monitoring framework. A consideration of policy options beyond the current 'light touch' approach of the voluntary industry-led GHG Action Plan may be needed in light of this.

Our recommendations to Government are summarised in Box 6.1.

Box 6.1: Key recommendations

GHG Action Plan: Ensure that industry monitors the effectiveness of the GHG Action Plan, including 'SMART' objectives, quantifiable targets and evidence of buy-in from farmers, to allow effective evaluation in the Government's review in 2016.

Forward look: Recognise the high delivery risk under the GHG Action Plan and, as part of the 2016 review, consider stronger policy options to ensure savings are delivered.

GHG emissions from peatlands: The GHG inventory should include emissions from upland peat as soon as possible, existing regulation should be enforced and the policy framework strengthened to enable further peatland restoration effort.

We set out the analysis that underpins these messages in five sections:

- Agriculture emissions: trends and drivers
- Progress against indicators
- Incentives to reduce agricultural emissions – the policy framework
- Land use, land use change and forestry
- Summary of progress and revised indicators

2. Agriculture emissions: trends and drivers

Agriculture emissions comprise largely non-CO_2 greenhouse gas emissions. Data availability means that the latest data on agricultural emissions are for 2012. In this section we report on trends and drivers over the first carbon budget period (2008-2012).

Emissions trends

A complete assessment of the trends and drivers in emissions is not possible given the current method used to calculate agricultural emissions:

- The method largely applies Tier 1 global emission factors to fertiliser application and livestock numbers, which do not reflect soil and climatic conditions of the UK nor the variation in animal diets and how they are housed.
- In addition, the agricultural inventory does not reflect the adoption of farm practices that could be reducing emissions.

This will remain the case until the new Smart Inventory is rolled-out next year, which will go a long way to addressing these significant uncertainties. What follows therefore is an assessment of best estimates for emissions that currently have significant error bars, which Defra estimates could range from 42-91 $MtCO_2e$[1].

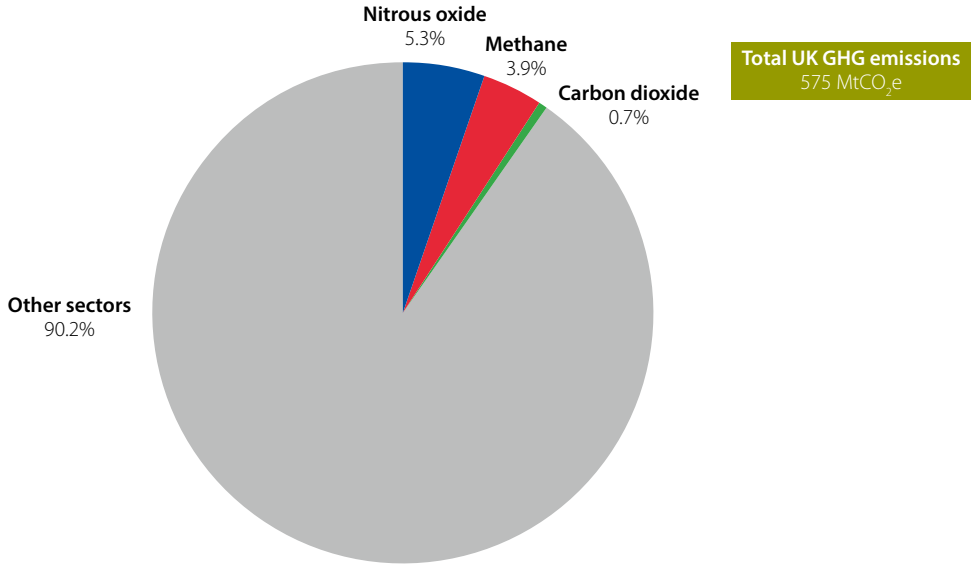
Emissions in the agriculture sector were just under 57 $MtCO_2e$ in 2012, accounting for 9.8% of total greenhouse gas emissions in the UK (Figure 6.1).

- Nitrous oxide (N_2O) emissions account for 54% of emissions in the sector, methane makes up 39% and carbon dioxide the remaining 7%. This split of emissions by greenhouse gas in 2012 is unchanged from 2007.
- Agricultural soils are the largest source of agricultural emissions (48%). Enteric emissions from digestive process account for a further 28%. Waste and manure management and combustion (stationary and mobile) account for 16% and 8% respectively of the remaining emissions (Figure 6.2).

1 DECC, '2013 UK Greenhouse Gas Emissions, Provisional', 2014

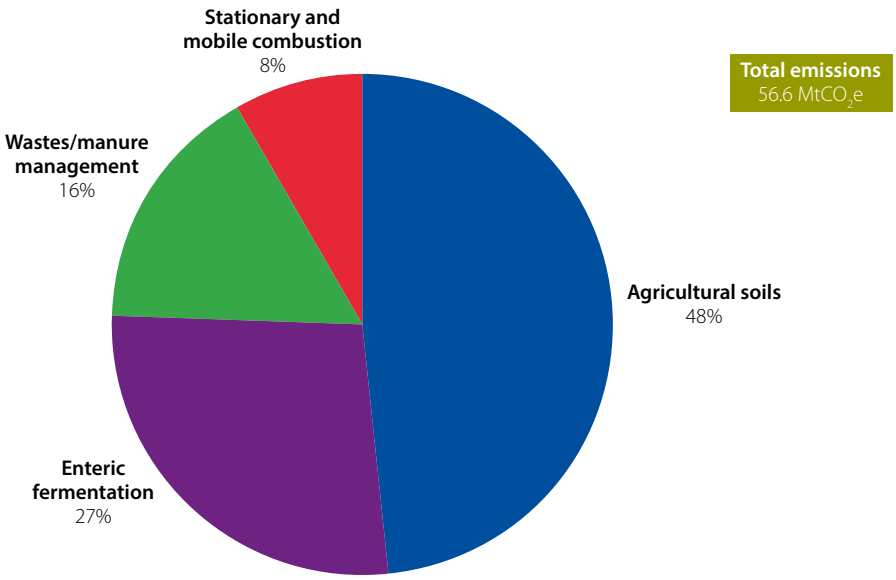
- Emissions from waste and manure management were revised upwards by 5 $MtCO_2$ in 2012 on previous inventory estimates[2]. This led to an increase in total agriculture emissions of 12% each year since 1990.

Figure 6.1: GHG emissions from agriculture in the context of total UK emission (2012)



Source: NAEI (2014).
Notes: Emissions from other sectors excludes international aviation and shipping sectors.

Figure 6.2: Agriculture emissions by source (2012)

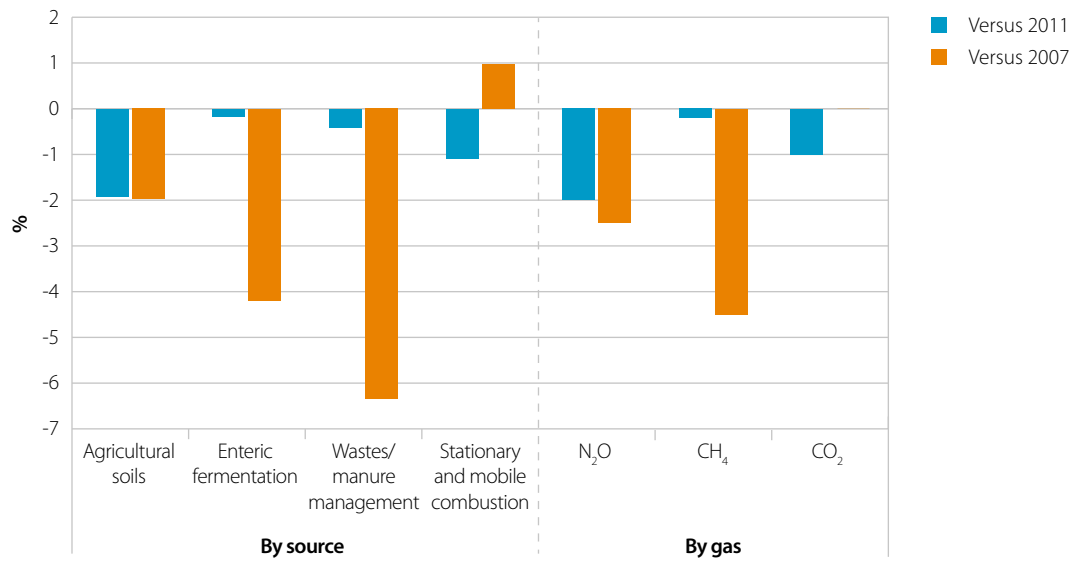


Source: NAEI (2014).

2 This reflects a change in the allocation of manure to different management systems (e.g. the volume of manure allocated to daily spread management has reduced and manure allocated to solid storage has been reallocated to deep litter)

On the basis of the revised inventory, agriculture emissions fell by 1% in 2012, and have declined by 3% from 2007 to 2012, with reductions observed across the range of gases and sources (Figure 6.3):

Figure 6.3: Change in agriculture emissions by source and gas in 2012 compared to 2011 and 2007



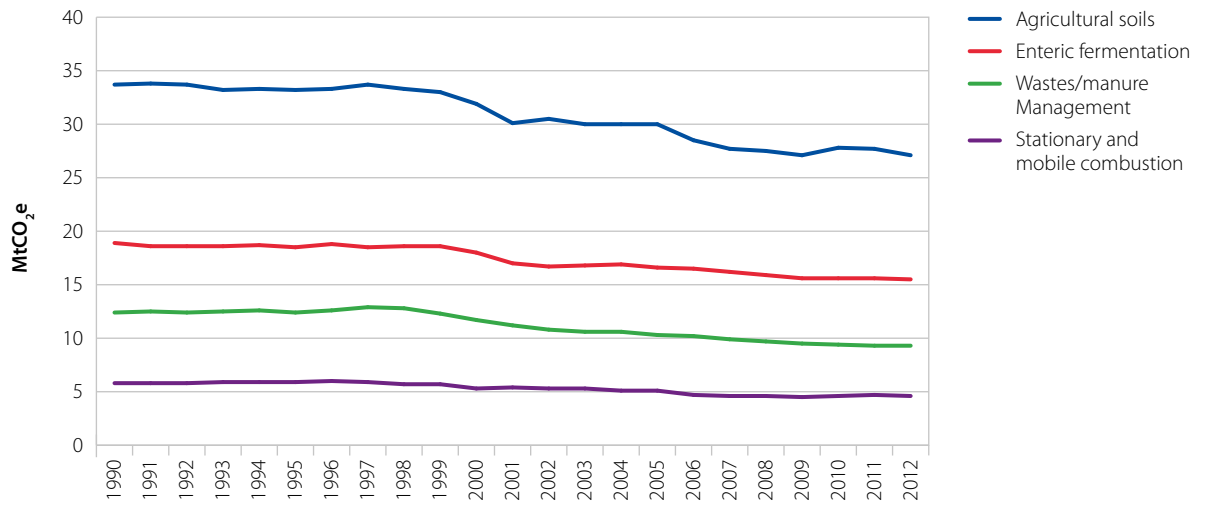
Source: NAEI (2014).

- N_2O and methane declined by 2.5% and 4.5% respectively from 2007 to 2012, while CO_2 remained unchanged. In the year to 2012, annual emissions of N_2O and CO_2 decreased slightly (2% and 1%) while methane emissions remained flat.
- Decreases of between 2% and 6% were noted for all the main sources of emissions from 2007 to 2012, with the exception of stationary and mobile combustion which increased slightly. Emissions from enteric fermentation and wastes and manure management remained broadly unchanged in 2012 compared to the previous year, while agricultural soils and stationary and mobile combustion emissions decreased by 2% and 1% respectively.

This pattern of emissions is consistent with the long-term declining trend (Figure 6.4).

- Since 1990, agricultural emissions have declined by 20%, with similar percentage reductions across all three gases. By source of emissions, agricultural soils declined by 20%, enteric fermentation by 18%, manure management by 26% and combustion emissions by 21%.

Figure 6.4: Agriculture CO_2e emissions by source (1990-2012)



Source: NAEI (2014).

Emissions drivers – nitrous oxide

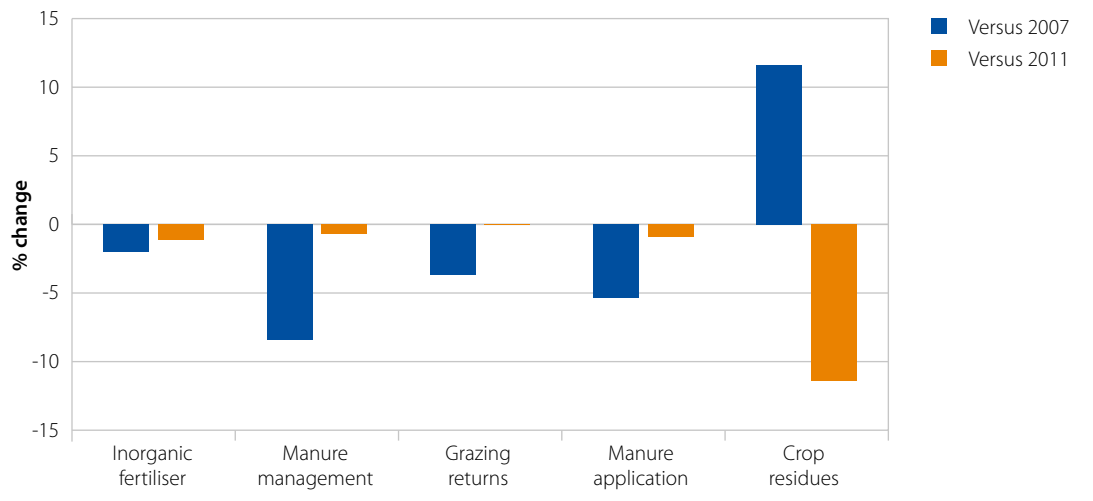
Around 90% of N_2O emissions result from agricultural soils, with the remainder arising mainly from manure management, with just 2% due to mobile and stationary combustion.

Soil emissions arise from multiple sources, with emissions from livestock waste accounting for half the emissions, application of inorganic fertiliser 36% and the remainder due to crop residues, histosols (cultivation of organic soils) and improved grassland. The reduction in emissions from these sources explains the decrease in N_2O emissions in agriculture since 2007 (Figure 6.5):

- Emissions from inorganic fertiliser declined by 1% in 2012 and by 2% since 2007.
- There were also reductions over the same periods from organic sources of fertiliser, namely grazing returns (deposits by livestock grazing on grassland), manure application and sewage sludge. Lower arable harvests in 2012 reduced the availability of cereal straw and stubble for incorporation into soils which resulted in a 11% decline in emissions from crop residues.
- Emissions from the management of manure declined by less than 1% in 2012 but by 8% since 2007.

In order to understand the extent to which these reductions could be due to the take-up of abatement measures or changes in farming practice rather than reductions in agricultural output, we consider changes in emissions intensity of output. Overall N_2O emissions intensity of agricultural output improved over the first carbon budget period by 7% but worsened marginally in 2012. In the next section we split the change in intensity between crops and livestock output.

Figure 6.5: Change in main sources of N_2O emissions (2012 compared to 2011 and 2007)



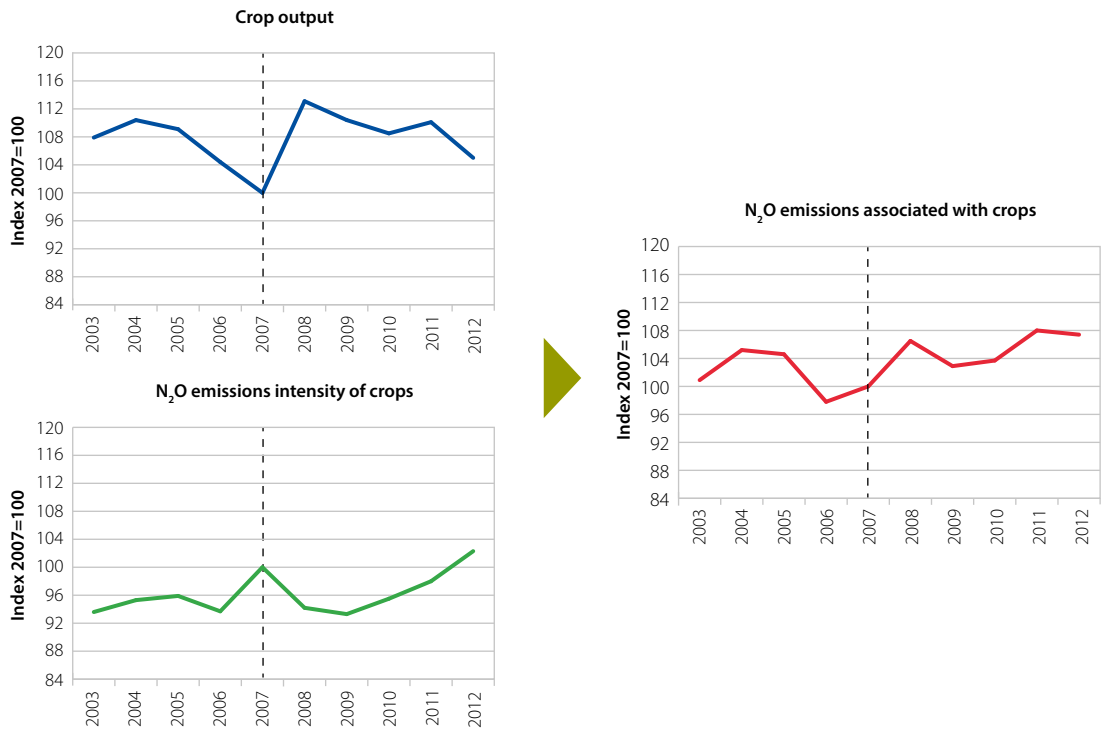
Source: NAEI (2014).

(i) Crops

The emissions intensity of crops increased from 2011 to 2012 by 4% and from 2007 to 2012 by 2% (Figure 6.6).

- Crop production was adversely impacted by weather conditions in 2012 (an extended drought in the first three months of the year was followed by higher than average rainfall and low temperatures in the spring and summer) resulting in a decline in total crop output of 5%. For example, yields of harvested wheat and barley fell by 14% and 3% respectively, and both were below the five year average. There was a smaller fall in N_2O emissions associated with growing crops in 2012 due in part to a smaller decrease in the application rate of inorganic fertiliser on cropland.
- While crop output increased by 5% over the five years of the first carbon budget (although this was against a low base as agricultural output in 2007 had fallen to its lowest levels since the early 1980s due to the very wet weather that year), growth in N_2O emissions was faster (7%). This was mainly due to more land being brought into production following the removal of set-aside in 2007 which increased the total amount of fertiliser used.

Figure 6.6: Crop output, N_2O emissions associated with crops and emissions intensity of crops (2003-2012)



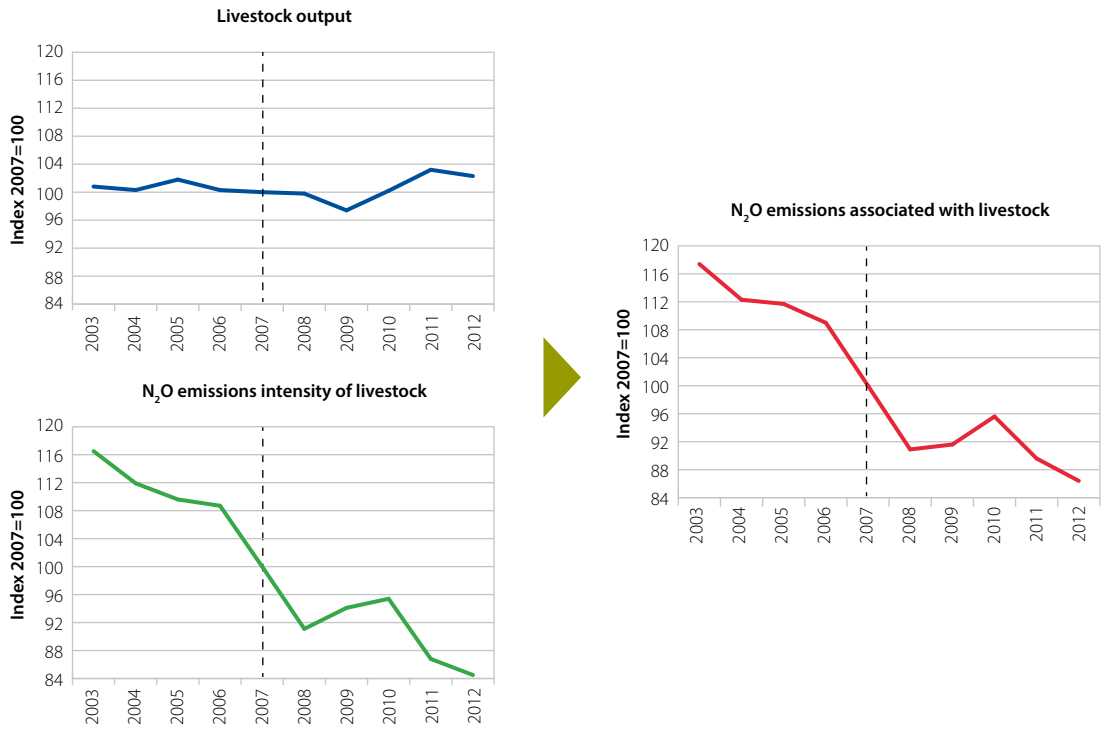
Source: NAEI (2014), AUK 2012, CCC calculations.
Notes: Base Year (2007) = 100.

(ii) Livestock

N_2O intensity of livestock improved both in 2012 and over the first carbon budget, as the fall in livestock related emissions outstripped changes in livestock output (Figure 6.7).

- The 1% fall in livestock output in 2012 is partly explained by the reduced quality and quantity of forage feed (e.g. maize and silage) as a result of adverse weather. However, there was a larger (3.5%) reduction in N_2O emissions associated with livestock, implying an improvement in emissions intensity of 2.7%. The on-going decline in animal numbers continues to drive down both inorganic and organic sources of N_2O emissions, with less nitrogen fertiliser being applied per hectare of grassland (down 4%), and less manure and wastes being produced by animals.
- The improvement in intensity in 2012 is part of a longer-term trend of decoupling emissions from output. Over the first carbon budget period, livestock N_2O intensity improved by 16% as livestock related N_2O emissions fell by 14% and output increased by 3%. With the area of grassland unchanged, the decline in livestock numbers over the period would appear to be the main contributing factor, driving down the application of inorganic fertiliser per hectare of grassland by 15% and reducing emissions from grazing returns, manure application and waste management by 5%.

Figure 6.7: Livestock output, N_2O emissions associated with livestock and emissions intensity of livestock (2003-2012)



Source: NAEI (2014), AUK 2013, CCC calculations.
Notes: Base Year (2007) = 100.

The changes in the use of inorganic fertiliser since 2007 reflect the long-term trend, with the overall decline driven by less intensive use on grasslands due to reduced stocking densities. The trend differs for arable land however, where apart from a temporary dip in 2008 and 2009 in response to historically high fertiliser prices, the rate of application on arable land has remained broadly flat.

Emissions drivers – methane

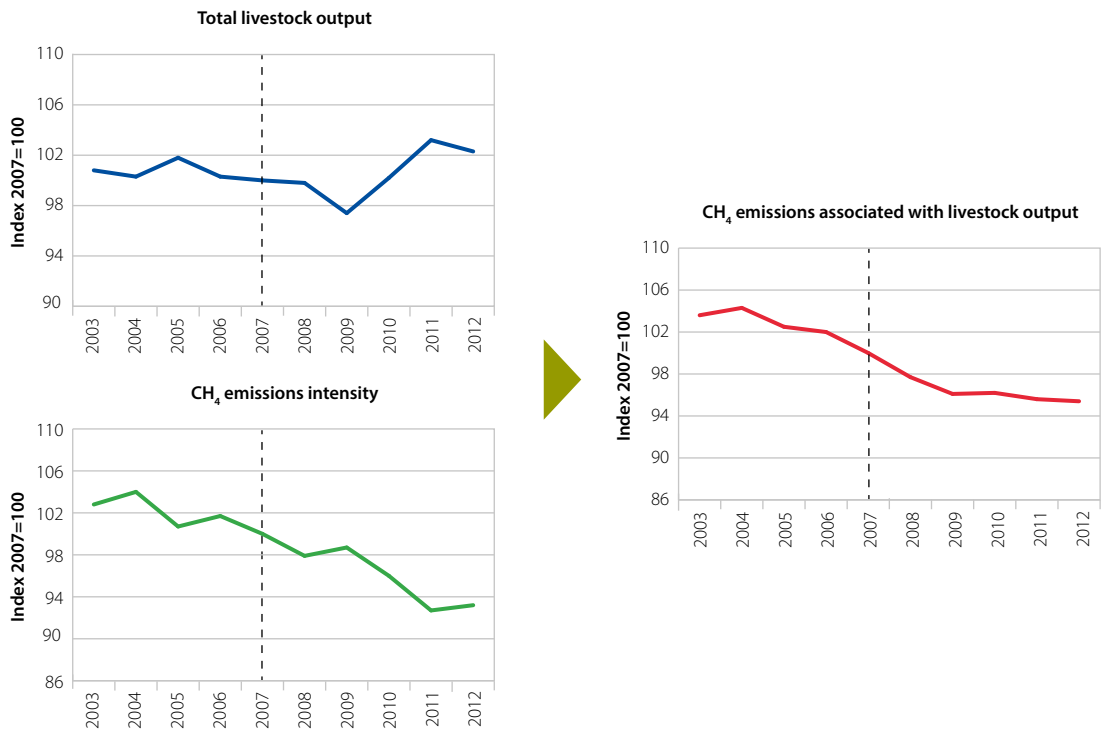
Enteric fermentation (gas released from the ruminant digestive processes of cattle and sheep) accounts for 70% of methane emissions, with the remainder arising from waste and manure management. Cattle account for three quarters of methane emissions.

Methane intensity of livestock output increased slightly in 2012, against the backdrop of an improvement over the first carbon budget period (Figure 6.8):

- There was a marginal decrease of methane emissions in 2012 (0.2%) reflecting a 0.6% fall in dairy and beef cattle numbers. There was a larger decline in livestock output (0.8%) such that methane emissions intensity of livestock increased by 0.6% in 2012.

- For the budget period, output increased by 2% with increases in beef, pig meat and poultry offsetting reductions in sheep and lamb meat and milk. This was accompanied by a 5% decrease in methane emissions as cattle and sheep numbers dropped by 4% and 5% respectively. The net effect was a 7% reduction in the methane emissions intensity of livestock output.

Figure 6.8: Total livestock output, CH_4 emissions and CH_4 emissions intensity of output (2003-2012)



Source: NAEI (2014), AUK 2013, CCC calculations.
Notes: Base Year (2007) = 100.

Changes in emissions intensity can be partly explained by changes in livestock productivity. While the adverse weather conditions in 2012 may have temporarily impacted the yields of certain animals, productivity gains were achieved during the carbon budget period.

- A deterioration in the quantity and quality of forage feed for dairy cattle reduced average milk yields by 1% in 2012, with the average dairy cow producing 83 litres less milk than the previous year. This reversed the long-term trend of increasing yields, which over the first carbon budget period increased by 8%.
- Average dressed carcase weights of beef and veal, clean sheep and lamb, and clean pigs were broadly flat compared to 2011. However, since 2007, the weight for beef and veal has increased by 2%, and 3% for clean pigs, while sheep and lamb declined by 2%.

Looking at improvements in yields alone does not entirely explain changes in emissions intensity as higher yields could be due to more emissions intensive inputs such as feed. For example there was a 3% increase in pig yields between 2007 and 2010 which may have been due to an 8% increase in the feed conversion ratio[3]. Assuming constant emissions intensity of feed, this implies a worsening emissions intensity. The feed conversion ratio for pigs is one of a suite of indicators that Defra tracks in order to provide some assessment of progress reducing agricultural emissions.

Conclusions on drivers of non-CO_2 emissions

It is clear from the above discussion that, beyond fluctuations due to weather, we are unable to explain what is driving N_2O emissions intensity of crops; although it is clear that the use of nitrogen fertiliser has not become more efficient. For livestock output, the improvement in N_2O emissions intensity is due to less intensive use of fertiliser on grassland as a result of reduced stocking densities. For methane, improvements in productivity can partly explain the reduced emissions intensity associated with livestock, but a better understanding of other drivers (e.g. feed regime and fertility) is required in order to make a complete assessment as to whether a real reduction in methane intensity is occurring.

These uncertainties highlight the urgent need for better information. The launch of the Smart Inventory next year and Defra's on-going work to improve its indicator framework for assessing progress in reducing emissions will contribute to improving the evidence base.

Emissions drivers – CO_2

Stationary and mobile machinery represent the largest source of CO_2 emissions in agriculture, accounting for 7% of agricultural emissions in 2012. Although CO_2 emissions are 15% lower than in 2000, there has been no reduction in emissions since 2007 with levels unchanged at 4.1 $MtCO_2$. Reducing fossil fuel use by mobile machinery through the use of more efficient engine technology and alternative vehicle fuels can deliver carbon savings. In addition, reducing demand through energy efficiency improvement and using more renewable energy can reduce emissions from stationary machinery (e.g. ventilation and cooling systems).

EU Benchmarks

It is difficult to make meaningful comparisons of agricultural emissions and emissions intensity across different countries due to different climatic and soil conditions and types of farming activity. The comparisons presented here therefore focus on:

- EU member states that have a similar agriculture structure in terms of types of crops grown and livestock farmed.

3 The feed conversion ratio (FCR) measures the amount of feed required to produce an extra kg of meat or litre of milk. An increase in the FCR could imply greater methane emissions if the increase in feed is lost as carbon via enteric emissions if not properly digested and used for growth.

- Intermediate indicators such as change in yields and feed conversion rates. While not relating directly to emissions intensity, these provide a useful indicator of relative productivity.

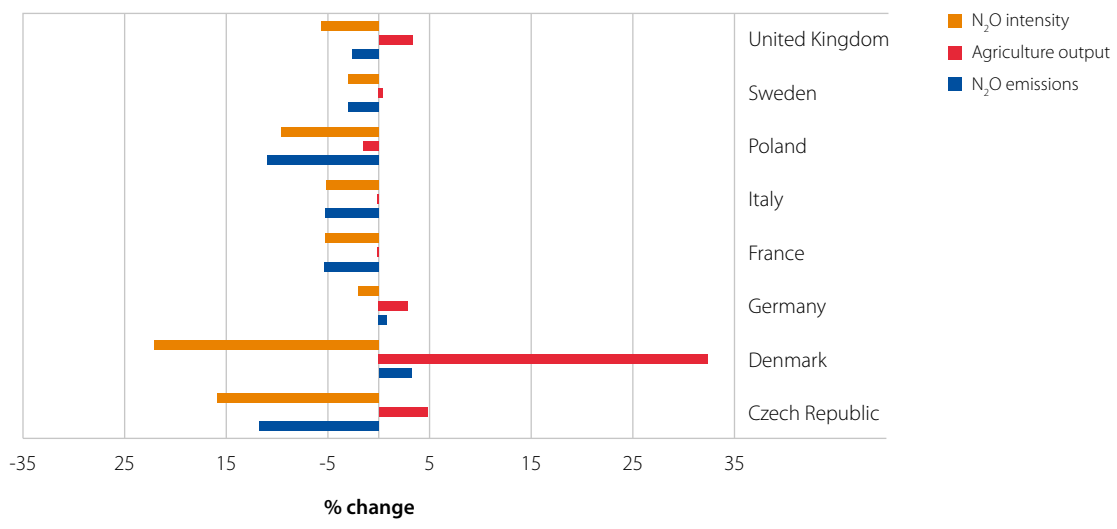
In the UK the vast majority of crops (over 95%) are either 'specialist cereals, oilseed and protein crops' or 'field crops'. The remainder are specialist fruit and horticulture crops. In addition, over half of agricultural land is used for livestock rearing or grazing. The EU countries most similar to this in terms of the mix are shown in Figure 6.9. The UK has relatively high N_2O intensity of output in 2012. However, over the first carbon budget period, N_2O emissions de-coupled from output, such that there was an improvement in intensity of output in all countries in this period, with the UK improving more than Germany, France, Italy and Sweden (Figure 6.9).

There is a greater divergence of types of livestock farming across the EU. In the UK, dairy cattle and other grazing livestock comprise around 25% of all livestock, with pigs and poultry around 20%. Countries most similar to this are shown in Figure 6.10, though differences remain.

Methane intensity of livestock output in the UK is similar to countries such as Sweden, France and Portugal and lower than Bulgaria and Ireland. Over the first carbon budget period, whilst methane intensity improved in the UK, there was mixed progress in other member states – in particular intensity rose in Sweden and Bulgaria, though this may be partly recession related as livestock output fell markedly in these countries (Figure 6.10).

Looking at yields is a useful way to compare productivity across EU member states although these can be affected by events outside farmers' control such as weather. Over the first carbon budget period, although wheat yields fell in the UK (partly weather related), beef and milk yields improved more than the EU-15 average (Figure 6.11).

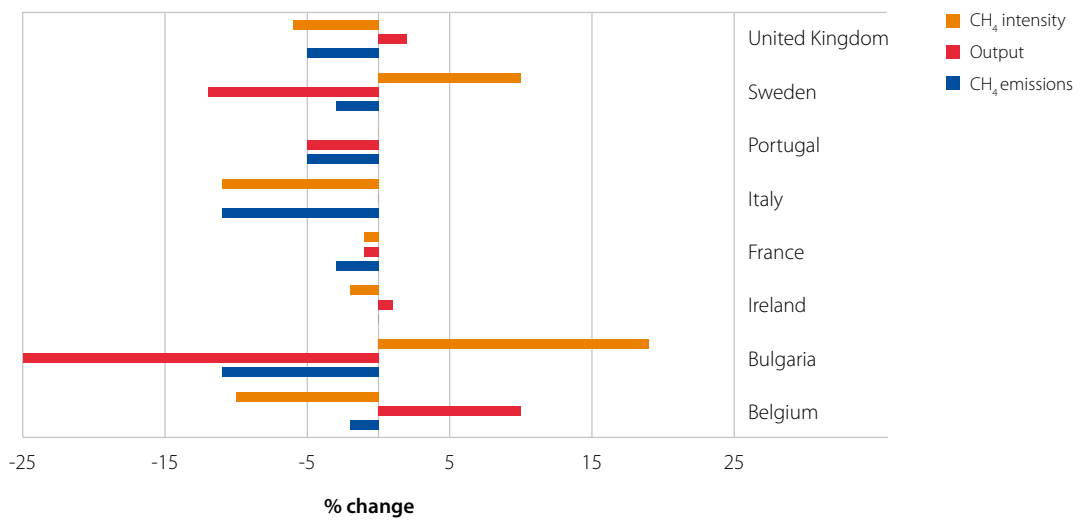
Figure 6.9: Change in N_2O emissions intensity in selected EU countries (2007-2012)



Source: Eurostat and CCC calculations.

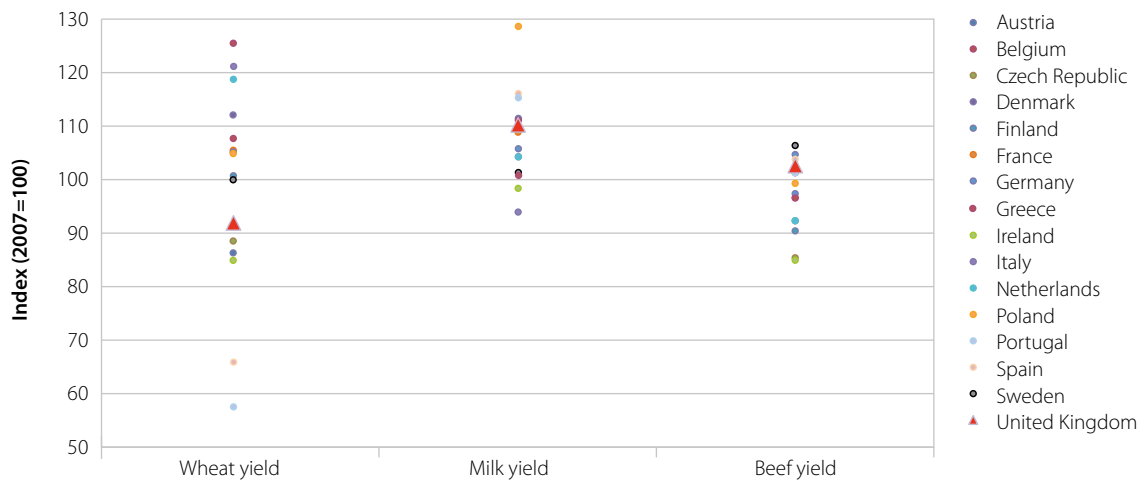
However, looking at yields alone does not provide a full comparison of carbon intensity, because it says nothing about the carbon intensity of inputs used to produce different products. To do this requires detailed analysis of GHG intensity of different inputs and products. Recent research by Lesschen et al (2011)[4] has shown that there are large variations in GHG emissions for different livestock products among EU countries, due to differences in animal production systems, feed types and nutrient use efficiencies (Box 6.2). Whilst uncertainties in data and methodologies exist, such studies provide a useful framework for analysing options to mitigate GHG emissions in agriculture and learning from best practice in other countries.

Figure 6.10: Change in methane emissions intensity in selected EU countries (2007-2012)



Source: Eurostat and CCC calculations.

Figure 6.11: Change in yields of key agricultural products in EU member states (2007-2012)



Source: AUK (2013), NAEI (2014).
Notes: Wheat yield: 100kg/ha; Milk yield: tonne milk/cow/pa; Beef yield: tonne/animal/pa.

4 J.P. Lesschen, M. van den Berg, H.J. Westhoek, H.P. Witzke, O.Oenema (2011) *Greenhouse gas emission profiles of European livestock sectors*. Animal Feed Science and Technology 166-167 (2011).

Box 6.2: GHG emission profiles of EU livestock sectors

Lesschen et al (2011) analysed GHG emissions for livestock products in EU-27 countries based on 2003-2005 data. The analysis was based on the MITERRA-Europe model which calculates annual nutrient flows and GHG emissions from agriculture. Input data consist of activity data (e.g. livestock numbers, feed, crop areas from Eurostat and FAO), spatial environmental data (e.g. soil and climate data) and emissions factors from IPCC and GAINS. The outputs are livestock production area and GHG emissions for different livestock outputs by source. This approach applies a uniform methodology across all countries, allowing for the direct comparison of GHG emissions among countries.

Key findings from the analysis were:

- Beef had the highest emissions intensity with 22.6 $kgCO_2e/kg$, followed by pork (3.5 $kgCO_2e/kg$), eggs (1.7 $kgCO_2e/kg$) and milk (1.3 $kgCO_2e/kg$). For most countries, the dairy and beef sectors accounted for the largest share of GHG emissions.
- Of the EU's four largest beef producers (France, Germany, Italy and the UK), the UK produced 47% more GHG/kg beef than France, 58% more than Germany, and 70% more than Italy. The older age of slaughter and reliance on pasture based production systems with high fertiliser application in the UK are largely responsible for these differences.
- UK milk production has one of the lowest GHG intensities in the EU, largely due to relatively low emissions from enteric fermentation (mainly related to differences in yields which are relatively high in the UK) and from organic soils which are much higher for the Baltic States, the Netherlands, and parts of eastern Europe.
- There was large variation in the GHG intensity of pork, poultry and egg production across the EU. For pork and eggs, the UK had below average EU GHG emissions/kg product, whilst for poultry, UK intensity was at the EU average.

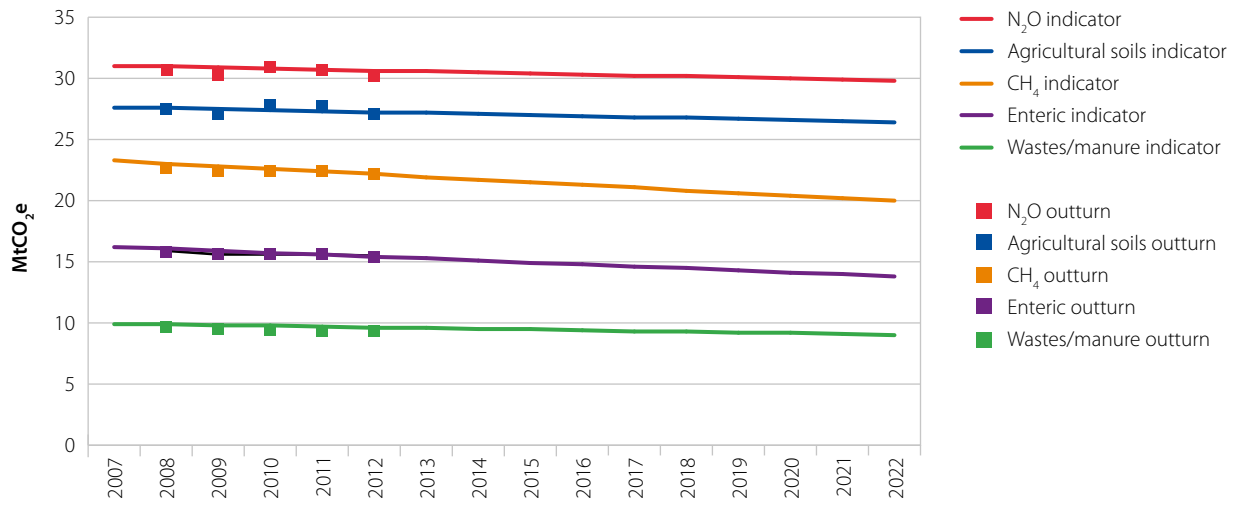
The results from this study are broadly in line with comparable studies, despite differences in approach, system boundaries and methodologies applied, and the considerable data uncertainties that exist.

3. Progress against indicators

In order to track progress in reducing non-CO_2 emissions in the agriculture sector, consistent with the Government's ambition for a 3 $MtCO_2e$ reduction in England from 2007 levels by 2022 (scaled up to 4.5 $MtCO_2e$ for the UK) we set out a preliminary set of indicators in our 2010 progress report. The indicators comprise trajectories for reducing emissions by gas and source and for improvements in carbon intensity and productivity (Figure 6.12):

- Agriculture met the trajectory for a 3% reduction in total non-CO_2 emissions over the five years of the first carbon budget.
- The single indicator for reduced emissions intensity of N_2O (2 tCO_2e per thousand hectares of land) was met. However, as the indicator covers both grassland and arable land, it masked the deterioration in emissions intensity of crop output grown on arable land (Section 1). On this basis we have decided to split out this indicator to capture intensity of grassland and arable land separately.
- For methane emissions intensity per unit of livestock output by animal type, while the indicator was met for beef, the one for milk was slightly off track with emissions intensity falling by 4% rather than the suggested 8% over the first carbon budget period.

Figure 6.12: Progress against indicators for agriculture to end of the third budget period



Source: NAEI ((2014), CCC calculations based on LCTP ambition.

In other sectors of the economy, we use traffic lights to compare actual progress against what we suggested could be achieved (e.g. on emissions reductions and uptake of measures). However, we have decided not to use the traffic light approach for assessing progress in agriculture because of the high uncertainty:

- Meeting the trajectories has been possible given the conservative level of ambition for emissions reduction in agriculture, which is towards the low end of the range of abatement (5-12 $MtCO_2e$) that we identified to be cost-effective by 2022.
- We are unable to assess whether the reductions were due to economic factors, policy or other actions taken by farmers.

Looking ahead, we estimate the sector is on track to deliver the 4.5 $MtCO_2e$ of savings by 2022. However, it is not possible currently to determine whether this is due to structural changes in the sector, changes in farming practice and/or policy drivers. In part this is due to the uncertainty in the current inventory, and in part due to the lack of an evaluation framework in the current GHG Action Plan.

With the exception of splitting out the N_2O emissions intensity of livestock and crop output, we propose to await the launch of the new Smart inventory next year before deciding what further amendments to existing indicators to 2022 are required. We will also extend our trajectories to 2027, in order to cover the fourth carbon budget period.

4. Incentives to reduce agricultural emissions – the policy framework

Voluntary approach

The GHG Action Plan is the sole policy mechanism in place to deliver the Government's ambition for a 3 $MtCO_2$ reduction in England by 2022. The plan is being delivered over three phases (Box 6.3). Completion of the first phase was achieved by 2012 which met our indicator trajectory.

Box 6.3: Delivery of the GHG Action Plan

The plan is being delivered in three phases under a voluntary approach based on provision of information and encouragement:

- Phase 1 (2010-2012) established the key activities required to deliver the planned 3 $MtCO_2e$ emissions reduction, including communications strategy, identifying key delivery routes and developing sector road maps.
- Phase 2 (2012-2015) is intended to promote improvements in farming practices in target sectors (i.e. crop nutrition improvements, promoting low emission animal diets and improvements to animal health).
- Phase 3 (2015-2020), with the benefit of an improved inventory, will promote those measures where there is more cost-effective potential to reduce emissions.

Regarding specific measures, the plan focuses on options which are more certain and cost-effective. The key areas of focus in the plan and associated ambition by 2020 are:

- Improvements to nutrient management plans to achieve a 0.6 $MtCO_2e$ reduction.
- Selection of different crop varieties which favour lower N_2O emissions to deliver a 0.2 $MtCO_2e$ reduction.
- Deployment of anaerobic digestion systems on farms reducing emissions by 0.55 $MtCO_2e$.
- Changing and improving ruminant diets to deliver emission savings of 1.6 $MtCO_2e$.
- The plan also includes ambitions to reduce CO_2 emissions, by improving energy efficiency and greater uptake of renewable energy sources, and to reduce land-use change emissions.

As the first phase of the Plan focused on identifying the principal sources of emissions and mitigation options the policy is not expected to start delivering emissions savings until 2013. However, evaluating progress will be difficult given there is no mechanism in place to assess whether emissions reduction is due to the GHG Action Plan as opposed to other policies and factors.

The overall UK contribution from agriculture towards meeting carbon budgets is 4.5 $MtCO_2e$ by 2022 which requires action by the devolved administrations. Action to date is also focused on using voluntary approaches, although Scotland has announced an intention to regulate if progress is below expectations, and in Northern Ireland there is clear buy-in from farmers given the emphasis on increasing productivity at the same time as reducing emissions intensity (Box 6.4).

Box 6.4: Devolved administrations

Scotland: The Farming for a Better Climate initiative was launched by the Scottish Government and Scotland's Rural College in 2009, and is designed to encourage voluntary uptake through the provision of information on win-win actions in five key action areas:

- using energy and fuels efficiently,
- developing renewable energy,
- locking carbon into soil and vegetation,
- optimising application of fertilisers and manures,
- optimising livestock management and storage of waste.

Given their cost-effectiveness, uptake for most of the measures is expected to increase by 50% and by 90% for nitrogen use efficiency (equivalent to 260 ktCO_2e of annual savings by 2020). Unlike England however, the Scottish Government has made clear its intent to introduce regulation if sufficient progress is not being made to increase nitrogen use efficiency.

Wales: A reduction target of between 0.6 MtCO_2e (10% below 2008 level) and 1.5 MtCO_2e by 2020 was set in its Climate Change Strategy announced in October 2010. The ambition is being delivered through a number of programmes including Glastir, which offers farmers financial support to develop sustainable land management practices and is funded via the Rural Development Programme.

Northern Ireland: The Greenhouse Gas Implementation Partnership (GHGIP) is a collaborative strategy between Government and industry. Given the importance of agriculture in Northern Ireland, there is a strong emphasis on improving efficiency and productivity. Phase one (2011-14) focused on improving awareness among farmers and identification of measures. Phase two (2014-20) will look at establishing emissions intensity baselines for specific commodities (starting with milk) back-cast to 1990, and the setting of achievable targets to reduce emissions intensity. The phase two plan will be published in 2015.

Other policy developments

In the last year, there have been a number of developments in the policy landscape both at the UK and EU level that could impact agricultural emissions:

- **Agri-tech strategy:** The Government published a new Strategy in July 2013. This aims to improve the productivity, sustainability and competitiveness of the agricultural sector by plugging a gap in applied research and facilitating collaboration between industry and the public and private research base. It also aims to improve the dissemination of research to farmers including new technology and farming methods that should be beneficial for reducing emissions. One strand is the Agri-Tech Catalyst which will fund projects looking to develop innovative solutions in the areas of crop and livestock production and non-food uses of arable crops (e.g. energy crops). Government is providing £370 million for the fund.
- **Common Agricultural Policy (CAP):** Reform of the CAP from 2015 is unlikely to have a significant impact on reducing emissions in agriculture, with the largest environmental gains expected to come from increased carbon sequestration and enhanced biodiversity (Box 6.5).

Box 6.5: CAP reform (2014-2020)

The new CAP scheme will start in 2015 and will retain the two pillars of funding. Direct payments linked to production will still be made to farmers under Pillar 1 through the Basic Payment Scheme, although 30% of the direct payment will be conditional on farmers undertaking three 'greening' measures:

- **Crop diversification:** arable farms of 10-30 hectares are required to grow two crops with no one crop covering more than 75% of the land. This increases to three crops for larger farms, with the 75% threshold also applicable.
- **Maintenance of permanent grassland:** in England, the share of permanent grassland compared to agricultural land must not fall by more than 5%.
- **Establish Ecological Focus Areas on 5% of arable land:** requires arable farmers to set aside 5% of their land for alternative measures such as field margins, hedges, trees and fallow land.

As minimal change in current farming practice will be required on most farms (e.g. only 7% will have to change to meet the crop diversification requirements), and a large proportion of farms will be exempt from undertaking some or all of the measures, 'greening' is expected to have a limited impact on emissions.

The second pillar will continue to pay farmers to undertake agri-environment schemes such as the planting of new hedgerows and reducing stocking densities. It is estimated that 70% of England's agricultural land is covered by one of these schemes. In England payments will be delivered through the next Rural Development Programme (2015-20). Defra is currently deciding on the suite of measures to include and although it is likely that the schemes will prioritise improving biodiversity and water quality, some measures will support emissions reduction with carbon sequestration expected to be the main beneficiary. For example, measures to enhance biodiversity on grassland and creating new woodland will increase carbon sequestration.

There is the flexibility to transfer up to 15% of funding from the direct subsidies budget (pillar 1) to rural development (pillar 2), termed 'voluntary modulation'. This is Defra's preference for England and 12% will be transferred to pillar 2, rising to 15% in 2018 and 2019. Modulation will ensure that although the overall size of the CAP budget has shrunk, funding for agri-environment schemes under Pillar 2 will remain unchanged.

We will consider a range of policy options that could be introduced to deliver emissions reductions as part of work for our next annual progress report and the fifth carbon budget report in 2015.

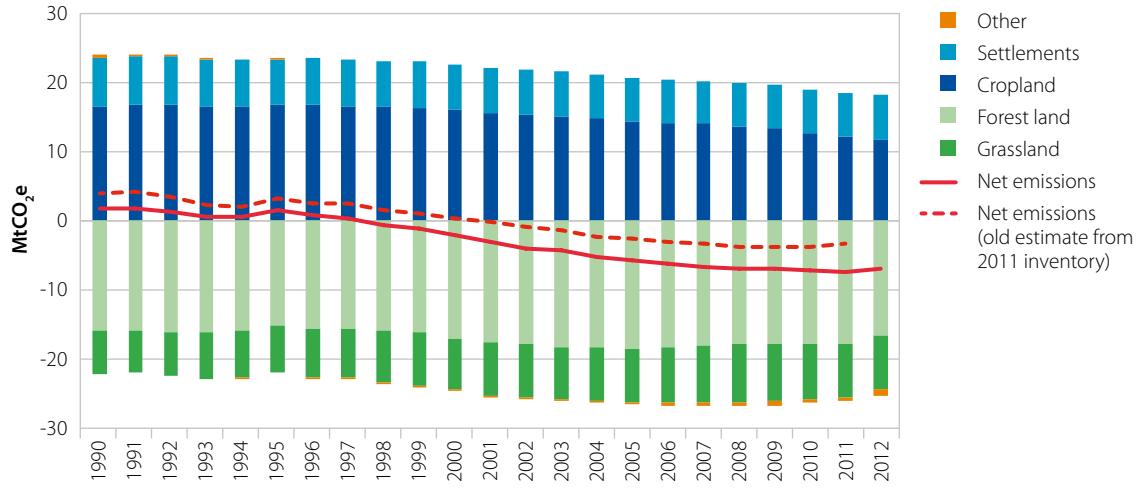
5. Land Use, land use change and forestry

Emissions trends

On a net basis, the land use, land use change and forestry (LULUCF) sector absorbed 7 $MtCO_2e$ in 2012. This represents a 7% decline for net removals on the previous year, reversing the long-term trend of increasing net removals since 1995. From 2007 to 2012, there was a 7% increase in net removals (Figure 6.13):

- Nearly 60% of emissions (11.7 $MtCO_2e$) in the sector arise from cropland. Emissions from this source declined by 3% in 2012 and by 16% from 2007 to 2012 consistent with the long-term declining trend. The main driver is the on-going decrease in emissions from the conversion of land into cropland (down 33% on 2007, and down 9% annually). Settlements, the second largest source of emissions became a larger emitter over the carbon budget period as the conversion of land into settlements increased emissions by 3%.

Figure 6.13: LULUCF emissions & removals (1990-2012)



Source: NAEI ((2014).

- Since 1998 emissions have been offset by carbon sequestered mainly from forestry and grassland. Total sequestration rates reached a peak in 2007 at 28.2 $MtCO_2$ before declining by 4% by 2012. While the level of carbon absorption from forestry has remained broadly unchanged over the five years, there has been a 26% decline in sequestration from land converted to grassland and forestry, equivalent to 2 $MtCO_2$.

Use of the new Carbine model to calculate the carbon release and sequestration of forests has resulted in a large revision to this year's LULUCF inventory (Box 6.6). Consequently, total net LULUCF removals across the time series are now higher than previously reported. For example, for 2011, net removals under the revised inventory totalled -7.5 $MtCO_2$ compared to -3.3 $MtCO_2$ under the old inventory.

Box 6.6: Carbine – the new forestry model

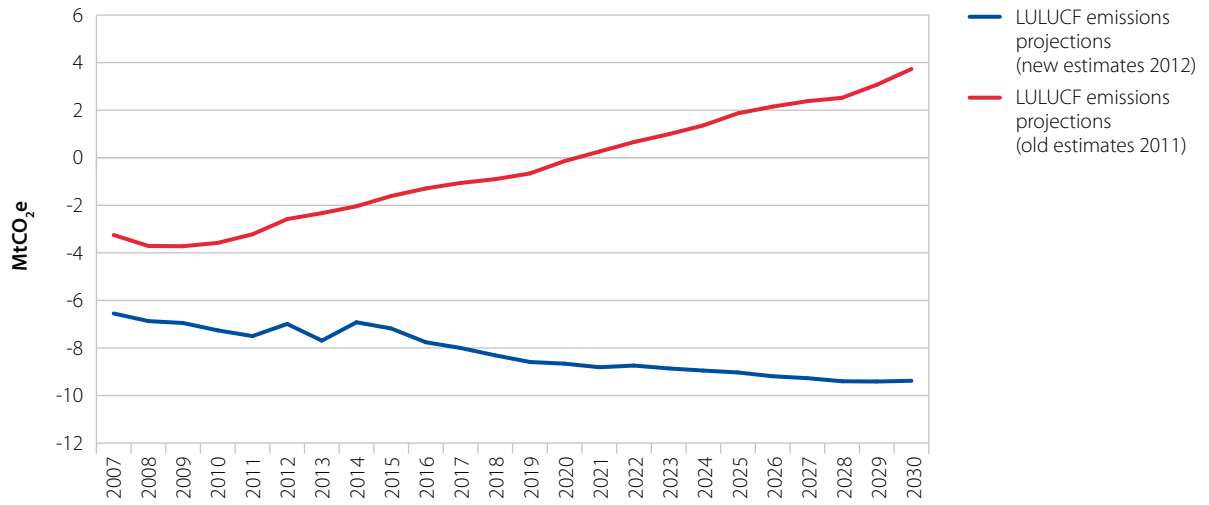
Carbine is the new model for carbon accounting in the forestry sector and replaces the C-Flow model used for previous inventories. The new assumptions in the model offer an improved representation of the diversity of the UK's tree species, forest growth rates and forest management practices, all of which impact on forestry emissions and sequestration. The main changes to the assumptions include:

- A better representation of the wide range of native and non-native species that make-up UK forests compared to C-Flow which only assumed one broadleaf (beech) and one conifer (sitka spruce) species to model all forests in the UK.
- The use of real harvesting data. Carbine assumes four broad forest management practices (clear-fell with thinnings, clear-fell without thinnings, thinned but not clear-felled and no timber production). A constant management regime was previously assumed under C-Flow, with thinnings at set intervals and conifers and broadleaves clear-felled after 60 years and 90 years respectively.
- Inclusion of historically planted forests from the year 1500 in recognition that some woodland does not reach carbon equilibrium for several centuries. In contrast C-Flow not only ignored forests that were planted before 1920 – assuming they had reached carbon equilibrium – but also their restocking after 1920.

As a result of the new assumptions and improved data sets used in Carbine, forestry sequestration is estimated to be 69% higher than previously. This is 7.3 $MtCO_2e$ higher for 2011 than was reported in last year's inventory.

The new assumptions used in the Carbine model also produced a significant change in the emissions projections for the LULUCF sector. While the sector was projected to become a net emitter in the early 2020s under the previous inventory, the sector will continue as a net carbon sink beyond 2050 under the new estimates (Figure 6.14).

Figure 6.14: LULUCF emissions projections (2007-2030)



Source: Centre for Ecology & Hydrology.
Notes: Assumes no new policy intervention and continuation of current policies.

Opportunities to reduce LULUCF emissions

The expansion of woodland and minimising carbon losses from peatland are two important ways of reducing emissions in the LULUCF sector.

Forestry

Expanding woodland cover increases sequestration whereby carbon is removed from the atmosphere and stored in trees. This offers scope for reducing emissions until woodland reaches equilibrium, beyond which no further carbon is absorbed.

Over the last two decades, tree planting rates in the UK declined significantly, reaching a low of 5,400 hectares by 2010, down 85% compared to 1989. To reverse the trend, England and the DAs have established targets to boost the creation of new woodland, which if successful could collectively achieve an additional 10,000 hectares a year by 2030:

- Scotland's ambition to plant 10,000 hectares each year by 2022 was hampered by bad weather in 2013 which led to a shortfall of 3,000 hectares in the year-to-March. However better planting conditions saw levels recover to 8,300 hectares in the year-to-March 2014.

- Under its forest strategy[5], the level of tree planting in 2013 and 2014 in Wales tripled to 900 hectares compared to 2011, as the Glastir Woodland Creation Grant Scheme, which was introduced in 2009, started to take effect.
- Elsewhere, tree planting rates in England remained flat in 2013, but increased by 700 hectares to 3,300 hectares for the latest planting year, while levels remained unchanged at 300 hectares in Northern Ireland for the fourth successive year. For the UK, woodland creation totalled 12,900 hectares in 2014, the highest level since 2003.
- Since the scheme was launched in 2011, the UK Woodland Carbon Code has promoted the creation of 14,000 hectares of new woodland (Box 6.7).

In support of each of the strategies Defra and the DAs, in conjunction with the Forestry Commission, have commissioned work to assess the cost-effectiveness of woodland creation in abating emissions. The final results are due over the summer and will include: how cost-effectiveness varies with different types of woodland; a regional analysis of where the woodland could be created; and the capacity for carbon to be stored in harvested wood products beyond the 'forest gate',

Box 6.7: UK Woodland Carbon Code

The voluntary code aims to encourage investment in woodland creation by verifying the claims of the levels of carbon captured and sequestered by new woodland. The code is attractive to UK companies when reporting on their carbon footprint under Defra's GHG Reporting Guidelines as it enables them to use savings to offset their wider emissions. It can also contribute to meeting other corporate responsibility objectives (e.g. creating natural habitat and increasing biodiversity). The companies that have taken part include Marks and Spencer and Stagecoach.

The code is also attractive to landowners, as it enables them to recover the costs of creating the woodland by receiving payment up-front from participating businesses who take on the rights of the carbon captured over the project's lifetime. In addition, the sale of woodland products can provide another source of income.

According to the Forestry Commission, which administers the scheme, 202 projects were registered under the code to March 2014 covering 14,000 hectares. It is estimated that these projects will sequester 5.7 $MtCO_2$ over the next 100 years.

Peat for horticultural use

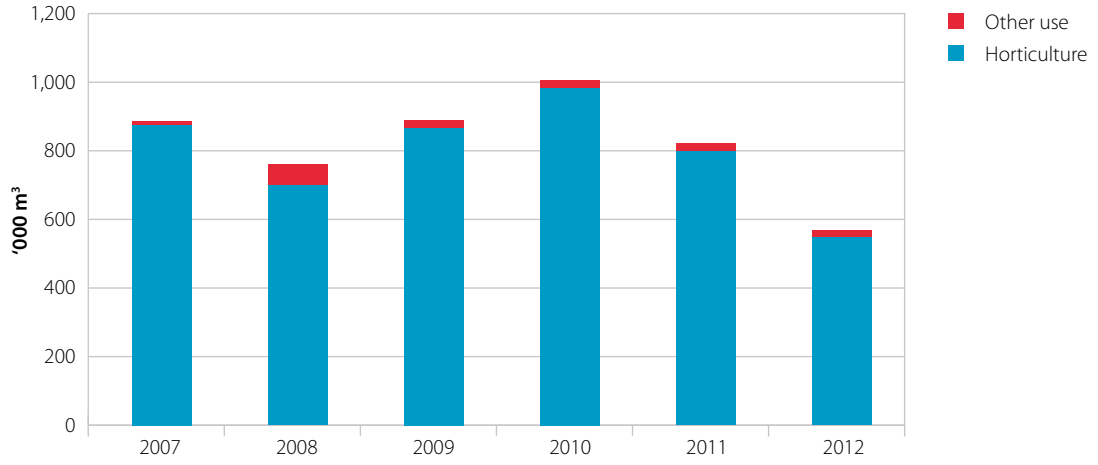
Horticulture is the main driver of lowland peat extraction accounting for around 0.4 $MtCO_2$. Rates of extraction are highly dependent on the weather and wet conditions in 2012 produced a 31% decline (Figure 6.15). Domestically sourced peat only accounts for just over a third of UK peat demand, with Irish supplies meeting around half the horticultural sector's requirements.

The Government has an ambition to phase out the use of all peat for horticultural use in England on a voluntary basis by 2030. Recent steps taken to achieve this include:

- Establishing a new Growing Media Panel in 2013 to oversee the delivery and assess progress.
- A commitment to undertake a policy review in 2015, which will be the first opportunity to revisit the target.

5 'Woodlands for Wales Action Plan' http://www.forestry.gov.uk/pdf/WoodlandforWalesActionPlan2012.pdf/$FILE/WoodlandforWalesActionPlan2012.pdf

Figure 6.15: Peat extraction in Great Britain



Source: DCLG.

- Match funding a new five-year research programme on the use of peat alternatives with a total value of £1 million.

With the Scottish government also signed up to the phase out, data indicates that the share of peat in the UK growing media market is on the decline. It fell from 73% in 2007 to 57% in 2012 as the use of alternative mediums become more popular backed by retailer support (e.g. one home improvement retailer announced in April that sales of its bedding plants this year would be 95-99% peat free).

Upland peat use and peat restoration

The LULUCF inventory only includes emissions from lowland peat. In England and Scotland this is mainly from the extraction of peat and the drainage of the Fens for agricultural use. Emissions from upland peat primarily due to historic drainage practices and to restoration of peat from land management practices (e.g. rewetting and vegetating) are currently excluded. However, work is underway that could see their inclusion in the future:

- The IPCC has finalised the methodology for capturing changes in emissions, focusing on the rewetting and restoration of peat land since 1990. Inclusion in the inventory by member states is voluntary.
- In England, it is estimated that two-thirds of upland peat is degraded and accounts for about 0.35 $MtCO_2e$. Defra is nearing completion of a five-year project that is looking at how best to restore drained upland peat to achieve the biggest emissions saving.
- For lowland peat systems in England and Wales, work is focused on quantifying emissions under different management and land uses (e.g. pristine bogs and land that have been impacted by grazing and extraction).

- The Scottish Government intends to include peat land restoration activity in the inventory once work to establish the carbon benefits have been completed. In the meantime, under their Scotland Rural Development Programmes (2014-2020), they have committed £15 million to fund restoration projects for 2014 to 16.

Upland peat in England was considered in depth in the 2013 progress report from the CCC Adaptation Sub-Committee[6]. That report concluded that upland peat is generally in a degraded condition due to a combination of land use, management practices, and pollution. In line with that advice, we recommend that the policy framework is strengthened to enable further restoration effort across the uplands and lowlands in the UK and that existing regulations are enforced to prevent damaging practices on protected sites.

For England, the aim is to use the results from the work on upland and lowland peat to develop a robust methodology with Tier 2 nationally derived emissions factors that will allow for reporting in the inventory. We recommend that all UK emissions from peat land are included in the inventory as soon possible.

Land management practices on agricultural land

The way agricultural land is managed can impact on soil carbon stocks, but such practices are currently not reported in the inventory. The EU and Defra are seeking to better understand how much additional abatement is possible and whether it can be achieved for both cropland and grassland. Initial work suggests:

- Few opportunities exist in cropland, with the application of manure considered to be the best land management technique for adding soil carbon.
- There is consensus that reduced or no-tillage has little impact on soil organic carbon losses. Instead different tillage regimes merely change the distribution of the carbon throughout the soil profile, with more accumulating near the top in no-tilled soil, compared to a more even mix in soil that is tilled.
- The level of carbon in permanent grassland may have reached saturation levels, and the focus should therefore be on preserving existing soil carbon stocks.

The EU timeframe for mandatory reporting of the impact of land management practices on soil carbon stocks by 2021 requires the submission of preliminary estimates by member states by 2015.

Progress against indicators

We have an indicator for additional tree planting of 10,000 ha/year over a 15-year period from 2015 in order to deliver 1 $MtCO_2e$ savings by 2030. Although the level of ambition that England and the DAs have set would collectively deliver this, it will require an increase in implementation given that current planting rates fall below the levels required.

6 CCC ASC (2013) 'Managing the land in a changing climate – Adaptation Sub-Committee progress report 2013'.

6. Summary of progress and revised indicators

Summary – past progress and future policy

In this chapter we have examined progress against indicators in agriculture and the LULUCF sectors. However, we do not use the 'traffic light' approach in assessing past progress, as adopted elsewhere in this report, due the large uncertainty currently attached to estimating emissions in agriculture.

Looking ahead to the end of the fourth carbon budget period, Government projections suggest baseline emissions in the absence of policy beyond those in the 2007 Energy White Paper could reach 53.8 $MtCO_2e$ by 2027.

If the estimated policy savings from the GHG Action Plan (scaled up to the UK) are included, projected emissions would decline to 49.3 $MtCO_2e$ by 2027. However, evaluating progress will be difficult given there is no mechanism in place to assess whether emissions reductions are due to the GHG Action Plan as opposed to other policies and factors. In addition the reliance on a voluntary approach rather than incentives or regulation puts delivery at risk. For these reasons we classify the savings from the GHG Action Plan to be at risk due to design and implementation problems (Table 6.1).

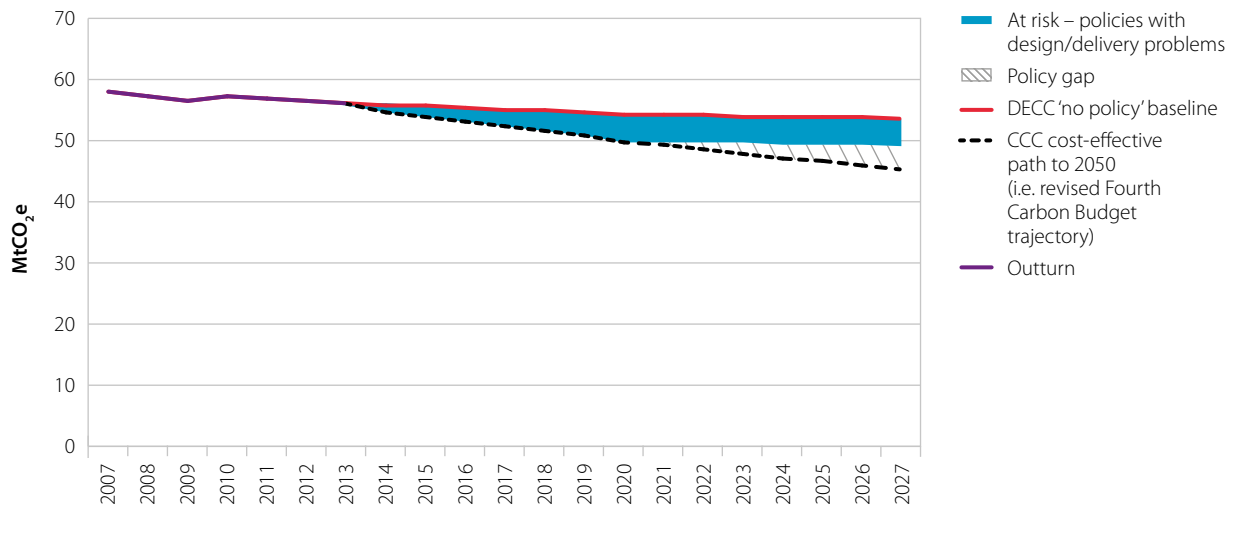
Table 6.1: Policy Table

Policy	Comment
At risk – policies with design/implementation problems	
GHG Action Plan	Targets cost-effective measures but reliance on a voluntary approach risks the delivery of carbon savings. No mechanism in place to evaluate if the policy is delivering emissions reductions in line with the ambition of the Plan.
Missing policies	
Further ambition in agriculture policies	No policy post 2022

Beyond 2022, there is no policy in place, and nor is there a commitment by Government to consider policy options. This puts at risk a further 3.9 $MtCO_2e$ of savings required to contribute to carbon budgets by 2027 (2.8 $MtCO_2e$ by 2025). In total, 8.4 $MtCO_2e$ of savings are at risk by 2027 (Figure 6.16).

Given the significant risk to emissions savings, it is important that industry puts in place measures to monitor the effectiveness of the GHG Action Plan so that the Government review in 2016 is better able to assess progress from measures taken under the plan. If progress falls short of our trajectory, we recommend that a full range of policy options to address any short-fall should be considered by the Government. This should include whether to continue with a voluntary approach, and the introduction of new incentives and regulation both for the near term and post-2022.

Figure 6.16: Assessment of planned policies against future targets – Agriculture



Source: Baseline and CCC cost-effective path includes CO2 emissions.
Notes: GHG Action Plan savings scaled up to the UK.

There is also an additional 1 $MtCO_2$ savings that is at risk from the LULUCF sector due to the level of tree planting rates falling short of what is required.

Revised indicators to 2030

We will continue to monitor progress in reducing emissions in the agricultural sector against a set of indicators.

With the exception of splitting out the N_2O emissions intensity of livestock and crop output, we will await the launch of the new Smart inventory next year before deciding what further amendments to existing indicators to 2022 are required, and the setting of new indicators to take account of the fourth carbon budget.

Key messages

- Agriculture emissions are **highly uncertain**...
  ... but data suggest these declined in 2012 and were broadly in line with our indicators for the first carbon budget period.
- There were reductions across the range of **sources and gases**...
  ... but there is a **lack of evidence** that changes in farming practices have driven these reductions...
  ... particularly as efficiency of inorganic **fertiliser use** for crops has **not improved** and it is unclear whether productivity improvements in livestock have resulted in reduced emissions per unit of output.
- The **Smart Inventory** is on track to be rolled-out next year, and this will help improve monitoring of emissions and key drivers in this sector.
- It is important that industry puts in place measures to **monitor effectiveness** of its GHG Action Plan.
- The absence of policy proposals beyond 2022 and the reliance on a voluntary approach put emissions reductions **at risk**. Stronger policy levers should be considered as part of the 2016 review.
- Action should be taken to enable further restoration and the prevention of damaging practices on **peatland**.

Table 6.1 The Committee's agriculture indicators

AGRICULTURE		Budget 1	Budget 2	Budget 3	2012 trajectory	2012 outturn
Headline indicators						
Emissions (indicative % change from 2007 reflecting LCTP ambition scaled to UK)						
CO_2e emissions		-3%	-6%	-9%	-2.8%	-3.3%
GHG emissions (% change in tCO_2e against 2007)	N_2O	-1%	-3%	-4%	-1.3%	-2.5%
	CH_4	-6%	-12%	-18%	-4.7%	-4.5%
	CO_2*	n/a	n/a	n/a	n/a	n/a
Source emissions (% change in tCO_2e against 2007)	Soils	-1%	-3%	-4%	-1.4%	-1.8%
	Enteric fermentation	-5%	-10%	-15%	-4.9%	-4.2%
	Animal waste	-7%	-13%	-20	-3.0%	-6.4%
	Machinery/fuels*	n/a	n/a	n/a	n/a	n/a
Drivers**						
tN_2O emissions per thousand hectares of arable land	2007 = 3.6	3.6	3.5	3.5	3.6	3.9
tN_2O emissions per thousand hectares of pasture land	2007 = 2.0	2.0	2.0	2.0	2.0	1.8
tCH_4 emissions per tonne of cattle and calf meat, dressed carcase weight	2007 = 11.6	11.2	10.7	10.3	11.2	11.2
tCH_4 emissions per thousand litres of milk	2007 = 0.45	0.41	0.37	0.34	0.41	0.43
tCH_4 emissions per tonne of sheep and lamb meat, dressed carcase weight	2007 = 11.6	11.3	10.9	10.5	11.3	11.0
tCH_4 emissions per tonne of pig meat, dressed carcase weight	2007 = 3.0	2.9	2.7	2.6	2.9	2.7
tCH_4 emissions per tonne of poultry, dressed carcase weight	2007 = 0.28	0.27	0.27	0.26	0.27	0.27

Table 6.1 The Committee's agriculture indicators

AGRICULTURE		Budget 1	Budget 2	Budget 3	2010 trajectory	2010 outturn
Supporting indicators						
Farming Practice **Measures where greater confidence exists (e.g. proven technology, considered best practice, consistent abatement results) but uncertainty about baseline use.**						
Nutrient management – including improved mineral and organic N timing, separating slurry and mineral N, using composts, and making full allowance for manure N	% of hectares where measures are in place	Better evidence about current farming practice is required to develop full trajectories.				
Livestock management – including breeding for fertility and productivity	% of livestock of different production/fertility efficiency	Better evidence about current farming practice is required to develop full trajectories.				
Manure management	% of manure/slurry stored in covered tanks or lagoons	Better evidence about current farming practice is required to develop full trajectories.				
Anaerobic Digestion	Installed AD capacity using manures (MW)***	32	68	102	Less than 2% of holdings have AD (2013)	
Measures that require further evidence to establish appropriateness and effectiveness in UK and in regional contexts						
Soil management (reduced tillage/drainage), nitrification inhibitors, and using more N-efficient plants (species introduction and improved N-use plants)	% of hectares where measures are in place	Not suitable for all hectares. Requires development of evidence base to resolve possible conflicts with other goals and to determine applicability, GHG benefits and costs under different conditions.				
Livestock management (including maize silage and dietary additives in form of propionate precursors or ionophores)	% of livestock consuming different diets and feed additives	Not suitable for all animals/farms. We will monitor the development of the evidence base around these measures, including applicability, net GHG benefits and resolution of possible conflicts with other sector goals.				

Table 6.1 The Committee's agriculture indicators

AGRICULTURE	Budget 1	Budget 2	Budget 3	2012 trajectory	2012 outturn
Policy Milestones					
Industry puts in place measures to monitor the effectiveness of the GHG Action Plan.		2014-15			
Government policy review (2016): • Review on voluntary approach • Consider of policy options for intervention • Set triggers for intervention		2016			
Introduce new smart inventory		2014			On-target for 2014 roll-out
Include upland peat emissions in the LULUCF inventory		By 2017			
Develop a policy framework to increase peatland restoration		By 2017			
Other drivers					
Crops/soils: Crop yields (e.g. cereals), cropping areas, N_2O emissions per hectare of cultivated land, N_2O emissions per unit of fertiliser use, output of product per unit of fertiliser use.					
Livestock: tCH_4/tonne dressed carcase weight (cattle & calves), weight of carcase produced per day of age, calves produced per cow per year.					
General: We will monitor development of the evidence base and R&D support for the various mitigation measures. We will also track upcoming CAP reform negotiations (to be complete by 2014) and implications for farming practice and emissions.					

Table 6.1 The Committee's agriculture indicators	
LAND USE, LAND USE CHANGE AND FORESTRY	**By 2030**
Headline indicator	
Emissions (annual savings from carbon sequestration by 2030)	
CO_2 sequestered	1 $MtCO_2e$
Supporting indicators	
UK woodland planting	At least 21,000 hectares/year from 2015
Policy Milestones	
Development and implementation of a woodland creation programme	Government has set ambition for England of average rate of 5,000 ha/year by 2060

* CO_2 abatement potential not factored into first three budget periods.
** Broadly consistent with LCTP ambition and industry roadmaps. UK Inventory at present will not fully capture reductions in emissions as a result of uptake of particular measures. Intensity indicators for budget periods assume constant output. Should output exceed assumed levels then lower intensities would be needed to deliver absolute emissions reduction.
*** Handling beef, dairy and pig manures and slurries.
**** 2007 baseline = 10.7 thousand hectares. Source: Forestry statistics 2010, figure 1.4.

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022. These indicators will be updated in work for the 5th carbon budget.

Key: Headline indicators Supporting indicators Other drivers

Chapter 7

Chapter 7: Progress reducing emissions from Waste and F-Gases

1. Introduction and key messages

Waste and F-gas emissions data lag other sector CO_2 emissions 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 in 2012, waste and F-gas emissions totalled 36 $MtCO_2e$, accounting for over 6% of total UK greenhouse gas emissions.

Waste emissions were 22 $MtCO_2e$ in 2012 and accounted for almost 4% of total UK greenhouse gas emissions. They are predominantly methane emissions which arise due to the decomposition of biodegradable waste in landfill sites in the absence of oxygen (around 86% of waste emissions). Emissions also arise due to wastewater treatment and incineration of wastes.

F-gas emissions were 15 $MtCO_2e$ in 2012 and accounted for almost 3% of total UK greenhouse gas emissions. F-gas emissions arise from their use as coolants in refrigeration and air conditioning.

In our previous progress reports we included analysis of waste emissions and set out indicators against which future progress can be monitored. We suggested that there was scope for emissions reductions beyond the Government's existing ambition, given further opportunities for waste prevention and recycling and other disposal methods such as anaerobic digestion and composting. We recommended that the introduction of stronger levers to address the full potential for reducing waste emissions may be required and should be kept under review.

Our key messages are:

Waste emissions

- Estimates of waste emissions have been revised upwards by around 30% since our last progress report due to a review of the methane capture rates at landfill sites. It is now estimated that landfill sites capture around 59% of the methane compared to 75% previously assumed.
- Waste emissions decreased by 5% in 2012, continuing a longer-term trend where emissions have fallen by 54% since 1990, largely due to reductions in the amount of biodegradable waste being landfilled and increased capture of landfill methane. There has also been good progress to reduce biodegradable waste generated by households and businesses and divert waste from landfill. This reduction has been driven by the landfill tax, voluntary responsibility deals, information awareness campaigns and strategies to support anaerobic digestion.

- Further reductions in waste emissions could be achieved by reducing biodegradable waste arising (specifically for food, paper/card, wood and textile waste) through stronger targeting of measures.
- Further potential to reduce emissions by improving capture for methane at landfill sites are possible given they are currently below levels being achieved in other countries and under best practice. Therefore, we recommend that the Government publish an approach to increase methane capture rates towards best practice, based on their improving evidence base with milestones and measures to ensure these are met.

F-gas emissions

- F-gas emissions rose slightly by 0.2% in 2012. From 1990 to 1997 there was a rise in F-gas emissions from 14 $MtCO_2e$ to 21 $MtCO_2$, then a fall to 11 $MtCO_2e$ by 2000, and a steady rise since then to 15 $MtCO_2$ in 2012. The rise in emissions is mainly due to their use as a replacement for ozone-depleting substances (ODS). The increase has also been driven by growth in demand for products such as air conditioning and refrigeration units.
- An update to the EU F-gas Regulation which will apply from January 2015 aims at cutting the EU's F-gas emissions by two thirds from 2014-2030. This now needs to be transposed in to UK legislation and we recommend that Defra ensure UK businesses comply with the regulation and seek opportunities to go further where cost-effective alternatives exist.

Our policy recommendations for waste and F-gases are summarised in Box 7.1.

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

- Waste and F-gas emission trends
- Opportunities for reducing waste and F-gas emissions
- Policy progress in waste and F-gases emissions
- Summary of progress in reducing waste and F-gas emissions

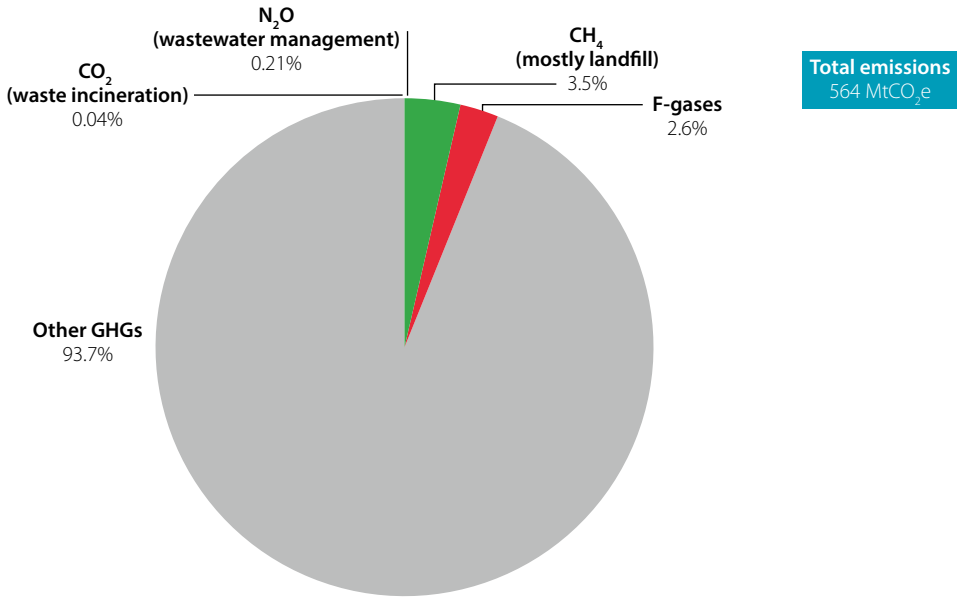
Box 7.1: Policy recommendations – Waste and F-gases

- **Publish specific strategies for reductions in the amounts of the main biodegradable waste sources sent to landfill** (specifically food, paper/card, and wood), and introduce stronger levers to ensure these are met unless there is clear evidence that these are not required.
- **Set out an approach to increase methane capture rates**, towards best practice, with milestones and actions to ensure these are met.
- Ensure UK businesses **comply with new EU F-gas regulation and seek opportunities to go further** where cost-effective alternatives exist; if these are found, push for stronger implementation at the EU level.

2. Waste and F-gas emission trends

Waste and F-gas emissions data lag other sector CO_2 emissions by a year due to the longer time required to collate non-CO_2 emissions data. In this chapter, we focus on the latest data which show that in 2012, waste and F-gas emissions totalled 36 $MtCO_2e$, accounting for over 6% of total UK greenhouse gas emissions (Figure 7.1).

Figure 7.1: GHG emissions from waste and F-gases in the context of total UK emissions (2012)



Source: NAEI. National Atmospheric Emissions Inventory (NAEI).

(a) Waste emission trends

Waste emissions were estimated to total 22 $MtCO_2e$ in 2012, accounting for almost 4% of total greenhouse gases in the UK (Figure 7.1).

Waste emissions are predominantly methane emissions which arise as biodegradable waste in landfill sites decomposes in the absence of oxygen. Nitrous oxide (N_2O) emissions in the waste sector arise primarily from wastewater treatment and are estimated based on the quantity of sewage sludge disposed, population levels, and protein consumption. CO_2 emissions arise primarily from incineration of wastes.

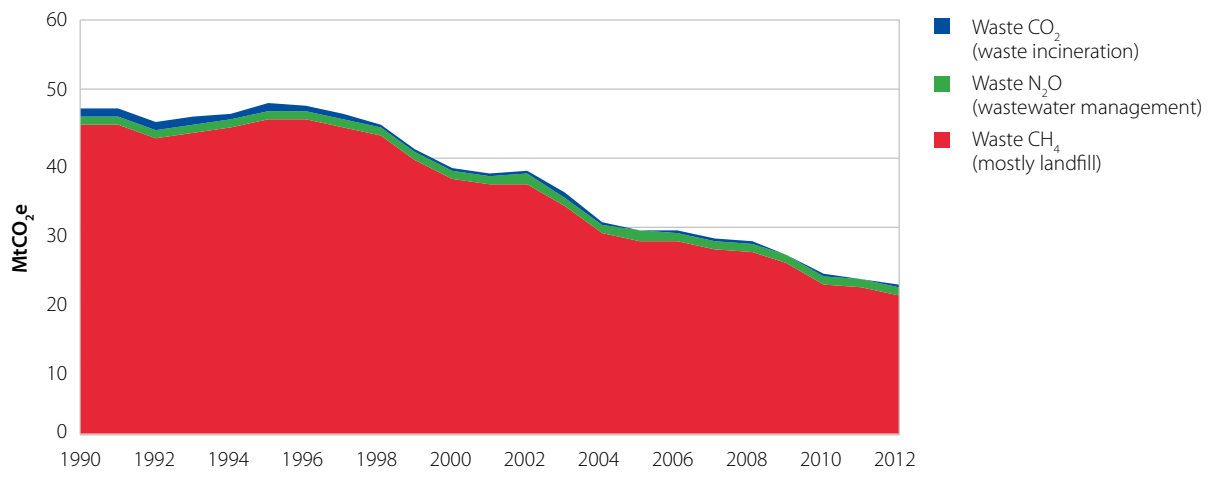
There have been large reductions in emissions since 1990 and during 2007-2012, largely due to reduced methane emissions arising from landfill sites. Emissions from wastewater treatment and waste incineration also fell.

- During 1990-2007 emissions from waste fell 40%, and this trend continued through 2007-2012 when waste emissions fell by 24%. In 2012, emissions fell by 5% (Figure 7.2).

- Methane emissions arising from landfill account for 86% of waste emissions and fell 26% over 2007-2012 (5% in 2012). Overall landfill methane emissions have fallen by 57% since 1990.
- Methane and nitrous oxide (N_2O) emissions arising from wastewater treatment account for 13% of waste emissions and fell 8% over 2007-2012 (2% in 2012).
- CO_2 emissions arising from waste incineration without energy recovery (e.g. clinical and sewage sludge) account for 1% of waste emissions and fell 23% over 2007-2012, 6% in 2012. Emissions from the incineration of wastes without energy recovery have fallen 80% since 1990, as the proportion of waste incinerated with energy recovery has risen and are counted within power sector emissions.

Given their dominance, we focus on methane emissions from landfill when considering the drivers of these trends.

Figure 7.2: GHG emissions from waste (1990-2012)



Source: NAEI.

(i) Waste emission drivers – methane

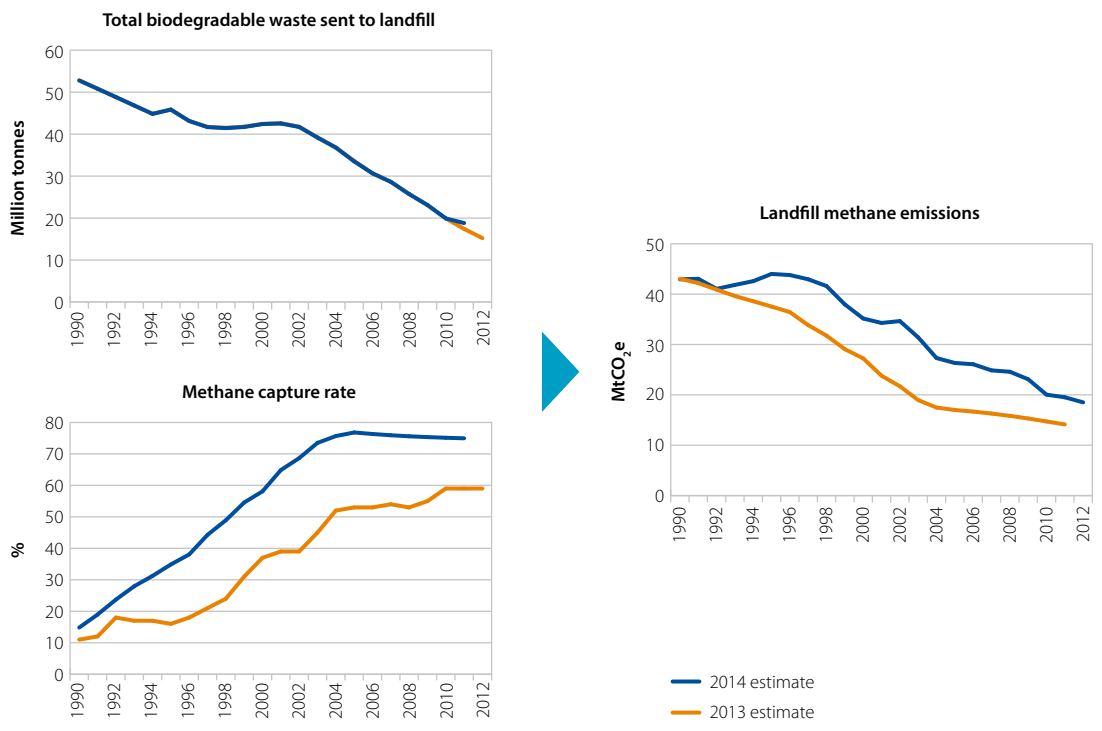
Landfill methane emissions are not directly measured but calculated based on : the quantity of biodegradable waste arsing; the amount that is sent to landfill sites; assumptions on the properties of waste streams such as methane yield and decay rates (e.g. how much and over how many years methane is emitted as different types of waste degrade); as well as the properties of landfill sites (e.g. how much methane is captured and flared or used for energy generation rather than emitted into the atmosphere).

- **Biodegradable waste arising.** Data on trends in biodegradable waste arisings are limited but Waste Reduction Action Programme (WRAP) data suggests that household food and drink waste has fallen by 15% between 2007 and 2012, from 8.3 to 7 million tonnes (Mt). Reductions in waste have been driven by waste prevention and resource efficiency campaigns, voluntary responsibility deals and more recently the recession.

- **Biodegradable waste sent to landfill.** This was reduced by an estimated 17% in 2012, continuing a longer-term trend where the amount of biodegradable waste landfilled has decreased by over 76% since 1990. These reductions have been driven by the UK landfill tax in place to meet EU Landfill Directive targets (Figure 7.3).
- **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, with field and experimental observations exhibiting wide variation (e.g. 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 will differ between and within sites. The Government has estimated that uncertainties over methane yield and decay rates mean that methane emissions from landfill could be 53% greater or lower than currently recorded in the inventory.
- **Methane captured at landfill sites.** Lifetime methane capture rates at landfill sites (the proportion of methane that is flared to CO_2 or used for energy generation, rather than emitted) are estimated to average 59% in 2012, rising from 54% in 2007 (Figure 7.3). The estimate of the proportion of methane captured at landfill sites has fallen from 75% to 59% since last year due to an improvement in the methodology for this estimation and now uses new Environmental Agency data on methane flaring (Box 7.2). We previously recommended that capture rates should be measured rather than assumed, and the new estimates reflect the latest attempts to measure performance.

As a result of these changes, landfill methane emissions have decreased by 57% between 1990 and 2012 (Figure 7.3).

Figure 7.3: Biodegradable waste, proportion of methane captured at landfill sites and methane emissions from landfill (1990-2012)



Source: GHG Inventory 1990-2012, NAEI.

Box 7.2: Review of methane capture rates

For modern landfill sites methane is either utilised for energy generation, flared, or released into the atmosphere. CO_2 from landfill is considered of biogenic origin, so is not included within the inventory. Combustion of methane through engines or flares converts the methane to CO_2 and is therefore considered mitigation under IPCC reporting guidelines. The combination of methane that is utilised for energy generation or flared and converted to CO_2 is thus considered to be 'captured' methane.

Up to last year, the quantity of methane captured was based on a survey of landfill operators. This resulted in an estimate that on average 75% of the methane was captured. As data on the amount of methane utilised for energy generation are already collected, the rest of the captured methane was assumed to be flared to CO_2.

However, based on recommendations from the UNFCCC to improve the estimate of methane captured at landfill sites, the GHG inventory now bases capture rates on actual data that includes use of a new Environment Agency dataset for volumes of gas flared in England and Wales (available from 2009).

This has resulted in a more accurate estimate for total methane captured, falling from 75% to 59% for 2012.

- In last years inventory it was calculated that the methane capture rate increased from 15% in 1990 to 77% in 2005, and falling to 75% in 2012.
- The new estimates suggest a capture rate of 11% in 1990 rising to 59% by 2010 and remaining at this level (Figure 7.3).

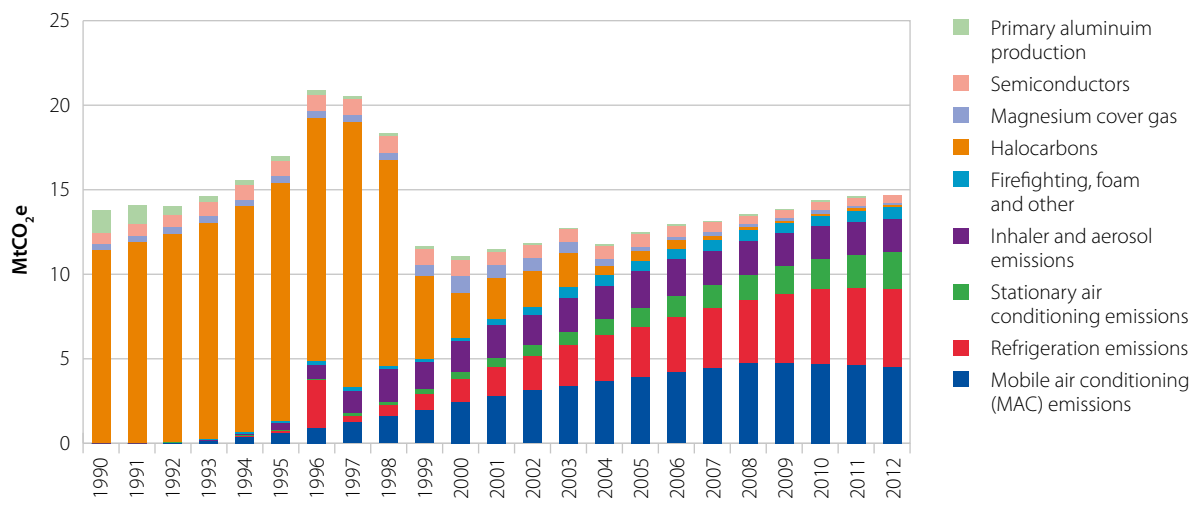
The new estimate is thought to better represent the entirety of the UK landfill site stock including new and ageing sites where the methane emissions are so low that engines for energy generation or flaring are not required by law, are not economic; or will not fully work with such low flow rates or gas quality.

Source: DECC and UK GHG inventory 1990-2012 Annual Report.

(b) F-gas emission trends

F-gases are used as coolants in refrigeration and air conditioning, leading to emissions when these gases leak. F-gas emissions have been rising since 1990 mainly due to their use as a replacement for ozone-depleting substances (ODS). From 1997 to 1999 there was then a drop in their use due to abatement equipment being fitted at halocarbon production facilities. Since 2000, F-gas use has been slowly rising again, driven by growth in demand for products such as air conditioning and refrigeration units. F-gas emissions rose by 0.2% in 2012 (Figure 7.4).

Figure 7.4: F-gas emissions by source (1990-2012)



Source: NAEI.

F-gas emissions arise from three types of fluorinated gases; hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6). These gases are emitted in industrial processes and buildings in very small amounts but have high global warming potentials (between 140 and 23,900 times that of CO_2) and long atmospheric lifetimes.

- **HFC emissions** make up the largest proportion of F-gas emissions. Since the Montreal Protocol was ratified in 1989, HFCs have been used as substitutes for ozone-depleting substances (ODS) such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). HFCs are therefore now used in applications which previously used CFCs and HCFCs, such as refrigeration and air conditioning equipment, foams, aerosols and fire extinguishers. HFCs are emitted during the manufacture, lifetime and disposal of these applications.
- **PFC emissions** arise mostly from use in industrial processes such as aluminium production and manufacture of semiconductors. PFCs are also used as solvents, firefighting agents and refrigerants.
- **SF6 emissions** arise from use in industrial applications such as magnesium casting and photovoltaic manufacture. They are also used in sound-proof windows and switchgear equipment.

Between 2007 and 2012 F-gases rose by 12%. There are a range of sources of F-gas emissions.

- **Mobile air conditioning (MAC) emissions** rose by 1% between 2007 and 2012. Within this period, they fell by 2% between 2011 and 2012. This reduction is being driven by the MAC directive which came into effect in 2011 and which restricts the use of F-gases in new cars. This has reversed the historical trend of increased emissions arising from the phase out of ozone-depleting CFCs and increased demand for air conditioning in vehicles.
- **Stationary air conditioning emissions** rose by 57% over 2007-2012, rising 9% in 2012. This increase is being driven by increased demand. These emissions are also covered under the F-gas regulation.
- **Refrigeration emissions** rose by 30% over 2007-2012, rising 2% in 2012. The increase in emissions is being driven by increased demand for refrigeration. The F-gas regulation (which attempts to reduce leakage and use of F-gases) may also be limiting the increase in F-gases from this sector, more details below.

This rise in F-gas emissions has occurred despite EU regulations to limit their growth. Based on this continued rise in emissions, the new EU F-gas regulation to come into effect in 2015 will go further and look to cut EU F-gas emissions by two-thirds in 2030 from 2014 levels, as set out in section 3.

(c) Trends compared to the Committee's waste and F-gas indicator framework

We have previously set out an indicator framework for monitoring progress in waste and F-gases towards meeting the first three carbon budgets. These include monitoring GHG emissions, biodegradable waste sent to landfill and the methane capture rate. Progress overall to date has been good, although two indicators were not met.

- Our emission indicator for **total waste GHG emissions** reflected a 9% fall to from 2007 to 2012. Outturn data shows that waste emissions fell 24% to 2012. This reflects that the amount of biodegradable waste sent to landfill was reduced more quickly than expected and methane capture rates at landfill sites improved.
  - Our indicator suggested that **biodegradable waste sent to landfill** could fall 30% from 2007 to 2012. Outturn data shows that biodegradable waste landfilled fell 44% to 2012.
  - Our indicator assumed that the 75% **methane capture rate** in 2007 would be maintained. A re-estimation of the capture rate at landfill sites has reduced the 2007 capture rate to 54%, although this has risen to 59% by 2012. Although the capture rate is now lower than previously thought, it has been increasing since 2007.
- Our indicator assumed **F-gas emissions** would fall 2% from 2007 to 2012. Outturn data shows that F-gas emissions rose almost 3% to 2012.

Overall, while reductions in waste emissions are exceeding our indicators, F-gas emissions continue to rise. There is, however, a range of opportunities to reduce emissions further in both waste and F-gases in section 3.

(d) Trends in UK emissions compared to the EU

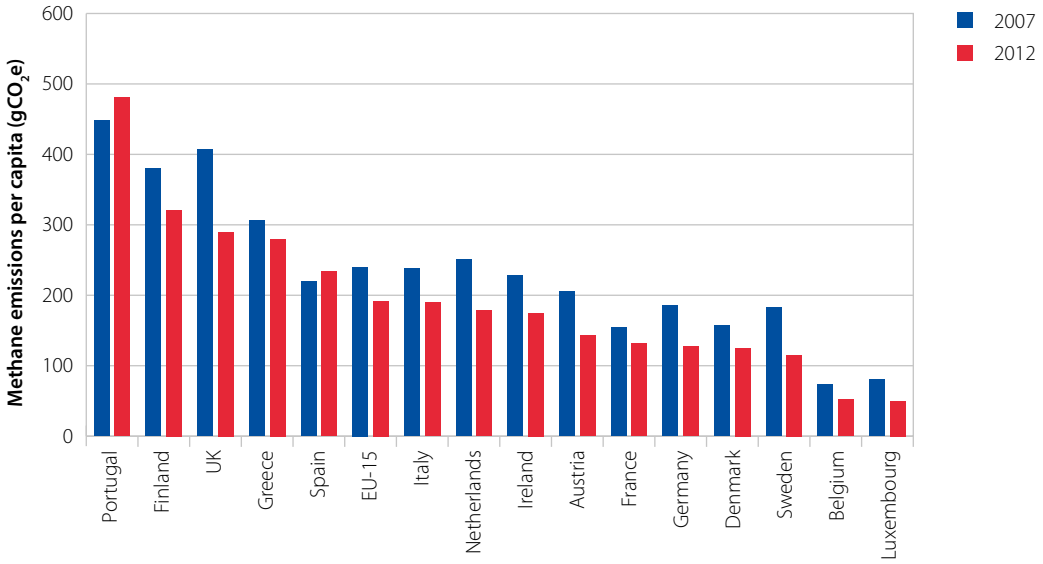
(i) Waste emissions – methane from landfill

The UK has one of the highest rates of methane emissions from landfilled waste per capita in the EU, though this has reduced by around 30% between 2007 and 2012 (Figure 7.5). The EU countries with the lowest methane emissions per capita, Sweden, Belgium, Denmark and Germany, neither all have the lowest waste generated per capita or the highest methane capture rates at landfill across the EU.

- UK waste arisings per capita in 2007 were above the EU-15 average, but had fallen nearly 20% by 2012, resulting in UK per capita waste arisings being below the EU-15 average. Denmark and Germany have two of the highest waste arising per capita in the EU, while Belgium and Sweden have two of the lowest (Figure 7.6).
- UK capture rate of methane from waste is the second highest in the EU, whereas Denmark, Germany and Sweden have average methane capture rates below the EU15 average (Figure 7.7).
- The treatment methods of waste differ substantially between EU member states (Figure 7.8). The UK sent a third of its municipal waste to landfill in 2012. However, many countries within the EU divert nearly all of their waste away from landfill and this is part of the reason why some countries achieve low capture rate of methane at landfill.

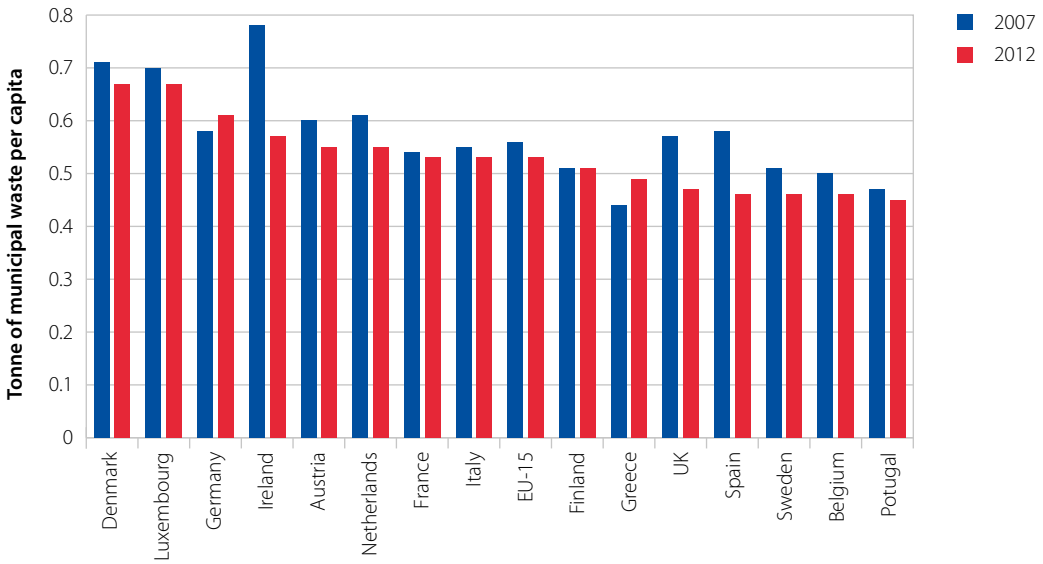
Diversion of waste away from landfill is why Denmark and Germany have two of the lowest methane emissions from waste per capita in the EU, while Belgium achieved lower emissions per capita through additional lower waste arising and Sweden has achieved even lower emissions per capita through improved methane capture at landfill.

Figure 7.5: Methane emissions from landfill waste (2007 and 2012)



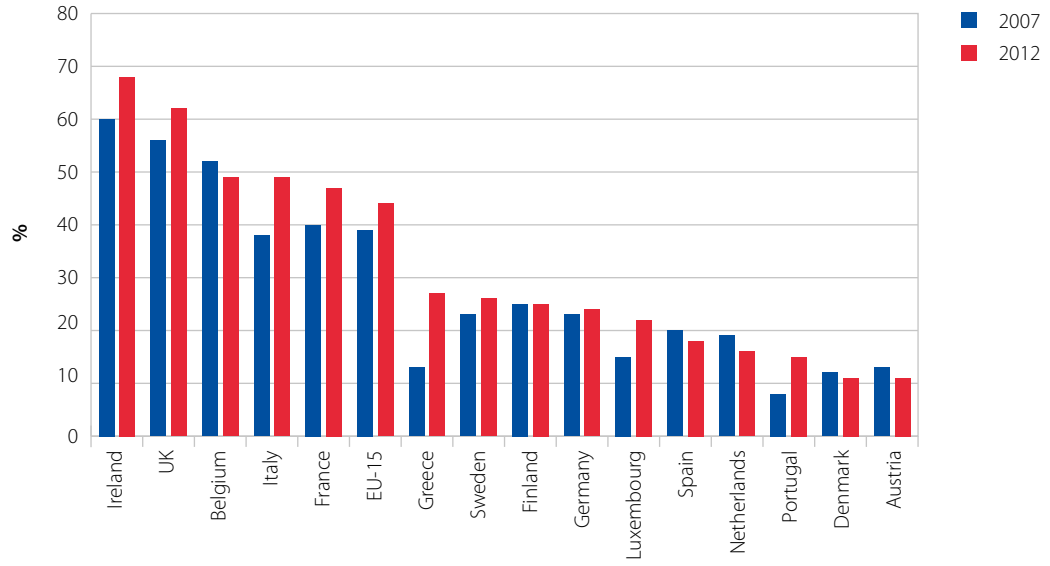
Source: European Environment Agency.

Figure 7.6: Municipal waste arising (2007 and 2012)



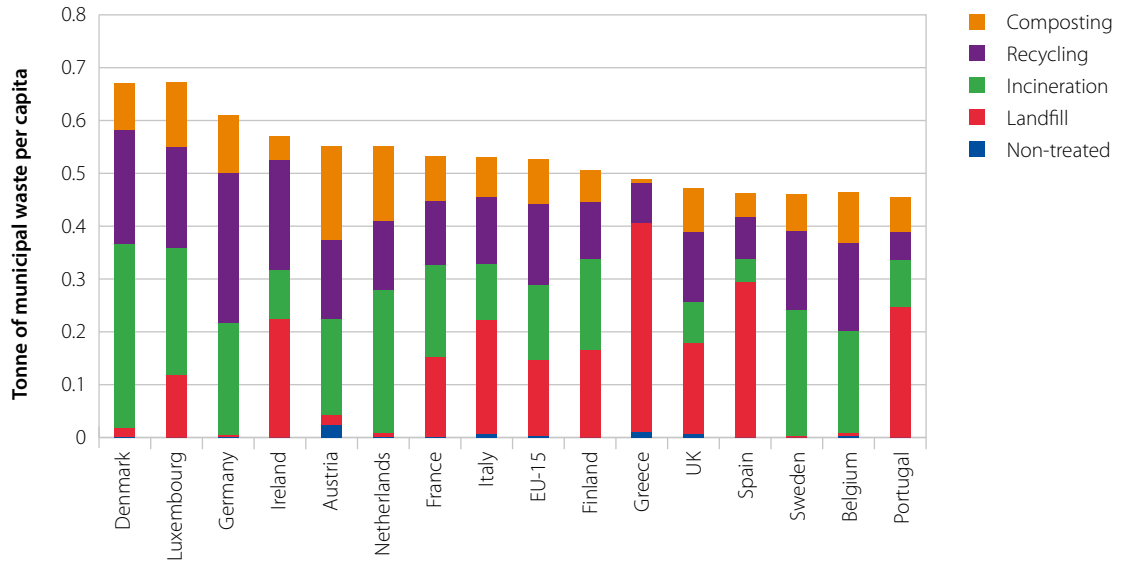
Source: European Environment Agency and CCC analysis.

Figure 7.7: Percentage of methane from landfilled waste captured (2007 and 2012)



Source: European Environment Agency.

Figure 7.8: Treatment of municipal waste in 2012

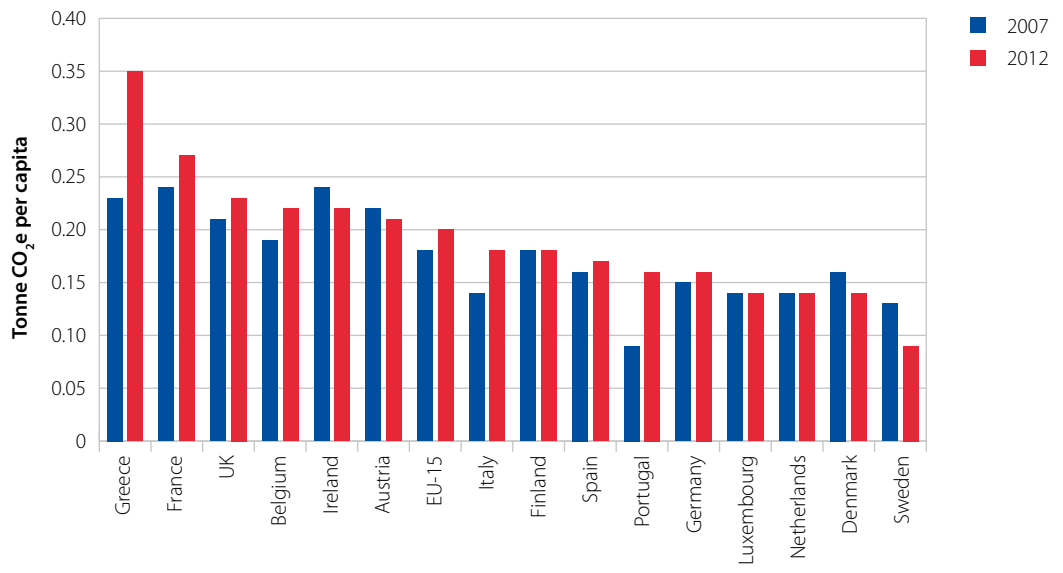


Source: European Environment Agency.

(ii) F-gas emissions

F gas emissions have risen in most EU countries between 2007 and 2012, driven by growth in demand for products that use these gases as coolants such as air conditioning and refrigeration units. UK F-gas emissions per capita are higher than the EU-15 average but grew slower over the last five years (Figure 7.9).

Figure 7.9: F-gas emissions (2007 and 2012)



Source: NAEI and CCC analysis.

3. Opportunities for reducing waste and F-gas emissions

(a) Opportunities for reducing waste emissions

In our 2012 progress report we discussed in detail the potential opportunities to reduce waste emissions.

- **Waste prevention**. Emissions can be further reduced through waste prevention, which offers substantial upstream environmental and economic gains associated with resource efficiency beyond the benefits of reducing methane from landfill.
- **Diversion of biodegradable waste from landfill**. There is potential to go significantly further than the Government's current ambition through opportunities for 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**. Methane capture at modern landfill sites is over 80% and can reach as high as 90%, with these sites set to play a bigger role as legacy emissions from older (and less efficient) landfill sites decline.

Recognising opportunities to go further than the Government's ambition, we present our indicators as a range, reflecting scenarios where biodegradable waste sent to landfill is reduced

at least in line with the Government's projections, and potentially reduced close to zero by 2020. This continues the approach we first set out in our 2012 progress report.

Regulatory guidance for landfill operators bases permit conditions on a target to collect at least 85% of the methane formed in landfills receiving biodegradable waste. Reducing variation by bringing sites in line with best practice could improve average capture rates and reduce emissions, although it is unclear whether this would be cost-effective across all sites. Improving methane capture rates and confidence in assumed estimates continue to be priorities for the Government and landfill operators.

(b) Opportunities for reducing F-gas emissions

There is potential for further reductions in F-gas emissions by replacing remaining F-gases with alternative compounds. A 2010 AEA study for Defra[1] showed that there are currently much lower GWP alternatives to HFCs, some of which are commercially available and some of which are in development:

- In refrigeration and air conditioning there are several options including hydrocarbons which are already in the market, as well as CO_2 and Hydrofluoroolefins (HFOs) which are in development.
- Metered dose inhalers, which are currently used in the UK, can be replaced with dry powder inhalers which have been a known technology for over 20 years and are more widely used in some countries than in the UK.
- Currently replacements for HFCs in aerosols are not widely used in the UK. However, HFOs are already being used as a replacement, with only small modifications to equipment required, in the EU.

An updated F-gas regulation will come into effect in 2015 and seeks to reduce the EU's F-gas emissions by two thirds from 2014-2030, see section 3 for details.

Going forward, we will monitor against reductions in waste and F-gas emissions as set out in Table 7.1.

Table 7.1: The Committee's waste and F-gas indicators (% change from 2007)

		Budget 2	Budget 3	Budget 4
Waste*	Total CO_2e emissions	-22% to -33%	-32% to -50%	-39% to -89%
	CH_4 (Landfill)	-25% to -37%	-36% to -56%	-44% to -71%
	N_2O (Wastewater treatment)	-2%	+2%	+4%
	CO_2 (Incineration)	No more than 25%		
	Biodegradable waste to landfill	-38% to -84%	-39% to -97%	-39% to -97%
	Methane captured at landfill	Rising above current rate of 59%		
F-gas*	CO_2e emissions	-23%	-40% to –50%	-52% to -60%

Source: CCC analysis.
Note: * we will return and update these indicator trajectories in light of our advice for the fifth carbon budget.

1 AEA (2010) *HFC consumption and emissions forecasting* available at www.gov.uk.

4. Policy progress in waste and F-gases emissions

(a) Waste emission reduction policies

Success in reducing landfill emissions reflects a combination of financial incentives introduced through the landfill tax, local authority and commercial/industrial actions in response to the landfill tax and other objectives, information and voluntary programmes for waste reduction and regulations to improve landfill management practices.

Waste policy is a devolved matter although the landfill tax currently applies UK-wide (but will be devolved in the future (see section iii).

While the UK landfill tax remains the key lever for reducing waste sent to landfill, the Government's 2011 Waste Review included an Action Plan setting out further waste policy commitments or measures to consider. Our policy milestone indicators cover actions identified in the Government's Waste Review and our recommendations for further actions.

(i) EU waste framework

The **EU Landfill Directive** required a 50% reduction in biodegradable municipal waste landfilled in the UK by 2013 relative to 1995 levels and requires a 65% reduction by 2020. Data for 2012 suggest that the target was being outperformed, with reductions in 2012 already at the level required by 2013.[2] The Directive also requires landfill operators to collect and treat gases arising from sites (e.g. for energy production or through flaring). The EU Commission is currently reviewing EU waste legislation and we will monitor and report on progress in future progress reports (Box 7.3).

Box 7.3: EU Commission review of waste legislation

The Commission is planning to present a single, comprehensive and coherent review of waste in 2014 and cover the following three elements:

- A review of key targets in EU waste legislation (in line with the review clauses in the Waste Framework Directive, the Landfill Directive and the Packaging Directive);
- An ex-post evaluation "fitness check" of five of the EU Directives dealing with separate waste streams: sewage sludge, PCB/PCT, packaging and packaging waste, end of life vehicles, and batteries;
- An assessment of how the problem of plastic waste can best be tackled in the context of the current waste policy framework, based on the publication of the Green Paper on a European Strategy on plastic waste in the environment.

The objective is to lay the ground for more effective design of waste legislation that promotes further the principle of the waste hierarchy to remove ambiguity and improve legal certainty, thus making legislation clearer, more effective and more easily enforceable. This may lead to the reinforcement of existing targets or to the introduction of new targets. At the same time, the review will look into possible overlaps and, if necessary, identify options to simplify legislation and improve clarity and consistency.

Notes: PCB/PCT = Polychlorinated biphenyls and polychlorinated terphenyls.

2 Based on data from UK Greenhouse Gas inventory 1990-2012.

In order to achieve current targets under the Directive the UK introduced the **Landfill Tax** in 1996. This imposes a charge on landfill operators for each tonne of waste landfilled, creating an incentive to reduce the waste sent to landfill either through waste prevention or diverting waste to other treatments (recycling, composting, recovery, and reuse):

- The tax has been increased from its initial rate of £7 per tonne to £80/t in 2014/15.
- At Budget 2014 it was announced that the landfill tax will increase in line with the RPI, rounded to the nearest 5 pence, from 1 April 2015.

There have also been a number of complementary approaches to encourage waste reduction (specifically food and packaging), increased recycling rates and diversion of waste from landfill (Box 7.4).

(ii) Waste reduction policies in England

In 2013-14 the Government has progressed in its policy framework through the launch of the National Waste Prevention Programme for England.

- **National Waste Prevention Programme (WPP).** At the end of 2013 the Government launched its WPP to drive waste further up the waste hierarchy by helping businesses and households realise cost savings through waste prevention and resource efficiency. The programme aims to:
  - Develop, through the Waste and Resources Action Programme (WRAP), a **Sustainable Electricals Action Plan**, aimed at catalysing sector action and seeking commitment on design for longer life, and increased technical durability.
  - Support innovation in design through **Technology Strategy Board's** investment of up to £5 million in collaborative research and development and their design challenges for a circular economy competition (£1.5 million).
  - Raise awareness of resource efficient business models and supply chain innovations through a £900,000 programme of Action Based Research pilots and WRAP run trials of take back schemes and leasing/hiring schemes.
  - Develop a £800,000, two-year scheme to support communities to take forward innovative waste prevention, reuse and repair actions in their local areas, working in partnership with local businesses, authorities and civil society groups
  - Improve access to finance for businesses, through improving the information available to banks, enabling them to promote the business benefits of investment in resource efficiency, particularly for small and medium sized businesses and by continuing the £1.5 million **Waste Prevention Loan Fund**.

- Work with businesses, local authorities and civil society to develop a suite of metrics by the end of 2014 to help monitor progress on waste prevention, enabling consistent measurement of, for example, financial, environmental and social impacts, and levels of engagement. Over time, they will look to expand these metrics to include wider environmental impacts.

- **Introduction of a new plastic bags charge.** In October 2015, the Government will introduce a 5p charge on all single-use plastic carrier bags in England. There is already a similar 5p charge on single-use bags in Wales and Northern Ireland, and Scotland is expected to introduce a charge later in 2014. However, unlike in Scotland, Wales and Northern Ireland small and medium-sized businesses will be exempt from the charge in England.

The WPP is a positive step towards a long term and sustainable circular economy, where waste is considered in everyday life, used or minimised. The WPP and other complementary measures like those for food waste reduction (Box 7.4) need to feed into overall strategies for reducing emissions from the main sources of biodegradable waste methane emissions. [3]

Box 7.4: Current policies and voluntary agreements to reduce waste generation and landfill methane emissions

Waste reduction

There are a number of voluntary programmes aimed at reducing food waste.

- **WRAP's Love Food Hate Waste Programme** – encourages voluntary reductions in food waste. 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. However, UK households are still throwing away 4 Mt of household food and drink annually that could be avoided, the equivalent of six meals every week for the average UK household.[3]
- **Courtauld Commitment** – a voluntary responsibility deal to improve resource efficiency in the grocery retail sector with an overall 20% reduction in household food waste under the three phases between 2005 and 2015. The commitment has been estimated to save more than 8 $MtCO_2e$ since 2005.
  - The first phase (2005-2009) – 1.2 Mt of food and packaging waste was prevented, with a monetary value of £1.8 billion, and a saving of 3.3 $MtCO_2e$.
  - The second phase (2009-2012) – 1.7 Mt of waste was prevented, with a monetary value of £3.1 billion, and a saving 4.8 $MtCO_2e$.
  - The third phase (2013-2015) – aims to reduce household food & drink waste by a further 5% and food & packaging waste by 3% from 2012 levels. All major supermarkets have signed up and signatories currently represent 90% of the market.
- **Hospitality and Food Service Agreement** – was launched in 2012 with the aim to cut food and packaging waste by 5% from 2012 levels and increase food and packaging waste that is being recycled, sent to AD, or composted to 70% by 2015.

We will continue to monitor delivery of these deals against objectives

3 WRAP (2014) – http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012

Box 7.4: Current policies and voluntary agreements to reduce waste generation and landfill methane emissions

Diversion of waste towards recycling and other treatments

There has been effort at the local and business level to divert waste away from landfill.

- **Household waste** – Partly incentivised by the landfill tax local authorities have supported the sorting of waste through providing for recycling collection (and in some cases for separate food waste collection), encouraging composting and investing in waste treatment facilities
- **Commercial and industrial waste** – The UK has a statutory producer responsibility regime to reduce packaging and recently set new targets requiring obligated producers to increase recovery rates of materials (e.g. paper/card, glass, aluminium and steel) from 74% in 2012 to 79% in 2017.
- **The Government's 2011 AD Strategy and Action Plan** aims to reduce barriers to uptake of AD in England. The Government has set up a £10 million loan fund to support new AD capacity, created an innovation fund to bring down costs of AD, identified potential sources of waste feedstock (through WRAP's Food Waste Resources Portal), and developed markets for digestate (an AD by product). There has been good progress with AD in the UK, with the number of plants increasing from 54 plants when the strategy and action plan was launched in June 2011 to 110 operational plants by July 2013.

Further Government action and leadership would help minimise waste going to landfill and further unlock potential for producing energy through anaerobic digestion.

Methane capture at landfill

- **Capture of methane at landfill sites** has significantly increased from an average rate of 11% in 1990 to 59% now due to 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).

With no further real increases planned for the landfill tax, progress may slow down in future, even though large volumes of paper/card, food, wood and textile waste continue to be sent to landfill and barriers may prevent the landfill tax from driving effective action throughout the waste chain (collection and disposal, as well as prevention).

We therefore repeat our recommendation for the Government to publish specific strategies on how to reduce each of the main biodegradable waste sources, consider mandating UK-wide provision of separate collection of food waste by local authorities, and to consider bans on major sources of biodegradable waste from landfill on a case-by-case basis.

- We made these recommendations in our 2013 progress report to Parliament. The Government responded that priority should be placed on waste prevention to reduce biodegradable waste sent to landfill, that they 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.

- Nevertheless, action needs be taken at every step along the waste chain including collection and disposal. Wales and Scotland already have or are planning both separate food waste collection and biodegradable waste landfill bans. Such actions to divert biodegradable waste from landfill could further unlock potential for producing energy through anaerobic digestion.

There may also be potential to reduce emissions by improving the average rate of capture for methane at landfill sites, given that the new estimates suggest this is lower than previously thought and below levels being achieved in other countries and under best practice. Therefore, we recommend that the Government publish an approach to increase methane capture rates towards best practice, based on their improving evidence base with milestones and measures to ensure these are met.

(iii) Devolved administrations waste policy

Waste management is a devolved issue, with each of the devolved administrations developing waste strategies and legislating waste measures (see chapter 8). Currently, the landfill tax is a UK-wide policy measure. However, as of April 2015, Scotland will acquire responsibility for the landfill tax and Wales will follow in 2018.

Stronger policy frameworks are in place in Wales and Scotland to encourage recycling by households and businesses. Both have set targets for 70% of waste to be recycled by 2025.

- Scotland has also banned the landfilling of biodegradable material by 2020 and is requiring local authorities to roll-out separate food waste collection services by the end of 2013, to be completed by 2015.
- Wales aims to divert all municipal biodegradable waste from landfill by 2020 and is the only UK country where food and/or food and green waste is collected separately by every local authority.
- Northern Ireland has set a household recycling/reuse target of 50% by 2020, with a proposal to increase the rate to 60%.

Separate waste collection and biodegradable landfill bans should be considered for roll out across the rest of the UK as in other EU members states (Box 7.5).

Box 7.5: EU member state waste policy

While the UK has made progress in reducing waste going to landfill through the landfill tax and provide financial incentives to capture landfill methane for use in energy generation, it has not achieved the success of other European countries.

For example, the Swedish government has been able to significantly reduce waste landfill emissions through measures to drive down waste being sent to landfill, and encourage recycling and recovery:

- In 2000, the Swedish government introduced a landfill tax which played a vital role in the diversion of municipal waste from landfill in favour of recycling and incineration.
- In 2002, the government brought in a landfill ban on sorted combustible waste and a ban on organic waste in 2005.
- The environmental objectives set by the Swedish government in 2005 include, among others, the target of 50 % recycling of household waste by 2010.

While the recycling target was not met, Sweden now has an equal share of recycling and incineration (49%), while the proportion of waste sent to landfill has been reduced to around 1% in 2010.

Belgium's waste management responsibility falls under three separate regions: Brussels Capital Region, Flanders and Wallonia. Each of the regions have introduced a portfolio of policy instruments with a focus on communication campaigns on waste prevention and separation, including education in schools, to achieve a high recycling rate:

- Belgium has one of the highest landfill taxes and landfill tax increases in Europe, combined with a landfill ban.
- Bruxelles Capital Region has introduced mandatory waste separation by householders with fines up to €625 for non-compliance from 2010
- Flanders has introduced mandatory quality thresholds for separately collected waste quantity thresholds for residual waste.

This has effectively diverted waste from landfill to recycling, meaning that Belgium has already met all the EU Landfill Directive diversion targets for biodegradable waste and the EU Waste Framework Directive 50% recycling target for municipal waste.

In Denmark the major initiatives to improve municipal management were taken before 2001 including a landfill and incineration tax introduced in 1987 and a total ban on the landfilling of combustible waste in 1997. In addition, the establishment of separate collection schemes for paper, glass packaging, and garden waste has contributed significantly to the increased level of recycling.

(b) F-gas emission reduction

There are currently two EU policies in place to reduce F-gas emissions. One focuses on air conditioning in cars and vans, while the other covers F-gas use as a whole:

- The **Mobile Air Conditioning (MAC) Directive** came into effect in 2011. It prohibits the use of F-gases with a global warming potential more than 150 times greater than CO_2 in air conditioning units in new types of cars and vans introduced from 2011 and in all new cars and vans produced from 2017.
- The **EU F-gas Regulation** was first introduced in 2006. An update to this regulation, which applies from January 2015, is aimed at cutting the EU's F-gas emissions by two thirds from 2014-2030. The new regulation strengthens the existing measures and introduces a number of far-reaching changes by:

- Limiting the total amount of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030. This will be the main driver of the move towards more climate-friendly technologies;
- Banning the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols;
- Preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.

This new regulation now needs to be transposed in to UK legislation. We recommend that Defra ensures UK businesses comply with the new regulation and seek opportunities to go further where cost-effective alternatives exist; if these are found, the Government should push for stronger implementation at the EU level.

(c) Revised policy indicators to 2030

In monitoring progress on reducing waste and F-gas emissions in future, we introduce new indicators given the need to strengthen incentives and overcome non-financial barriers if measures are to be effective in reducing emissions (Table 7.2).

Table 7.2: The Committee's waste and F-gas indicators

Sector	Indicator	Budget 2	Budget 3	Budget 4
Waste	Defra to agree responsibility deals with sectors specified in waste review (waste management, paper, packaging, textiles)	End 2015		
	Defra to explore scope to strengthen incentives through the waste chain.	End 2017		
	Defra to consider and publish an approach to increase methane capture rates, towards best practice, with milestones and measures to ensure these are met.	End 2017		
	Defra to publish specific strategies on how to reduce each of main biodegradable waste sources (specifically food, paper/card, and wood) from households and businesses, with milestones and measures to ensure these are met.	End 2016		
	The Government to consider mandating UK-wide provision of separate food waste collection services by local authorities.	End 2016		
	Defra to follow the examples of Scotland and Wales which plan to ban or divert biodegradable waste from landfill, by reconsidering bans on major sources of biodegradable waste, on a case by case basis.	End 2016		
F-gas	Defra to ensure compliance with new EU F-gas regulation	Ongoing		

5. Summary of progress in reducing waste and F-gas emissions

(a) Summary – past policy

In this chapter we have considered progress against indicators in waste. We summarise this below in the form of 'traffic light' ratings as outlined in Chapter 1 for a set of our key indicators (Table 7.3).

For each key indicator, we compare the outturn data over 2008-13 to our indicators, and to assign it a colour of red, amber or green where (broadly):

- Green signifies on-track performance or outperformance (e.g. in terms of lower emissions, higher deployment, or policy that is either in place earlier than we recommended, or more comprehensive).
- Amber signifies slight underperformance against our indicator (e.g. policy implementation delays).
- Red signifies significant underperformance or rejection of certain policies and/or measures.

Waste emission indicators were met for the first carbon budget (2008-12) due to reductions in biodegradable waste going to landfill and an increase in the methane capture rate. The Government has made progress in publishing their National Waste Prevention Programme and moving forward with responsibility deals and strengthened incentives through the waste chain. However, more work needs be done to develop strategies to reduce specific waste sources including further consideration on landfill bans.

F-gas emissions did not meet our indicator for the first carbon budget (2008-12).

Table 7.3: Traffic light assessment of CCC indicators		
Indicator	**Traffic light**	**Comment**
Biodegradable waste sent to landfill	Green	47% fall compared to 30% in indicator
Percentage of methane captured at landfill sites	Amber	Indicator suggested maintain at 75%, but a re-estimation suggests that the rate was 59% in 2012, although rising from 54% in 2007
Develop National Waste Prevention Programme by end 2013	Green	Published December 2013
Agree responsibility deals with sectors specified in Waste Review by 2015	Green	Ongoing; Courtauld, Hospitality/Food Service deal
Explore scope to strengthen incentives through the waste chain by 2017	Green	Ongoing research, inc. trialling of reward/ recognition trial schemes by local authorities
Launch consultation on wood landfill restriction by autumn 2012	Amber	Completed, with decision (February 2013) not to pursue wood waste landfill ban
Review case for material-specific landfill restrictions by mid 2013	Red	Decision not to pursue other bans such as food or paper/card at present based on wood waste evidence.
Improve estimates of methane captured and explore opportunities for capturing more methane from landfill	Amber	New evidence has brought down estimate to 59% for 2012, up from 54% in 2007
Develop specific food and paper/card waste strategy by end 2013	Red	No specific strategies for these sources of waste, but some policies have been introduced to address food and paper/card.
Update to the EC's F-gas regulation to make it fit for purpose by end 2013	Amber	New EU F-gas regulation published in April 2014 and to come into force in 2015, Government still to transpose within UK legislation
Source: CCC analysis.		

(b) Revised indicator trajectories & policy indicators

Going forward, we will continue to monitor progress in the waste sector against a range of indicators. Since the new outturn data for waste emissions are yet to be applied to forecasts we will maintain our previous indicators for waste emissions and will update these in the future (Table 7.4).

Key findings

- Estimates of waste emissions have been **revised upwards by around 30%** since our last progress report due to a review of the methane capture rates at landfill sites.
- Waste emissions **fell by 24%** since 2007, and are now 54% below 1990 levels. This is largely due to reduced methane emissions from landfill, driven by falling biodegradable waste going to landfill and improved rate of methane capture at landfill sites.
- There has been good progress to reduce waste generated by households and businesses, or going to landfill through **voluntary responsibility deals, information awareness campaigns and strategies to support anaerobic digestion**.
- Further reductions in waste emissions could be achieved by **reducing biodegradable waste arising and sent to landfill** through stronger targeting of measures, separate food collection and bans on major sources of biodegradable waste going to landfill.
- Given the improving data on landfill emissions the Government should set an **approach to increase capture of landfill methane** towards best practice rate.
- F-gas emissions **rose by 12%** since 2007, and are now 33% above 2000 levels. The rise in emissions is mainly due to their use as a replacement for ozone-depleting substances (ODS) and growth in demand for products that they are used in, such as air conditioning and refrigeration units.
- A new **EU F-gas regulation** aims to reduce emissions two thirds by 2030 from 2014 levels.

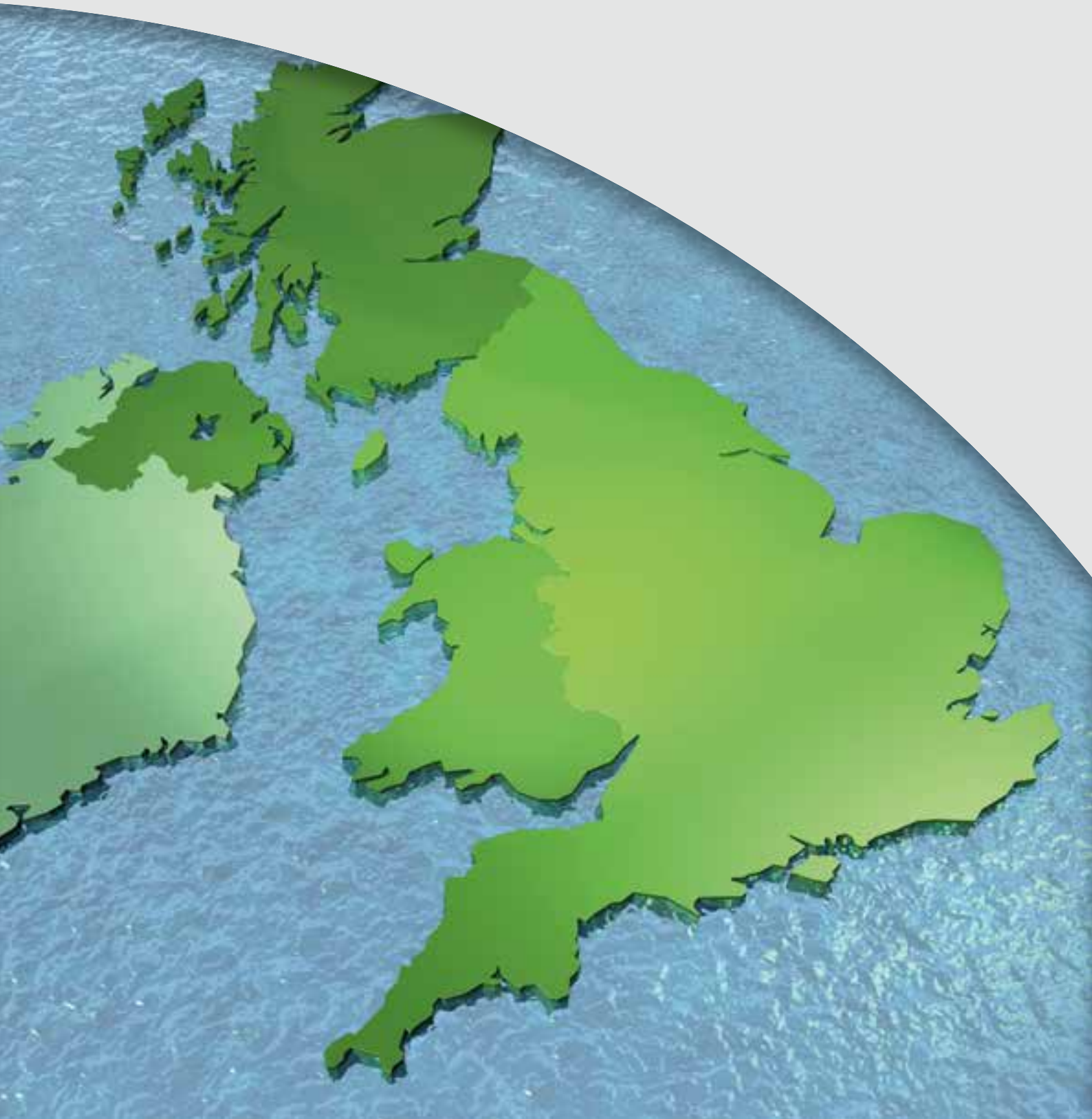
Table 7.4: The Committee's waste and F-gas indicators (% change from 2007)				
WASTE AND OTHER NON-CO_2 SOURCES	Budget 2	Budget 3	Budget 4	2013 Outturn
Waste*				
Headline indicators				
Emissions (indicative % change from 2007)*				
Total CO_2e emissions	-22% to -33%	-32% to -50%	-39% to -89%	-24%
Landfill – CH_4	-25% to -37%	-36% to -56%	-44% to -71%	-25%
Wastewater treatment – N_2O	-2%	+2%	+4%	-0.2%
Incineration – total CO_2	No more than 25%			-23%
Biodegradable waste sent to landfill	-38% to -84%	-39% to -97%	-39% to -97%	-47%
Percentage of methane captured at landfill sites	Rising above current rate of 59%			59%
F-gas*				
CO_2e emissions	-23%	-40% to –50%	-52% to -60%	+12%
Supporting Indicators				
Waste				
Defra to agree responsibility deals with sectors specified in waste review (waste management, paper, packaging, textiles)	End 2015			
Defra to explore scope to strengthen incentives through the waste chain.	End 2017			
Defra to consider and publish an approach to increase methane capture rates towards best practice, with milestones and measures to ensure these are met.	End 2017			
Defra to publish specific strategies on how to reduce each of main biodegradable waste sources (specifically food, paper/card, and wood) from households and businesses, with milestones and measures to ensure these are met.	End 2016			
The Government to consider mandating UK-wide provision of separate food waste collection services by local authorities.	End 2016			
Defra to follow the examples of Scotland and Wales which plan to ban or divert biodegradable waste from landfill, by reconsidering bans on major sources of biodegradable waste, on a case by case basis.	End 2016			
F-gas				
Defra to ensure compliance with new EU F-gas regulation	Ongoing			

Source: CCC analysis.

* we will return and update these indicator trajectories in light of our advice for the fifth carbon budget.

Key: Headline indicators Supporting indicators Other drivers

Chapter 8



Chapter 8: Devolved administrations

1. Introduction and key messages

The devolved administrations have an important role to play in achieving the UK's carbon budgets. Scotland, Wales and Northern Ireland account for 20% of UK emissions (8.8%, 8.0% and 3.6% respectively). 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. Emissions have fallen across the devolved administrations during the first carbon budget period, although progress against their own targets has been mixed and they remain extremely challenging to achieve.

The devolved administrations have (fully or partially) devolved powers in a number of areas relevant to carbon budgets, in particular buildings, energy efficiency, agriculture, forestry, and waste. They can also make a contribution to less devolved areas (such as renewable energy deployment[1]) through the provision of additional incentives and their approach in areas such as planning consents.

The devolved administrations are often leading the UK with innovative policies and effective implementation. In this chapter, we highlight a number of areas of good practice.

The key messages in this chapter are:

- **Emissions:** From 2007 to 2012 emissions fell by 15% in Scotland, 6% in Wales and 7% in Northern Ireland, compared to a 12% reduction across the UK. The different rates of reduction in part reflect the relative dominance of different sectors (e.g. agriculture has a very high share in Northern Ireland and UK-wide agricultural emissions have fallen less quickly than in other sectors). It also reflects the importance of individual power and industry installations at the devolved level (e.g. one reactor closing at Wylfa nuclear power station and being replaced by fossil fuel generation had a very large impact on emissions in Wales).
- **Policies:** In some policy areas the devolved administrations lead the UK, in particular in residential energy efficiency, waste and agriculture where there are devolved competencies:
  - *Energy efficiency and fuel poverty*: Unlike in England, the devolved administrations still operate tax-payer funded schemes to tackle fuel poverty in addition to the supplier obligations. These often focus on area-based delivery, working with local authorities.

1 Energy is completely devolved in Northern Ireland.

- *Waste*: Ambitious household waste recycling targets have been set in Scotland and Wales. Wales met its target for 52% of household waste to be recycled in 2012/13, but Scotland missed its first target for 2010/11 and is likely to have missed the 50% household recycling target for 2013 without a substantial improvement. Northern Ireland is progressing towards its 2015 household waste recycling target of 45%.
- *Agriculture*: Like England, the devolved administrations place considerable emphasis on a collaborative approach with the farming industry. In contrast to England, where the uptake of measures is also voluntary, Scotland has made it clear that it will introduce regulation if insufficient progress is made.

- **Further action:** Reduction targets remain challenging to achieve – stronger action will be required in key areas including improving energy efficiency, increasing low-carbon heat penetration, encouraging greater uptake of electric vehicles, and increasing the rate of tree planting.

We set out the analysis that underpins these points in 7 sections:

- Emission trends
- Power sector
- Buildings
- Industry
- Transport
- Agriculture and land use
- Waste

2. Emission trends

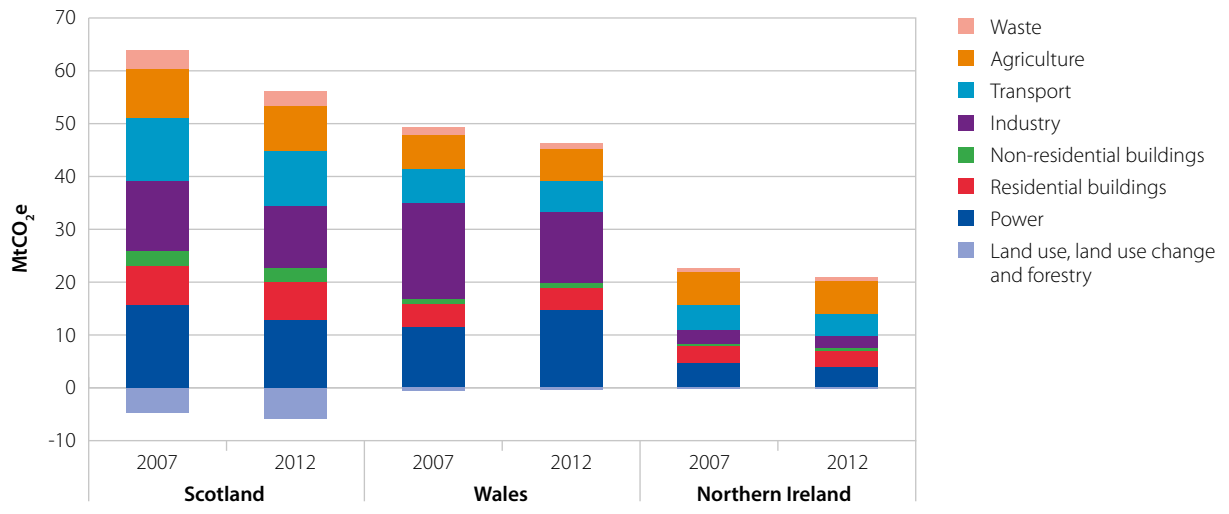
The latest UK emissions data considered elsewhere in this report are for 2013, but the latest data available for the devolved administrations are for 2012. We focus in this section on analysis of emission trends from 2007 to 2012 (i.e. from the last year before the first carbon budget to the last year of the budget). We also consider contextual information for 2013 (temperature, macroeconomic and EU ETS data) to give an indication of likely changes.

(a) Latest emissions data

UK-wide, greenhouse gas emissions decreased by 12% between 2007 and 2012 (Chapter 1). In the devolved administrations (Figure 8.1), Scottish emissions fell further (15%), while both Wales and Northern Ireland reduced emissions by less (6% and 7%, respectively). As at the UK level, emissions increased in the devolved administrations in 2012 due to colder winter temperatures.

- In **Scotland,** total emissions fell by 15% to 50.5 $MtCO_2e$ from 2007 to 2012. There were some fluctuations within this period, with emissions rising in 2010 and 2012 due to the impact of colder weather. Scotland missed its legislated target in 2012. However, revisions to the inventory since the Scottish targets were set in 2010 makes achieving the annual targets more challenging, as these were set on an absolute basis.
  - There were strong falls in emissions from the waste (24%) and power (19%) sectors over the first carbon budget period, whilst the emissions sink from land use, land use change and forestry (LULUCF) increased by 23% to 5.7 $MtCO_2e$ (i.e. LULUCF made an increased contribution to emission reductions).
  - In 2012, emissions rose by 1.3%, with the largest increases from residential (11.1%) and non-residential (5.2%) buildings. This reflected colder than average temperatures in 2012. In contrast, emissions from waste fell by 5.3% and there was a 2.6% decline in emissions from industry in 2012.
  - 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 2012, the Scottish target was 53.23 $MtCO_2e$ compared to a Net Scottish Emissions Account of 55.67 $MtCO_2e$. As a result, Scotland missed its legislated annual target for the third successive year.
  - However, revisions to the greenhouse gas inventory continue to make achieving the legislated targets increasingly challenging. The recent revisions to the inventory added 1.2 $MtCO_2e$ to Scotland's estimated emissions in 2011 and at least that much in every year going back to 1990.

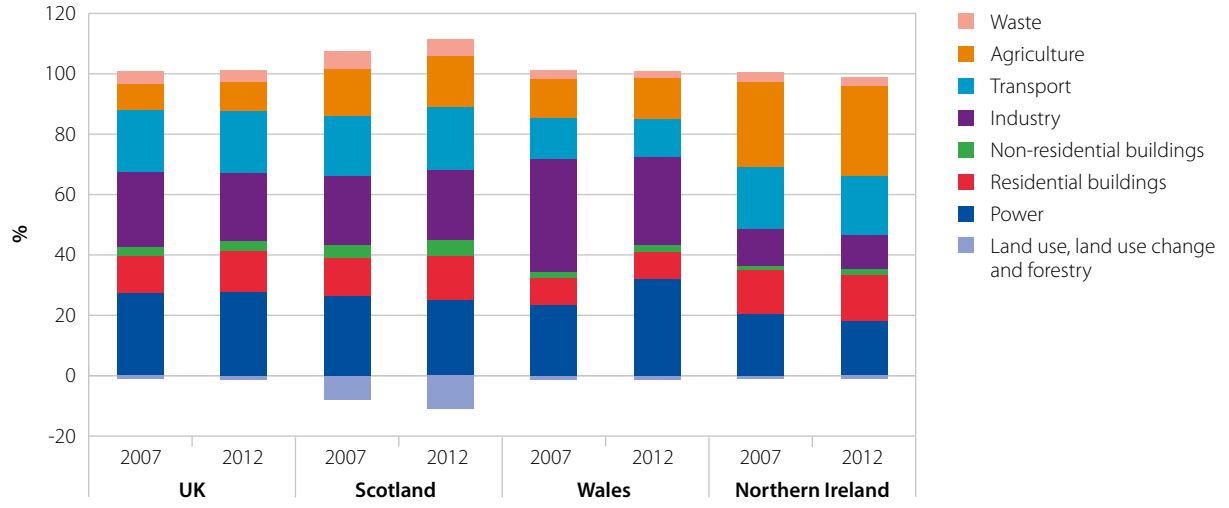
Figure 8.1: Greenhouse gas emissions in devolved administrations by sector (2007 and 2012)



Source: NAEI (2014).
Notes: Emissions are presented here before accounting for trading in the EU ETS, and do not include emissions from international aviation and shipping.

- In **Wales**, overall emissions fell by 6% over the first carbon budget period, although there were some variations during this period. Emissions rose in 2008, 2010 and 2012. A marked increase in the generation of electricity from coal in 2008 contributed to the overall rise in emissions, whilst colder temperatures in 2010 and 2012 increased the demand for heating. Wales has set both a 2020 and annual emissions reduction targets, both of which remain challenging to achieve.
  - Emissions from the power sector rose by 29% over the first carbon budget period, driven by a marked increase in electricity generation from coal and a fall in nuclear generation, whilst those from industry declined by 25%.
  - Total emissions increased by 5% in 2012, driven by a marked rise in emissions from the power sector (40%) and from residential buildings (10%). This reflected colder temperatures than average in 2012, and switch from gas to coal in power generation alongside a 4.3% increase in generation from renewables.
  - Wales has a target to reduce greenhouse gas emissions by 40% from 1990 levels by 2020. In 2012, emissions were 18% lower than in 1990 (compared to 26% for the UK). On the basis of progress to date, achieving the 40% target by 2020 is likely to be very challenging. There has been significant progress across a number of sectors (industry, waste, non-residential buildings) but emissions from the power sector have increased by 30% since 1990. This partly reflects the importance of individual power and industry installations at a devolved level (e.g. one reactor closing at Wylfa nuclear power station and being replaced by fossil fuel generation had a large impact on emissions in Wales).
  - In addition, Wales has a 3% annual emissions reduction target (against a 2006-2010 baseline) in areas of devolved responsibility: transport, resource efficiency and waste, business, residential, agriculture and related land use, public sector. In 2011 (the first target year), Wales achieved a 10.1% reduction against the baseline, therefore exceeding its target. This strong performance in the first year will mean that, even though greenhouse gas emissions in Wales increased in 2012, the target is likely to have been achieved given that it is cumulative and given the size of the outperformance against the target in 2011. The Welsh Government will publish its assessment of performance in 2012 later in 2014.
- In **Northern Ireland,** emissions fell by 7% over the first budget period. Within this period, there were some fluctuations, with colder weather contributing to increases in emissions in 2010 and 2012. Northern Ireland's emission reduction target is lower than the Scottish and Welsh targets, reflecting the larger share of emissions from difficult to reduce sectors (in particular agriculture).
  - Over the first carbon budget period, emissions from the power sector fell by 18% and those from industry by 16%. In contrast, the land use, land use change and forestry sector became a net emitter over the period (0.2 $MtCO_2e$).
  - Emissions were 21 $MtCO_2e$ in 2012, 16% lower than in 1990 and 3.6% of the UK total. Emissions rose by 2.2% during 2012, which reflected increases in emissions from the power (2.3%) and residential (1.5%) sectors. Colder weather during the year led to a rise in residential emissions and there was a switch between coal and gas in power generation.

Figure 8.2: Greenhouse gas emissions in devolved administrations by sector contributions (2007 and 2012)



Source: NAEI (2014).

– Northern Ireland has a target to reduce emissions by at least 35% compared to 1990 levels by 2025. In 2012, emissions in Northern Ireland were 16% below their 1990 levels. Whilst significant progress has been made across a number of sectors, transport emissions have increased by 23% since 1990, emissions from the land use and forestry sectors have also increased, and agriculture emissions have fallen by only 8% over the period.

Overall, all three devolved administrations have reduced emissions over the first carbon budget period. The differing rates of reduction across the countries in part reflect the relative dominance of different sectors (Figure 8.2). They have set themselves ambitious targets, but progress against these has been mixed. However, different baselines and the impact of data changes mean that levels of progress cannot be easily compared. It is not clear whether emissions are falling fast enough to meet increasingly challenging targets over time.

(b) Change in emissions in 2013

In 2013, UK emissions fell by 2%, driven by an 8% fall in emissions from the power sector. This reduction in the carbon-intensity of electricity contributed to falling emissions across other sectors, including buildings and industry, although direct emissions from these sectors rose.

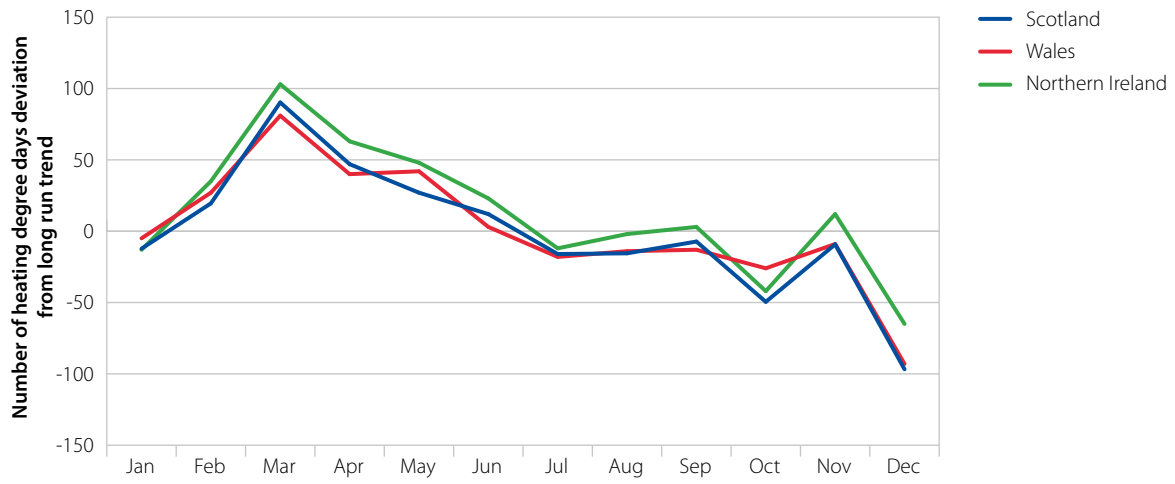
Temperatures at the beginning of 2013 were below the long-term average leading to a slight increase in the number of heating days for the year across all the devolved administrations (Figure 8.3). At the UK level, this led to a 3% increase in gas consumption and a similar increase in heating demand will have been seen across the devolved administrations.

The latest economic data for the devolved administrations show that (Figure 8.4):

- In **Scotland**, overall GVA increased by 1.6% in 2013, the fastest rise since before the recession in 2007. Within this, production and services output increased by around 2% and construction output rose by 3%.

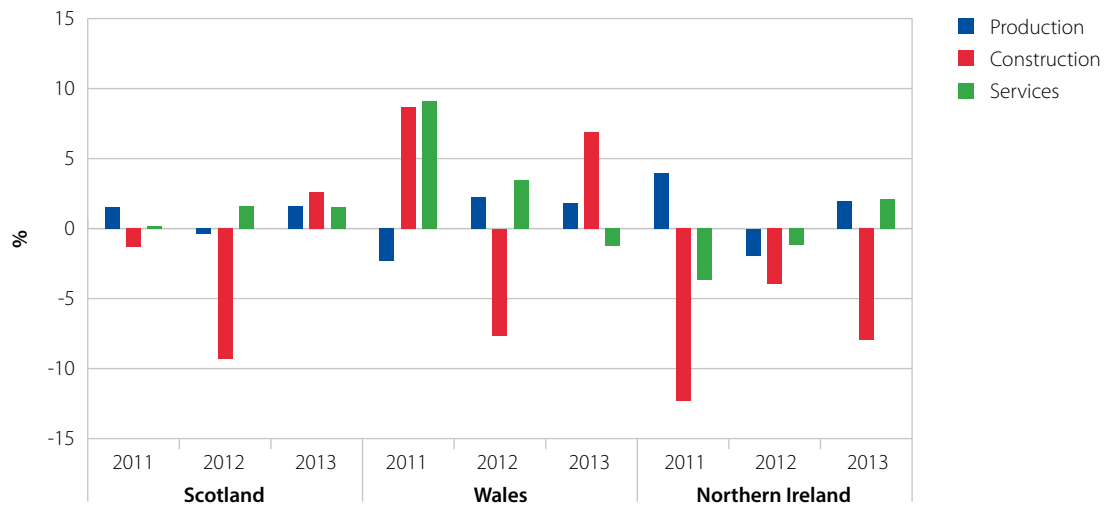
- In **Wales**, (data for GVA are not available for 2013) production output rose by 2% for a second successive year, whilst the services sector saw a slight fall of 1%, following strong growth in recent years. Construction output rose by 7% in 2013.
- In **Northern Ireland**, (data for GVA are not available for 2013) the construction sector continued its recent poor performance in 2013, with output declining by 8%. Production and services output both rose by 2% during the year.

Figure 8.3: Heating degree days in 2013 – deviation from long run trend



Source: Vesma.com (2014).
Notes: Heating degree days (HDDs) are calculated relative to a baseline temperature, typically 15.5°C, which is the outside temperature above which a building does not require heating. One HDD is the number of degrees centigrade deviation from the base temperature of the actual temperature on a given day (e.g. if the temperature was 5.5°C for one day the number of HDD would be 10). The long run trend is 1971-2000. Points above 0 reflect colder than average temperatures, and points below indicate higher than average temperatures.

Figure 8.4: Output trends in Scotland, Wales and Northern Ireland – percentage change from previous year (2011-2013)



Source: Scottish Government, Welsh Government, Northern Ireland Executive.

In previous years, we have looked at the changes in emissions from the EU ETS to give an indication of trends in emissions at the devolved administration level. However, changes in the scope of the EU ETS in 2013 mean that it is not possible to compare the installation-level data for 2013 with previous years to obtain a picture for the devolved administrations.

Data for the devolved administrations for the generation of electricity by source will not be available until later in 2014, but data on renewables shows that the amount of electricity generated from renewable sources increased across the devolved administrations in 2013. At UK level, overall electricity generation fell by 0.5% and if a similar trend is seen for the devolved administrations, the proportion of generation from renewables will have increased in 2013.

Taken together, these data, coupled with the UK trends, suggest that emissions are likely to have fallen in the devolved administrations in 2013.

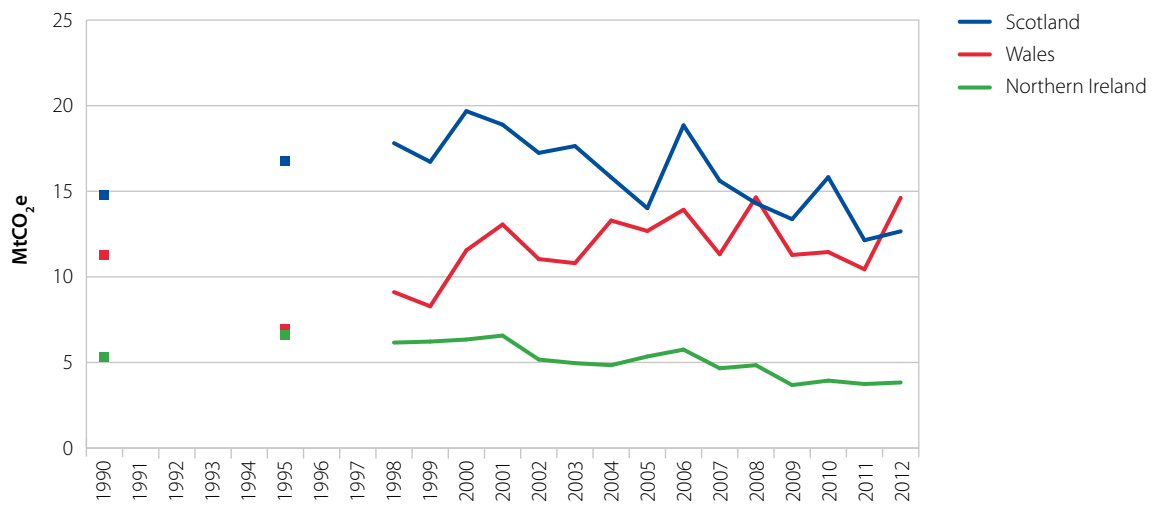
In the remainder of the chapter we look at sector emission trends and discuss progress implementing policies, with a particular focus on areas where the devolved administrations lead the UK.

3. Power sector

(a) Emissions trends

Power sector emissions fell in both Scotland and Northern Ireland over the first carbon budget period (2008-2012), but rose in Wales (Figure 8.5). This reflects changes in the fuel mix over this period (Figure 8.6).

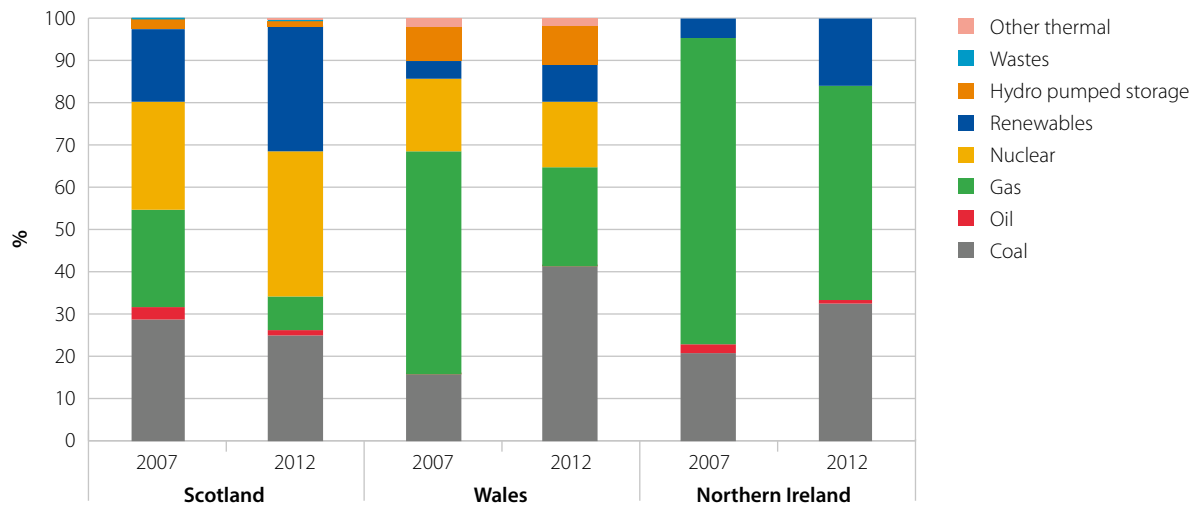
Figure 8.5: Power sector emissions in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

- In **Scotland**, emissions from the power sector declined by 19% over the first carbon budget period, although there was some variation between individual years. This reflected a change in the fuel mix of generation, as overall generation increased by 3%. Renewable generation increased by 79% (to 14.8 TWh in 2012) and nuclear generation by 38% over the period. In contrast, generation from coal fell by 11%.
- Emissions from the power sector in **Wales** increased by 29% over the first carbon budget period, with particularly large increases in 2008 and 2012. This was despite a reduction in overall generation of 20% over this period. Generation from renewables increased by 66%, to 2.3 TWh in 2012, but generation from nuclear fell by 27%, reflecting lower load factors and the closing of the second reactor at Wylfa in 2012. In addition, generation from coal more than doubled to 10.8 TWh in 2012.
- Over the first budget period in **Northern Ireland**, power sector emissions fell by 18%, with some slight variations between individual years. Whilst generation from coal increased by 27% over the period, this was more than offset by a three-fold increase in generation from renewables (1.2 TWh in 2012) and a fall of 19% in overall generation.

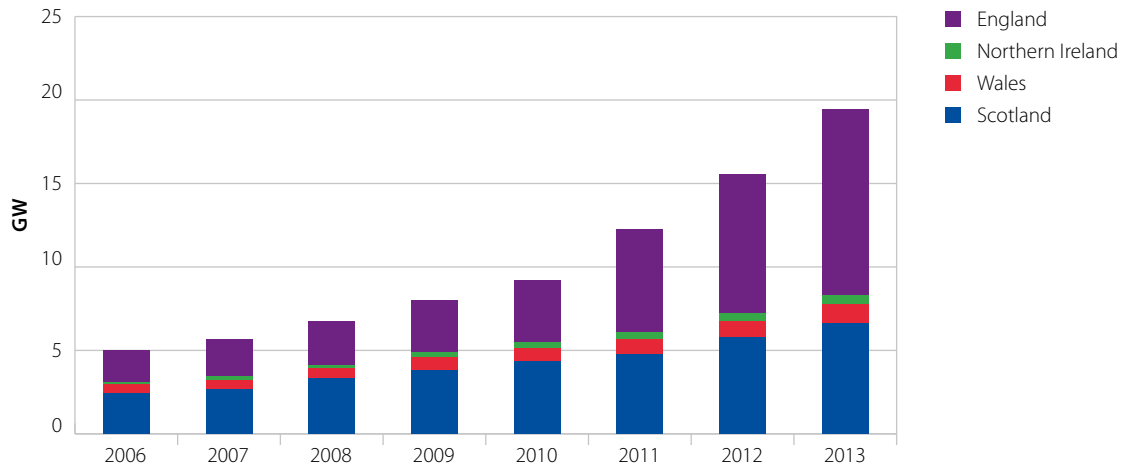
Figure 8.6: Proportion of generation by fuel type in Scotland, Wales and Northern Ireland (2007 and 2012)



Source: DECC (2013).

At the UK level, emissions fell by 11% in the power sector over the first carbon budget period (2008-2012), reflecting a fall in demand for electricity and a reduction in the carbon intensity of electricity supply. Whilst Scotland and Northern Ireland saw slightly stronger falls in emissions than at the UK level, the increase in emissions from the power sector in Wales was in contrast to UK trends. However, as discussed this highlights the impact of individual installations at the devolved level, with the closure of one plant able to significantly affect the overall picture.

Figure 8.7: Renewable deployment in the UK (2006-2013)



Source: DECC (2013).

(b) Progress and policy on renewables

There has been ongoing progress in the deployment of renewables across the devolved administrations (Figure 8.7), which together now account for 43% of UK renewable capacity.

Scotland

The Scottish Government has set a target for the equivalent of at least 100% of gross electricity consumption to be delivered from renewables by 2020. Analysis by the Scottish Government suggests that this is likely to require an increase in capacity from 6.6 GW in 2013 to between 14 and 16 GW.

Over the first budget period, the installed capacity of renewables in **Scotland** increased from 2.7 GW at the end of 2007 to 5.8 GW in 2012. This 3.1 GW increase compared to an increase of 10 GW at the UK level (from 5.7 GW to 15.5 GW). In Scotland, renewable installed capacity continued to increase in 2013, rising by 14% (0.7 GW), to take total installed capacity to 6.6 GW. This is equivalent to 34% of the UK's installed capacity, while Scotland only accounts for 9% of UK electricity consumption.

Regional generation by fuel data is only available for the devolved administrations to 2012. In Scotland in 2012, compared to 2011:

- Overall generation of electricity in Scotland fell by 3.9%
- Coal generation increased by 1.6 TWh (14%)
- Gas generation more than halved to just 4 TWh
- Generation from renewable sources increased by 1 TWh (7.5%), although hydro generation fell by 9%

There is currently 6.6 GW of renewables capacity in Scotland which has been approved or is awaiting construction, the vast majority of which is onshore and offshore wind. In addition, there is a further 7 GW of capacity in the planning process. Assuming half of this capacity currently in the planning process goes ahead, consistent with past success rates, it should be possible for the Scottish Government's estimated capacity requirement to be achieved by 2020.

Wales

Installed capacity of renewables in Wales increased from 0.6 GW at the end of 2007 to almost 1 GW in 2012, an increase of 72%. This was a significantly smaller increase than the 174% seen at the UK level. In 2013 capacity rose further, increasing by 200 MW (20%) to take total installed capacity to 1.2 GW. This is 6% of the UK's total installed capacity.

In Wales in 2012, compared to 2011:

- Overall generation of electricity fell by 4.5%
- Coal generation rose by 4.6 TWh (75%)
- Gas generation dropped by 4.7 TWh (44%)
- Generation of electricity from nuclear fell by 1.2 TWh (23%)
- Generation from renewable sources edged up by 0.1 TWh (4.3%)

Northern Ireland

In Northern Ireland, installed capacity of renewables increased from 0.2 GW at the end of 2007 to 0.5 GW in 2012, an increase of 127%. This is a weaker rise than at the UK level, and is from an exceptionally low base. In 2013, installed capacity increased by a further 100 MW (20%), taking the total to 0.6 GW, 3% of the UK's installed capacity.

In terms of generation by fuel, in 2012, compared to 2011:

- Overall generation of electricity in Northern Ireland fell by 6.8%
- Coal generation increased by 1 TWh (66%)
- Gas generation fell by 1.7 TWh (31%)
- Generation from renewable sources increased by 0.2 TWh (18%)

Northern Ireland has a target to meet 40% of its electricity consumption from renewable sources by 2020. There are additional interim targets for 12% in 2012 and 20% in 2015. Northern Ireland exceeded its 2012 target, with 13% of electricity demand met by renewables.

As at the UK level, uncertainty about ongoing support for renewables and the specific technologies which will benefit from this support puts the current pipeline of renewables at risk.

4. Buildings

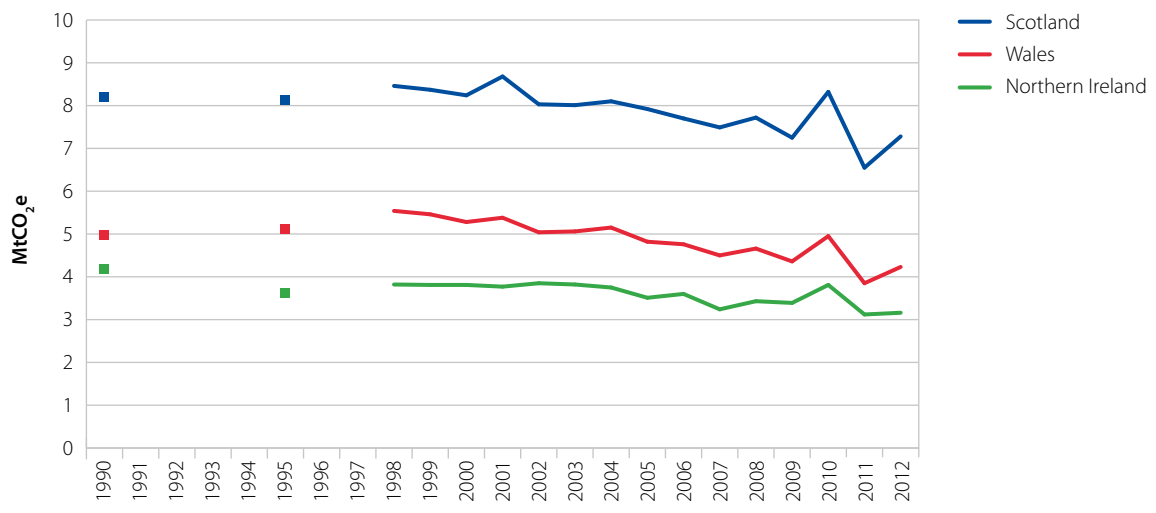
(a) Emissions from residential buildings

Direct residential emissions declined across the devolved administrations between 2007 and 2012, although there were fluctuations within this period (Figure 8.8). Trends were fairly similar to the overall UK trend. These largely reflected increased demand for heating during colder than average years (2008, 2010 and 2012).

- In **Scotland**, emissions from residential buildings declined by 3% over the first carbon budget period, compared to 6% for the UK. Emissions from the sector, which took a 14% share of emissions in Scotland in 2012, were 11% lower than 1990 levels.
- Over the first carbon budget period in **Wales**, emissions from residential buildings declined by 6%. Emissions from the sector, which took a 9% share of total Welsh emissions in 2012, were also 15% lower than 1990 levels.
- Emissions from residential buildings in **Northern Ireland** declined by 2% over the first budget period. The sector accounted for 15% of total emissions in 2012, and emissions were 15% lower than in 1990.

The energy efficiency of buildings has played an important role in reducing emissions across the UK. The devolved administrations have developed their own policies to improve residential energy efficiency, to which we now turn.

Figure 8.8: Residential emissions in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

(b) Policy progress

The main energy efficiency schemes, the Green Deal and the Energy Company Obligation (ECO) are GB-wide[2] (see Chapter 3) but Scotland and Wales have devolved powers to develop their own additional schemes. In Northern Ireland, energy efficiency is fully devolved and the Executive has developed schemes similar to the GB ones.

Notwithstanding the overall reduction in measures delivered under the ECO compared to its predecessor schemes (see Chapter 3), Scotland and Wales have seen a higher proportion of measures installed than their share of the housing stock (Table 8.1):

Table 8.1: Provisional number of ECO measures by ECO obligation and proportion of GB total, to March 2014

	Carbon Saving Target (CSO)	Carbon Savings Community (CSCO)	Affordable Warmth (HHCRO)	Total Number of ECO measures delivered
Scotland (9% GB housing stock)	43,314 (13%)	10,753 (9%)	34,609 (11%)	88,676 (11%)
Wales (5% GB housing stock)	15,095 (4%)	4,403 (4%)	25,884 (8%)	45,382 (6%)

Source: DECC (2014)
Note: Households can have more than one measure installed and a number of different measures installed under different ECO obligations.

- The first phase of the Green Homes Cashback scheme in **Scotland** finished in March 2014, and under the scheme, 36,000 vouchers had been issued. By the end of May 2014, 11,000 of these had been paid, with a value of £7.8 million, following the installation of measures. More than 80% of the cashback vouchers were for easy measures such as condensing boilers, loft insulation, LED light bulbs and heating controls. The Scottish Government has recently announced an additional £15 million of funding for 2014/15 for a further phase of the scheme. Households can claim up to £7,300 (compared to £1,200 under the first phase) for measures which have been recommended in a Green Deal Assessment Report.
- DECC's Green Deal Cashback scheme ran from January 2013 to June 2014 and covered England and **Wales**. As at the end of March 2014, 489 cashback vouchers had been paid in Wales, 4% of the total for England and Wales. New incentives are available in England and Wales from June 2014, through the Green Deal Home Improvement Fund.
- The Sustainable Energy Programme is **Northern Ireland's** supplier obligation scheme. There is £7.9 million of funding available for 2014/15. The majority of the schemes within the Sustainable Energy Programme are targeted at low-income households, but grants are available for loft and cavity wall insulation for households that do not qualify for a priority scheme. Around 20% of the funding available for 2014/15 is available for non-priority domestic and commercial schemes.

Scotland and Wales have been successful in leveraging funding from ECO, taking a higher share of the measures than their housing stock and Scotland has provided a substantial amount of funding to encourage the uptake of the Green Deal. Northern Ireland has

2 The ECO covers England, Scotland and Wales but excludes Northern Ireland.

developed its own supplier obligation, largely focused on low-income households, but offering grants for insulation measures for non-priority households.

(c) Fuel poverty

Improving the energy efficiency of the housing stock is particularly important in the devolved administrations as levels of fuel poverty are comparatively high (Table 8.2). The devolved administrations continue to use the 10% definition[3], rather than the Low Income High Cost (LIHC) measure recently adopted in England.

Fuel poverty is a partially devolved issue, with each devolved administration having their own targets, although Wales and Scotland are covered by the fuel poverty-focused elements of the ECO (the Affordable Warmth Scheme).

Table 8.2: Number of households in fuel poverty in the UK using the "10% definition" and percentage of total households

	2011	2012
England	3,200,000 (15%)	3,050,000 (14%)
Scotland	610,000 (26%)	650,000 (27%)
Wales	370,000 (29%)	390,000 (29%)
Northern Ireland	290,000 (42%)	N/A

Source: DECC (2014)

- In **Scotland**, the fuel poverty rate was 26% in 2011, and increased to 27% in 2012. The Scottish Government has a target to end fuel poverty in Scotland by 2016, a significant challenge. In addition to the fuel poverty-focused measures in the ECO, there are Scottish Government funded measures under the Home Energy Efficiency Programmes for Scotland (HEEPS) which was launched in April 2013. In 2014/15, there is £60 million available for HEEPS schemes. In addition, funding is available to support renewable energy projects for fuel poor homes.
  - Area-based schemes are delivered by local authorities and prioritise fuel poor areas, providing a range of insulation measures. £60 million has been allocated to local authorities for 2014/15.
  - The Energy Assistance Scheme is focused on the most vulnerable and poor households which were previously eligible for heating and insulation measures, but who would otherwise miss out under the Affordable Warmth Scheme. There is £16 million available for 2014/15.
  - Rural off-gas grid households can access the £50 million Warm Homes Fund, which provides grants and loans to support renewable energy projects (including district heating) in fuel-poor communities.

3 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.

- The fuel poverty rate in **Wales** was 29% in both 2011 and 2012. In addition to GB-wide measures aimed at reducing fuel poverty, there are two schemes in Wales, *Nest* and *arbed*. For 2014/15, £36m is available for both schemes.
  - *Nest* provides eligible households (those in receipt of a means-tested benefit and living in the most energy inefficient properties) with energy efficiency improvements free of charge, including boilers, central heating, loft and cavity wall insulation, external wall insulation and technologies such as air source heat pumps and biomass.
  - *arbed* is an area-based scheme, focused on some of the most deprived areas of Wales. The scheme improves insulation in existing properties, replaces inefficient boilers, switches homes to more affordable or renewable fuel types and installs energy efficient systems. The second phase of the scheme will run until March 2015.
- **Northern Ireland** has the highest rate of fuel poverty across the UK, at 42%, reflecting the relatively high proportion of off-gas-grid households who use alternative, more expensive, fuels to heat homes. It is also due to the higher proportion of lower income households than elsewhere in the UK. There is funding of £16.5 million available for the Warm Homes scheme in 2014/15 and £7 million for a boiler replacement scheme.
  - The Warm Homes scheme is open to households in receipt of certain benefits and can provide cavity wall and loft insulation, and a hot water tank jacket. Warm Homes Plus can provide insulation and heating measures to those who have Economy 7, solid fuel, bottled gas/LPG heating or no heating system at all.
  - The Department for Social Development for Northern Ireland is planning to move Warm Homes to an area-based scheme approach, with a consultation held earlier in 2014.
  - The boiler replacement scheme is part funded by the EU European Regional Development Funds. The scheme is to help with the cost of replacing boilers that are more than 15 years old and is for those households with an income of less than £40,000.
  - The majority of the domestic schemes under the Northern Ireland Sustainable Energy programmes are targeted towards low-income households, and 80% of the funding for 2014/15 is allocated for these priority schemes.

Fuel poverty remains a significant problem for the devolved administrations, partly due to the housing stock characteristics. However, the Fuel Poverty Monitor 2014 report[4] from National Energy Action (NEA) showed that in 2013/14, there have been substantial differences in the level of resources aimed at energy efficiency programmes across England and the devolved administrations (excluding ECO). In England the investment was £3.52 per domestic electricity customer, in Scotland £36.48, in Wales £31.31 and in Northern Ireland £27.55.

The figures from the NEA do not include any contributions from the ECO (nor the low-income aspects of the Northern Ireland Sustainable Energy programme) but Scotland and Wales have been successful leveraging funding in this area as well.

4 http://www.nea.org.uk/policy-and-research/publications/2014/monitor-2014

(d) Emissions from non-residential buildings

Emissions from non-residential buildings rose across the devolved administrations over the first carbon budget period (Figure 8.9).

- In **Scotland** emissions from non-residential buildings increased by 1%, with emissions from commercial buildings declining by almost 5% and those from the public sector increasing by almost 8%. The non-residential buildings sector is one of the smallest, accounting for just 5% of total emissions in 2012.
- In **Wales**, emissions from non-residential buildings also rose by 1%, although it is a very small sector, accounting for 2% of total emissions in 2012. Emissions from commercial buildings fell by 5% over the first budget period, whilst those from the public sector fell by 8%.
- In **Northern Ireland**, emissions from non-residential buildings increased by 11% over the first carbon budget period. Emissions from the commercial sector increased by 15%, compared to a rise of 7% from public sector buildings. The non-residential buildings sector accounted for just 2% of total emissions in Northern Ireland in 2012.

While England, Wales and Scotland do not have any energy efficiency programmes specifically targeted towards non-residential buildings, the Sustainable Energy programmes in Northern Ireland also cover commercial properties. Measures available under the scheme include insulation, lighting, boiler burner controls, heat recovery on compressed air systems and more efficient pumps for refrigeration systems.

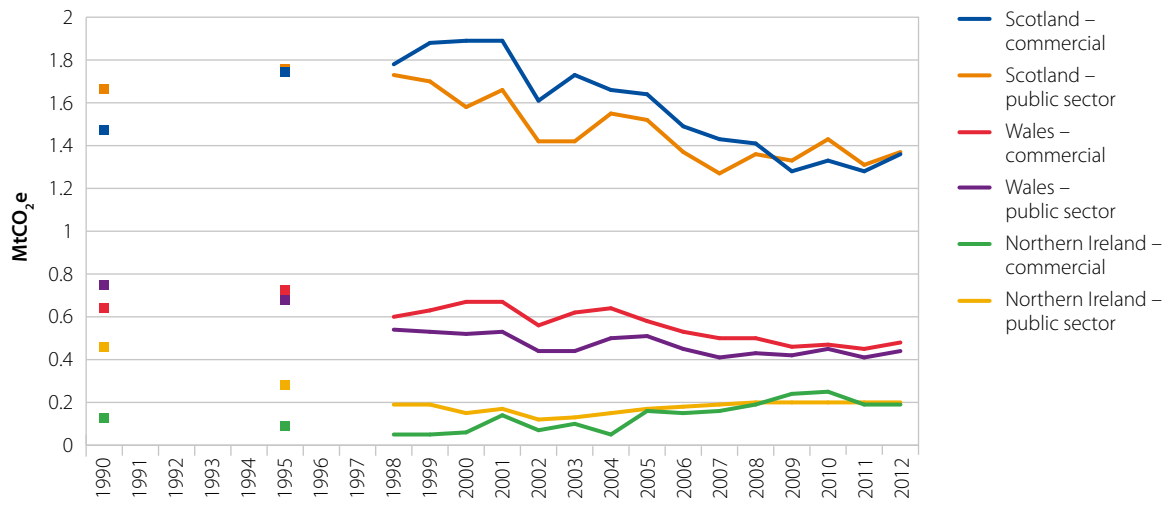
(e) Low-carbon heat

The Renewable Heat Incentive (RHI) is GB-wide, and provides payments to those who generate and use renewable energy to heat their buildings.

- The first phase of the RHI focuses on the industrial and commercial sectors. By March 2014, the scheme had supported around 700 MW of installed capacity, of which 19% is in Scotland and 6% in Wales. This is a greater proportion than would be expected based on GVA shares (8% and 3%, respectively).
- The second phase of the scheme covers additional technologies and was extended to the residential sector several years later than originally planned in April 2014.
- Prior to the launch of the domestic RHI scheme, residential installations qualified for support under the Renewable Heat Premium Payment (RHPP). As at the end of March 2014, the scheme had supported around 130 MW of installed capacity, of which 15% is in Scotland and 9% in Wales. Again, these are higher proportions than would be expected from shares of the GB housing stock (9% and 5%, respectively).

In addition to the GB-wide policies, the devolved administrations have their own policies to encourage the uptake of low-carbon heat.

Figure 8.9: Emissions from non-residential buildings in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

- The **Scottish** Government's target is to source 11% of heat demand from renewable sources by 2020, and to have a largely decarbonised heat sector by 2050. Its draft heat generation policy document included a target for district heating, currently expected to be 1.5 TWh of heat by 2020. In addition, the Scottish Government is committed to connect up to 40,000 more homes to heat networks by 2020. Funding includes:
  - the District Heating Loan Fund provides loans of up to £400,000 per project for low-carbon and renewable technologies. There is a further £8 million of funding for the scheme between 2014 and 2016;
  - the £50 million Warm Homes Fund provides funding for renewable energy projects to support communities in fuel poverty; and
  - the Home Energy Scotland Renewables Loan scheme provides interest free loans up to £10,000 for renewable heat installations for owner occupiers.
- As we highlighted in our 2013 **Welsh**[5] progress report, there is currently no heat strategy for Wales and no renewable heat targets to measure progress against. In addition, there is no Wales-specific data on heat demand, so we are unable to comment on the significance of installed capacity from RHI and RHPP data.
  - A baseline study of renewable energy[6] showed that in 2012 there was almost 60 MW of renewable heat capacity installed in Wales, with the potential to generate 166 GWh per year[7]. The majority of this is biomass (38 MW), but there is 12 MW of installed capacity from heat pumps, 8 MW from solar thermal and a negligible amount of sewage gas capacity.

5 http://www.theccc.org.uk/wp-content/uploads/2013/01/1673_Welsh-Rep-2013FINALWEB.pdf
6 http://wales.gov.uk/docs/desh/publications/140605low-carbon-baseline-survey-en.pdf
7 This figure for the estimated generation from installed renewable heat capacity is from the baseline survey report, and it is not clear what assumptions have been used for hours of operation and heat generation efficiency.

- **Northern Ireland** has a target of 4% of total heat consumption to be provided by renewable sources by 2015 and 10% by 2020. To support the development of low carbon heat, the Northern Ireland Executive has introduced its own RHI and RHPP schemes. These operate in the same way as they do at a GB level.
  - The RHPP scheme was launched for domestic customers in May 2012. To date, there have been 1,804 applications and 982 installations, with an installed capacity of 14.5 MW. The installations are largely biomass boilers (45%) and solar hot water (35%) with the remaining 20% air source and ground source heat pumps.
  - The RHI scheme was launched for non-domestic customers in November 2012. Since then, there have been 169 applications and 113 accredited installations with an installed capacity of 12.8 MW.

To support the development of low-carbon heat, funding under both RHI schemes should be committed until 2020, with a commitment made to its continued existence post-2020 (see Chapter 3). Measures should be introduced to contain funding costs and reduce delivery risks through addressing financial and non-financial barriers to uptake of low-carbon heat. Consideration should be given to targeting part of the RHI funding to cost-effective investment for fuel poor households. The additional funding in Scotland available for low-carbon heat should encourage investment, but progress against the 2020 heat target needs to be monitored.

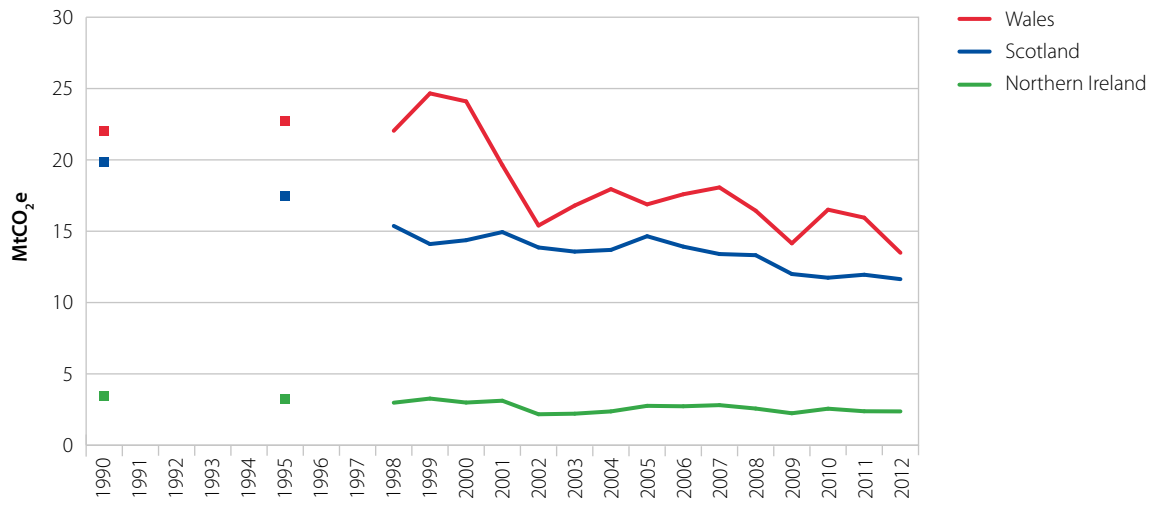
5. Industry

Emissions from industry declined across the devolved administrations from 2007 to 2012 (Figure 8.10). As at the UK level, this was largely due to the impact of the recession, which reduced output and disproportionately hit the more energy-intensive sectors (e.g. iron and steel).

- In **Scotland**, emissions from industry fell by 13% over the first carbon budget period. Emissions from the sector accounted for 23% of Scottish emissions in 2012.
- In **Wales**, emissions from industry fell by 25% over the first carbon budget period and took a 29% share of overall Welsh emissions in 2012. There are indications that energy-intensive plants have been under-utilised.
- Emissions from industry in **Northern Ireland** accounted for just 11% of total emissions in Northern Ireland in 2012 and fell by 16% over the first carbon budget period.

As outlined in Chapter 4, there are a number of policies for reducing emissions from industry, which largely operate at the UK/EU level. These include EU ETS, CRC Energy Efficiency Scheme, Climate Change Levy and Climate Change Agreements (CCAs) and the Renewable Heat Incentive (RHI).

Figure 8.10: Industry emissions in Scotland, Wales and Northern Ireland (1990 – 2012)



Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

The devolved administrations all offer interest-free loans for SMEs (small and medium-sized enterprise) for energy efficiency or resource efficiency projects.

- The Resource Efficient **Scotland** advice service was launched in April 2013 to provide support to businesses, third sector and public sector organisations to reduce costs through implementing resource efficiencies in energy, raw materials, water and waste management. Interest-free loans are available to SMEs from £1,000 to £100,000 for resource efficiency projects. They also offer loans for renewable energy projects, with an interest rate of 5% for businesses signing up for Feed-In-Tariffs (FiTs) or the Renewable Heat Incentive (RHI).
- Whilst the Carbon Trust lost its core funding from the UK Government in 2011, the **Welsh** Government has continued to provide support for the Carbon Trust to deliver advice, footprinting and technology services to businesses to cut their carbon emissions and costs. Interest-free business loans of between £3,000 and £100,000 are available for SMEs. The size of the loan depends on the projected carbon savings, with £1,000 of loan given for every 1.5 tonnes of CO_2 saved per annum.
- In **Northern Ireland**, businesses can apply for an interest-free loan through the Carbon Trust for energy efficiency projects. £15 million of funding was allocated for this scheme over the 2012 to 2015 period; as of the end of March 2014, £10 million had been offered for energy efficiency projects and the scheme will continue in 2014/15.

The Green Investment Bank announced in June 2014 that £2 million of funding would be made available to SMEs in the UK to provide loans for energy efficiency projects. Initial loans are in progress for lighting and small-scale biomass projects. Whilst this scheme is UK-wide, it is important to note that SMEs in the devolved administrations can access additional funding for energy efficiency projects.

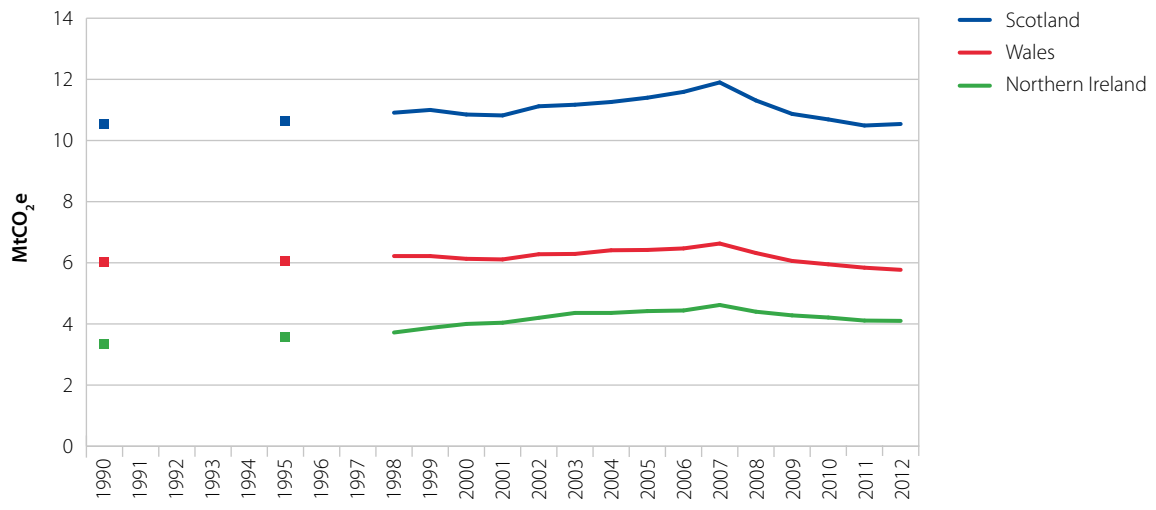
6. Transport

(a) Emissions trends

Emissions from transport fell across the devolved administrations from 2007 to 2012 (Figure 8.11).

- In **Scotland**, transport emissions fell by 11% over the period, although they were broadly unchanged from 1990 levels. Transport emissions in Scotland accounted for 21% of Scottish emissions, broadly in line with the UK figure (20%).
- In **Wales**, the transport sector accounts for a smaller share of overall emissions, taking a 13% share in 2012. Emissions from transport declined by 13% over the first budget period and were 5% below 1990 levels.
- In **Northern Ireland**, transport emissions fell by 11% over the budget period but were 23% higher than they were in 1990. Emissions from the sector took a 20% share of overall emissions in 2012. This 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 also has the highest share of emissions from rural driving at 61%, compared with 53% in Wales, 49% in Scotland and 40% across the UK as a whole.

Figure 8.11: Transport emissions in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

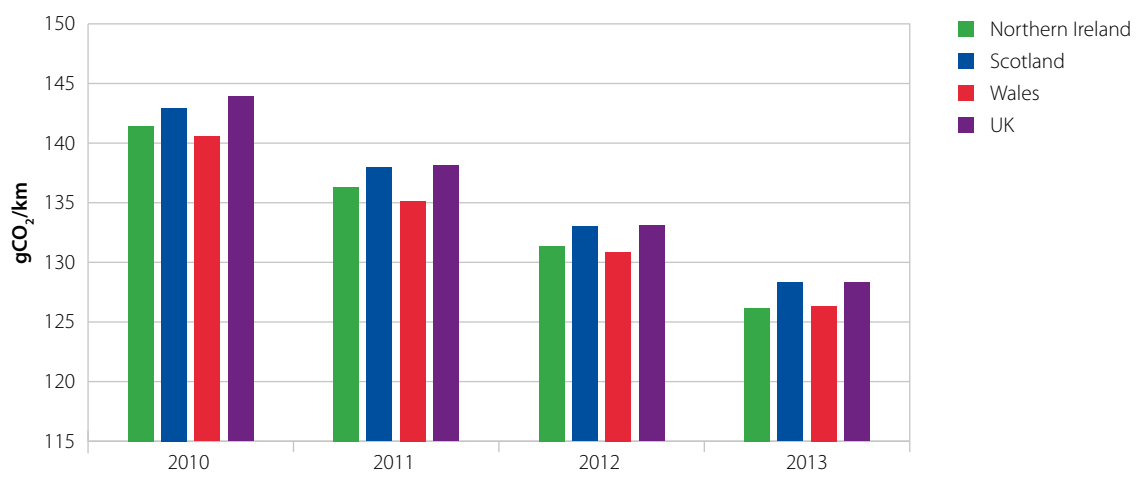
The reduction in emissions from the transport sector reflects an increase in new car efficiency and a reduction in annual vehicle kms.

- In **Scotland**, overall road traffic fell by 2.7% over the first budget period. Heavy goods vehicles saw the strongest reduction in kms travelled (11.3%), whilst cars saw a decline of 2.2%.
- The fall in overall road traffic over the first budget period was stronger in **Wales**, at 4.4%. Vehicle kms from goods vehicles declined by 17.7% over the period, whilst distances travelled by cars fell by 4.1%.
- Data for **Northern Ireland** for 2012 is not yet available, but overall vehicle-km travelled fell by 1% over the 2007-2011 period. Within this, the distance travelled by cars increased by 1%, whilst that travelled by goods vehicles fell markedly.

The efficiency of new cars is driven by EU legislation, however, there has been some variation in progress towards achieving the EU's 2020 target of 95 gCO_2/km in 2020 (Figure 8.12).

- Average new car efficiency in **Scotland** improved by 17.6% between 2007 and 2012 and a further 3.5% in 2013. However, at 128.3 gCO_2/km in 2013, average new car efficiency in Scotland is lower than in both Wales and Northern Ireland, but in line with the UK.
- In **Wales**, average new car efficiency improved by 18.2% between 2007 and 2012, and a further 3.5% in 2013. At 126.3 gCO_2/km in 2013, new car efficiency is better than the UK average (128.3 gCO_2/km).
- **Northern Ireland** has seen the strongest improvement in new car efficiency, as gCO_2/km fell from 162.0 in 2007 to 126.2 in 2012, a fall of 18.9%. The CO_2 intensity of new cars improved by a further 4% in 2013 to 126.2 gCO_2/km.

Figure 8.12: New car efficiency in Scotland, Wales, Northern Ireland and the UK (2010-2013)



Source: The Society of Motor Manufacturers and Traders (2014).

Although there have been some differences in the performance of new car efficiency across the devolved administrations, they have all made good progress and met the EU 2015 target of 130 gCO_2/km two years early.

(b) Progress developing electric vehicle markets

There has been an increase in electric vehicle 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 90% of the total UK market in 2013. Sales of electric vehicles in Scotland accounted for 6% of UK sales in 2013, with Wales and Northern Ireland each taking a 2% share. These shares were lower than the proportion of overall vehicle sales for Scotland and Wales, at 9% and 4%, respectively, but the share of electric vehicle sales in Northern Ireland was in line with its share of overall vehicle sales at 2%. As discussed in Chapter 5, the UK Government has made £500 million of additional funding available at a UK level for ultra-low emission vehicles (ULEVs) for 2015 to 2020.

Scotland and Northern Ireland have made progress developing infrastructure and markets for electric vehicles, following on from Plugged in Places funding from DfT.

- At the end of September 2013, there were approximately 300 charging points across **Scotland** and a further 200 in non-public locations. As part of the ChargePlace Scotland scheme, funding is available from the Energy Saving Trust for 100% of the cost of installing a home charge point and there is also funding for private organisations to install charge points. Transport Scotland has been awarded £600,000 of funding for 2014/15 to install rapid charge points at 50 mile intervals along Scotland's primary road network. In 2014/15, an additional £2m funding has been allocated for electric vehicle charging which is expected to fund up to 300 charging points, taking the total to 1,200.
- The ecar project has installed electric vehicle charging infrastructure in **Northern Ireland**, and there are now 334 charging points available at 174 different locations. Grants of up to £1,500 are available for electric vehicle owners to install electric charging points in homes or workplaces. Around £125 million is available in 2014/15 for a range of projects related to sustainable transport, including ecar and cycling projects.
- In **Wales** there has been less of a push for the EV market, partly as it was not a pilot area under the Plugged In Places scheme. A Low Carbon Vehicle steering group has been set up to provide advice and recommendations on the development of a low carbon vehicle sector, looking at maximising the sector's opportunities for growth and jobs and also considering barriers and opportunities to uptake.

At the UK level and for the devolved administrations, significant barriers, both financial and non-financial to the mass uptake of electric vehicles remain. These barriers can be addressed through a combination of innovative financing; further investment in charging infrastructure; changed planning rules to facilitate widespread on-street charging; and car manufacturers engaging consumers through innovative marketing strategies.

(c) Changing travel behaviour

The devolved administrations have various policies in place to change travel behaviour, encouraging the use of alternative modes of transport and promoting walking and cycling.

- Following the evaluation of the Smarter Choices, Smarter Places pilot programme in **Scotland**, £5 million of funding has been announced for 2015/16 for the behavioural change aspects of the programme to be rolled out across Scotland. It will be focused on locally designed initiatives, including travel planning, and the aim is to attract match funding. In addition, £7 million of funding has been allocated for 2014/15 for walking and cycling infrastructure, and, again, the Scottish Government is hoping to attract match funding to take the total amount available to £14 million.
- 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. For 2014/15, £5 million of funding has been announced for the Safe Routes in Communities programme.
- In **Northern Ireland**, the Executive published an active travel strategy in 2013. This includes a number of aspirational targets, including increasing the average distance walked, the average distance cycled and the percentage of trips taken by cycling to be in line with their UK counterparts. There is also a focus on promoting active travel to school-age children to ensure that, by 2015, 36% of primary school pupils and 22% of secondary school pupils are walking or cycling to school as their main means of transport.

These policies and action plans can help the devolved administrations to encourage the use of more sustainable methods of transport such as walking and cycling, but the infrastructure needs to be in place for these to be successful.

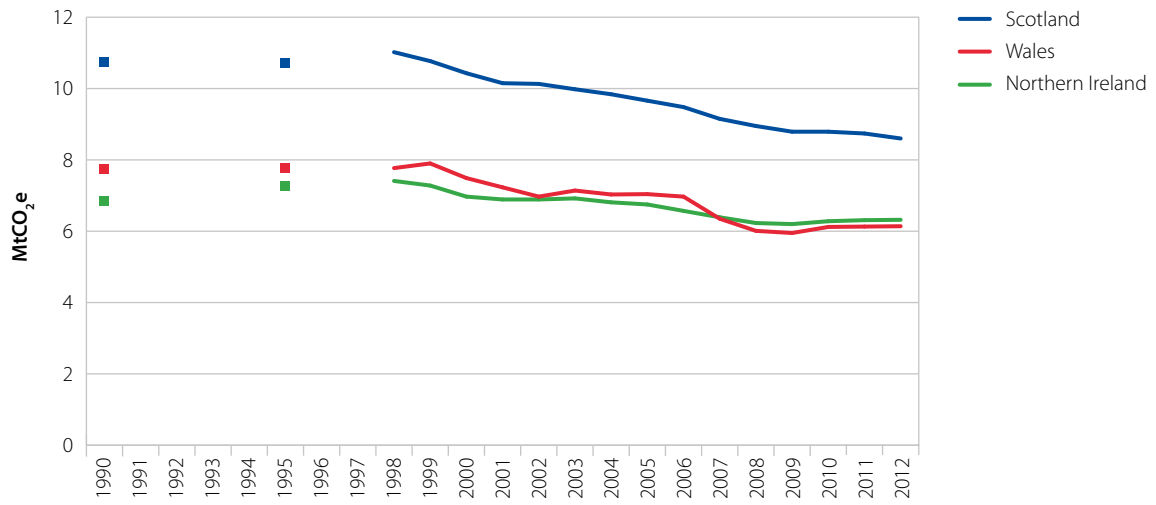
7. Agriculture and land use

(a) Agriculture emissions

Emissions from agriculture across the devolved administrations declined between 2007 and 2012 (Figure 8.13). Agriculture in the devolved administrations is relatively more important than in the UK as a whole, with emissions from the sector in Scotland taking a 17% share of the total in 2012, 13% in Wales and 30% in Northern Ireland. This compared to 10% at the UK level in 2012.

- In **Scotland**, agricultural emissions fell by 6% over the first budget period. Emissions from the sector were 20% lower than in 1990.
- Over the first budget period, emissions from agriculture in **Wales** declined by 3%. Emissions were 21% below 1990 levels.
- Emissions from the agricultural sector in **Northern Ireland** fell by just 1% over the first carbon budget period and were 8% lower than they were in 1990.

Figure 8.13: Agriculture emissions in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (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.

- In **Scotland**, the *Farming For a Better Climate* initiative was launched in 2009, and is designed to encourage voluntary uptake of measures through the provision of information about win-win actions in five key action areas: using energy and fuels efficiently; developing renewable energy; locking carbon into soils and vegetation; optimising application of fertilisers and manures; optimising livestock manage and the storage of waste.
  - Given their cost-effectiveness, uptake for most of the measures is expected to increase by 50% and by 90% for nitrogen use efficiency (equivalent to 260 ktCO_2e of annual savings by 2020).
  - As in England, the uptake of these measures is voluntary, but should sufficient progress not be made to increase the efficiency of nitrogen fertiliser use, the Scottish Government has clearly stated its intention to introduce regulation.
- **Wales** has set a reduction target of between 0.6 MtCO_2e (10% below 2008 level) and 1.5 MtCO_2e by 2020 in its Climate Change Strategy announced in October 2010. The ambition is being delivered through a number of programmes including *Glastir*, which offers farmers financial support to develop sustainable land management practices and is funding via the Rural Development Programme.

- In **Northern Ireland**, the *Greenhouse Gas Implementation Partnership* (GHGIP) is a collaborative strategy between Government and industry. There is a strong focus on improving efficiency and productivity, given the importance of agriculture in Northern Ireland. Phase one (2011-2014) focused on improving awareness among farmers, showing that efficient farming is profitable, and it also identified specific measures. Phase two (2014-2020) will look at establishing emissions intensity baselines for specific commodities, back cast to 1990, and it will also look at the setting of achievable targets to reduce emissions intensity. The phase two plan will be published in 2015.

Action to date across the devolved administrations is focused on using voluntary approaches, as in England, but it is important to note that Scotland has announced an intention to regulate if progress is below expectations.

(b) Forestry and land use emissions

The size of the carbon sink from the land use, land use change and forestry sector declined in Wales but increased substantially in Scotland between 2007 and 2012 (Figure 8.14). In Northern Ireland, the sector was a net emitter in 2012.

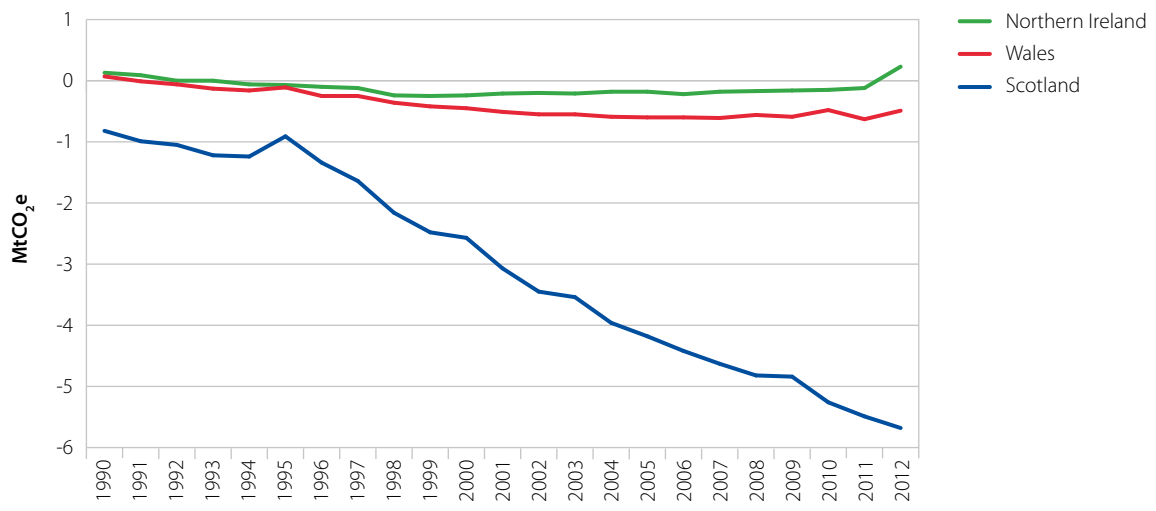
- In **Scotland**, the size of the carbon sink increased by 23% over the first carbon budget period and reached 5.7 $MtCO_2e$ in 2012. This is a significant increase from 1990, when the sink was just 0.8 $MtCO_2e$. This reflects the changing age profile of the trees and their ability to sequester carbon.
- In **Wales**, the sink decreased by 20% over the first budget period, falling to 0.5 $MtCO_2e$ in 2012. However, this was an improvement from 1990 when the sector was a net emitter (0.1 $MtCO_2e$). The proportion of land converted to cropland in Wales, a source of emissions, has been decreasing since 1999, but emissions from biomass burning have increased since 2000.
- In **Northern Ireland**, the sector became a net emitter in 2012 for the first time since 1992, emitting 0.2 $MtCO_2e$. It was also an increase from 1990 when the sector emitted 0.1 $MtCO_2e$. The main reason for the sector becoming a net emitter in 2012 was the increased area of forest fires.

For the forestry sector, the devolved administrations have ambitious targets to increase the rates of forest planting.

- In **Scotland**, the Second Report on Proposals and Policies[8] included a policy to increase the afforestation rate to 10,000 hectares per year, creating 100,000 hectares by 2020. As yet, this annual afforestation rate has not been achieved. In 2012, around 9,000 hectares of new forest were planted, but the rate of afforestation declined to 7,000 hectares in 2013. This decline was due to poor weather conditions early in the year which made it difficult to plant in many areas of Scotland. The afforestation rate increased again in 2014, to 8,300 hectares, but rates will have to rise substantially if 100,000 hectares are to be planted by 2020.

8 RPP2: http://www.scotland.gov.uk/Resource/0042/00426134.pdf

Figure 8.14: Emissions from land use, land use change and forestry in Scotland, Wales and Northern Ireland (1990-2012)



Source: NAEI (2014).

- In 2010, the **Welsh** Government announced a target of planting 100,000 hectares of new woodland over a 20 year period. This is equivalent to 5,000 hectares per year. Data from the Forestry Commission shows that new woodland planting rates fell to just 200 hectares per year between 2008 and 2010, before increasing slightly to 300 hectares in 2011. There was a marked jump in 2012, as the planting rate increase to 800 hectares and was 900 hectares in both 2013 and 2014. Whilst this recent increase is encouraging, and due to the *Glastir* programme gaining traction, the rate of new woodland planting needs to increase substantially if 100,000 hectares are to be planted by 2030.
- **Northern Ireland** has a strategy to double the area of forest from 6% in 2006 to 12% in 2056, which is equivalent to a planting rate of 1,700 hectares per year. In 2010, the planting rate fell to a low of just 200 hectares per year, and although it increased slightly to 300 hectares in 2011, the rate has remained unchanged since then.

The LULUCF inventory only includes emissions from lowland peat, and emissions related to upland peat use due primarily to historic drainage practices and to restoration of peat (e.g. rewetting and vegetating) are currently excluded. However, the IPCC has finalised the methodology for capturing the changes in emissions, focusing on the rewetting and restoration of peat land since 1990. Inclusion in the inventory by member states is voluntary.

- Peatlands cover approximately 20% of **Scotland**'s land area and account for 60% of the UK's peatlands. Historically many of these peatlands have been damaged or drained, but there has been little drainage over the past two decades. Scotland's National Peatland Plan is currently out for consultation and the Scottish Government is looking to restore at least 10,000 hectares of peatland by 2015. RPP2 proposes an accelerated rate of restoration, targeting up to 21,000 hectares per year. Around £1.5 million of funding was committed for funding peatland restoration between 2012 and 2015, and an additional £15 million was announced in 2013 for 2014/15 and 2015/16.

- In **Wales**, around 25% of the land area is peat. The Resilient Ecosystem fund provided some funding for a range of projects, including some for the restoration of peatlands.
- Peatlands cover 13% of the land area of **Northern Ireland** but store 42% of the country's soil carbon store. Around 80% of Northern Ireland's peatlands have been degraded[9]. Financial support has been given to peatland restoration projects, largely through the Rural Development Programme.

The Scottish Government intends to include peatland restoration activity within Scottish emissions accounting in future.

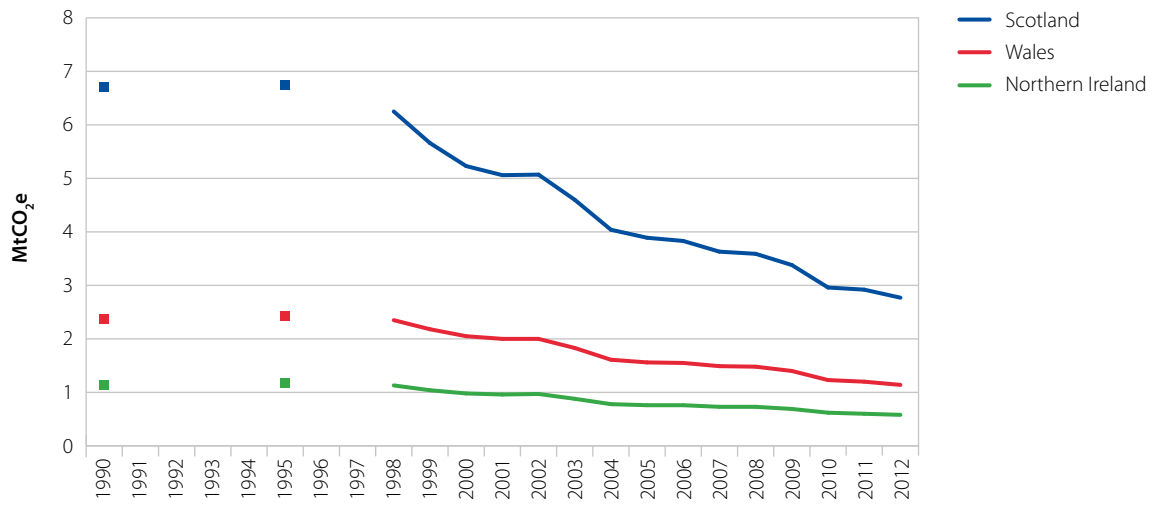
8. Waste

(a) Emissions trends

Emissions from waste declined across all the devolved administrations between 2007 and 2012 (Figure 8.15).

- Over the first budget period, emissions from waste in **Scotland** fell by 24%, reaching 2.8 $MtCO_2e$ in 2012. Emissions, which accounted for 5% of Scotland's total in 2012, were also 59% lower than in 1990.
- In **Wales**, emissions from waste also declined by 24% during the first carbon budget period, falling to 1.1 $MtCO_2e$ in 2012. Waste emissions in Wales were 52% below their 1990 levels. The sector contributed just 2% to overall emissions in Wales in 2012, compared with 4% at the UK level.

Figure 8.15: Waste emissions in Scotland, Wales and Northern Ireland (1990-2012)



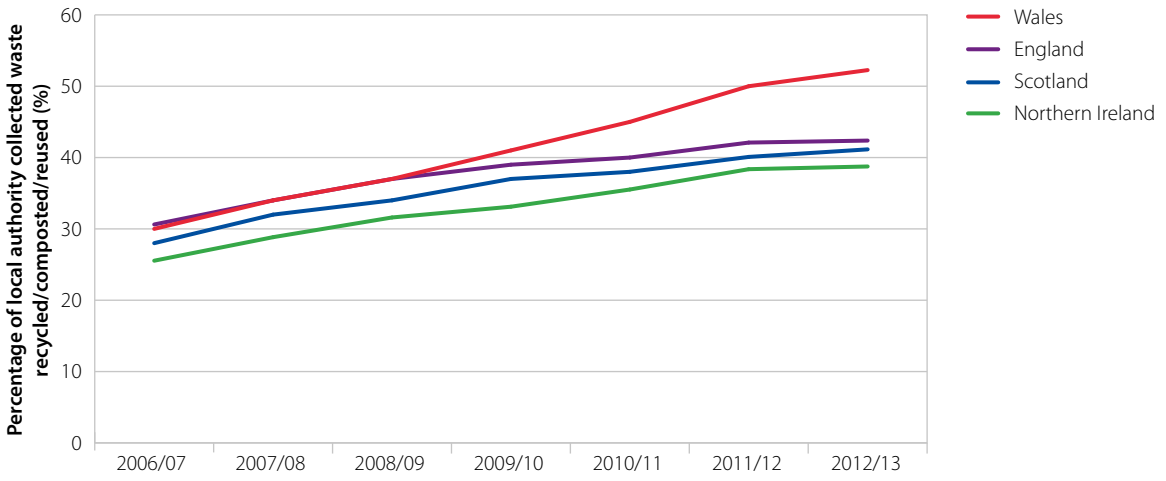
Source: NAEI (2014).
Notes: No inventory data are available for devolved administrations for 1991-1994 or 1996-1997.

9 http://www.climatenorthernireland.org.uk/cmsfiles/ClimateNI_RSPBFINAL.pdf

- In **Northern Ireland**, waste emissions fell by 21% over the first budget period to 0.6 $MtCO_2e$ in 2012. This was also 49% below their 1990 levels. In 2012, emissions from the sector took a 3% share of total emissions in Northern Ireland.

Recycling rates across the devolved administrations have been improving in recent years (Figure 8.17), with more than half of municipal waste sent for recycling/composted/reused in Wales in 2012/13. Scotland, Northern Ireland and England all have recycling rates around the 40% mark.

Figure 8.16: Recycling rates in Scotland, Wales, Northern Ireland and England (2006/07-2012/13)



Source: Defra, SEPA, Environment Agency Wales, and the Northern Ireland Executive.

Scotland

In Scotland, the Zero Waste Plan sets a number of targets for the waste management sector:

- 70% of household waste to be recycled/composted/reused by 2025, with interim targets for 2013 (50%) and 2020 (60%);
- Reducing the proportion of total waste sent to landfill to a maximum of 5% of all waste by 2025; and
- Recycling 70% of all waste (including commercial and industrial waste) by 2025.

The Zero Waste Plan is supported by the Waste (Scotland) Regulations which were passed in May 2012, and include a ban for various material to landfill from 2014 and for separate waste collection services to be offered (dry recyclables, food waste) to households and businesses.

In addition, the *Safeguarding Scotland's Resources – Blueprint For A More Resource Efficient and Circular Economy* report, published in 2013, develops a waste prevention plan as required in the EU Waste Framework Directive. The report contains the following targets:

- Reduce waste arisings in Scotland by 7% by 2017 against a 2011 baseline; and
- Reduce waste arisings in Scotland by 15% by 2025.

Progress towards the targets in Scotland has been mixed:

- Scotland missed its first Zero Waste Plan target, with only 38% of household waste being composted, recycling or reused in 2010/11. This increased slightly in both 2011 and 2012, to 40% and 41%, respectively, but this needs to increase substantially in 2013 to meet the second target of 50% in 2013; and
- In terms of reducing waste sent to landfill, the proportion of total waste arising sent to landfill fell from 43% in 2004 to 27% in 2010. However, the proportion increased markedly to 35% in 2011, although this was a result of changes to the calculation methods for commercial and industrial waste. Total waste arisings in Scotland fell by 22% in 2011, but the proportion sent to landfill increased by 3%.

Waste data for Scotland for 2012 has not yet been published.

Wales

In Wales, the 'Towards Zero Waste' strategy was launched in 2010 and includes statutory recycling targets for local authorities for municipal waste as follows:

- 2012/13 – 52%
- 2015/16 – 58%
- 2019/20 – 64%
- 2024/25 – 70%

Data from 2012/13 showed that overall Wales met its first target, recycling, reusing or composting 52.3% of municipal waste. However, there was substantial variation between local authorities, with rates ranging from 46.2% to 58%.

The Waste Prevention Programme for Wales was published in December 2013 and sets targets for the reduction of waste across different types of waste, from a 1.4% annual reduction for industrial and construction and demolition to a 1.2% annual reduction for household and commercial waste. These are annual targets for each year to 2050 from a 2006/07 baseline.

Northern Ireland

In Northern Ireland, Waste Regulations (Northern Ireland) 2011 set new targets of:

- 50% of weight of waste from households to be prepared for reuse or recycled by 2020; and
- 70% by weight of Construction and Demolition wastes to be subject to materials recovery to 2020

The Northern Ireland Waste Management Strategy was published in December 2013 and set various additional targets, including for recovery and recycling of packaging materials, and for end-of-life vehicles. A 45% recycling and reuse rate for household waste has been set for 2015. The recycling rate for household waste in Northern Ireland was 39% in 2012/13.

Wales and Scotland have introduced ambitious recycling targets for household waste, going further than the EU target of 50% in 2020, with targets of 64% and 60%, respectively. Northern Ireland and England have adopted targets of 50%, in line with the EU requirements.

9. Summary

Emissions fell across the devolved administrations between 2007 and 2012, although progress against their targets remains mixed and they will be very challenging to achieve.

In a number of policy areas, the devolved administrations have set more challenging targets than the UK and have allocated funding in addition to that available for GB-wide policies. This is particularly evident in areas such as residential energy efficiency and fuel poverty, waste and agriculture which are devolved competencies.

- **Energy efficiency and fuel poverty**: Unlike England, the devolved administrations still operate tax-payer funded schemes to tackle fuel poverty in addition to the supplier obligations. These often focus on area-based delivery and work with local authorities.
- **Waste**: Ambitious household waste recycling targets have been set in Scotland and Wales. Wales met its target of 52% for 2012/13, but Scotland missed its first target for 2010/11 and is likely to have missed the 50% target for 2013. Northern Ireland is progressing towards its 2015 target of 45%.
- **Agriculture**: Like England, the devolved administrations place considerable emphasis on a collaborative approach with the farming industry. In contrast to England, where the uptake of measures in also voluntary, Scotland has made it clear that it will introduce regulation if insufficient progress is made.

However, the devolved administrations have each set stretching targets and these remain challenging to achieve. Stronger action will be required in key areas including energy efficiency programmes, increasing low-carbon heat penetration, encouraging greater uptake of electric vehicles, increasing the rate of tree planting and ensuring that their waste targets are met.

Key findings

- Emissions in **Scotland, Wales and Northern Ireland** account for 20% of UK emissions (8.8%, 8.0% and 3.6% respectively).
- From 2007 to 2012, **emissions fell by 15% in Scotland, 6% in Wales and 7% in Northern Ireland**, compared to a 12% reduction across the UK.
- **Emissions are likely to have fallen in 2013** across the devolved administrations, in line with the UK, reflecting a reduction in the carbon-intensity of electricity generation through increased generation from renewables and the closure of coal plants.
- Progress includes increased **renewable capacity**, commitments to **additional funding for fuel poverty** programmes over and above GB-wide policies and **ambitious recycling targets** in Scotland and Wales.
- **Key areas of devolved powers** include transport demand-side measures, energy efficiency, waste, agriculture and land use, while there is also an important role in supporting implementation of UK policy.
- The devolved administrations have each adopted their **own ambitious targets** for reducing emissions but these remain challenging to achieve and stronger action will be required in key areas.

Future work of the Committee

The Committee has a number of deliverables over the next two years, either required under the Climate Change Act or requested by Government:

Mitigation

Progress reports to Parliament to be published in June 2015 and June 2016 respectively: These reports will incorporate latest data to consider progress against indicators.

Advice on the fifth carbon budget (2028-32) by the end of 2015: The Committee is required under the Climate Change Act to advise on the appropriate level of the fifth carbon budget by the end of 2015. In undertaking this work, the Committee will consider any new scientific evidence, appropriate global trajectories, UK contributions to those trajectories, and emissions reduction opportunities.

Advice on the 2030 electricity decarbonisation target range: As part of assessing the cost-effective path through the fifth carbon budget, we will identify the appropriate target range for carbon intensity of the power sector in 2030, as provided for under the Energy Act 2013. We will also consider potential cost-reduction pathways and advise on key elements of commercialisation strategies for offshore and CCS, consider the roles of specific technologies, and set out required funding commitments for low-carbon generation over the period to 2030.

We will also advise Scotland:

We will deliver the following reports to the Scottish Government:

- Reports on progress towards meeting annual targets, in January 2015 and January 2016.
- Advice on the level of legislated targets for 2028-32, by the end of 2015, alongside the UK fifth carbon budget advice.

Adaptation

First statutory report to UK Parliament: In July 2015, the ASC will publish its first statutory report to Parliament on implementation of the UK Government's National Adaptation Programme. This report will bring together and update the ASC's previous progress reports to provide an overall assessment of the effectiveness of the Government's programme in helping the country prepare for climate change.

Evidence report on the Climate Change Risk Assessment: The ASC is required under the Climate Change Act to provide advice to the UK Government on the Climate Change Risk Assessment. For the 2017 risk assessment, the Government has requested that the ASC produce the independent evidence report that will be used to inform the Government's report to Parliament. The evidence report must be completed by July 2016.

First statutory report to Scottish Parliament: Scottish Ministers have requested that the ASC deliver an independent assessment of the Scottish Climate Change Adaptation Programme, which was published in June 2014. The ASC's assessment is due in September 2016.

Glossary

Achievable Emissions Intensity
The minimum average annual emissions intensity of electricity generation that could be achieved in a given year, given the installed capacity, projected demand and the projected profile of that demand.

Anaerobic Digestion (AD)
A treatment process breaking down biodegradable material, particularly wastes, in the absence of oxygen. Produces a methane-rich biogas that can substitute for fossil fuels.

Availability
For an electricity generating station, this is the proportion of the time that the generator is physically able to supply electricity.

Battery Electric Vehicle (BEV)
A vehicle that receives all motive power from a battery.

Biodegradable
A substance capable of being decomposed by bacteria or other living organisms and thereby avoiding pollution.

Biofuel
A fuel derived from biomass and used to power vehicles (can be liquid or gas). Biofuels are commonly derived from cereal crops but can also be derived from other plant material, trees and even algae.

Biomass
Biological material that can be used as fuel or for industrial production. Includes solid biomass such as wood and plant and animal products, gases and liquids derived from biomass, industrial waste and municipal waste.

Bunker fuels
Fuels consumed for air and maritime transportation.

Bus Services Operator Grant (BSOG)
A grant paid to operators of eligible local bus services and community transport organisations to help them recover some of their fuel costs.

Carbon Budget
A restriction on the total amount of greenhouse gases the UK can emit over a 5-year period.

Carbon Capture and Storage (CCS)
Set of technologies to capture the carbon dioxide emitted from industrial processes or from burning fossil fuels or biomass, transport it, and store it in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

Climate Change Agreement
A voluntary agreement that allow eligible sectors to receive up to 90% reduction in the Climate Change Levy (CCL) if they sign up to government agreed absolute or relative energy efficiency targets.

Climate Change Levy
A tax on energy delivered to non-domestic users.

Carbon dioxide (CO_2)
A greenhouse gas covered by the Kyoto Protocol.

Carbon dioxide equivalent (CO_2e) concentration
The concentration of carbon dioxide that would give rise to the same level of radiative forcing as a given mixture of greenhouse gases.

Carbon dioxide equivalent (CO_2e) emission
The mass of carbon dioxide emission that would give rise to the same level of radiative forcing, integrated over a 100-year time period, as a given mixture of greenhouse gas emissions.

Carbon leakage
Carbon leakage occurs when there is an increase in emissions in one country/region as a result of emissions reduction by a second country/region with a strict climate policy.

Carbon price
The price at which 1 tCO_2e emissions can be purchased. We use projections for the carbon price as a comparator for judging cost-effectiveness of potential emissions reduction measures.

Carbon price floor
Policy to ensure a set minimum amount is paid for every unit of carbon dioxide emitted.

Carbon price support
A top up on the carbon price from the EU ETS to the Carbon Price Floor.

CRC Energy Efficiency Scheme
A mandatory carbon reduction and energy efficiency scheme for large non-energy intensive public and private sector organisations. The CRC captures CO_2 emissions not already covered by Climate Change Agreements and the EU Emissions Trading System.

Carbon sink
An absorber of carbon (usually in the form of carbon dioxide). Natural carbon sinks include forests and oceans.

Certificate of Professional Competency (CPC)
A mandatory requirement for HGV drivers to complete 35 hours of training every 5 years.

Combined Heat and Power (CHP)
Is the use of a heat engine or power station to simultaneously generate electricity and useful heat.

Contract for Difference (CfD)
Form of hedging on the future price of a commodity in which a strike price is pre-specified. Payments are made between counterparties depending on the difference between the strike price and the market price at the time.

Credits
Emissions credits purchased in international carbon markets, generally corresponding to 1 tCO_2e per credit. Also referred to as 'carbon units' in the Climate Change Act. It is not clear how carbon markets will develop by the 2020s. Therefore, where we refer to credits for the 2020s these could be allowances purchased in schemes such as the current EU ETS, or offset credits from project-based schemes (e.g. such as those generated under the Kyoto Protocol's project-based flexibility mechanisms, Joint Implementation and Clean Development Mechanism).

Devolved administrations
The national authorities of Scotland, Wales and Northern Ireland.

Display Energy Certificate (DEC)
The certificate shows the actual energy usage of a building and must be produced every year for public buildings larger than 1,000 square metres.

Eco-driving
Eco-driving involves driving in a more efficient way in order to improve fuel economy. Examples of eco-driving techniques include driving at an appropriate speed, not over-revving, ensuring tyres are correctly inflated, removing roof racks and reducing unnecessary weight.

Electric vehicle
Vehicle capable of full electric operation driven by an electric motor fuelled by battery power. These include battery electric (BEV), plug-in hybrid electric (PHEV) and hydrogen fuel-cell vehicles.

Electricity Demand Reduction
A pilot scheme that will auction financial incentives for equipment that offer lasting electricity savings as an alternative to electricity generation.

Electricity Market Reform
Current reform of the electricity market, including provision of support for low-carbon generation through Feed-in Tariffs with Contracts for Difference (FiT CfDs).

Electricity Networks Strategy Group (ENSG)
Joint government and industry group addressing key strategic issues affecting electricity networks in the shift to a low-carbon economy.

Energy Company Obligation (ECO)
The ECO places legal obligations on larger energy suppliers to deliver energy efficiency measures to domestic energy users. The costs of the measures are passed through to consumer energy bills.

Engine downsizing
Use in a vehicle of a smaller engine that provides the power of a larger engine.

Enhanced Capital Allowances
Where companies can write off 100% of the cost of the new plant or machinery against the business's taxable profits in the financial year the purchase was made.

European Commission (EC)
Executive arm of the European Union.

European Union Allowances (EUAs)
Emissions credits traded within the EU ETS.

European Union Emissions Trading Scheme (EU ETS)
Cap and trade system within the EU covering the power sector, energy-intensive industry and, from the start of 2012, all domestic and international aviation.

Extended Ambition scenario
Emissions reduction scenario for measures to 2020, developed in our 2008 report and updated in our 2009 and 2010 progress reports. We recommended that the measures in this scenario should be implemented given the need to prepare for the 2050 target and the relative cost-effectiveness of many of the measures.

Feed-in-tariffs
A type of support scheme for electricity generators, whereby generators obtain a long term guaranteed price for the output they deliver to the grid.

Fluorinated Gases (F-gases)
Family of greenhouse gases containing fluorine. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) are used in industrial processes, refrigeration and air conditioning. They generally have high Global Warming Potentials.

Fuel Cell Electric Vehicle
Vehicle that receives motive power from a fuel cell which converts hydrogen (stored in a fuel tank) into electricity, which is used to drive an electric motor.

Fuel Consumption Meters (FCM)
An in-car device which displays real time information on fuel consumption to the driver.

Fuel poverty
In the devolved administrations, 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. England uses a low income, high cost (LIHC) definition that takes account of low incomes and higher than typical energy costs to define fuel poverty.

Gear Shift Indicator (GSI)
An in-car device which indicates the appropriate time for a driver to change gear.

Global Warming Potential (GWP)
The standard metric used to calculate CO_2-equivalent emissions of different greenhouse gases in carbon budgets and the Kyoto Protocol. GWP measures the total radiative forcing over a given period (usually 100 years) after a pulse emission, relative to that from the same mass of CO_2.

Grazing returns
Excreta (dung and urine) from livestock kept outdoors (mainly cattle and sheep) deposited directly on land as the animal grazes and not subject to management.

Green Deal
The Green Deal is a financial mechanism enabled through the Energy Act 2011. It eliminates the need to pay upfront for energy efficiency measures in buildings and instead allows the costs to be paid back through savings on the electricity bill. The Green Deal charge is attached to the property, not the owner.

Green Investment Bank (GIB)
The Green Investment Bank has been set up by the UK Government under the Companies Act to provide financial solutions to accelerate private sector investment in the green economy. It is capitalised with £3 billion.

Greenhouse Gas (GHG)
Any atmospheric gas which absorbs thermal radiation emitted by the Earth's surface. This traps heat in the atmosphere and keeps the surface at a warmer temperature than would otherwise be possible.

Gross Domestic Product (GDP)
A measure of the total economic activity occurring in the UK.

Gt
A gigatonne (1,000 million tonnes).

Heat pumps
Working like a 'fridge in reverse', heat pumps use compression and expansion of gases or liquid to draw heat from the natural energy stored in the ground or air. Both air source and ground source heat pumps can provide heating for buildings.

Heating degree day
The number of degrees that a day's average temperature is below a baseline temperature (typically either 15.5°C or 18°C), below which buildings need to be heated.

Heavy Goods Vehicle (HGV)
A truck over 3.5 tonnes (articulated or rigid).

Hybrid vehicle
A vehicle powered by an internal combustion engine and electric motor that can provide power to the drive train individually or together.

Indirect Land Use Change
Occurs when land for an existing activity (e.g. food or timber production) is converted to grow bioenergy feedstock, which results in the relocation of that displaced activity to another land area which is converted from a different use.

Intended budget
As proposed in our 2008 report, the Intended budget (2008-2022) corresponds to the UK share of an EU 30% 2020 target. We recommended it should be enacted in the context of a global deal to reduce emissions.

Intergovernmental Panel on Climate Change
A scientific body under the auspices of the United Nations (UN) to review and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change.

Interim budget
As proposed in our 2008 report, the Interim budget corresponds to the UK share of an EU 20% 2020 target. This is the current set of legislated budgets to 2022.

Kilowatt-hour (kWh)
A unit of energy, equal to the total energy consumed at a rate of 1,000 watts for one hour. Related units are: Megawatt-hour (MWh) = 1,000 kWh, Gigawatt-hour (GWh) = 1,000 MWh and Terawatt-hour (TWh) = 1,000 GWh. The kilowatt-hour is equal to 3.6 million Joules.

Kyoto gas
A greenhouse gas covered by the Kyoto Protocol; specifically carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Kyoto Protocol
Adopted in 1997 as a protocol to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol makes a legally binding commitment on participating countries to reduce their greenhouse gas emissions by 5% relative to 1990 levels during the period 2008-2012.

Lading Factor
A measure of freight utilisation which shows the ratio of actual tonne-kilometres to possible tonne-kilometres if goods vehicles were fully laden on loaded legs.

Landfill
The disposal of waste material through burying.

Load factor
A measure of the output of an electricity generator relative to the maximum output it could produce.

Low Carbon Transition Plan (LCTP)
White paper from the Department of Energy and Climate Change (DECC) published in 2009.

Low Rolling Resistance Tyres (LRRT)
A tyre specifically designed to minimise rolling resistance, while maintaining grip levels.

Major Infrastructure Planning Unit (MIPU)
Advisory body to the Secretary of State on the determination of planning applications of large infrastructure projects (e.g. over 50 MW).

Marginal Abatement Cost Curve (MACC)
Graph showing costs and potential for emissions reduction from different measures or technologies, ranking these from the cheapest to most expensive to represent the costs of achieving incremental levels of emissions reduction.

Methane (CH_4)
Greenhouse gas covered by the Kyoto Protocol with a Global Warming Potential of 21 (1 tonne of methane emission corresponds to 21 tonnes CO_2e).

Mitigation
Action to limit the causes of climate change, principally by reducing sources (or enhancing sinks) of greenhouse gases.

Mt
Million tonnes.

National Atmospheric Emissions Inventory (NAEI)
Data source compiling estimates of the UK's emissions to the atmosphere of various gases.

New European Drive Cycle
Stylised driving cycle used to test fuel efficiency and emissions of new light-duty in the European Union.

Nitrous oxide (N_2O)
Greenhouse gas with a global warming potential of 310 (1 tonne of nitrous oxide emission corresponds to 310 tonnes CO_2e).

NO_x
Oxides of nitrogen, defined as the sum of the amounts of nitric oxide (NO) and nitrogen dioxide (NO_2).

Offset credits
See credits.

Ofgem (Office of Gas and Electricity Markets)
The regulator for electricity and gas markets in Great Britain.

Ozone-depleting substances (ODS)
Gases which damage the ozone layer in the upper atmosphere.

Plug-in hybrid Electric Vehicle (PHEV)
A vehicle that receives motive power from both a battery and a secondary source (e.g. an internal combustion engine). The battery will generally be charged in the same way as that in a BEV, but all electric range will be more limited (e.g. 40 rather than 100 miles).

Process emissions
Emissions from chemical reactions in the industrial production process.

Renewable Heat Incentive (RHI)
A feed-in-tariff type mechanism to provide long-term financial support to producers of low-carbon heat.

Renewables
Energy resources derived from natural processes that are replenished constantly. They include geothermal, solar, wind, tide, wave, hydropower, biomass and biofuels.

Renewables Obligation Certificate (ROC)
A certificate issued to an accredited electricity generator for eligible renewable electricity generated within the UK.

Renewable Transport Fuel Obligation (RTFO)
UK legislation requiring fossil fuel suppliers to supply a specified percentage of sustainable biofuels for each litre of fuel used by road transport in the UK.

Smarter Choices
Measures that influence travel behaviour away from cars and towards less carbon-intensive alternatives such as public transport, cycling and walking, by providing targeted information and opportunities to consider alternative modes.

Standard Assessment Procedure (SAP)
The methodology used by the Government to assess and compare the energy and environmental performance of dwellings. It compares the energy performance of dwelling on a scale of 1 to 100, with 100 being the best performance.

State Aid
Where a company or sector receives government financial support that distorts competition or affects trade between EU member states.

Solar photovoltaics (PV)
Panels that generate electricity from sunlight.

Ultra-low emissions vehicle
Vehicle with very low tailpipe emissions (e.g. less than 50 gCO_2/km).

Vehicle Energy Calculation Tool (VECTO)
A computer simulation tool being developed to estimate emissions from Heavy Goods Vehicles in different configurations.

Vehicle Excise Duty (VED)
Commonly known as road tax, an annual duty which has to be paid to acquire a vehicle licence for most types of motor vehicle. VED rates for private cars have been linked to emissions since 2001, with a zero charge for the least emitting vehicles (under 100 gCO_2/km).

Warmfront
Treasury-funded fuel poverty programme in England to deliver energy efficiency and heating measures. Funding expired at the end of financial year 2012-13.

World Light Duty Test Procedure
Global harmonized standard for determining emissions and energy consumption of light-duty vehicles, designed to better reflect real-world driving conditions.

Abbreviations

AWBR	Advanced Boiling Water Reactor
AD	Anaerobic Digestion
BEV	Battery Electric Vehicle
BIS	Department for Business, Innovation & Skills
BSOG	Bus Services Operators Grant
CAP	Common Agricultural Policy
CCA	Climate Change Agreement
CCC	Committee on Climate Change
CCGT	Combined-Cycle Gas Turbine
CCL	Climate Change Levy
CCS	Carbon Capture and Storage
CCT	Company Car Tax
CERT	Carbon Emissions Reduction Target
CERO	Carbon Emission Reduction Obligation
CESP	Community Energy Saving Programme
CFCs	Chlorofluorocarbons
CfD	Contract for Difference
CH_4	Methane
CHP	Combined Heat and Power
CLG	Department for Communities and Local Government
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPC	Certificate of Professional Competence
CPF	Carbon Price Floor
CPS	Carbon Price Support
CRC	CRC Energy Efficiency scheme (previously Carbon Reduction Commitment)
CSCO	Carbon Savings Community Obligation

CSRF	Centre for Sustainable Road Freight
CSRGT	Continuing Survey of Road Goods Transport
DEC	Display Energy Certificate
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DSA	Driving Standards Agency
DUKES	Digest of UK Energy Statistics
DVLA	Driver and Vehicle Licensing Agency
EA	Environment Agency
EC	European Commission
ECA	Enhanced Capital Allowance
ECO	Energy Company Obligation
EMR	Electricity Market Reform
ENSG	Electricity Network Strategy Group
ENUSIM	Energy End-Use Simulation Model
EPC	Energy Performance Certificate
ESOS	Energy Savings Opportunity Scheme
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EUA	European Union Allowance
EV	Electric vehicle (BEV or PHEV)
FCEV	Fuel Cell Electric Vehicle
FCM	Fuel Consumption Meter
FEED	Front-End Engineering Design
F-gases	Fluorinated gases
FIDER	Final Investment Decision Enabling Regime
FTA	Freight Transport Association
FTE	Full Time Equivalent
FYA	First Year Capital Allowance

GDA	Generic Design Assessment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIB	Green Investment Bank
GPS	Global Positioning System
GSI	Gear Shift Indicator
GVA	Gross Value Added
GW	Gigawatts
GWh	Gigawatt hours
GWP	Global Warming Potential
HCFCs	Hydrochlorofluorocarbons
HDD	Heating Degree Days
HDV	Heavy Duty Vehicle
HFCs	Hydrofluorocarbons
HFOs	Hydrofluoroolefins
HGV	Heavy goods vehicle
HMG	HM Government
HMT	HM Treasury
HS2	High Speed 2
IAS	International Aviation and Shipping
ICAO	International Civil Aviation Organisation
ICE	Internal Combustion Engine
ILUC	Indirect Land Use Change
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
kW	Kilowatt
kWh	Kilowatt-Hours
LA	Local Authority
LCRS	Logistics Carbon Reduction Scheme
LCVP	Low Carbon Vehicle Partnership

LIHC	Low Income High Cost
LMDI	Log Mean Divisia Index
LRRT	Low Rolling Resistance Tyre
LSTF	Local Sustainable Transport Fund
LULUCF	Land use, land use change and forestry
MAC	Mobile air conditioning
MBT	Mechanical biological treatment
MIPU	Major Infrastructure Planning Unit
MOT	Ministry of Transport Test
MW	Megawatt
MWh	Megawatt-Hour
N_2O	Nitrous oxide
NAEI	National Atmospheric Emissions Inventory
NEDC	New European Drive Cycle
NOX	Oxides of nitrogen
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NVZ	Nitrate Vulnerable Zone
ODS	Ozone-depleting substances
Ofgem	Office of the Gas and Electricity Markets
OLEV	Office for Low Emissions Vehicles
ONS	Office for National Statistics
PCB	Polychlorinated biphenyls
PCP	Personal Contract Plan
PCT	Polychlorinated terphenyls
PFCs	Perfluorocarbons
PHEV	Plug-In Hybrid Electric Vehicle
PiCG	Plug-In Car Grant
PIFI	Plugged-In Fleets Initiative
PiP	Plugged-In Places

PM	Particulate Matter
PPP	Purchasing Power Parity
PWR	Pressurised Water Reactor
R&D	Research and development
RHI	Renewable Heat Incentive
RHPP	Renewable Heat Premium Payment
RO	Renewables Obligation
ROC	Renewables Obligations Certificate
RPI	Retail Prices Index
RPP2	The Second Report on Policies and Proposals (Scottish Government)
RTFO	Renewable Transport Fuel Obligation
SAP	Standard Assessment Procedure
SF6	Sulphur Hexafluoride
SHETL	Scottish Hydro Electric Transmission Limited
SMEs	Small and Medium Enterprises
SMMT	Society of Motor Manufacturers and Traders
TNP	Transitional National Plan
TW	Terawatts
TWh	Terawatt hours
UCO	Used Cooking Oil
UEP	Updated Energy Projections
UK	United Kingdom
ULEV	Ultra-low emission vehicle
VECTO	Vehicle Energy Calculation Tool
VED	Vehicle Excise Duty
v-km	Vehicle kilometre
WLTP	World Light Duty Test Procedure
WPP	Waste Prevention Programme
WRAP	Waste and Resources Action Programme
ZCH	Zero Carbon Homes

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