Meeting Carbon Budgets – the need for a step change

Progress report to Parliament
Committee on Climate Change
12 October 2009

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

naturallyresponsible

THE QUEEN'S AWARDS FOR ENTERPRISE: SUSTAINABLE DEVELOPMENT 2007

Printed by Seacourt to the most stringent environmental systems using **Waterless** Offset (0% water and 0% Isopropyl alcohol or harmful substitutes), 100% renewable energy and vegetable oil based inks on paper with 100% recycled content. **Seacourt** is registered to EMAS and ISO 14001, prints to ISO12647 Colour Standard, is a CarbonNeutral® company and FSC certified TT-COC-2132.

Contents

Foreword

Last December the Committee on Climate Change (CCC), in its first report recommended that the UK set a long-term target to reduce greenhouse gas emissions to 80% below 1990 levels by 2050 and we recommended the levels of the first three carbon budgets, defining an emissions reduction path from 2008 to 2022. The Government subsequently accepted our recommendations and the first three budgets became legally binding following Parliamentary approval in May 2009. In July 2009 the Government published a very comprehensive account of opportunities for reducing emissions in its Low Carbon Transition Plan.

The Climate Change Act 2008 requires that the Committee delivers annual reports to monitor progress against budgets; this is the first such annual report. Two specific factors, however mean that this years report is somewhat different in content and structure from that which we envisage in future. The first is that we are only in the second year of the first budget period, and do not yet have even first year (i.e. 2008) verified emission figures. The second is that it is now clear that the economic recession, in the UK and across Europe, will have major implications for the path of emissions in the early years of the first budget.

In these specific circumstances, we have focussed work for this report on:

- Putting in place a monitoring approach with which we will assess progress in future years, focussing not just on emissions results but on forward indicators of likely future emissions.
- Quantifying the likely impact of the recession on emissions to enable us to distinguish cyclical from underlying trends.
- Fine tuning our estimates of feasible emissions reductions in three specific areas: power generation, home energy efficiency improvement, and the potential pace of deployment of electric cars.
- Comparing the pace of emissions reduction required in the first three budgets with that achieved in 2003-07.

In some respects therefore this is a rather technical report, equipping the Committee with the tools to monitor progress in future years. But our analysis has led us to two important conclusions:

- The significant emissions reductions produced by the recession could both produce an over rosy impression of progress against budgets and undermine steps to drive long-term reductions, in particular by reducing the carbon price within the EU ETS.
- Progress in reducing emissions in the five years before the first budget period, both overall and in most sectors, was far slower than now required to meet budget commitments. A step change in pace of reduction is essential.

The report therefore considers the measures required to achieve this step change and to offset the danger that the recession slows underlying progress. It concludes that achieving the step change is likely to require new approaches in two areas in particular:

- In power generation where the current combination of markets and market instruments (the electricity markets and the EU ETS) is not best designed to deliver required long-term decarbonisation and where a combination of additional policies and more fundamental review of approaches is likely to be required.
- In home energy efficiency improvements, where a more forceful role for Government and a more integrated whole house approach is appropriate.

The report is the first of two this year. In December our report on aviation emissions will cover the steps required to meet the Government's target that UK domestic and international aviation emissions should be no higher in 2050 than in 2005. 2010 will see a review of appropriate carbon budgets in the light of the Copenhagen agreement, the second annual monitoring report, a report on low carbon research and development, recommendations on targets for the Carbon Reduction Commitment, advice to the Scottish Government on their emissions reduction targets, and recommendations for emissions reduction in the fourth budget period (2023-27).

This represents a demanding programme of work for both the Committee and the Secretariat. On behalf of the Committee I would like to thank the Secretariat for their excellent support and hard work over the last year.

The Committee on Climate Change

Lord Adair Turner, Chair

Lord Turner of Ecchinswell is the Chair of the Committee on Climate Change and Chair of the Financial Services Authority. He has previously been Chair at the Low Pay Commission, Chair at the Pension Commission, and Director-General of the Confederation of British Industry (CBI).

David Kennedy, Chief Executive

David Kennedy is the Chief Executive of the Committee on Climate Change. Previously he worked on energy strategy at the World Bank, and design of infrastructure investment projects at the European Bank for Reconstruction and Development. He has a PhD in economics from the London School of Economics.

Dr Samuel Fankhauser

Dr Samuel Fankhauser is a Principal Research Fellow at the Grantham Research Institute on Climate Change at the London School of Economics. He is a former Deputy Chief Economist of the European Bank for Reconstruction and Development and former Managing Director (Strategic Advice) at IDEAcarbon.

Professor Michael Grubb

Professor Michael Grubb is Chief Economist at the UK Carbon Trust and Chairman of the international research network Climate Strategies. He is also senior research associate at Cambridge University and holds a visiting professorship at Imperial College.

Sir Brian Hoskins

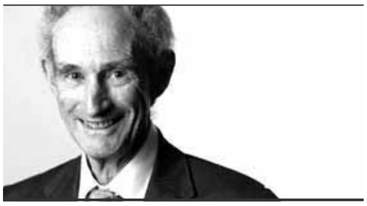
Professor Sir Brian Hoskins, CBE, FRS is the Director of the Grantham Institute for Climate Change at Imperial College, London and Professor of Meteorology at the University of Reading. He is a Royal Society Research Professor and is also a member of the National Science Academies of the USA and China.

Professor Julia King

Professor Julia King became Vice-Chancellor of Aston University in 2006, having previously been Principal of the Engineering Faculty at Imperial College, London, before that she held various senior positions at Rolls-Royce plc in the aerospace, marine and power business groups. In March this year, she delivered the 'King Review' that examined vehicle and fuel technologies that, over the next 25 years, could help to reduce carbon emissions from road transport.

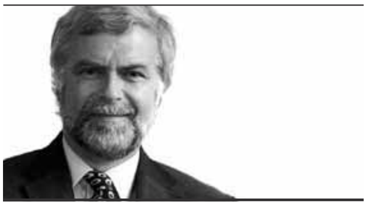
Lord John Krebs

Lord Krebs is an internationally renowned scientist and Principal of Jesus College, Oxford University and also chair of the Adaptation Sub-Committee. He sits in the House of Lords as an independent cross-bencher and is currently chairing an enquiry by the Science and Technology Select Committee into Nanotechnology and Food.



Lord Robert May

Professor Lord May of Oxford, OM AC FRS holds a Professorship jointly at Oxford University and Imperial College. 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 is Research Director at UK Energy Research Centre (UKERC) having previously been the Director at the Policy Studies Institute (PSI). He has also acted as Launch Director for the Low Carbon Vehicle Partnership and was Director of the Economic and Social Research Council's Global Environmental Change Programme.

Acknowledgements

The Committee would like to thank:

The team that prepared the analysis for the report. This was led by David Kennedy and included: Mark Bainbridge, Alice Barrs, Owen Bellamy, Russell Bishop, Ute Collier, Ben Combes, Kristofer Davies, Adrian Gault, Neil Golborne, Rachel Hall, David Joffe, Swati Khare-Zodgekar, Katherine Kinninmonth, Eric Ling, Rachel Lund, Nina Meddings, Sarah Naghi, Akshay Paonaskar, Michele Pittini, Stephen Smith, Kiran Sura, Indra Thillainathan, Mike Thompson, Peter Thomson, Claire Thornhill, Emily Towers.

A number of individuals who provided significant support: Emma Campbell, Hannah Chalmers, Tom Corcut, Stephen Elderkin, Jon Gibbins, Stephen Glaister, Phil Goodwin, Chris Holland, Richard Houston, Neville Jackson, Roger Lampert, Margaret Maier, James Miners, Dennis Morgan, David Newbery, Paul Nieuwenhuis, Cecilia Nyqvist, Stephen Oxley, Mike Parker, John Rhys, Dick Stimpson, Philipp Thiessen, Dan Thomas, Mark Weiner, Tony White and David Wilson.

A number of organisations for their support, including Association of Electricity Producers, British Energy, British Institute of Energy Economics, Cambridge Economic Policy Associates, Campaign for Better Transport, Carbon Trust, CBI, Centrica, Citibank, Climate Change Capital, Commission for Integrated Transport, Department for Business Innovation and Skills, Department for Environment, Food and Rural Affairs, Department for Transport, Department of Energy and Climate Change, Department of the Environment in Northern Ireland, EdF Energy, Energy Saving Trust, Environment Agency, E.ON, Ernst and Young , Greater London Authority, Low Carbon Vehicle Partnership, Market Transformation Programme, National Grid, Ofgem, Scottish and Southern Energy, Scottish Government, Shell, Society of Motor Manufacturers and Traders, UK Business Council for Sustainable Energy, Welsh Assembly Government and Yorkshire Energy Services.

A wide range of stakeholders who engaged with us, attended our expert workshops, or met with the CCC bilaterally.

Structure of the report

The report comprises six chapters:

Chapter 1: Progress developing a legal framework and reducing emissions summarise progress developing a framework for emissions reductions in the UK and internationally. It provides an overview of emissions trends for the economy in aggregate, for each sector, and for each nation within the UK.

Chapter 2: Implications of the recession and credit crunch for meeting budgets considers the implications of the recession for meeting carbon budgets including:

• Non-traded sector emissions reductions which could make it possible to meet the first budget without implementation of measures necessary for sustainable cuts to meet subsequent budgets on the way to meeting the 80% emission reduction required by 2050.

• Traded sector emissions reductions which have resulted in a low carbon price that could undermine incentives for investment in low carbon technology in energy intensive industries.

• Constraints on available finance for necessary investments in renewable electricity.

Chapter 3: Emission reduction scenarios and indicators updates our economy wide emissions reduction scenarios to reflect new commitments by the Government, new analysis, and new judgments by the Committee. It sets out the rationale for our indicator framework and provides a summary of our indicators for power, buildings and industry, and transport sectors.

Chapter 4: Reducing power sector emissions starts with an assessment of trends in power sector emissions. It sets out our indicators for low carbon generation including a scenario for sector decarbonisation and forward indicators related to the project cycle and the enabling framework for wind, nuclear and CCS generation. It includes the Committee's views on the government's proposed framework for investment in CCS. It also includes analysis of and recommendations on current power market arrangements and the need to consider alternatives which would provide more confidence for investment in low carbon generation.

Chapter 5: Reducing emissions in buildings and industry considers progress reducing emissions from buildings and industry and sets out our indicators for assessing progress going forward. It also includes an assessment of the current policy for improving residential energy efficiency (CERT) and the Committee's recommendations on a new approach. It sets out new analysis of renewable heat covering the range of technologies (biomass, biogas, air source heat pumps, ground source heat pumps, solar thermal). It includes the Committee's recommendation on renewable heat, public sector buildings, and SMEs.

Chapter 6: Reducing surface transport emissions through more low carbon cars and consumer behaviour change assesses emissions trends and sets out our indicators for the transport sector. It presents new analysis of electric and plug in hybrid cars covering costs, required price support, and charging infrastructure, and recommends a target level of roll out and supporting measures. It sets out new analysis of scope for emissions reduction through road pricing, roll out of smarter choices, and an integrated approach to land use planning and transport emissions.

Executive Summary

In May 2009 the Government put into legislation the Committee's recommended carbon budgets, and in July 2009 published an ambitious high level vision in its Low Carbon Transition Plan (Box 1). This is the Committee's first annual report to Parliament, required under the Climate Change Act, on progress towards meeting budgets. Comprehensive data is not yet, however, available even for the first year of the first budget (2008). In this report, therefore, we focus on developing a monitoring approach which will better enable us to track progress against budgets going forward, and on identifying clear challenges likely to be faced in meeting budgets.

Box 1 The Low Carbon Transition Plan

The Government's Low Carbon Transition Plan makes three key contributions:

- It provides an overview of opportunities for reducing emissions, and high level commitments from departments that if delivered would achieve carbon budgets.
- It gives an overview of the policy framework including policies under development (e.g. for clean coal and residential buildings)
- It sets out the economic opportunities (e.g. jobs in low carbon industries) from meeting carbon budgets

This has entailed four main blocks of work:

- **Understanding the trajectory of UK carbon emissions** as we entered the first budget period, and thus the extent to which a major change in pace is required.
- **Understanding the impact of the recession,** to enable us to distinguish underlying trends from temporary recession impacts in the first budget period.
- **Developing a set of indicators** which will enable us in future years to assess emission trends. These include forward indicators of progress in investments, and policies which are required in early years to ensure that meeting subsequent budgets is feasible.
- **Filling in gaps in our evidence base** with new analysis of emissions reduction opportunities in the UK (e.g. scope for increased penetration of renewable heat).

The key conclusions which we have reached are:

- **A major shift in the pace of UK carbon emissions reduction must be achieved.** In the five years before the first budget period (i.e. in 2003 to 2007) greenhouse gas (GHG) emissions were falling at less than 1% annually. They need now to fall at 2% annually on average in the first budget and thereafter, and 3% following a global deal at Copenhagen.
- **The recession is likely to result in reduced emissions**. This could create a false impression of rapid progress in 2008 and 2009. Implementation of measures to reduce emissions in the first budget period is required to be on track to meeting the second and third budgets.

- **The recession has also had a major impact on the EU Emission Trading Scheme (ETS) market.** Dramatic price reductions in recent months create a significant danger that the carbon price will be too low to incentivise the investment needed in energy-intensive industries to ensure progress in the second and third budget periods and beyond.

Given the need for a major shift in trajectory and the dangers of recessionary impacts undermining discipline and incentives, the Committee believes that the Government should:

- **Plan to out-perform the first budget** and, subject to the Committee's advice at the appropriate time, plan not to bank any outperformance of the first budget into subsequent budget periods.
- **Review the current set of market arrangements for power generation** and consider new rules which would strengthen the investment climate for low-carbon power generation. This should mitigate risks that investment continues to flow predominantly to conventional fossil fuel generation in the third budget period and beyond.
- **Make a major shift in the strategy on residential home energy efficiency,** moving away from the existing supplier obligation, and leading a transformation of our residential building stock through a whole house and street by street approach, with advice, encouragement, financing and funding available for households to incentivise major energy efficiency improvements.
- **Introduce a new set of financial and other incentives** to meet very ambitious renewable heat targets.
- **Put in place a clear strategy,** with appropriate financial incentives, to meet EU targets for new car emissions by 2015 and drive take-up of electric vehicles.
- **Roll-out Smarter Choices** to encourage better journey planning and increased use of public transport across the UK.

A full overview of our indicators and recommendations is provided in Box 1, with a more detailed summary set out in 5 sections below:

1. Progress reducing emissions

2. Implications of the recession

3. Delivering low-carbon power

4. Making buildings and industry more carbon efficient

5. Decarbonising road transport.

The Committee will pragmatically use the indicators set out in this report for its annual assessments of progress reducing emissions as required under the Climate Change Act. The indicators should not be seen as fixed targets, but rather as an evolving framework which the Committee will develop in the light of new analysis (e.g on cost/feasibility of options for reducing emissions). The indicators will provide a basis for understanding whether emissions reductions are sustainable (i.e. through implementation of measures) and will provide the opportunity for early identification of slippage that could increase the risk of missing budgets. The Committee's next annual report to Parliament will be published in June 2010.

Box 2 Summary of indicators for monitoring progress towards meeting carbon budgets

The Committee's indicators for power generation, use of energy in buildings and industry, and transport comprise measures which will reduce emissions and new policies which will drive implementation of these measures. We summarise here the indicators and milestones set out more fully in the report – which includes indicators for the path to 2022 together with forward indicators (e.g. relating to stages of the project cycle for investment in wind generation).

Power sector indicators

The Committee's Extended Ambition scenario for power sector decarbonisation embodies around a 50% cut in emissions due to falling carbon intensity from the current level of 540 gCO_2/kWh to around 300 gCO_2/kWh in 2020, driven by:

- Addition of 23 GW of wind generation (e.g. around 8,000 3 MW turbines).
- Addition of up to 4 CCS (i.e. clean coal) demonstration plants.
- Addition of up to 2 new nuclear plants by 2020, a third by 2022.

In order to achieve deep cuts in power sector emissions through the first three budget periods and beyond, policy strengthening will be required:

- **Market rules –** Investment in low-carbon generation is risky and may not be pursued sufficiently under current market arrangements. A review of alternative options for strengthening low-carbon generation investment incentives (e.g. carbon price underpin, low-carbon obligations/feed-in tariffs, emissions performance standard, etc.) is now needed.
- **Support for CCS –** A new framework to support investment in CCS generation is required. This should include an early review of CCS viability (e.g. no later than 2016) and financial support for roll-out, limits on generation from conventional coal beyond the early 2020s, and timely commencement of a second demonstration competition; the Government will publish a CCS framework later this year.
- **Grid strengthening –** Early decisions on transmission network access and investment are required to support very significant increases in wind generation in areas where the grid is currently congested.

Indicators for energy use in buildings and industry

The Committee's scenarios for emissions reductions in buildings and industry include a 35% reduction in residential buildings in 2022 compared to 2007 figures, and a 27% reduction in non-residential buildings and industry.

We set out detailed indicators for the residential sector, with aggregate indicators for renewable heat and non-residential buildings and industry. Our indicators for residential buildings include:

- loft & cavity wall insulation (10 million lofts and 7.5 million cavities insulated by 2015)
- solid wall insulation (2.3 million by 2022)
- replacement of old boilers (12 million non-condensing boilers replaced by 2022)
- increase in stock penetration of A+ rated washing machines and dishwashers (around 80% by 2022) and A++ fridges and freezers (45% by 2022)

Policy strengthening will be required in at least three areas to achieve the emissions reductions in the Committee's scenarios

- **Energy efficiency improvement in homes – ** The current Carbon Emission Reduction Target (CERT) scheme for energy efficiency improvement in homes should be replaced by a new Government-led policy including: a whole house approach (i.e. where houses are given an energy audit followed up by hassle-free implementation of cost-effective measures); a neighbourhood approach (i.e. where local areas are systematically targeted and local authorities play an important delivery role); low-cost long-term financing for households to be repaid from energy bill reductions following energy efficiency improvement, and to be blended with grant funding (especially for the fuel poor). Additional policy measures are also likely to be required to accelerate the purchase of efficient appliances (e.g. tax incentives as have been introduced in Italy).
- **Energy efficiency improvement in the commercial sector (including SMEs) –** A new framework to encourage energy efficiency improvement for SMEs should be introduced. The first step towards such a framework is widespread roll out of Display Energy Certificates (DECs) and Energy Performance Certificates (EPCs) to SMEs and other commercial sector organisations.
- **Support for renewable heat –** A new framework to provide financial (such as the planned Renewable Heat Incentive) and other incentives for uptake of renewable heat is required.

Transport indicators

The Committee's scenarios for transport result in a 25% emissions reduction on 2007 levels by 2020 driven by:

- Falling carbon intensity of new cars to 95 g/km in 2020 from the current 158 g/km.
- 240 thousand electric cars and plug-in hybrids by 2015, and 1.7 million by 2020, supported by appropriate charging infrastructure.
- 3.9 million drivers trained and practicing eco-driving by 2020.

Key areas for policy strengthening to achieve required emissions reductions are:

- **Support for electric cars and plug-in hybrids –** A comprehensive strategy should be developed for rolling out electric cars and plug-in hybrids, including targets for penetration, a funded plan for charging infrastructure, and large-scale pilots starting at the end of the first carbon budget period and building on the Government's current small-scale demonstrations.
- **Smarter choices –** Phased roll-out of Smarter Choices measures across the UK to encourage better journey planning and more use of public transport.
- **Integrated land use and transport planning – ** A new strategy is required to ensure that land use planning decisions fully reflect implications for transport emissions (e.g. covering urban regeneration versus new out of town settlements, investment in road infrastructure, investment in public transport infrastructure, planning reform to support electric car roll-out, etc.).

1. Progress reducing emissions

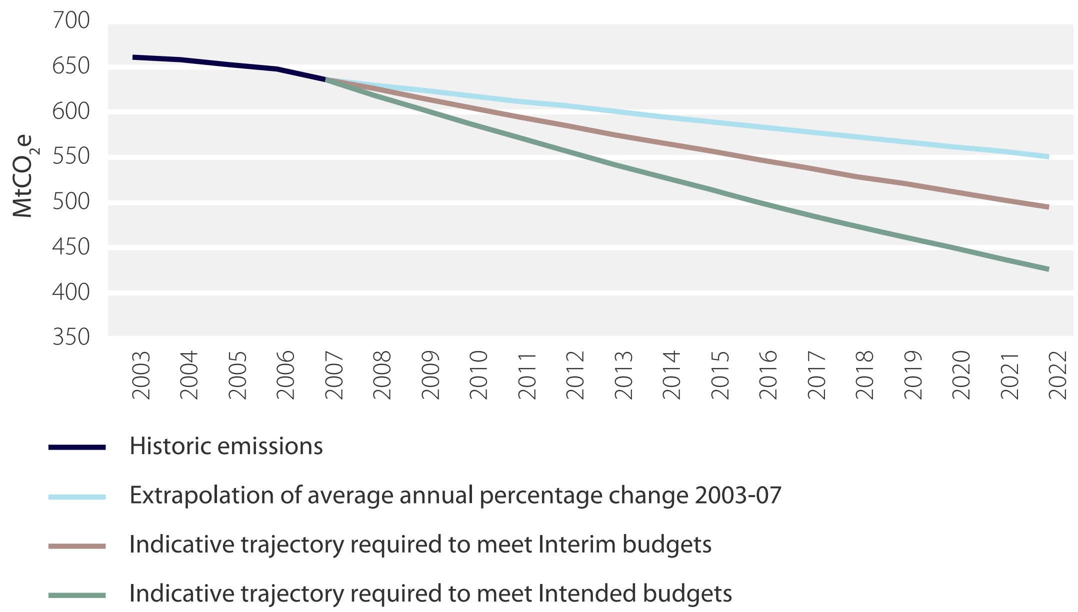
Sustainable emissions reductions in the UK through implementation of measures to improve carbon efficiency have been very limited in recent years:

- GHG emissions over the period 2003 to 2007 fell at an annual average rate under 1%.
- Preliminary data for 2008 suggests a 2% reduction in CO_2 emissions, mainly due to switching from coal to gas in power generation in response to short-term changes in relative prices rather than any more fundamental shift to low-carbon power generation.
- It is likely that emissions will fall in 2009 as a result of the recession, but this will not continue beyond the near term once GDP growth resumes.

Going forward a step change will be required to achieve deep emissions cuts required through the first three carbon budget periods and beyond:

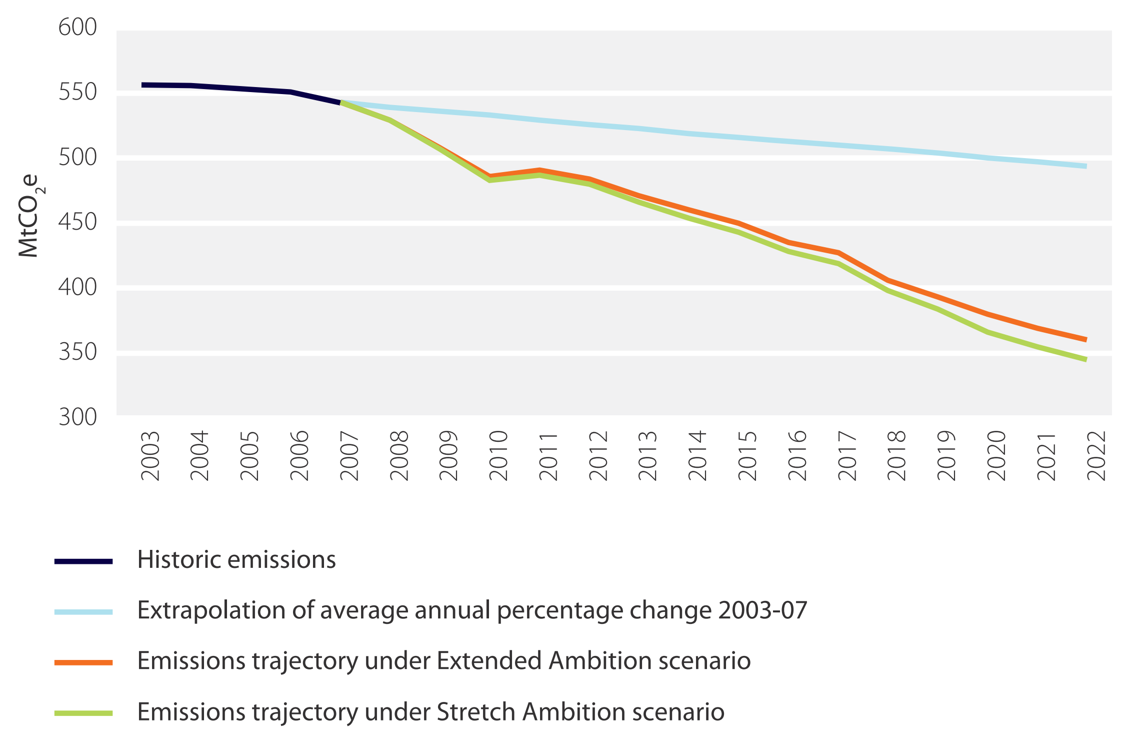
- Meeting carbon budgets requires annual average emissions reduction over the first three budget periods of 1.7% for the Interim (currently legislated) budget and 2.6% for the Intended (following a new global deal) budget (Figure 1).
- Much of the emissions reduction in recent years has been in non-CO_2 gases, where potential for further cuts in coming years is limited. CO_2 emissions reductions in the period 2003-07 averaged 0.6% annually. The need to increase the pace of emission reduction is therefore more pronounced for CO_2 than for all GHGs (Figure 2).
- Where CO_2 emissions have fallen, the extent to which this has been through implementation of measures to improve energy or carbon efficiency is very limited. Implementation of measures will, however, be required across power, buildings and industry, and transport to meet the first three carbon budgets (Figures 3-5).

Figure 1 Recent UK GHG emissions and indicative reductions required to meet legislated carbon budgets



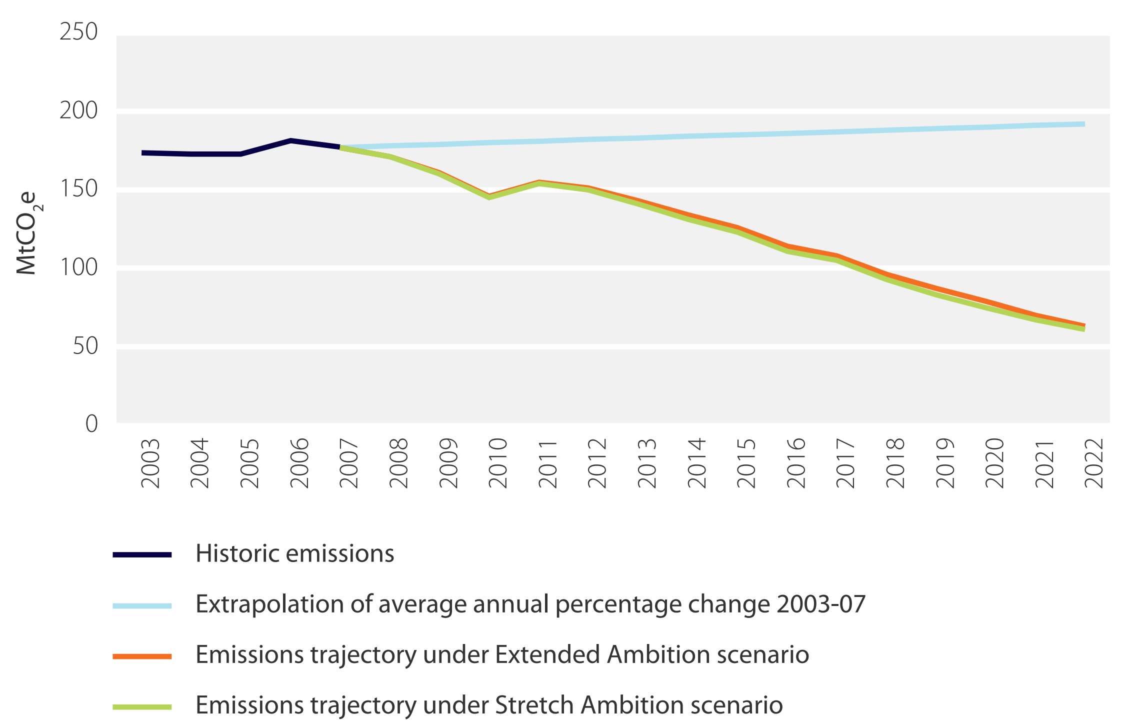
Source: NAEI (2009); CCC Modelling.

Figure 2 Recent UK CO_2 emissions and reductions under CCC emissions reduction scenarios



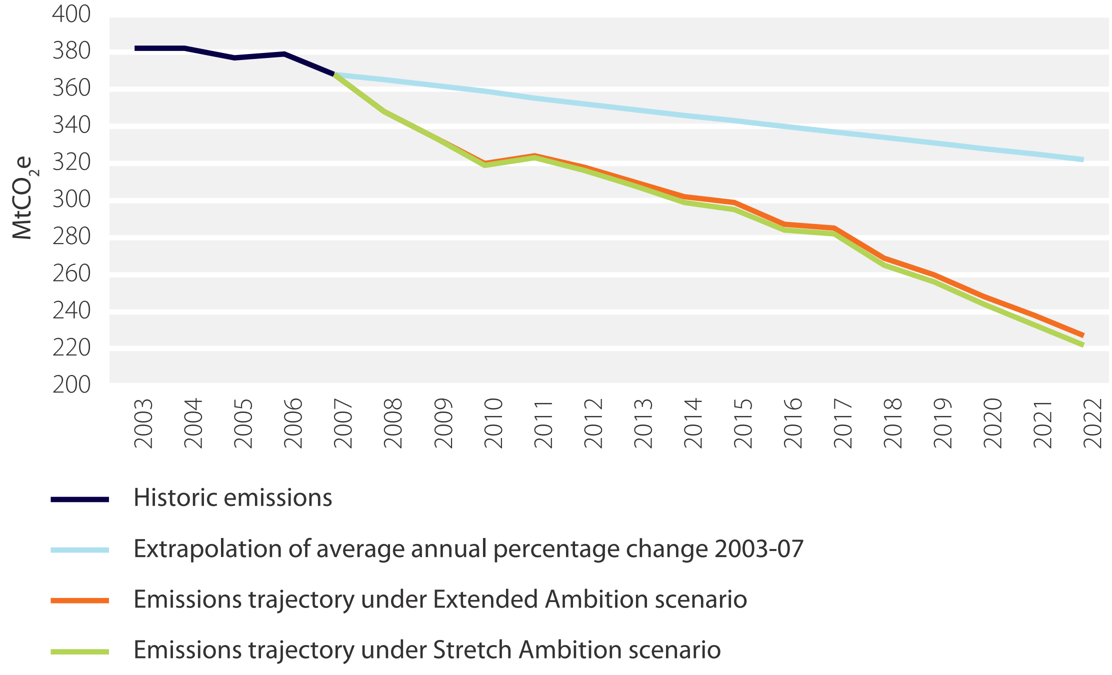
Source: NAEI (2009); CCC Modelling.

Figure 3 Recent power sector CO_2 emissions and reductions under CCC emissions reduction scenarios



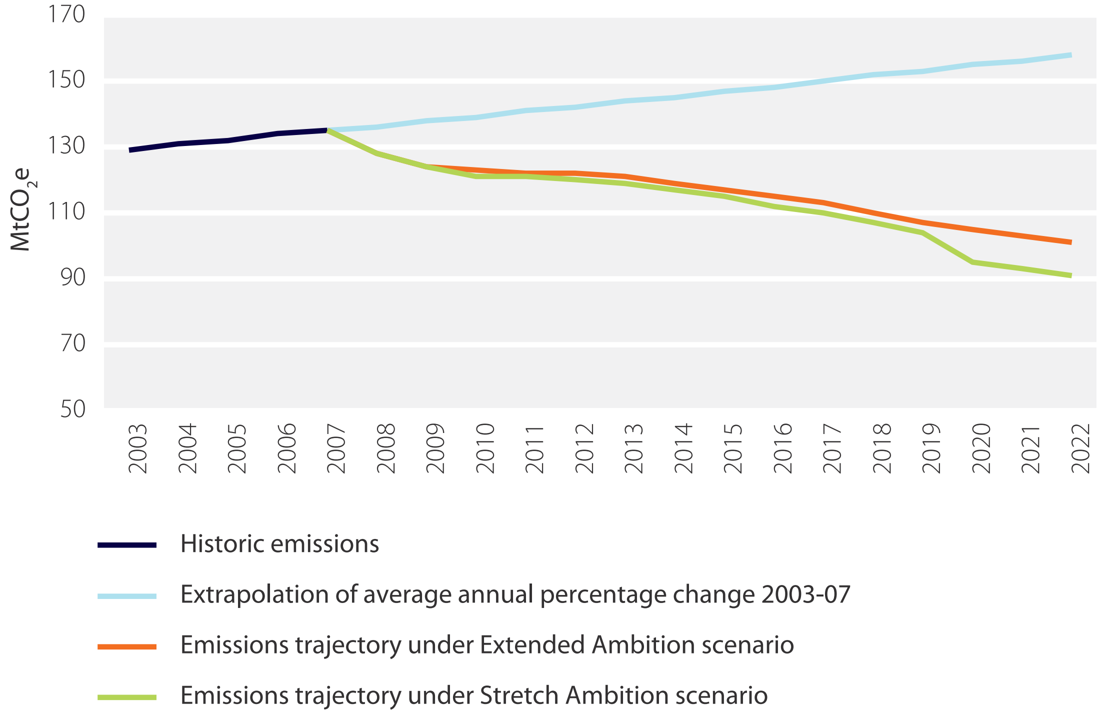
Source: NAEI (2009); CCC Modelling.

Figure 4 Recent buildings and industry CO_2 emissions and reductions under CCC emissions reduction scenarios



Source: NAEI (2009); CCC Modelling.

Figure 5 Recent transport CO_2 emissions and reductions under CCC emissions reduction scenarios



Source: NAEI (2009); CCC Modelling.

2. Implications of the recession

The recession and credit crunch have had three key impacts on meeting carbon budgets:

- The recession has led to a reduction in emissions which will make it easier to meet the first non-traded sector budget without early implementation of required measures to improve carbon efficiency. It will not, however, take away the need for deep cuts through implementation of measures to meet the second and third budgets.
- The recession has also led to a reduction in EU traded sector emissions which has reduced the carbon price and could undermine incentives for investment in low-carbon technologies in the UK's energy-intensive sectors, including power generation.
- The credit crunch could restrict availability of finance for investment in new wind generation capacity that is required to be on track to meeting very ambitious 2020 targets and decarbonising the power sector.

Recession impact on non-traded sector emissions: aiming to outperform budgets

Emissions remain – at least in the short to medium term - a function of economic activity. With lower levels of activity than previously envisaged for the first budget period, we would expect emissions to fall, thus making the first budget easier to meet without implementation of measures to improve carbon efficiency. This would be problematic given the need for early implementation of measures to be on track to making the deep emissions cuts required through the first three budgets and beyond.

Detailed modelling suggests emissions are likely to be at least 40 $MtCO_2$ lower, and could be up to 75 $MtCO_2$ lower, over the first budget period. The first budget could therefore be achieved with little or no implementation of required measures. Given this risk, the focus of emissions reduction strategy should be implementation of required measures rather than emissions *per se*. To the extent that outperformance of budgets ensues, this should not be banked in order to preserve incentives for implementation of measures required to meet subsequent budgets.

Recession impact on traded sector emissions: the need to strengthen carbon price signals

The EU ETS carbon price is determined by the level of emissions reduction required under this scheme. For a given cap, falling emissions in the energy-intensive sectors will require less abatement within EU ETS and therefore a lower carbon price. Our analysis suggests that there will be a lower carbon price as a result of the recession (e.g. around 20 Euro/tCO_2 in 2020 compared to our previously projected 50 Euro/tCO_2). This is problematic given the extent to which we rely on the carbon price to provide incentives for investment in low-carbon technology in the energy-intensive sectors. Options to strengthen the carbon price signal which should be seriously considered include:

- Ideally EU level action would be taken to increase the carbon price (i.e. the EU ETS cap would be tightened and firmed up beyond 2020) and reduce uncertainty (e.g. through introducing an auction reserve price). Tightening the cap may be feasible as part of the move from the EU's 20% to 30% economy-wide GHG emissions reduction targets following a Copenhagen deal.
- UK action to underpin the carbon price could provide support for required low-carbon investments (e.g. through introduction of a tax that adjusts according to EU ETS price fluctuations to deliver a target carbon price in the UK).
- UK action might instead be in the form of electricity market intervention (e.g. through a low-carbon obligation, tendering for low-carbon capacity, etc. – see section 3).

The impact of the credit crunch on renewable electricity finance: the need to reduce project risks

There are currently up to 7 GW of new wind generation projects which have gained planning consent but not yet proceeded to construction. Timely implementation of these projects is important to be on track to achieving 23 GW of new investment by 2020 required to meet EU targets and be on the path to deep decarbonisation of the power sector in the 2020s. Our analysis suggests that the credit crunch has, however, restricted finance for onshore projects sponsored by independent project developers, and offshore projects in general.

The key in securing finance is to strengthen underlying project economics and reduce risks. In this respect, the Government's interim increase in financial support for offshore projects has helped secure finance for the 1 GW London Array project. Commitment of up to €4 billion by the European Investment Bank (EIB) is useful. This facility may not, however, be structured in a way that changes project risks and supports increased lending.

The Committee therefore recommends that the Government should closely follow the market response to the EIB facility, and consider interim mechanisms to provide comfort to banks (e.g. loan guarantees), as appropriate, to secure required finance over the next one to two years. Beyond the near term, the Committee proposes that further measures to mitigate project risks (e.g. indexing of ROC prices on key cost and revenue drivers) should be considered in order to secure large amounts of project finance that will be required to support investments in the second and third budget periods.

3. Delivering low-carbon power

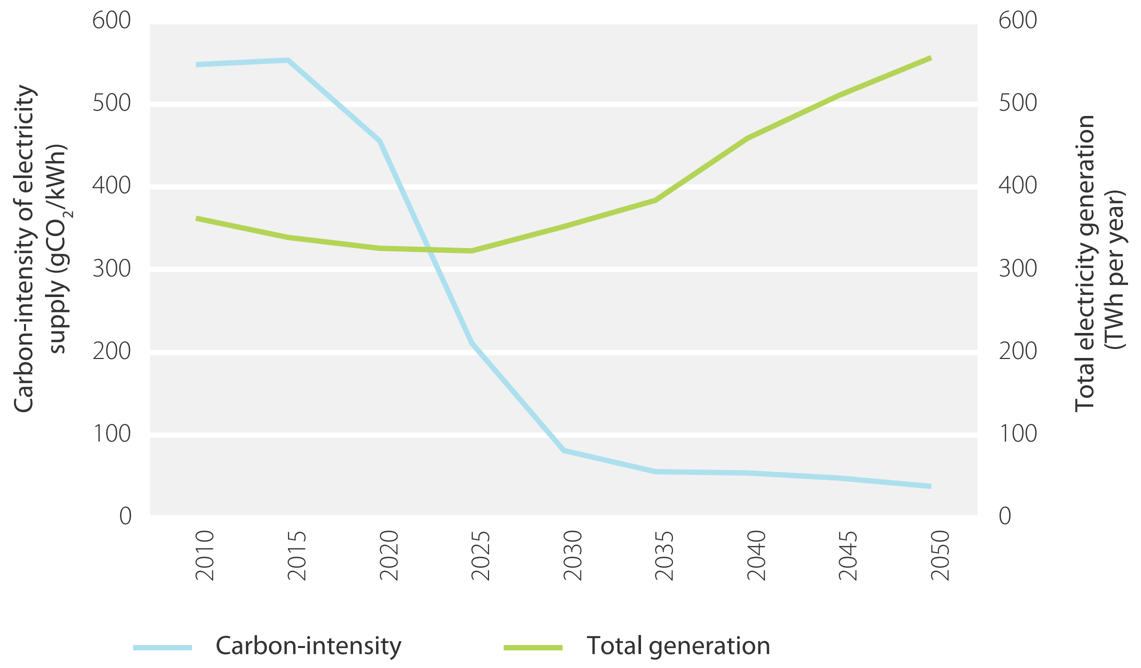
There are four areas of focus in the report on decarbonising the power sector:

- Setting out a scenario for emissions reductions and indicators to deliver it.
- Analysis of current market arrangements to identify whether these are likely to deliver required investments in low-carbon power generation.
- Assessment of the draft framework to support investment in CCS power generation.
- Assessment of the enabling framework for investment in wind and nuclear generation

Scenario for power sector decarbonisation over the first three budget periods

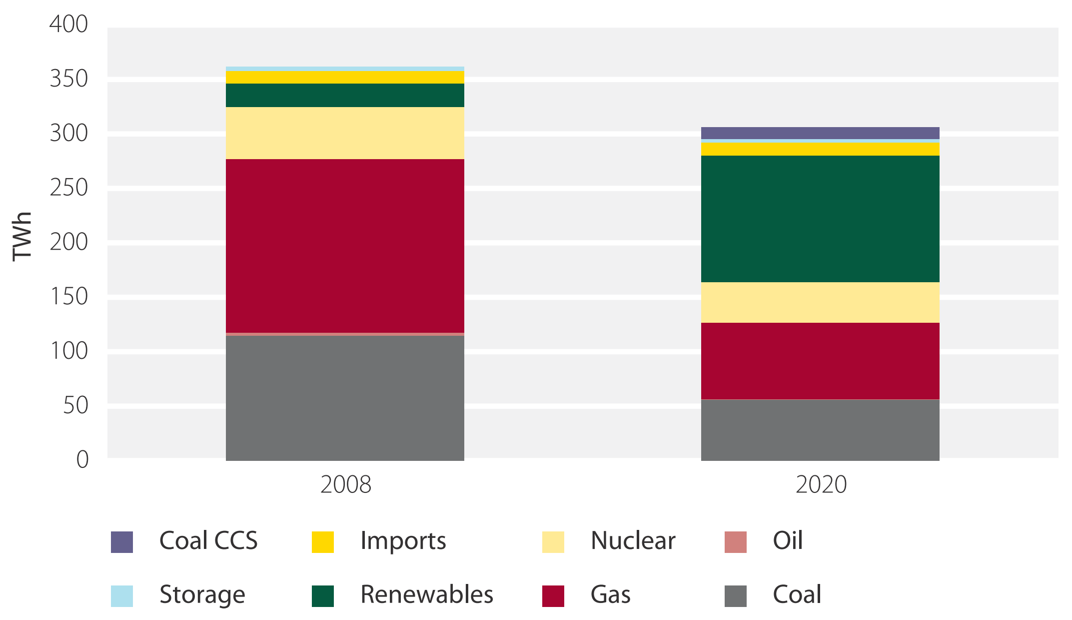
The report sets out a scenario for power sector decarbonisation to 2022 that is demanding but feasible, and necessary on the path to deep decarbonisation of the power sector by 2030 (Figure 6). The scenario includes addition of 23 GW new wind capacity and four CCS demonstration plants by 2020, with three new nuclear plants by 2022 (Figure 7). The report includes a set of indicators, with forward indicators and milestones, underpinning this scenario (e.g. time series of projects in development, construction, etc.) which the Committee will use in future reports assessing progress reducing emissions to achieve budgets.

Figure 6 Declining carbon-intensity and increasing generation of electricity to 2050



Source: CCC based on AEA (2008) *MARKAL-MED model runs of long-term carbon reduction targets in the UK.*

Figure 7 Scenario for generation mix in 2020 compared to actual generation mix in 2008



Source: DECC (2009); *DUKES*; Tables 5.6, 7.4 and 5.1 and CCC.

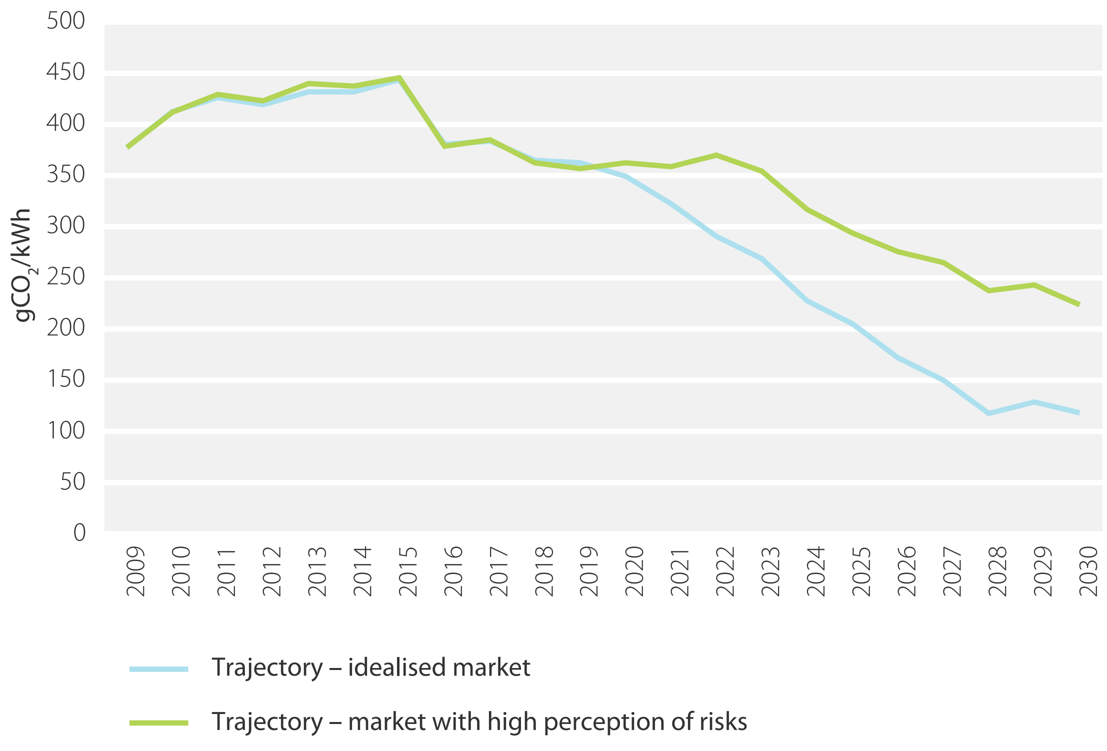
Changing current market arrangements to support investment in low-carbon power generation

Current power market arrangements were designed to achieve efficient dispatch of fossil fuel-fired plant, and not to secure large investments in capital-intensive low-carbon technologies such as nuclear power and CCS generation.

Under current arrangements, private investors face multiple risks around fossil fuel prices, electricity prices, carbon prices, and technology costs; given these risks, investors will be biased towards investing in conventional fossil fuel fired rather than low-carbon generation. In contrast, the only relevant choice for a society committed to an 80% emissions reduction target, given the centrality of power sector decarbonisation to cutting emissions in the wider economy, is not whether but which low-carbon technology to invest in. Therefore the only relevant risks are those that relate to the costs and performance characteristics of alternative low-carbon technologies.

We have undertaken new analysis which shows plausible scenarios where, faced with the various risks under current market arrangements, investors choose to invest in increasingly expensive gas-fired rather than low-carbon generation through the 2020s, resulting in deviation from the path towards meeting long-term targets (Figure 8).

Figure 8 CO_2 intensity of generation under alternative scenarios



Source: Redpoint modelling for the CCC
Note: Emissions intensity is not adjusted for losses during transmission and distribution.

Given the need to decarbonise power to meet longer-term emissions reduction goals, concerns over increasing prices, and possible security of supply problems with increased reliance on imported gas, the Committee recommends that a range of options to reduce risks for investing in low-carbon generation are considered:

- Measures to strengthen the carbon price (e.g. extending to all low-carbon generation an exemption from the Climate Change Levy, or a carbon price underpin/tax).
- Measures to provide certainty over the price paid to low-carbon generation (e.g. feed-in tariffs for low-carbon power generation, tendering for low-carbon capacity).
- Measures to ensure investment in low-carbon generation (e.g. an emissions performance standard, a low-carbon obligation).

The Committee recommends that these options are considered in parallel with wider consideration of any implications from Copenhagen for the carbon price, so that any changes to current arrangements can be implemented in time to support decisions at the beginning of the second budget period on the 25 GW of low-carbon investments required in the 2020s.

Providing clear and early signals about investment in clean coal generation

The Committee broadly welcomes the Government's response to recommendations in our December 2008 report, namely the draft framework – published in June 2009 – to support investment in CCS and phase out conventional coal generation.

The Committee recommends, however, five key changes to be incorporated as the draft framework is finalised:

- The Committee's analysis shows that there is a very limited role for conventional coal-fired plant beyond the early 2020s. The Government should provide a strong signal to investors now that this is the case whether or not CCS is later proven – to prevent investments proceeding on the misconception (based on the lack of a clear carbon price signal) that conventional coal will continue to operate (even at low load factors) over the next decades.
- The economic viability of CCS should be judged (based on UK and international evidence) in the broad sense of whether the costs of this technology can be justified given its potential contribution to meeting the strategic objective of power sector decarbonisation in the UK and internationally. Viability should not be judged in the narrow sense of whether the cost penalty of CCS is covered by the carbon price.
- It is likely that there will be a period where CCS is deemed viable but where the carbon price is insufficiently high to cover the CCS cost penalty. In these circumstances, a successor support mechanism would be required. An early signal that such a mechanism would be introduced as appropriate should be provided to reduce risks for investors in the first set of partially fitted CCS plants.
- Such a mechanism should then be introduced no later than 2016. A review in 2020 as proposed by the Government would not allow roll-out until the second half of the 2020s, therefore limiting the role of CCS at a time when it is likely to have a crucial role to play decarbonising the power sector.
- Competitions for CCS demonstration finance should be designed to encourage bids for oversized pipes which could later support investment in clusters of plant that would benefit from scale economies in infrastructure provision. Before the demonstrations are complete the Government should develop a CCS infrastructure strategy and should consider the best approach to deliver that strategy (e.g. whether through a statutory monopoly).

Developing an enabling framework for investment in wind and nuclear generation

The Government has made significant progress developing the legal and regulatory frameworks for investment in wind and nuclear power. Further progress is required in the areas of network access and investment and planning including:

- Agreement on enduring arrangements for network access (i.e. to succeed the existing interim arrangements) is required by June 2010 to provide confidence for investors in wind generation.
- Agreement on new investments to ease bottlenecks in the transmission network and accommodate significant increases in the level of wind generation is required at the latest by 2011, so that construction can commence in 2012.
- A national policy statement for nuclear power generation is required by Spring 2010 to support passage of proposals for nuclear new build through the planning process.
- Timely approval of large wind and nuclear projects by the Infrastructure Planning Commission, and smaller wind projects by local authorities, is crucial to support investment proceeding on timescales required to meet targets for sector decarbonisation.

The Committee will monitor progress consolidating the enabling framework in these and other respects as part of its annual progress reporting.

4. Making buildings and industry more carbon efficient

The report focuses on three areas within buildings and industry emissions:

- Indicators and policies for energy efficiency improvement in the residential sector.
- Scenarios for increased renewable heat consumption
- Emissions reduction in non-residential buildings and industry.

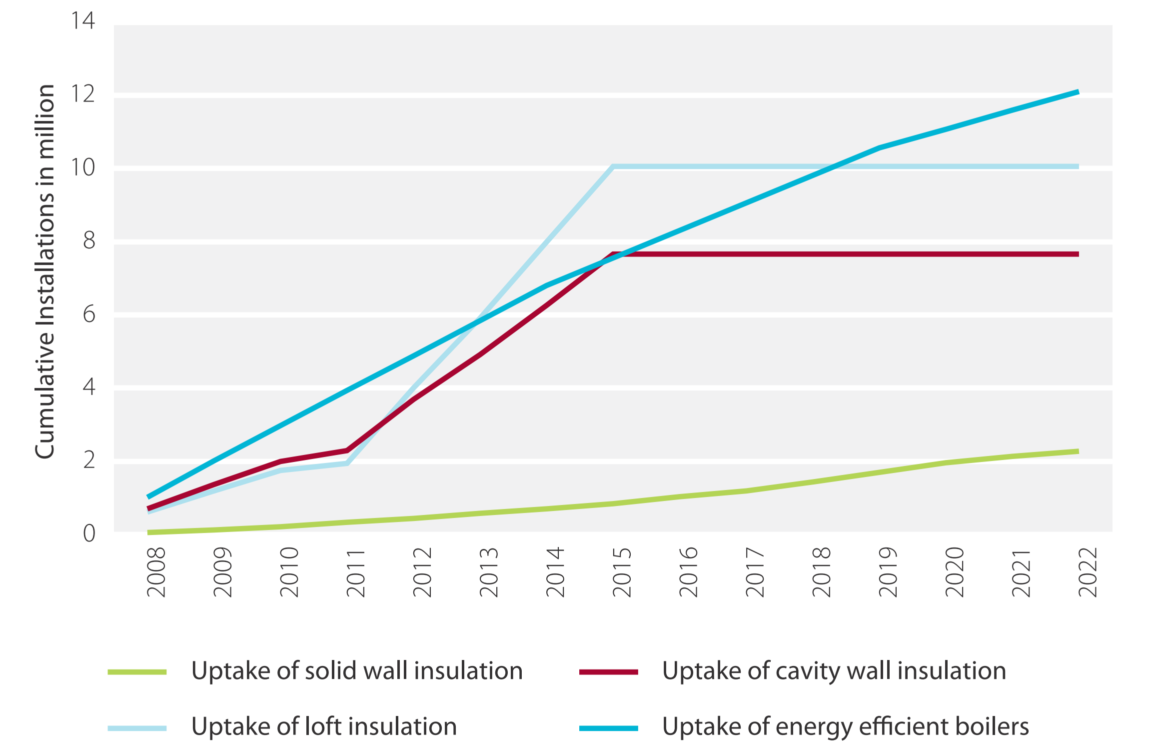
Indicators and policies for energy efficiency improvement in the residential sector

In our December 2008 report we set out high level scenarios for emissions reduction in the residential sector due to energy efficiency improvement (through better insulation, replacement of old inefficient boilers, etc.). In this report, we present detailed trajectories for implementation of required measures (Figure 9):

- 10 million lofts and 7.5 million cavity walls are insulated by 2015, supported by a high level energy audit of all homes in the UK.
- 2.3 million solid walls are insulated by 2022.
- all (i.e. 12 million) old inefficient non-condensing boilers are replaced by 2022.
- Stock penetration of A+ rated washing machines and dishwashers is increased to around 80% by 2022 and A++ rated fridges to 45% by 2022.

The Committee will report annually on progress against these indicators, which together with other residential sector measures would reduce emissions by around 50 $MtCO_2$ against current emissions in 2022.

Figure 9 Uptake of main residential building measures 2008 - 2022



Source: CCC analysis.

Our analysis suggests, however, that emissions reductions will not ensue to the extent required under the current framework (i.e. CERT, led by energy suppliers, which has been most successful at providing free energy efficient lightbulbs).

The Committee has considered the high level framework proposed by the Government in its draft Heat and Energy Saving Strategy and recommends the following approach:

- **Whole house –** There should be a whole house approach involving an energy audit with a follow up package including installation and financing. The approach should be applied to the full range of cost-effective (i.e. cost per tonne saved less than the carbon price) measures: loft insulation, cavity wall insulation, solid wall insulation, early replacement of old inefficient boilers, installation of heating controls to support behaviour change.
- **Street by street/neighbourhood approach –** The Committee has reviewed social research evidence suggesting that people are looking for a government lead on energy efficiency improvement, and want to act in a context where they can see that others are acting. The Committee therefore recommends a neighbourhood approach led by national government (e.g. providing political leadership, strategy, legislation, etc.), with a delivery role for local government in partnership with energy companies and other appropriate commercial organisations. To ensure full take up of measures under this approach, additional price or regulatory incentives may be needed particularly for the private rented sector.

- **Financing –** There may be scope for some pay as you save type individual charging. However, some element of subsidy – either socialisation of costs via energy bills or grants – should be retained, given that some measures will take a long time to pay back (e.g. solid wall insulation) and given the need to improve energy efficiency in the 4-5 million homes of the fuel poor who may be unable to take on financial obligations.

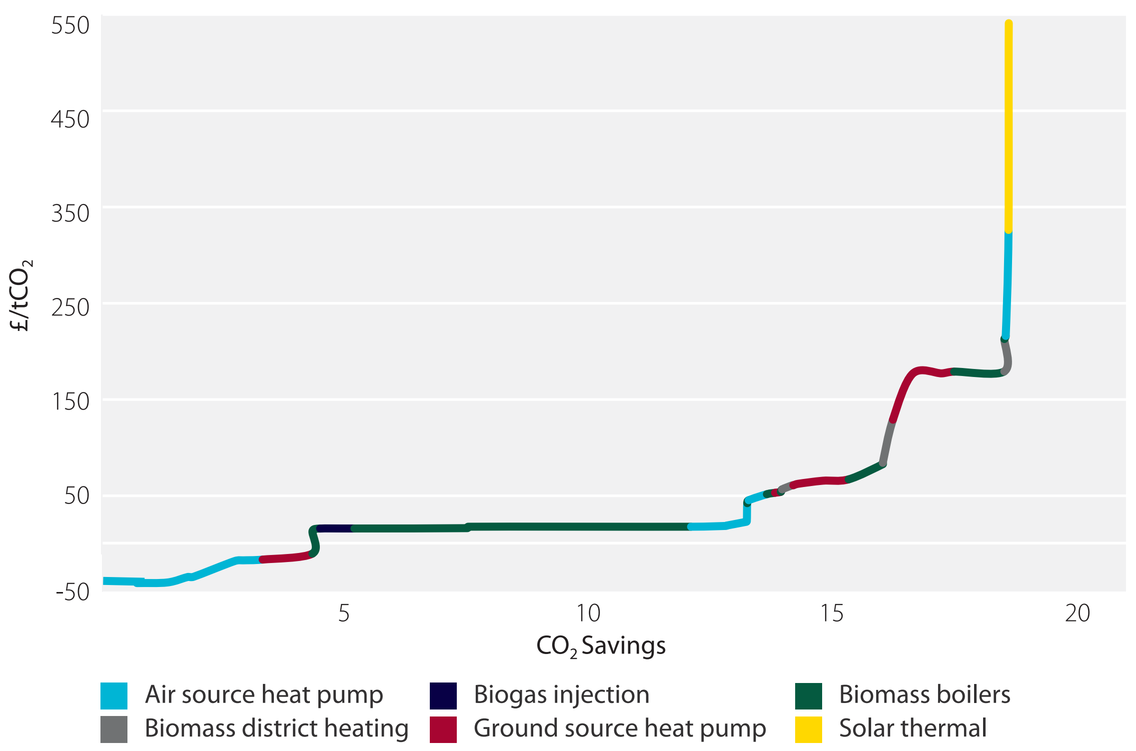
Scenarios for increased renewable heat consumption

We present new analysis of a wide range of renewable heat technologies: biomass boilers, air source and ground source heat pumps, solar thermal, and biogas. The analysis suggests that there are cost-effective opportunities (i.e. at a cost per tonne of CO_2 abated less than our projected carbon price) for deployment of each of these technologies, although deeper penetration may be more costly (Figure 10). For both cost-effective and more expensive deployment, financial support will be required given the absence of a carbon price in most of the heat sector.

Given our assessment of costs and feasible deployment, the Committee assumes the Government's proposed ambition as set out in its Renewable Energy Strategy to achieve 12% renewable heat penetration from current very low levels (around 1%) with roll-out incentivised by a new Renewable Heat Incentive in 2011. We note, however, that achieving this target could be very expensive at the margin.

Significantly increased penetration based on a portfolio of technologies will develop options for further deployment in the 2020s. The appropriate path for heat decarbonisation in the 2020s and beyond is currently uncertain; the Committee will review this in detail in the context of its advice on the fourth budget (2023-2027) to be published at the end of 2010.

Figure 10 Renewable Heat in Central Scenario 2022



Source: NERA (2009).
Note: Where a technology appears at different points of the curve this reflects different applications (e.g. residential and non-residential, etc.).

Emissions reduction in non-residential buildings and industry

The Committee will consider the appropriate level of the first capped phase for the Carbon Reduction Commitment (CRC) in 2010. Deployment of innovative technologies in the energy intensive sectors will be considered in the context of advice on the fourth budget.

Reducing public sector emissions is crucial because there is significant potential in this sector, because Government must reduce its own emissions in order to be credible leading on emissions reductions in other sectors, and because there is scope for encouraging behaviour change in the large number of people who use public sector buildings. The Committee proposes that all cost-effective measures in central government buildings and other public sector buildings covered by the CRC should be implemented by 2018 (i.e. the end of the first capped phase of the CRC).

The Committee recommends Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs) should be required for all non-residential buildings by the end of the second budget period.

In relation to SMEs, the report builds on previous analysis of significant potential for emissions reduction and considers policy options to provide incentives for unlocking this potential. The key issue identified is the lack of an evidence base to design or implement policy. Information from EPCs and DECs would help form the basis for new policy (for example, similar to the proposed new approach for the residential sector or a regulatory approach).

5. Decarbonising road transport

The transport chapter of the report focuses on three areas:

- Indicators for emissions reduction
- Scenarios and measures to support roll-out of electric cars
- Emissions reduction from consumer behaviour change and land use planning.

Indicators for emissions reduction from cars

The Committee previously set out an Extended Ambition scenario which would reduce carbon intensity of new car emissions to 95 gCO_2/km in 2020. In April 2009 the EU adopted a 130 gCO_2/km target for new car emissions in 2015, and a 95 gCO_2/km target in 2020. The Committee believes that the UK should move from the current situation where the UK tracks above the EU average, converging on the EU target by 2015 and reaching 95 gCO_2/km by 2020.

- This is desirable both to prepare the way for deep emissions cuts in transport in the 2020s, and in order that transport makes an appropriate contribution to meeting non-traded sector budgets.
- It can be achieved through a range of supply side measures (e.g. increasing fuel efficiency of conventional engines, increased uptake of hybrid car, electric and plug-in hybrid cars, non-powertrain measures) and through some change in customer choice.

The Committee will therefore focus in its future monitoring on new car emissions and the impact that this has on overall car emissions, which we estimate could fall by 16 $MtCO_2$ in 2020 if 95 gCO_2/km is achieved.

Scenarios and measures to support roll-out of electric cars

Whilst useful in helping to meet the first three carbon budgets, there is a limit to how much carbon intensity of conventional cars can be improved. It is therefore very important to develop electric car options, which currently appear to be the most viable from alternatives (e.g. second generation biofuels, hydrogen, etc.) for deep emissions cuts in road transport in the 2020s. The report includes new analysis of the technical and economic aspects of electric cars, and recommendations on arrangements to support roll-out of electric cars:

- **Market readiness –** Electric cars are market ready, with some cars already on the road, and new models scheduled to come to market in the near future.

- **Battery costs –** Upfront costs of electric cars are relatively expensive compared to conventional alternatives, mainly due to battery costs (for example, an estimated early model battery cost for a small car is around £7,800). Our analysis suggests, however, that there is scope for a 70% battery cost reduction through learning effects as electric cars are deployed. With a 70% cost reduction, electric cars would be competitive with conventional cars once operating cost savings at current levels of fuel duty are taken into account.

- **Price support –** Our analysis suggests that price support of up to £5,000 per car proposed by the Government is appropriate in conjunction with innovative business models for spreading upfront costs over time (e.g. battery leasing). Price support should no longer be required for some types of car from 2014, depending on the pace at which battery costs fall. Total support required to get to break even and to achieve a level of penetration to provide a critical mass for widespread roll-out in the 2020s is likely to be considerably higher than the Government's £250 million commitment (e.g. £800 million).

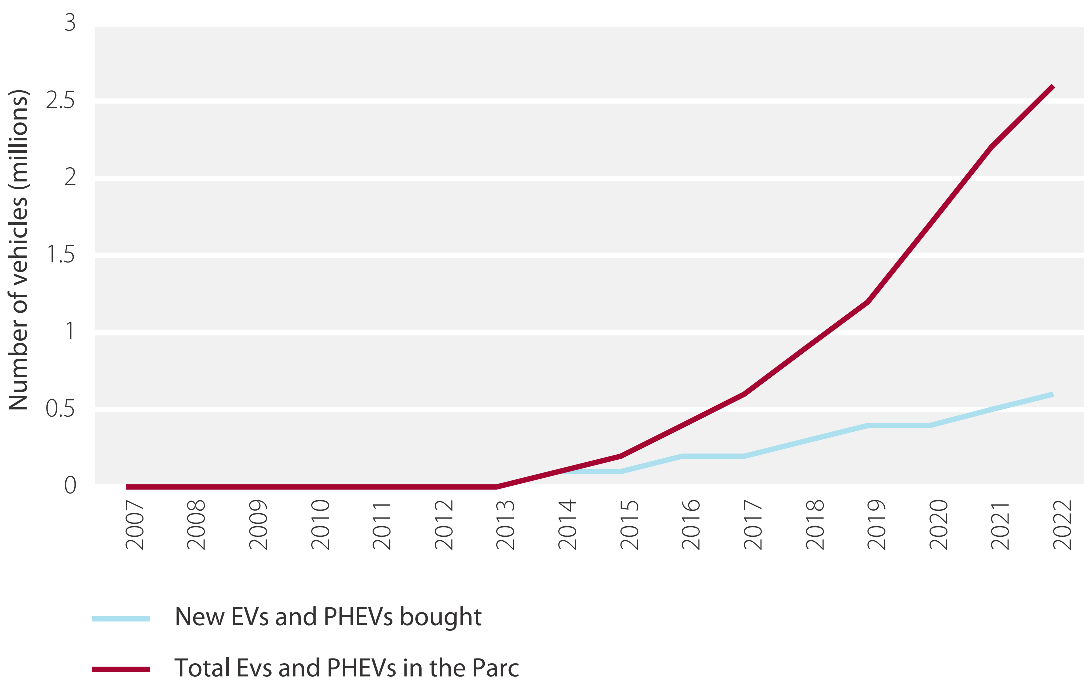
- **Charging infrastructure –** The typical range for electric cars is around 80 miles, possibly increasing to 250 miles as battery technology develops. The current range is sufficient to cover the vast majority of trips. Charging options include: off-street home charging, which would be an option for up to 75% of car-owning households; on-street home charging; workplace charging; charging in public places (e.g. car parks, supermarkets, etc.); battery exchanges. A charging infrastructure to support roll-out to 2020 could be achieved at a cost in the low hundreds of millions rising to around £1.5 billion depending on the level of sophistication of charging meters. Charging infrastructure would have to be funded at least in part by government.

- **Implications for the power system –** Roll-out of electric cars to 2020 based on overnight charging should have very limited implications for the power system. Full roll-out in the 2020s could have implications, with for example the need to upgrade distribution substations if there is widespread daytime fast charging. Such upgrades would not be prohibitively costly, and would be accommodated within the normal investment programmes of energy companies.

- **Pilot projects –** Electric car roll-out should be concentrated in certain areas to allow exploitation of economies of scale. Pilot projects should cover several cities and target deployment of around 240,000 cars by 2015 on the way to 1.7 million cars on the road in 2020. Funding required for charging infrastructure to support pilot projects should be no more than £230 million, and could be considerably less..

The report sets out scenarios in which electric cars and plug-in hybrids account for around 16% of new cars purchased in 2020 (Figure 11); this level of penetration is feasible, desirable both to meet carbon budgets and on the path to deeper cuts in the 2020s, and consistent with Government's stated objective to be a leader in ultra low-carbon vehicles.

Figure 11 Electric and Plug-in hybrid vehicles in the Extended Ambition scenario



Source: CCC.

Emissions reduction from consumer behaviour change and land use planning

Introduction of road pricing – Our December 2008 report considered evidence on travel demand and concluded that price levers are potentially useful in reducing emissions (e.g. fuel duty might be used to offset reductions in the oil price, or fuel duty might be increased to yield a short-term emissions reduction if the carbon budget is off track).

There is a good economic rationale to introduce road pricing and thereby reduce congestion. Evidence in this report suggests that road pricing would result in a significant emissions reduction (e.g. around 6 $MtCO_2$ in 2020) if there were no offsetting reductions in other aspects of transport pricing (i.e. fuel duty, VED). The Committee recommends therefore that the Government should seriously consider road pricing, and includes emissions reductions from this measure in our Stretch Ambition scenario.

Roll out of Smarter Choices – In our December 2008 report, we included an emissions reduction of around 3 $MtCO_2$ for implementation of Smarter Choices (e.g. programmes to support better journey planning, more use of public transport, etc.). In this report we summarise new evidence on Smarter Choices implementation from Sustainable Travel Town pilot projects, suggesting that emissions reduction potential is in line with, and possibly exceeds, our original estimate.

Smarter Choices therefore offer significant low cost potential for reduction of transport emissions, and the Committee recommends that there is phased roll-out of smarter travel towns and cities. We include emissions reductions of 3 $MtCO_2$ in 2020 in our Extended Ambition scenario; we will consider evidence of any reduction in car miles/ emissions through implementation of Smarter Choices in our annual progress reports.

Land use planning and transport policy. There are significant differences in emissions for different towns and cities in the UK and beyond – depending on urban density, the relative location of homes/workplaces/shops, public transport infrastructure and policy, network and pricing measures (e.g. bus lanes, pedestrianisation, road pricing, etc.).

This suggests that there may be an opportunity for emissions reductions depending on the approach to land use planning and transport policy (e.g. through promoting urban regeneration rather than migration of population away from urban areas, mixed use development rather than out of town shopping centres, investment in public transport infrastructure and policies to support this such as smarter choices and network management measures, etc.).

There is a specific opportunity relating to the 3 million new homes that the Government envisages will be built in the period to 2020; locating these in urban areas would result in significant emissions reduction relative to dispersed location.

The Committee recognises that a high level planning framework is in place, but is not confident that – in practice – this fully addresses risks of increasing transport emissions or scope for transport emissions reduction. We therefore recommend that an integrated land use planning and transport strategy attaching appropriate weight to transport emissions is developed by the Government.

Emissions reductions in recent years have been very modest. Going forward, a step change is required if carbon budgets are to be achieved.

The Committee has identified opportunities for deep cuts in emissions, but believes that significant policy strengthening is required to make the step change. In this report we have set out high level policy options in key areas within power, buildings and industry, and transport.

In a world where policies are strengthened and carbon budgets are achieved in 2020 we will cut emissions from current levels of 9 tCO_2/capita to 6 tCO_2 and people will typically:

- Meet more of their energy needs from low-carbon power.
- Live in well-insulated homes with new efficient boilers and advanced heating controls.
- Purchase energy efficient appliances and use these on low-carbon cycles (e.g. low temperature washing and dishwashing).
- Work in energy efficient offices with power and heating from low-carbon sources.
- Drive more carbon efficient cars, including hybrids, electric cars and plug-in hybrids, with charging infrastructure at home, at work and in public places.
- Drive in an eco-friendly manner (e.g. not carrying excess weight in the car) and within the existing speed limit.
- Plan journeys better and use public transport more.

Implementation of the required measures to achieve budgets would in some instances save people and businesses money and in total cost less than 1% of GDP. Achieving carbon budgets could lead to significant improvements in, for example, energy security of supply and air quality, therefore maintaining or enhancing quality of life.

The Committee now calls on the Government to build on its Low Carbon Transition Plan, moving from a high level vision to developing and putting in place a framework for delivery to which people and businesses can respond.

Chapter 1: Progress developing a legal framework and reducing emissions

Introduction and key messages

Since the Committee's advice on appropriate levels of carbon budgets was published in December 2008, there has been progress in developing a legal framework both internationally and in the UK:

- The EU agreed a package to support delivery of its 20% greenhouse gas (GHG) emissions reduction target, for 2020.
- The G8 has agreed an objective to limit global average temperature increase to 2°C and cut developed country emissions by 80% in 2050.
- The UK has put into legislation its first three carbon budgets.

Further, the UK – and other countries – have experienced a recession with impacts not anticipated in our earlier work.

This chapter reviews progress in developing a legal framework to underpin UK and international effort that will together reduce the risks of dangerous climate change.

The chapter also considers trends in UK aggregate, sectoral and regional emissions; with more detailed discussion provided in Chapters 4-6 of this report.

The key messages in the chapter are:

- The overall ambition of the EU package is reasonable provided there is a timely switch to the 30% GHG target with deep cuts in other developed countries such that global emissions peak before 2020. It is therefore crucial to achieve an ambitious global deal and to trigger the switch to the 30% target. It is also important that any free allowances allocation within the EU ETS is very limited.
- Legislated UK carbon budgets are fully consistent with the Committee's advice. The Government accepted the Committee's proposals that the Interim budget should be based on a 34% cut in emissions in 2020, that this should relate to all GHGs rather than just CO_2, and that this should be achieved through domestic emissions cuts rather than purchase of credits in the non-traded sector.
- UK GHG emissions have reduced only slightly in recent years, with increases in some sectors. Whilst emissions currently appear to be falling as a result of the economic recession, this will be largely reversed when the economy returns to growth. There is, therefore, a need for a step change if we are to achieve the 1.7-2.6% average annual reduction necessary to meet the first three carbon budgets.

The chapter is structured in 4 sections:

1. The EU framework
2. Copenhagen and the international framework
3. Carbon budgets legislated by the UK
4. Progress reducing emissions in the UK.

1. The EU framework

The EU agreed at its Spring Council in 2007 to adopt a unilateral target to reduce GHG emissions by 20% in 2020 relative to 1990, moving to a 30% target following a new global deal to reduce emissions. In January 2008 the EC published a draft package to support achievement of the 20% and 30% targets including EU-wide caps for non-traded and traded sectors, mechanisms for distributing these caps across member states and sectors, and limits on the use of credits to meet caps. This draft package was one factor that the Committee considered in developing its advice on carbon budgets. Since our advice was published in December 2008, a final EU package has been agreed (Box 1.1).

This section provides a summary of the agreed EU package and considers:

(i) The non-traded sector

(ii) The traded sector

(iii) Transitioning from 20% to 30% targets.

It concludes with a high level Committee view on the agreed package, drawing out implications for carbon budgets.

(i) The non-traded sector

The non-traded sector cap

The non-traded sectors of the economy include direct CO_2 emissions from buildings, transport and less energy-intensive industry, as well as non-CO_2 emissions, and account for around 60% of total EU emissions. Proposals in the January package for non-traded sector emissions reductions, reflected in the Committee's budget advice, were carried through to the agreed package:

- The EU-wide target for non-traded sector emissions is a 10% cut in 2020 relative to 2005 for a 20% GHG target.
- This is allocated across countries based on ability to pay as measured by GDP per capita.
- The EU's non-traded sector target for the UK is to cut emissions by 16% in 2020 relative to 2005 for a 20% GHG target.
- The Committee's proposals included a 17% cut in emissions in non-traded sector emissions in 2020 under the Interim budget. This is consistent with the EU's 20% GHG target after allowing for accounting differences between the EU and UK frameworks (e.g. the UK framework includes land use change and forestry).

Use of offset credits

The agreed package allows use of offset credits up to 3% of 2005 emissions to meet non-traded sector targets. The Committee advised, however, that the UK should not plan to use offset credits to meet the Interim budget. The Committee argued that the Interim budget should be met through domestic emissions reductions both to support the transition to the Intended budget following a global deal, and to be on track to meeting the 80% emissions reduction target for 2050.

Box 1.1 EU Greenhouse gas emission reduction targets

EU ambitions for overall GHG emission reductions by 2020:

- a unilateral commitment to a 20% reduction (we sometimes refer to this as a **'20% world'**)
- agreement to move to a 30% reduction following a global deal to reduce emissions (we sometimes refer to this as a **'30% world'**)

are set against 1990 levels of emissions.

EU targets for the non-traded and traded sectors in 2020:

- a 10% reduction in non-traded sector emissions
- a 21% reduction in traded sector emissions

are established for the '20% world' and against 2005 levels of emissions.

In the event of a new global deal to reduce emissions, and a move to a '30% world', the non-traded and traded sector targets will be reconsidered.

(ii) The traded sector

The traded sector cap

The traded sectors of the economy include energy-intensive industries (e.g. iron and steel, cement, refining) and power generation and account for around 40% of EU emissions. Proposals in the January package for traded sector emissions reduction, reflected in the Committee's budget advice, were carried through to the agreed package:

- The traded sector cap requires an EU-wide 21% reduction in 2020 relative to 2005 for a 20% GHG target.
- This is allocated across countries via mechanisms for distributing auction revenues to governments and free allowances to firms.
- The traded sector cap for the UK requires a 31% cut in 2020 relative to 2005 for a 20% GHG target.
- The Committee's proposals reflected a 28% cut in 2020 relative to 2005 under the Interim budget. This is consistent with the 20% GHG target after allowing for differences in accounting between the EU and UK frameworks (e.g. the Committee's proposals included domestic aviation in the traded sector) and slight differences in assumptions on free allowance allocation to UK firms.

Auctioning of EU ETS allowances

The Committee highlighted the general need to auction EU ETS allowances in order both to provide carbon price signals to consumers, and to avoid windfall profits for EU ETS participants. The Committee noted that it may, however, be desirable to issue free allowances where energy-intensive firms are subject to competition in the global market from firms operating in countries without carbon constraints. Alternatively, the Committee argued that risks of carbon leakage could be mitigated through introduction of carbon-related border tariff adjustments.

The agreed framework requires:

- Phasing out of free allowances for the power sector from 2013.
- Phasing out of free allowances for other sectors starting at 80% in 2013 falling to 30% in 2020 and zero in 2027.
- Free allowances for sectors subject to global competition. The EC will publish a list of sectors regarded as being globally competitive at the end of 2009, with an in-depth assessment to follow in 2010.

Use of offset credits

The Committee argued that limited use of offset credits to meet traded sector targets should be accepted with the caveat that this should not undermine the carbon price and hence incentives for investment in low carbon technologies. The agreed package limits the use of offset credits to 50% of the emissions reduction required to meet the traded sector cap under a 20% GHG target; this is unchanged from the January proposal.

(iii) Transitioning from the 20% to the 30% world

The EU's January package included detailed proposals for a 30% world (EU non-traded and traded sector caps, member state burden shares for the non-traded sector, use of credits to meet non-traded and traded sector caps, etc.). The agreed package, however, no longer includes details of the 30% world. Instead, following any Copenhagen agreement, there will be a political process involving both the European Parliament and the European Council (i.e. member states) to agree detailed arrangements to deliver a 30% GHG target .

(iv) Summary of the Committee's position

Agreement of a package is a positive step forward. In particular, the non-traded sector cap for the UK under the agreed package would support, if met through domestic emissions reduction, the transition to the Intended budget and be on the path to meeting the 80% emissions reduction target for 2050.

The Committee is concerned, however, about the traded sector cap and the resulting carbon price, particularly given lower emissions from energy intensive sectors as a result of the recession. There is a risk that the carbon price will not be sufficiently high to incentivise investments in low carbon technologies. We set out our analysis of the carbon price and options to strengthen incentives for investment in low-carbon technologies in power generation in Chapters 2 and 4 of this report.

The move to full auctioning of EU ETS allowances for the power sector will transfer windfall profits away from energy companies. There are questions over whether auctioning could be introduced to other sectors at a faster pace, and how extensive auctioning will be. The Committee stresses the need to ensure that the definition of sectors requiring special treatment be limited to those which are clearly shown to be subject to global competition and that these sectors should not necessarily receive 100% free allowances.

In our December report we argued that the 20%-30% range straddles the sort of developed country emissions reductions which are likely to be required to meet global climate stabilisation goals: 20% would be too low, but 30% would be adequate if other countries were making commensurate commitments.

The crucial point for the Committee, therefore, is the early transition from the 20% to the 30% target and the UK's transition from the Interim to the Intended carbon budgets. Following Copenhagen, the EU will have to decide whether the 30% target should be triggered, and the Committee will have to advise on whether to move to the Intended budget.

It is important to note that the recommendations by the Committee for the Intended budget were to be revisited following a Copenhagen agreement. Once agreement is reached, questions to be answered will include the level of emissions reduction ambition underpinning any Intended budget and the extent to which this should reflect any new detailed arrangements to meet the EU's 30% GHG target. The Committee will consider budget revisions following Copenhagen with the current intention that new, more ambitious budgets could be legislated either in 2010 or early 2011.

2. Copenhagen and the International framework

The Committee's advice on required global emissions reductions

The Committee based its advice on the appropriate level of global emissions reduction on consideration of evidence about climate change damage from the IPCC's Fourth Assessment and more recent studies. This led us to adopt a climate change objective that central estimates (i.e. 50% probability) of global average temperature increase over the 21st century should be limited at or close to 2°C and that the probability of an extreme 4°C change should be kept to very low levels (e.g. less than 1%). We assessed a range of emissions trajectories and concluded that, in order to achieve the climate objective, emissions should peak in the period before 2020 with 3%-4% annual cuts beyond the peaking year leading to a minimum 50% cut in 2050 across all Kyoto gases and all sectors (Box 1.2).

The UK negotiating position

The Government's published negotiating position for the Copenhagen meeting in December 2009 to agree a successor deal to the Kyoto agreement is in line with the Committee's advice.

In particular, the Government will seek an agreement in Copenhagen based on emissions peaking before 2020 with a global emissions cut of 50% in 2050 across all Kyoto gases and all sectors including aviation and shipping (Box 1.3). The Government also took the Committee's recommendation that the UK should cut emissions by 80% in 2050 as the basis for its position that all developed countries should achieve a similar target.

Box 1.2 The long-term target

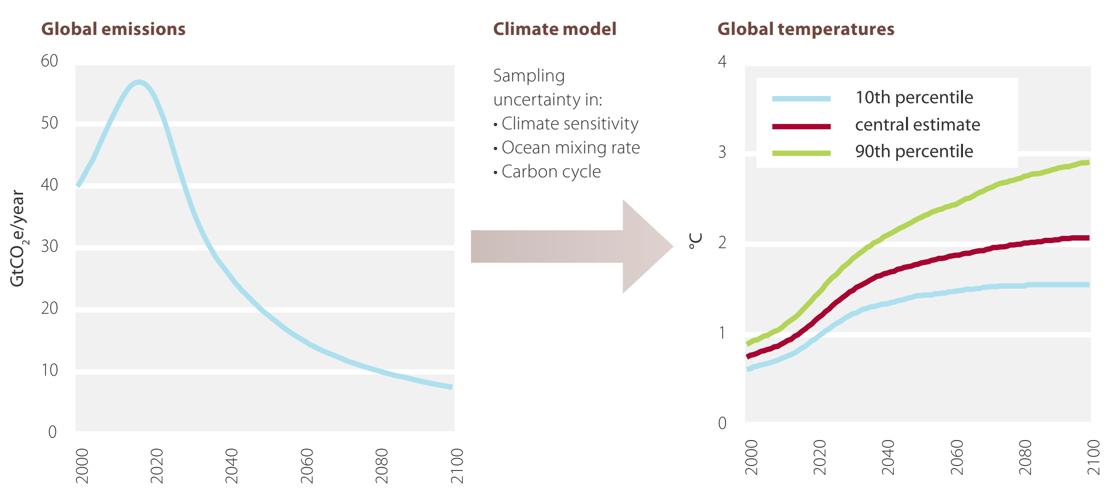
The UK emissions targets outlined in the Committee's 2008 report are designed as a fair contribution to an ambitious global climate objective. In setting these targets it is important to recognise that there are uncertainties in our understanding of the climate system, making it difficult to aim precisely for a specific temperature outcome. There is strong scientific confidence in the link between GHG emissions and global warming, but different climate models predict different levels of temperature increase because of the alternative ways by which they represent some processes.

Recognising this uncertainty, the Committee took a risk-based approach to setting targets. Work carried out by the Met Office Hadley Centre[1] accounted for the spread in model projections by giving probabilities of temperature increase based on current understanding (see Figure B1.2). Results show that global emissions of Kyoto GHGs must peak before 2020, and then reduce at a rate of 3-4% per annum throughout the century, in order to keep a 50% chance of remaining close to 2°C above pre-industrial levels. Reductions of this magnitude would also keep the chance of a 4°C increase very low (i.e. of the order of 1%). On this pathway, global Kyoto GHG emissions would be halved by 2050.

Stronger emissions reductions will result in a greater chance of staying within temperature limits. The Committee therefore recommended that the world should cut emissions in 2050 by at least 50%. It was also emphasised that climate change is not just driven by the level of emissions in a given target year (e.g. 2020 or 2050), but by the accumulated total of long-lived GHGs over time. As a result, if global emissions peak in 2020 or later, or if they grow faster before peaking, further subsequent cuts will be required in order to conserve total emissions by 2050.

More recent studies have reached similar conclusions; for instance, a science conference convened in Copenhagen during March stated that 'if peak greenhouse gas emissions are not reached until after 2020, the emission reduction rates required thereafter to retain a reasonable chance of remaining within the 2°C guardrail will have to exceed 5% per annum'[2]. The Committee will continue to monitor scientific developments closely, and will assess any implications for UK emissions targets when advising on the fourth carbon budget in 2010.

Figure B1.2 Schematic of modelling process for relating emissions pathways to temperature targets.[1]



1 See Technical Appendix to Chapter 1 of the Committee's December 2008 report: *Projecting global emissions, concentrations and temperatures.*
2 Richardson et al (2009) *Climate Change: global risks, challenges and decisions Synthesis Report.*

Box 1.3 Aviation and Shipping – progress towards international agreements

In our 2008 report, we recommended that both international aviation and shipping emissions needed to be covered by an international agreement. This box summarises the context, developments and ongoing discussions regarding international agreements in these two sectors in the run-up to Copenhagen:

UNFCCC (Kyoto Protocol)

Article 2.2 of the Kyoto Protocol stated that 'the parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) respectively'.

ICAO and IMO progress

Both organisations have made progress towards targets and/or measures to improve fuel efficiency:

Fuel efficiency

- The ICAO Council has adopted medium and long-term fuel efficiency goals and undertaken to develop a CO_2 standard for new aircraft types.
- The IMO, meanwhile, has made progress on its Energy Efficiency Design and Operational Indices (EEDI & EEOI) for new and existing ships respectively.

Market-based measures

- Both organisations remain open to market-based measures as a mechanism to reduce emissions.
- The key challenge in getting a widespread agreement on emissions reduction to-date, however, has been the difficulty in reconciling the 'parties included in Annex I' with the organisations principles that all contracting or member states are treated equally. This is due to the reality that some have interpreted Article 2.2 of the Kyoto Protocol to imply that non-Annex I countries shouldn't be required to make commitments and/or reductions.

EU progress

In January 2009 the Directive to include aviation in the EU ETS was published in the Official Journal of the EU. From 2012, all flights departing from and arriving at EU airports (both domestic and international) will be included in the EU ETS. The cap in the medium term (2013 to 2020) will be 95% of the average annual 2004-06 emissions. Aircraft operators have reporting and monitoring obligations in 2010 and 2011.

The European Commission (EC) is also now looking at options to reduce GHG emissions from international shipping. The EC have contracted an in-depth study, due to be published later this year, which is considering various market-based and/or technical regulatory options that could achieve emissions reduction in this sector.

Negotiating text for Copenhagen

In June the UNFCCC published the revised negotiating text in the lead-up to Copenhagen. In respect of international bunker fuels four main options are being considered:

1. IMO to be encouraged to continue its work on reducing GHG emissions without delay and regularly report back to the Conference of the Parties (COP).

2. UNFCCC to set reduction target and then parties to work through ICAO and IMO to enable effective international agreements, developing mechanisms by 2011.

3. Parties to work through ICAO and IMO (similar to Kyoto Protocol Article 2.2), although there is flexibility regarding whether this applies to Annex I countries or all countries.

4. UNFCCC to set reduction target and then parties to start negotiations on two global sectoral agreements in 2010, with a view to concluding by 2011.

Committee position on international aviation

In a recent letter to the Secretaries of State for Transport and Energy and Climate Change, the Committee set out their advice to Government on a framework for reducing global aviation emissions. The key messages were as follows:

- Aviation CO_2 emissions should be capped, either through a global sectoral deal or through including (domestic and international) aviation emissions in national/regional (e.g. EU) emissions reduction targets.
- Ideally all aviation CO_2 emissions would be capped. It may be necessary, however, that there is an interim phase where the cap applies to all departing and arriving flights in developed countries with exemptions for intra-developing country flights.
- The level of emissions reduction ambition under any international agreement should be no less than that already agreed by the EU (i.e. developed country net emissions in 2020 should be no more than 95% of average annual emissions from 2004-06).

For shipping, a global cap would be appropriate and both sectors need to plan for deep cuts in gross emissions relative to baseline projections in the longer term, with emissions trading providing flexibility in the near to medium term.

Positions of the G8 and others

The G8 had already agreed in July 2008 a willingness to share with all countries a target to cut global emissions by 50% in 2050. Building on this, in July 2009 the G8 recognised the broad scientific view that global average temperature increase ought not to exceed 2 degrees and agreed a goal that developed countries should cut emissions by 80% in 2050 as an appropriate contribution to the 50% global cut; these commitments are consistent with the Committee's advice on global and UK emissions reductions.

In the US, new legislation (the Waxman–Markey Bill) was proposed in Congress in March 2009. Under this legislation, US emissions would be capped and a number of measures introduced to support required emissions cuts (e.g. energy efficiency regulations, renewable electricity obligations, etc.). The draft bill has passed through the House of Representatives and is scheduled for discussion in the Senate in Autumn 2009.

There have been changes in the positions of other countries too. For example, Japan has recently announced a target to reduce emissions by 25% in 2020 as against 1990 levels. India has indicated a willingness to reduce emissions through unilateral mitigation measures. China also has plans for substantial reductions in emissions as against business as usual, and has announced an intention to reduce carbon intensity by 2020.

The Committee's position on Copenhagen

The Committee has set out what is sees as a broad shape for an appropriate deal in Copenhagen (e.g. global emissions peaking before 2020, 50% cut in global emissions by 2050, etc.). The Committee therefore views the UK negotiating position, agreements by the G8 and progress in various countries as positive steps, though securing a global agreement remains challenging.

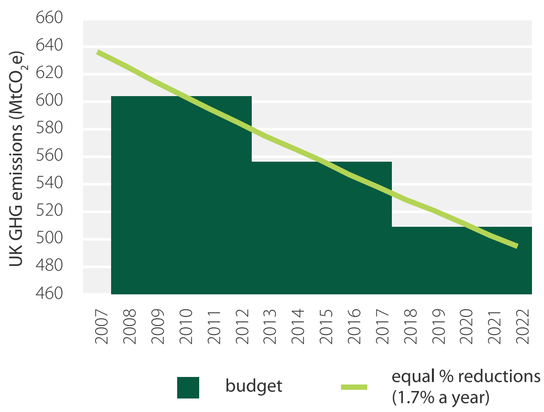
It is not, however, the role of the Committee to take a view on detailed negotiating positions (e.g. the appropriate cap for the US and a possible cap for China) or what the outcome of negotiations is likely to be. The Committee will monitor closely outcomes in Copenhagen with a view to assessing implications for the UK and, in particular, to assess whether moving from the interim to the intended budget would be appropriate and to assess the precise level of the intended budget.

3. Carbon budgets legislated by the UK

In April 2009 the Government announced carbon budgets, which subsequently passed into legislation in May 2009 (Table 1.1). We welcome that these fully reflected the Committee's advice on the level of ambition, the use of credits, and the high level set of measures to meet carbon budgets:

- The legislated budget is based on a 34% cut in 2020 relative to 1990 with an annual average emissions reduction of 1.7% over the first three budget periods (i.e. it is the Committee's Interim budget) (Figure 1.1).
- The budget split between the non-traded/ traded sectors reflects that proposed by the Committee (i.e. it has the result that non-traded sector emissions account for 60% of total allowed emissions over the first three budget periods).
- The budgets, in line with the Committee's advice, exclude emissions from international aviation and shipping. Aviation is, however, included within the EU's 20% and 30% GHG emission reduction targets. Our budget proposals were based on that framework and do, therefore, implicitly take account of international aviation emissions.
- The Government does not intend to use offset credits to meet the Interim budget. It has legally committed to this for the first budget (the Climate Change Act makes provision for legal commitment on the use of offset credits for the first – and not second/third – budget periods at the current time).
- The document containing the Government's budget proposals and the subsequent 'UK Low Carbon Transition Plan' set out an ambitious high level vision of how budgets will be met through the range of measures in the Committee's December 2008 report: decarbonisation of the power sector, energy efficiency improvement in buildings, increased penetration of renewable heat, reduced transport emissions through more carbon-efficient vehicles and changes in consumer behaviour, reduced agricultural emissions through soils and livestock measures.

Figure 1.1 Indicative annual percentage emissions reductions required to meet legislated carbon budgets



Source: CCC calculations.

Table 1.1 Legislated carbon budgets and split between traded and non-traded sectors

	Budget 1	**Budget 2**	**Budget 3**
	2008-2012	**2013-2017**	**2018-2022**
Carbon budgets ($MtCO_2e$)	3018	2782	2544
Percentage reduction below 1990 levels	22%	28%	34%
Traded sector ($MtCO_2e$)	1233	1078	985
Non-traded sector ($MtCO_2e$)	1785	1704	1559

Source: HM Government's *'Building a low-carbon economy: implementing the Climate Change Act 2008'* (April 2009) Table 3.B: Proposed carbon budget levels.

The Government also committed to a more ambitious budget following a global deal in Copenhagen, without stating what this budget would be. This is consistent both with provisions under the Climate Change Act and the Committee's advice:

- Under the Climate Change Act, the Government must consult the Committee before any change to carbon budgets is made.
- The Committee's Intended budget is to be revisited with final proposals to be determined following a global agreement.

For the period before the Intended budget is legislated, the Government will aim to outperform the Interim budget through a range of measures proposed in the Extended and Stretch Ambition scenarios in our December 2008 report. This will support the transition to the Intended budget, and provide the option to meet the Intended budget largely through domestic emissions reductions rather than the purchase of offset credits.

Legislation of carbon budgets is the first step towards realising deep emissions cuts in the UK, which together with cuts in other countries will limit the risk of dangerous climate change. The challenge now is to move from legal commitments and high level visions to detailed implementing frameworks, both at the national and regional levels. The Committee's view on the detailed measures that will be required to meet carbon budgets and the policies that will drive these measures is summarised in Chapter 3 and set out in more detail in chapters 4-6.

4. Progress reducing emissions in the UK

The ultimate test of success for the framework established under the Climate Change Act is that emissions fall sufficiently to meet carbon budgets.

Going forward, as required under the Act, the Committee will report on progress in reducing emissions and meeting budgets in annual reports to Parliament.

There is limited scope for such reporting at the current time given that we are in the second year of the first budget period, with preliminary emissions data only available for the first year. It is therefore not possible to make analytically robust and meaningful statements about whether we are on track to meet the first budget.

It is useful, however, to consider emissions trends in recent years[3] with a view to assessing the extent of the change in trend required to meet carbon budgets. This section therefore summarises:

(i) Economy-wide emissions trends

(ii) Sectoral emissions trends

(iii) Regional emissions trends.

In considering trends, we look at data from 1990 for completeness. A better predictor, however, is more recent data. We therefore assess emission trends over the period 2003-2007 at the economy-wide and sectoral level. Our conclusion is that emissions have reduced only slightly in recent years, with increases in some sectors. The most recent provisional data show emissions falling as a result of the economic recession, but these reductions will be reversed once the economy starts to grow again. It is clear that action is therefore required if we are to achieve the 1.7-2.6% average annual reduction necessary to meet the first three carbon budgets.

We note that, whilst emissions reduction can be achieved sustainably through implementation of measures (e.g. to improve energy efficiency, decarbonise the power sector, etc.), they can also be driven by a number of other factors (e.g. changes in GDP, fossil fuel prices, population change, external temperature, etc). In understanding progress towards meeting carbon budgets, it is therefore important to monitor implementation of measures that will result in sustainable emissions reductions; we consider this issue further in Chapter 2 and set out our view of the detailed measures required to reduce emissions and meet carbon budgets in Chapters 3-6 of this report.

3 In our December 2008 report the final year of available historic data was generally 2006. For the current report we are able to update to include 2007 and, sometimes, 2008 data. Where the 2008 data is provisional, or reflects estimates from other sources, this is generally represented by a dotted, rather than solid, line to the data point in the relevant chart. In the text we are sometimes able to draw on part year data for 2009.

(i) Economy wide emissions trends

Total GHG emissions in 2007 – the last year for which final data are available – were 636 $MtCO_2e$, comprising 85% CO_2 and 15% non-CO_2.

Over the period 1990-2007, GHG emissions fell by 18%, at an average annual rate of 1.2%. This was driven by an 8% reduction in CO_2 emissions and a 49% reduction in non-CO_2 emissions, and notwithstanding that energy demand increased in most sectors (Figures 1.2, 1.3):

- A significant factor driving CO_2 emissions reductions was a 13% reduction in power sector emissions due to the dash for gas (i.e. replacement of coal with gas-fired power generation) in the 1990s, which was partially offset by increasing electricity demand.
- Direct (i.e. non-electricity) emissions reductions of 40% reflecting fuel switching and lower energy demand due to industry restructuring were also important in reducing CO_2 emissions.
- Transport emissions increased by 11% over the period 1990-2007 due to increased demand which was only partially offset by increasing carbon efficiency of vehicles.
- The reductions in non-CO_2 emissions occurred mainly in waste and industry.

More recently, however, GHG emissions have reduced at a lower rate:

- GHG emissions fell by 3.8% between 2003 and 2007 and 0.95% on average per year. Emissions reductions have therefore slowed relative to the preceding decade.
- Preliminary data for 2008 suggests a 2% reduction in CO_2 emissions relative to 2007, reflecting a switch from coal to gas in power generation, combined with lower fossil fuel consumption in industry and transport.
- Data for the first quarter of 2009 suggests that energy consumption fell relative to the same period in the previous year as a result of the economic recession, although the impact of this on emissions may have been offset by switching from gas to coal in power generation.

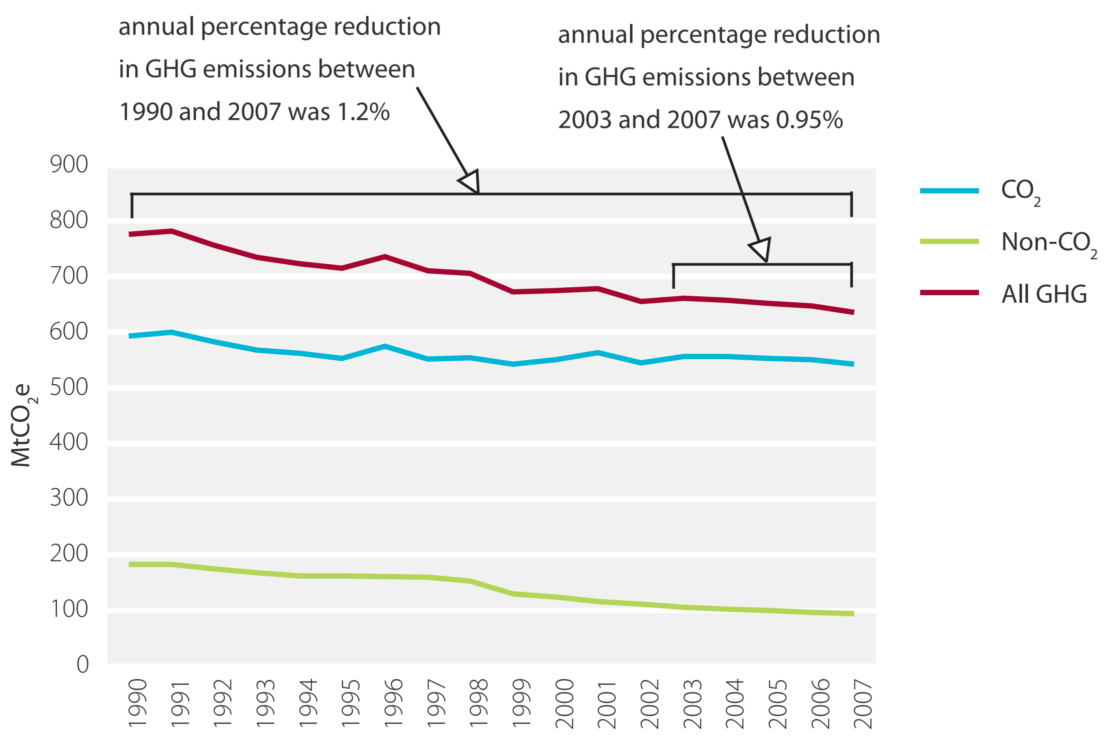
It may be the case that full year data for 2009 shows a significant emissions reduction relative to 2008. This would not, however, signal the downward trend required through the first three budget periods (i.e. annual emissions reductions of 1.7% to meet the Interim budget, and 2.6% to meet the Intended budget), under an assumption that economic growth is likely to resume in the near term and allowing for a further increase in population of 9% from 2009 to 2022 (Figure 1.4).

This conclusion is even more apparent when we look separately at CO_2 emissions. Most of the reduction in GHG emissions since 1990 has reflected a fall in non- CO_2 emissions (Figure 1.2). However, there is limited potential for continued non-CO_2 emission reduction. CO_2 emissions in 2007 are no lower than in 1999, and fall at only 0.6% annually from 2003 to 2007. A much greater reduction will therefore be required going forward (Figure 1.5).

Given the relatively flat emissions trend in recent years, reduced potential for reductions from non-CO_2 and the fact that there has been very limited progress reducing emissions through implementation of measures that will be required going forward to meet budgets (e.g. loft and solid wall insulation in homes, investment in renewable heat and electricity, transport emissions reductions, carbon efficiency improvement in agriculture, etc.), a fundamental step change is required in order that deep emissions cuts are achieved going forward.

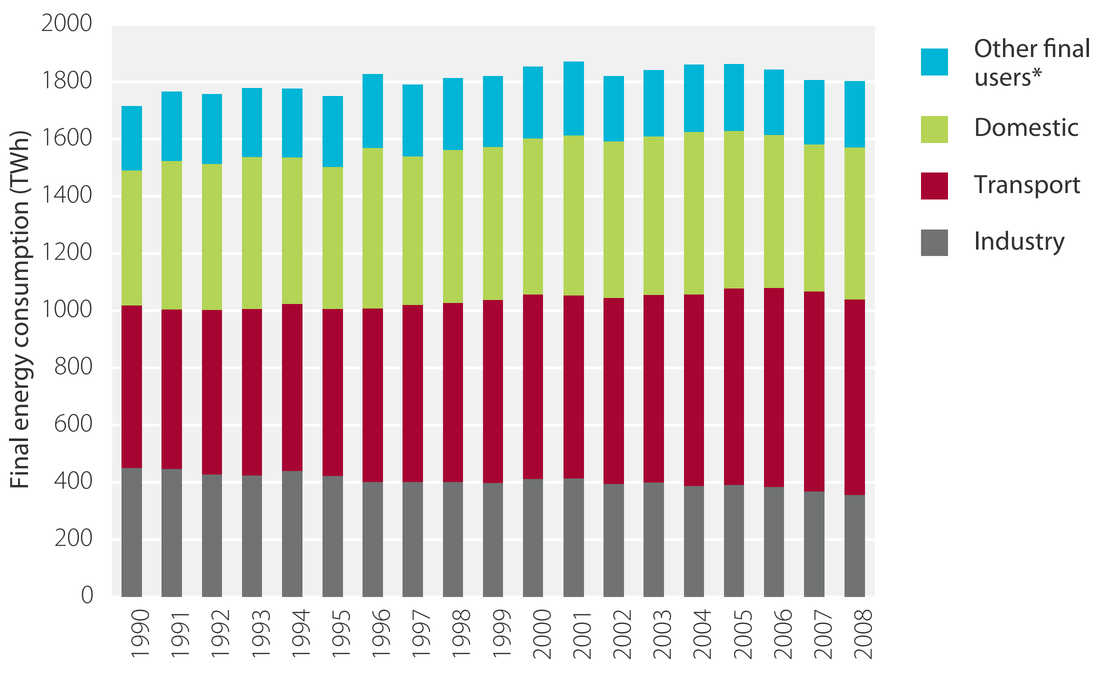
We set out what in the Committee's view will drive these cuts in Chapters 3-6, and the set of measures that we will monitor together with emissions trends when assessing progress meeting budgets in Chapter 3.

Figure 1.2 UK greenhouse gas emissions 1990-2007



Source: NAEI (2009); DECC (2009), *Energy Trends March 2009.*

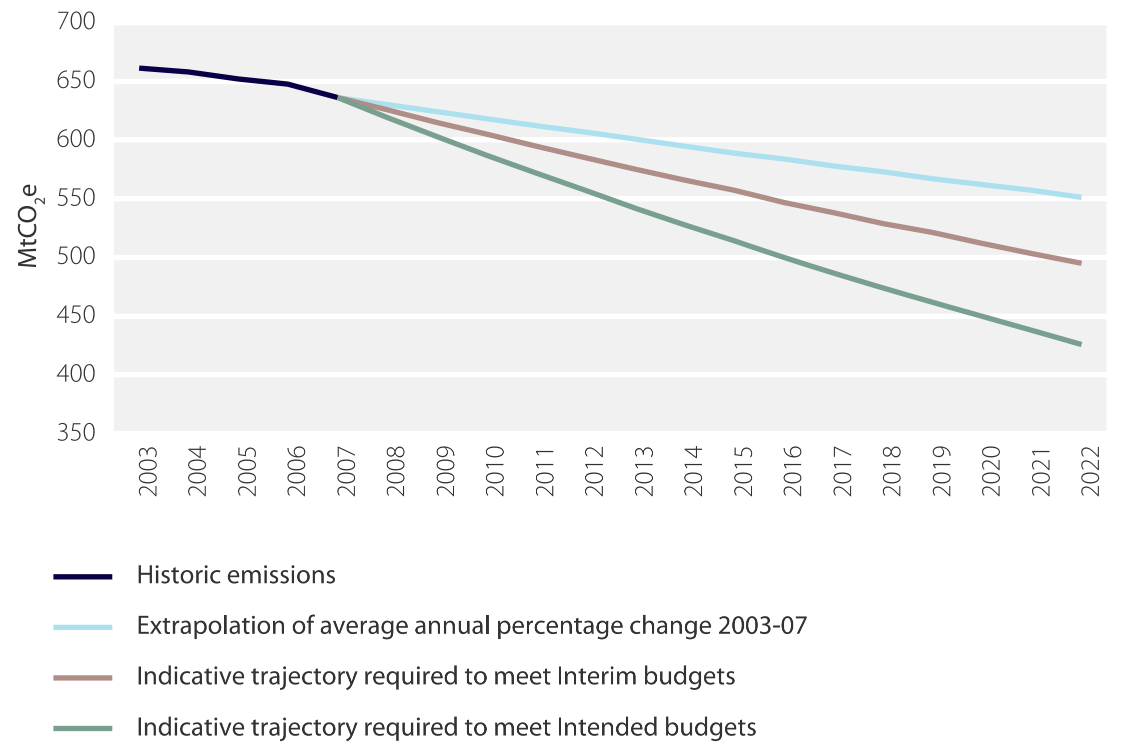
Figure 1.3 Energy demand by final users 1990-2008



* mainly public administration, commerce and agriculture

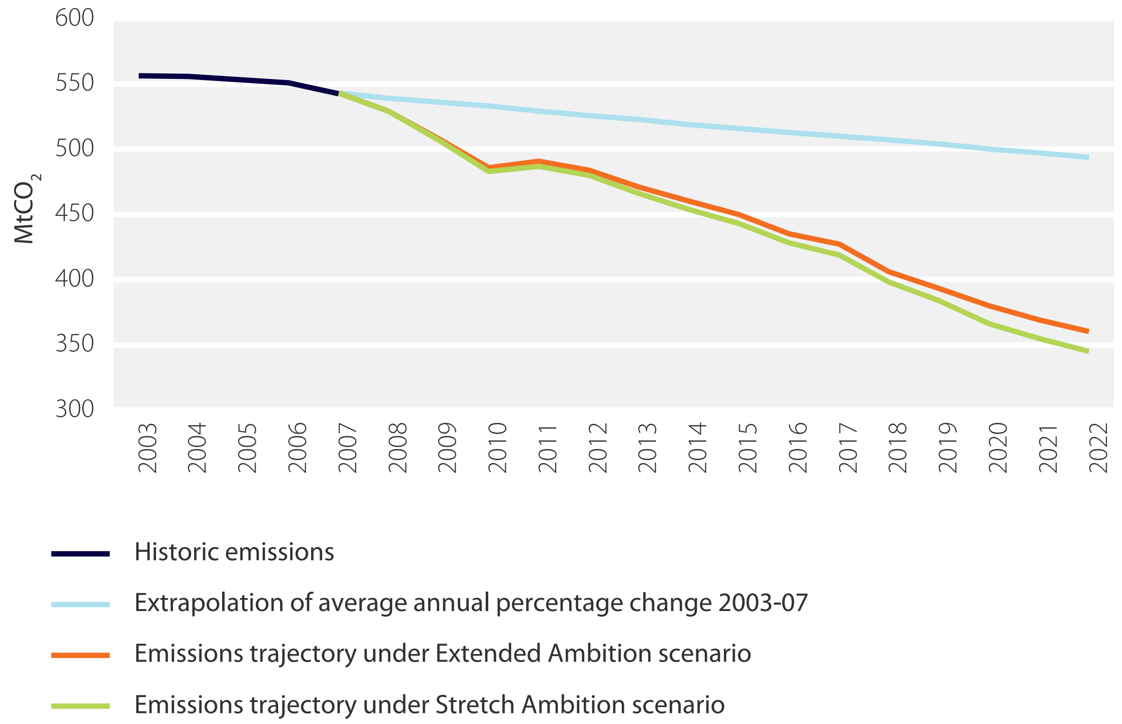
Source: DECC (2009); *DUKES.*

Figure 1.4 Recent UK GHG emissions and indicative reductions required to meet carbon budgets



Source: NAEI (2009); CCC Modelling.

Figure 1.5 Recent UK CO_2 emissions and reductions under CCC emission scenarios



Source: NAEI (2009); CCC Modelling.

(ii) Sectoral emissions trends

Power sector emissions

UK CO_2 emissions from power generation have fallen significantly since 1990 due to fuel switching from coal to gas (Figure 1.6), which more than offset demand growth (Figure 1.7):

Demand

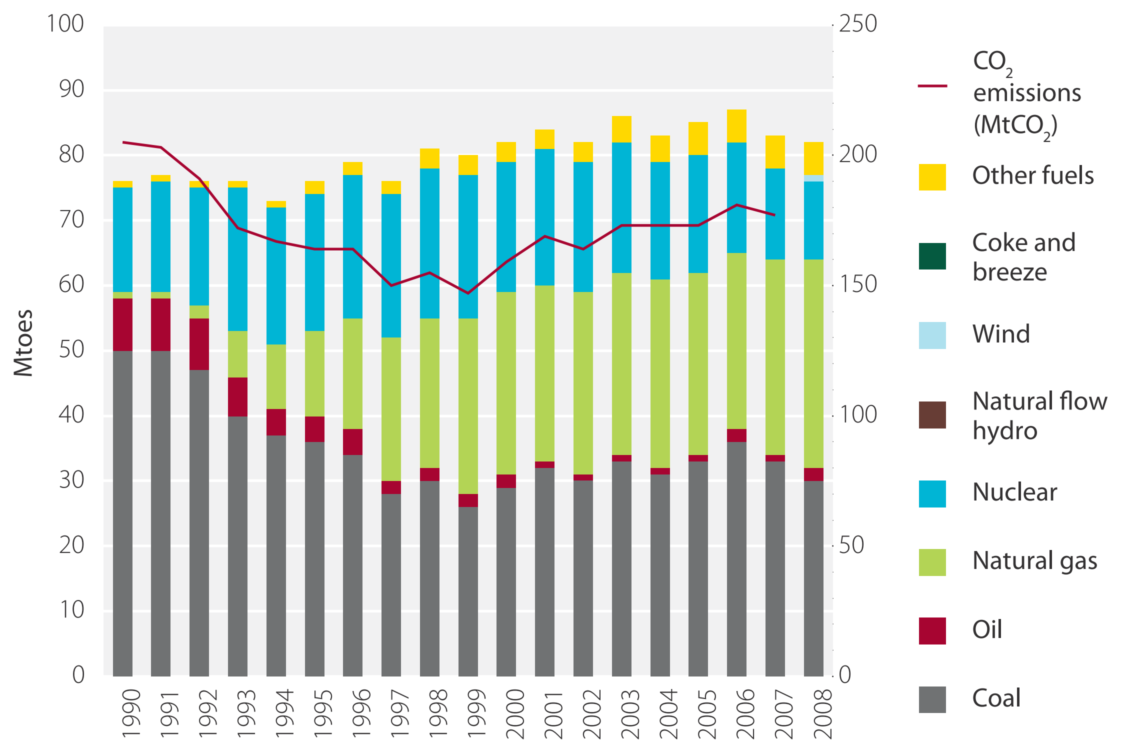
- Demand over the period 1990-2005 increased at an annual rate of around 1.6%.
- More recently, there was a 1.5% demand reduction between 2005 and 2007, with flat demand in 2008. Preliminary data for 2009 suggests that demand may fall significantly as a result of the recession (e.g. generation in the first quarter of 2009 was 5.1% lower than in the same period in 2008).

Generation

- Fuel switching occurred in the 1990s as a result of the dash for gas.
- Since this fundamental shift, there has been a changing balance of coal and gas-fired generation in response to changes in relative coal and gas prices and carbon prices. Gas generation rose and coal generation fell in 2008, but coal generation in the first quarter of 2009 was 12% higher, and gas generation 22% lower than in the same period in 2008.

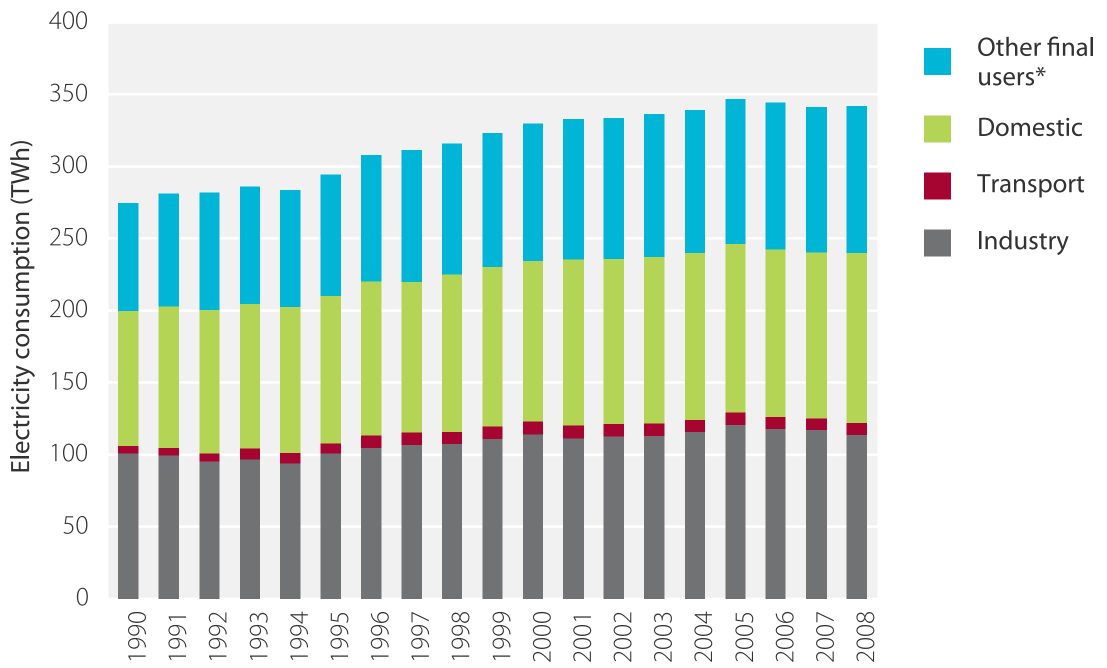
The combination of these factors has resulted in significant reductions in the carbon intensity of power generation since 1990, but fluctuating intensity in recent years (Figure 1.8). The change in emissions intensity in recent years is therefore not consistent with the deep power sector emissions cuts required to 2020 and beyond (Figure 1.9, and see Chapter 4).

Figure 1.6 Fuel input and emissions from power generation 1990-2008



Source: NAEI (2009); DECC (2009); *DUKES*.

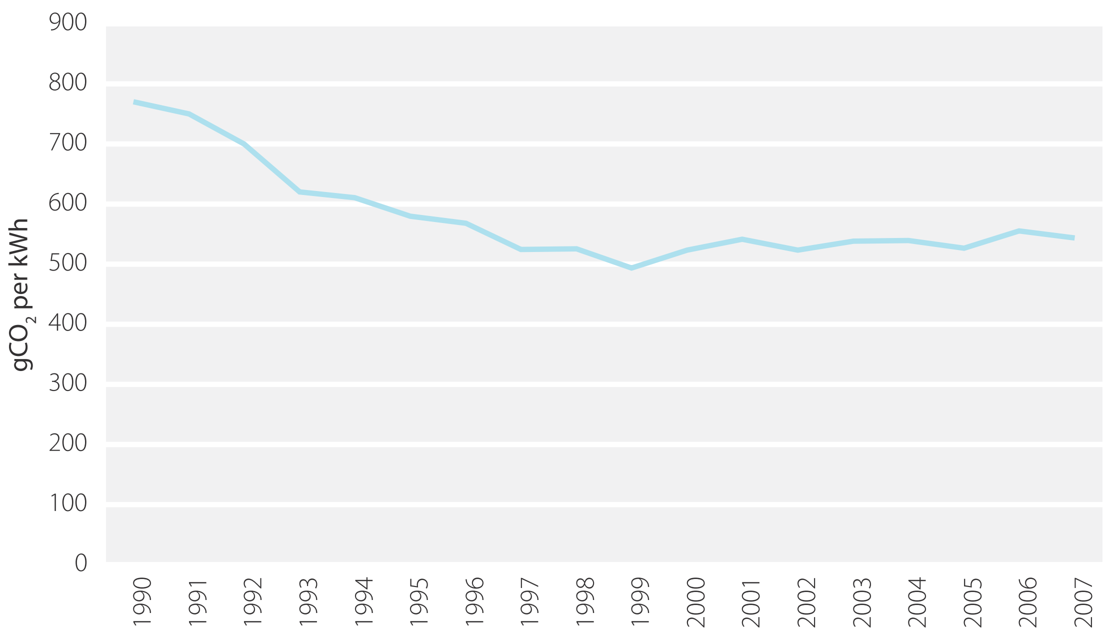
Figure 1.7 Electricity demand by final users 1990-2008



* mainly public administration, commerce and agriculture

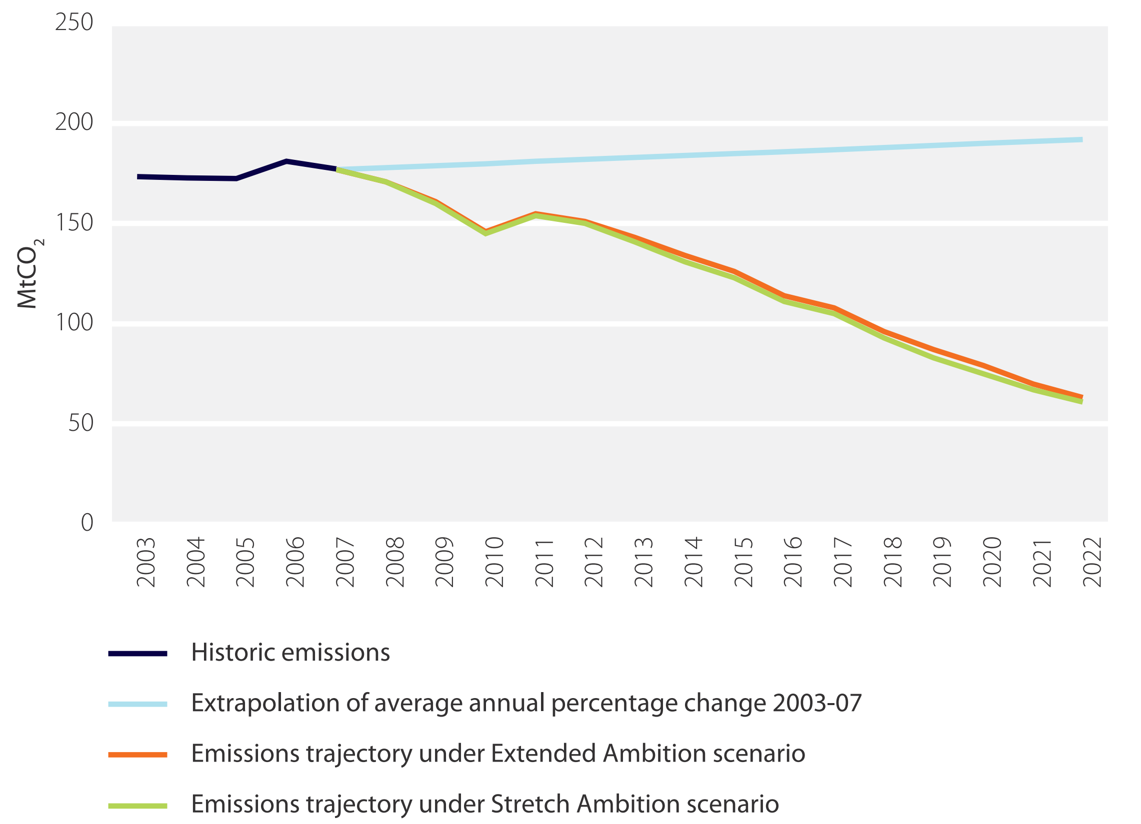
Source: DECC (2009); *DUKES*.

Figure 1.8 Carbon intensity of electricity generation 1990-2007



Source: Defra (2009), *GHG conversion factors for company reporting*.
Note: These emission intensity figures represent the average CO_2 emissions from the UK national grid per kWh of electricity used at the point of final consumption. Transmission and distribution losses are included. These cannot be compared directly to Figure 8 and Figure 4.28, which are modelled differently and do not include transmission and distribution losses.

Figure 1.9 Recent power sector CO_2 emissions and reductions under CCC emissions reduction scenarios



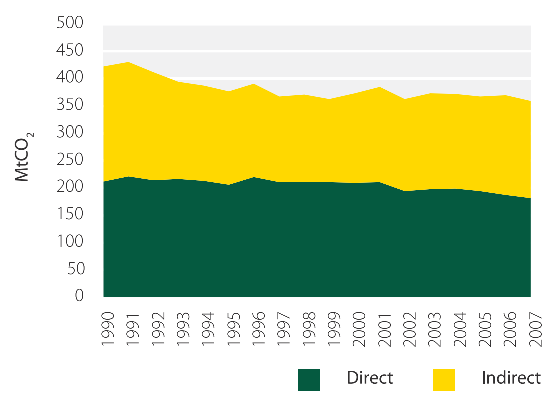
Source: NAEI (2009); CCC Modelling.

Emissions in buildings and industry

Emissions from buildings and industry account for around two-thirds of all CO_2 emissions in the UK, comprising around 50% each from direct (e.g. due to burning of fuel for heat) and indirect (predominantly electricity-related) emissions. Total emissions from buildings and industry fell by 15% over the period 1990-2007, with direct emissions falling by 14% and indirect emissions by 16% (Figures 1.10-1.11):

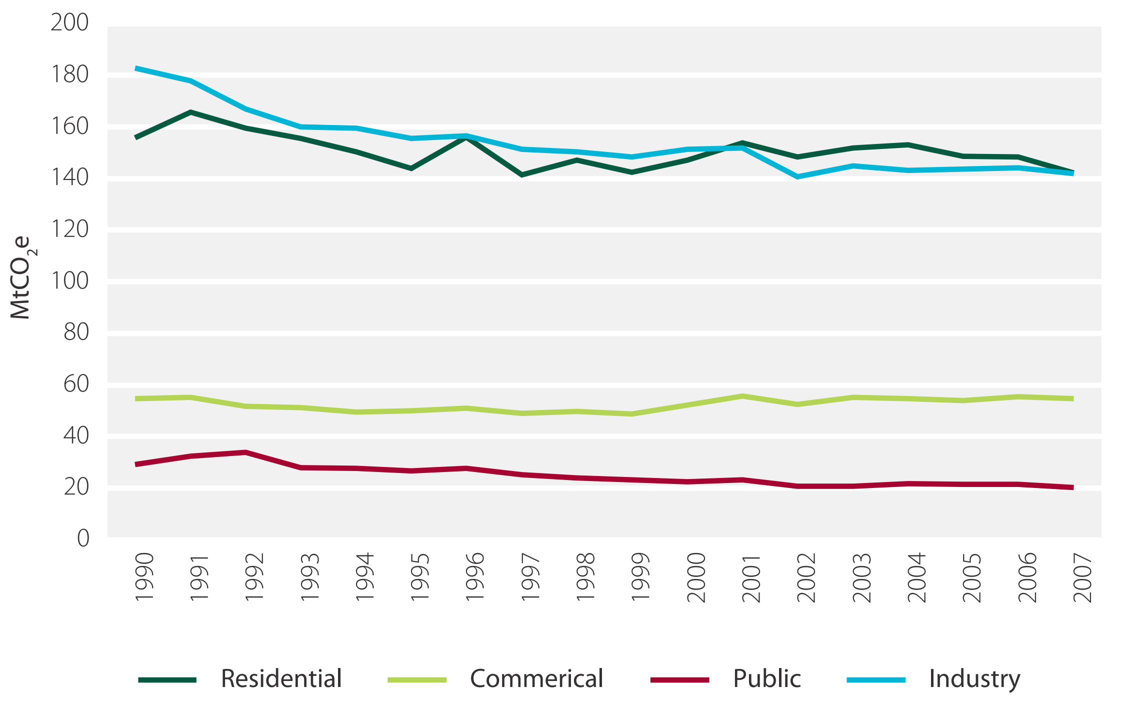
- Emissions reductions of 9% in the residential sector were largely due to lower indirect emissions as a result of reduced carbon intensity of power generation in the 1990s.
- Emissions reductions of 30% were achieved in the public sector through the use of more carbon-efficient fuels rather than reduced energy consumption.

Figure 1.10 Total direct and indirect CO_2 emissions from buildings and industry 1990-2007



Source: NAEI (2009).

Figure 1.11 CO_2 emissions from buildings and industry by sector 1990-2007



Source: NAEI (2009).

- Commercial sector emissions in 2007 were broadly at the same level as in 1990.
- Industry emissions fell by 22% between 1990 and 2007 as a result of industry restructuring, the use of more carbon-efficient fuels, and switching from coal to gas in power generation.

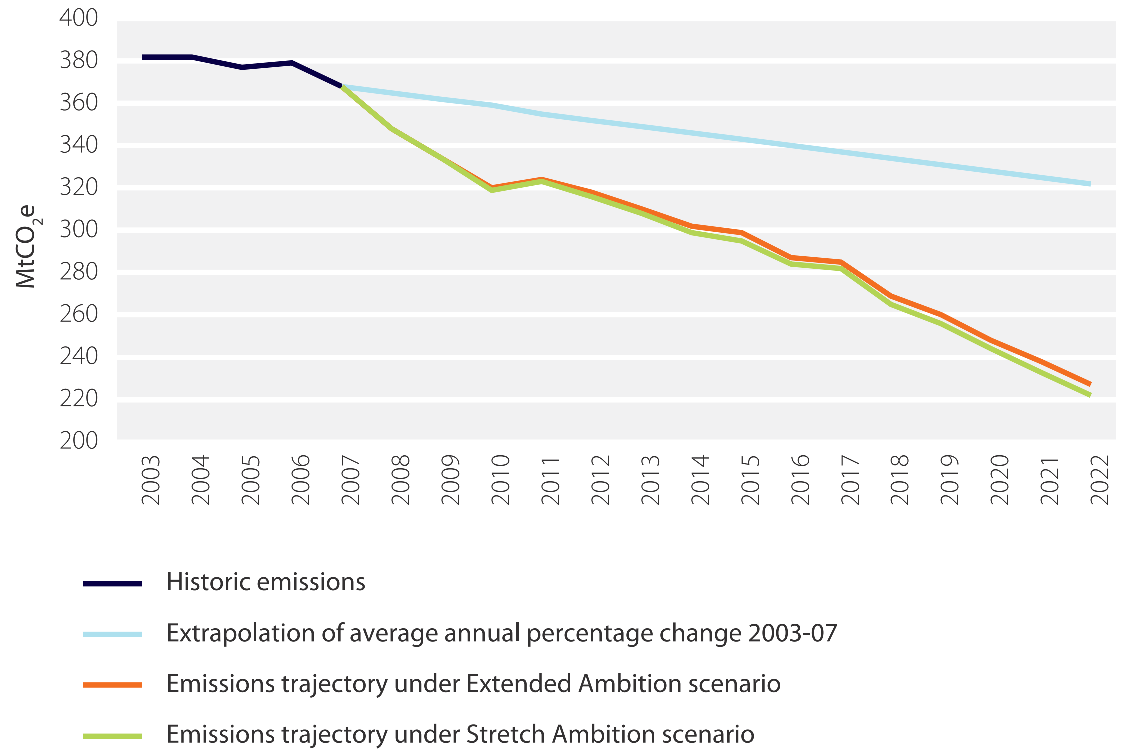
In the period 2003-2007, reductions of 8% have been achieved for direct emissions from buildings and industry while indirect emissions were broadly flat:

- Direct emissions from the residential sector fell by 11% at least partially due to increased energy prices, while indirect emissions were broadly flat. Provisional data for 2008 suggests a 5% increase in direct emissions.
- Public sector emissions fell by 2% over the period 2003-2007 with indirect emissions increases partly offsetting direct emissions reductions of 5%.
- Commercial sector emissions were broadly flat between 2003 and 2007 with increases in indirect emissions (which account for around 80% of commercial sector emissions) largely offsetting direct emissions reductions of 12%.
- Industrial emissions remained broadly flat from 2003-2007, with reduced direct emissions being offset by increased indirect emissions. Provisional data suggest direct emissions fell in 2008 as a result of the recession; energy consumption in the first quarter of 2009 was lower than a year earlier.

Based on recent trends, therefore, there has been some reduction in direct emissions from residential, public and industrial sectors.

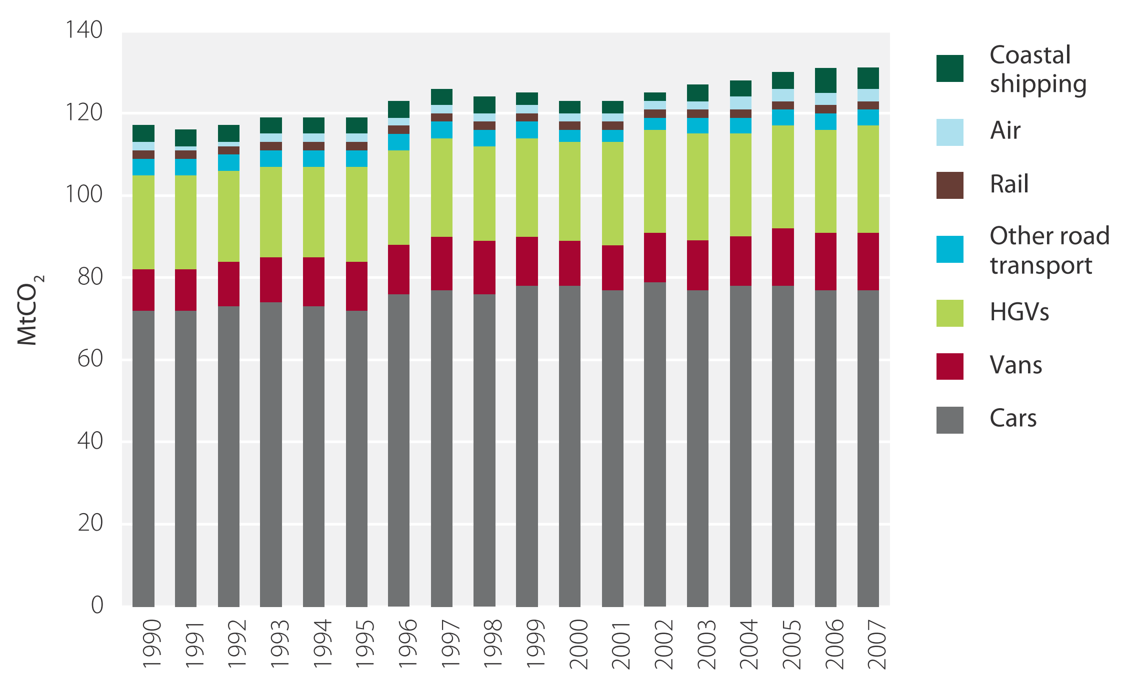
Going forward, however, a much faster pace of direct and indirect emissions reduction will be required (Figure 1.12), to be achieved primarily through implementation of measures to improve energy efficiency and increase renewable heat penetration. We set out our view of the required emissions trajectory for buildings and industry and measures to achieve this trajectory in Chapter 5.

Figure 1.12 Recent buildings and industry CO_2 emissions and reductions under CCC emissions reduction scenarios



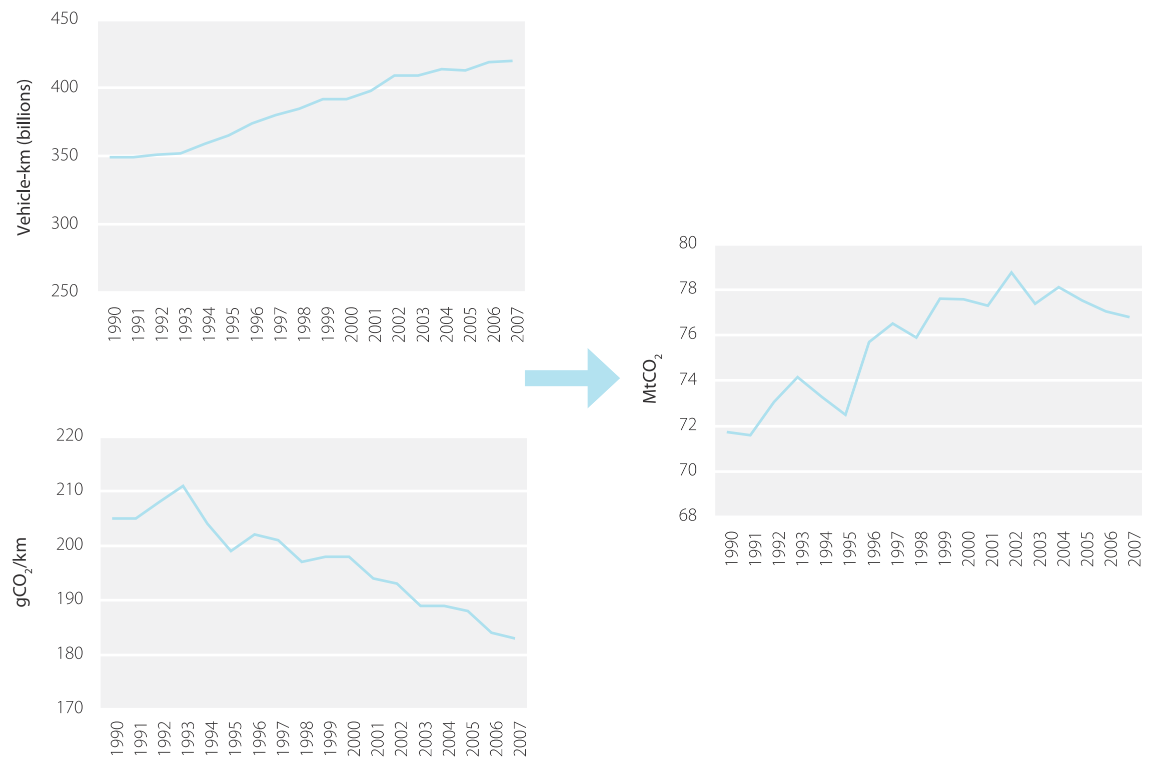
Source: NAEI (2009); CCC Modelling.

Figure 1.13 CO_2 emissions from transport by mode 1990-2007



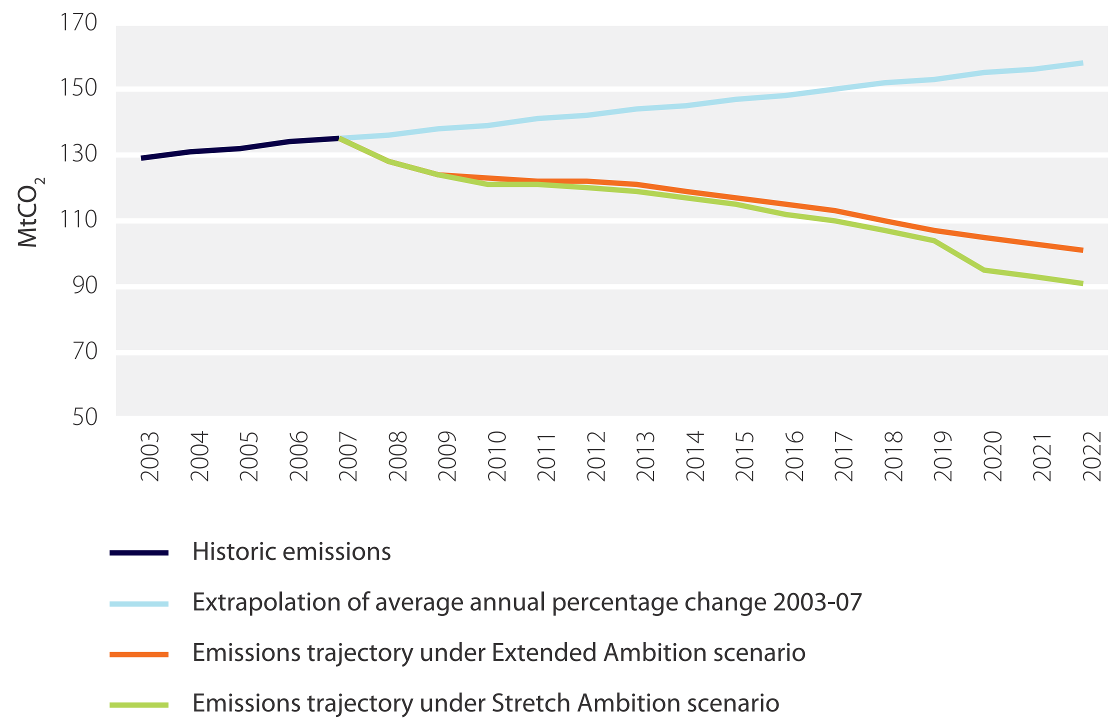
Source: NAEI (2009).

Figure 1.14 Car vehicle-kms, carbon intensity of car travel and CO_2 emissions from cars 1990-2007



Source: DfT (2008), *Transport Statistics Great Britain*; NAEI (2009).

Figure 1.15 Recent transport CO_2 emissions and reductions under CCC emissions reduction scenarios



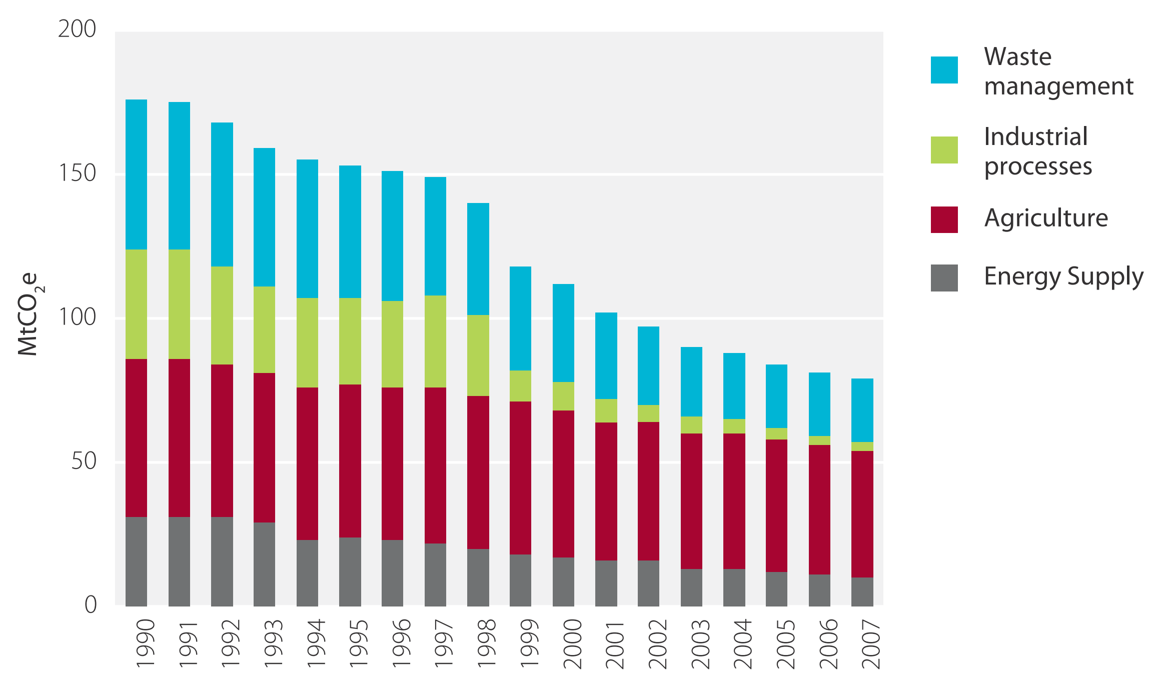
Source: NAEI (2009); CCC Modelling.

Transport emissions

Domestic transport emissions accounted for 24% of total CO_2 emissions in 2007 on a source basis, having increased by 11% over the period 1990-2007 and by 4% between 2003 and 2007 (Figure 1.13):

- Car emissions account for the majority (58%) of domestic transport emissions. Over the period 1990-2007, car emissions increased by 7% as demand increases of 20% offset fuel efficiency increases of 11% (Figure 1.14).
- For the period 2003-2007, car emissions remained broadly constant, as increasing demand (ie. vehicle-km) was offset by carbon efficiency increases. Preliminary data for 2008 suggests that demand fell by 0.6% in 2008 and by a further 0.8% (1.5% on an annualised basis) in the first two quarters of 2009 as a result of the recession.
- Van emissions increased by 40% over the period 1990-2007 due to mileage increases of 71%. Although the effects of mileage increases were partially offset by a reduction in the carbon intensity of the van fleet to 1998, there has been no strong downward trend in carbon intensity since then. The long-term trend has continued in recent years, with emissions growth of 25% over the period 2003-2007, although DfT's provisional estimates suggest that van traffic fell by 0.4% in 2008 and again very slightly (0.1% on an annualised basis) in the first two quarters of 2009.
- HGV emissions increased by 13% from 1990-2007 and by 2% from 2003-2007 due to increased demand, partially offset by reduced carbon intensity, which has improved on average by around 1% per year. DfT's provisional estimates suggest that HGV traffic fell by 2.4% in 2008 and by a further 4.4% (8.7% on an annualised basis) in the first two quarters of 2009.
- Provisional estimates indicate that transport emissions as a whole fell by 2.5% between 2007 and 2008, largely due to lower petrol consumption stemming from reduced demand as a result of the recession. Such a decline is consistent with expectations in the context of the recession, and it is currently considered that as economic growth resumes, demand will return to its long-term upward trend.

Figure 1.16 Non-CO_2 emissions by sector 1990-2007



Source: NAEI (2009).

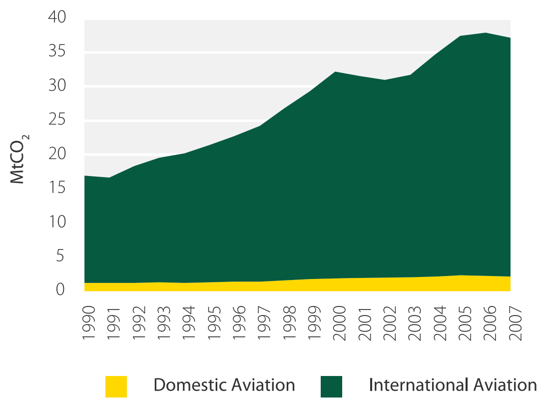
An upward trend for transport emissions is not sustainable, and significant emissions reductions will be required going forward (Figure 1.15). We consider measures to reduce transport emissions (e.g. through more low carbon vehicles, greater use of public transport, etc) in Chapter 6.

Non-CO_2 emissions

Non-CO_2 emissions accounted for 24% of total emissions in 1990 and 15% of total emissions in 2007, with the changing share reflecting non-CO_2 emissions reduction of 49% from 1990-2007 (Figure 1.16):

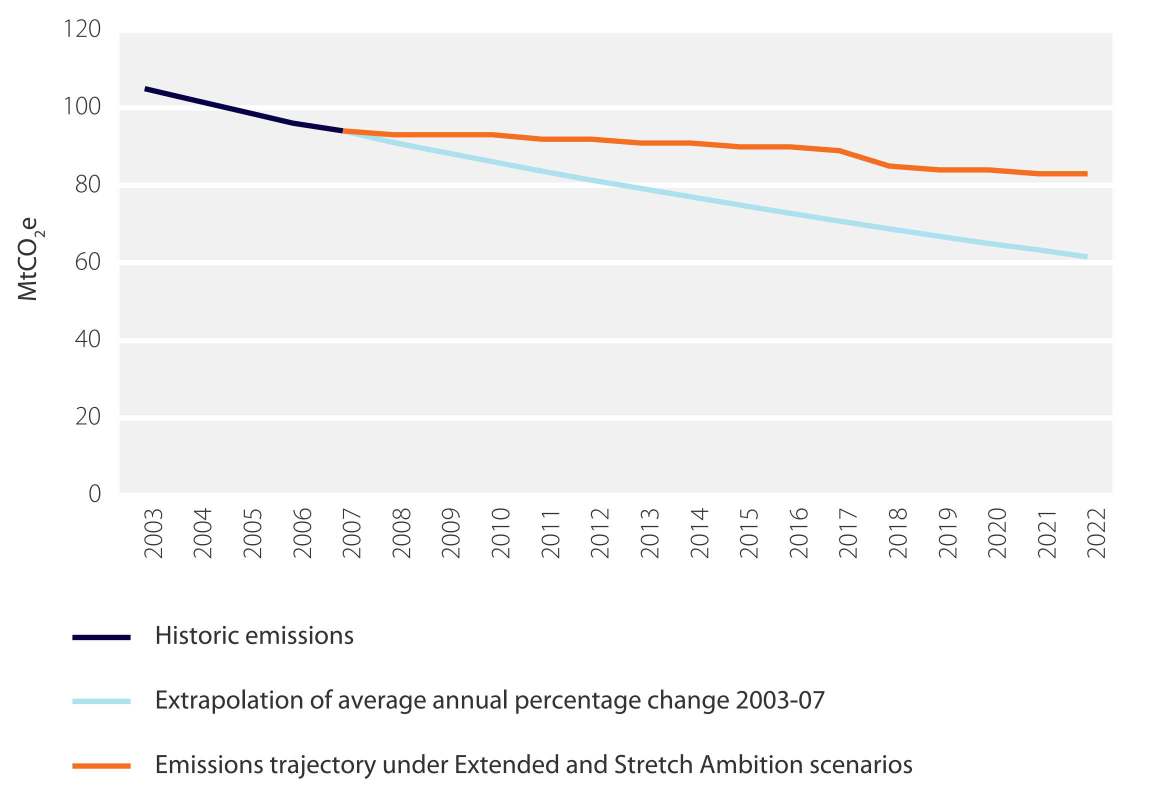
- Methane emissions fell by more than 50% from 1990-2007 due mainly to reduced emissions from landfill.
- A 79% reduction in emissions of N_2O emissions was achieved through more widespread use of clean technology in industry.
- Fugitive emissions from the gas distribution network and coal mines were reduced by around 70%.
- Agricultural emissions were reduced by around 20%, mainly due to falling livestock numbers and reduced fertiliser use.

Figure 1.18 UK Aviation CO_2 emissions (bunker fuels basis)



Source: NAEI (2009).

Figure 1.17 Recent non-CO_2 emissions and reductions under CCC emissions reduction scenarios



Source: NAEI (2009); CCC Modelling.

The recent trend for emissions reduction is consistent with the longer term trend (e.g. non-CO_2 emissions fell by 11% from 2003-2007). Going forward, there is scope for some further reduction in non-CO_2 emissions, particularly in agriculture, though these are likely to be significantly less than achieved in the previous five years (Figure 1.17).

Our December report provided a preliminary assessment of opportunities for emissions reduction in agriculture and a high level set of policy options for consideration. Following the Government's acceptance of the Committee's recommendations on agriculture (in the UK Low Carbon Transition Plan), we will undertake further analysis of emissions reduction opportunities and policies, which we will publish in our report to Parliament in June 2010.

Aviation emissions

UK aviation emissions doubled over the period from 1990 to 2007, reflecting strong underlying growth in both passenger and freight demand (Figure 1.18). Passenger numbers fell by 2% in 2008 and are likely to fall further in 2009 as a result of the recession, but then growth is expected to resume once GDP increases. Going forward, aviation emissions cannot increase at the rates of the last two decades given the target adopted by the Government in January 2009 to reduce gross UK aviation emissions in 2050 back to 2005 levels; the Committee will report on options for meeting this target in December 2009.

Shipping emissions

We noted in our December 2008 report that allocation of international shipping emissions to the national level is difficult. Ships travelling to the UK may, for example, fuel in other countries, and under the UNFCCC convention emissions would therefore be allocated to these countries.

On a UK bunker fuel basis, shipping emissions (domestic and international) in 2007 were 11.8 $MtCO_2$, relative to 10.8 $MtCO_2$ in 1990, a 9% rise. As a comparison, international port traffic to/from the UK grew by 37% over the comparable period. Since international emissions grew by only 3% on a bunker fuel basis, this suggests increased movements to/from the UK are not fully reflected in the UK fuel sales data.

Shipping emissions are potentially very significant relative to total allowed global emissions in the period to 2050 and should therefore be covered by an international agreement (e.g. a global cap and trade scheme). If there were a global agreement, allocation of emissions to the national level would not be required, thus avoiding the complexities identified above. At a global level, the IMO has made progress (see Box 1.3) and the Committee will comment on this, and progress at the EU and UK levels, in our report to Parliament in June 2010.

(iii) Regional emissions trends

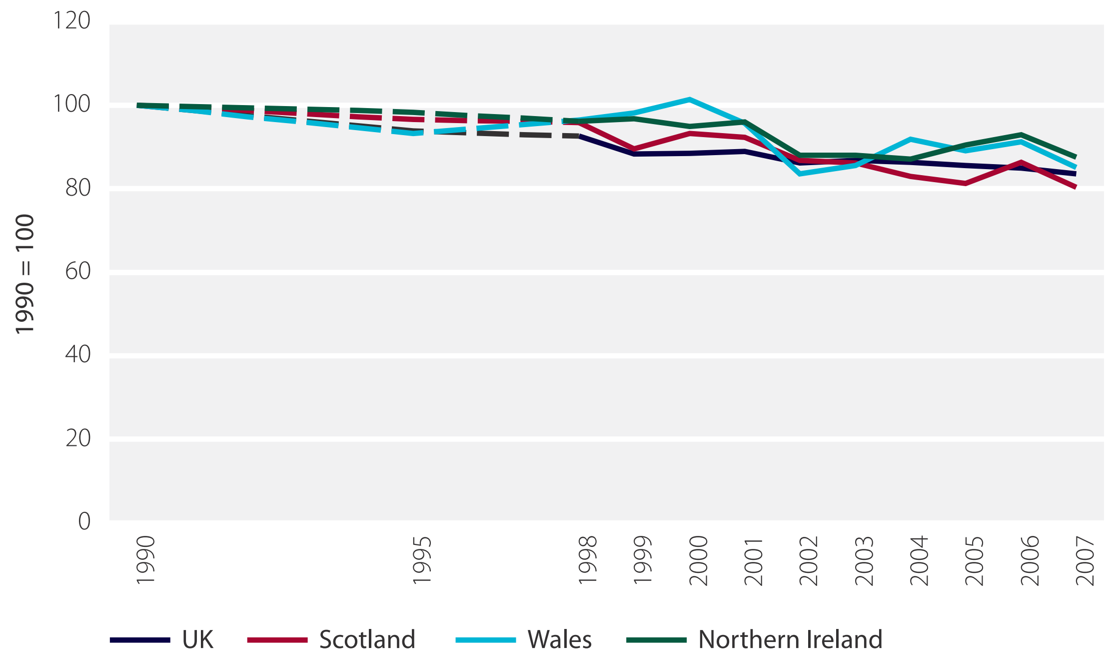
GHG emissions fell in each of the Devolved Administrations between 1990 and 2007 (Figure 1.19; Box 1.4):

- GHG emissions fell in Scotland by 20%, due mainly to emissions reductions in residential buildings, industry, waste and agriculture.
- In Wales, reductions in emissions from residential buildings, services, industry, waste and agriculture resulted in total GHG emissions reductions of 15%.
- GHG emissions reductions of 12% were achieved in Northern Ireland, driven by emissions reductions in power, residential buildings, services and industry, waste and agriculture.

Due to their smaller size, emissions in the Devolved Administrations are more sensitive to specific changes in the power sector (eg. individual station outages or closures). Excluding power, emissions have fallen by 27% in Scotland, 19% in Wales and 12% in Northern Ireland.

Going forward, a faster pace of emissions reductions will be required in order that Devolved Administrations meet their own targets (Box 1.5) and, based on emissions reduction opportunities identified in our December 2008 report, make an appropriate contribution to meeting UK carbon budgets.

Figure 1.19 Greenhouse Gas Emissions in the UK and Devolved Administrations 1990–2007

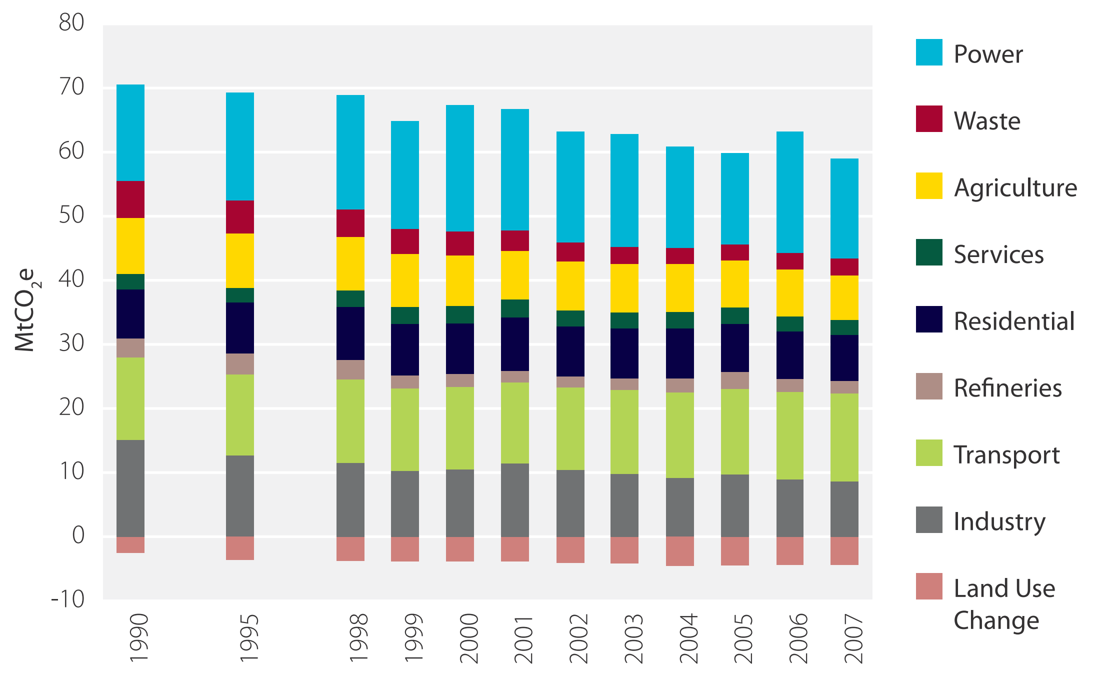


Source: NAEI (2009).
Note: Emissions date for Devolved Administrations is available on an annual basis from 1998 only.

Box 1.4 GHG emissions in the Devolved Administrations 1990-2007

Scotland

Figure B1.4a Scotland Greenhouse Gas Emissions by UEP sector 1990–2007



Source: NAEI (2009).
Note: UEP = Updated Energy Projections.

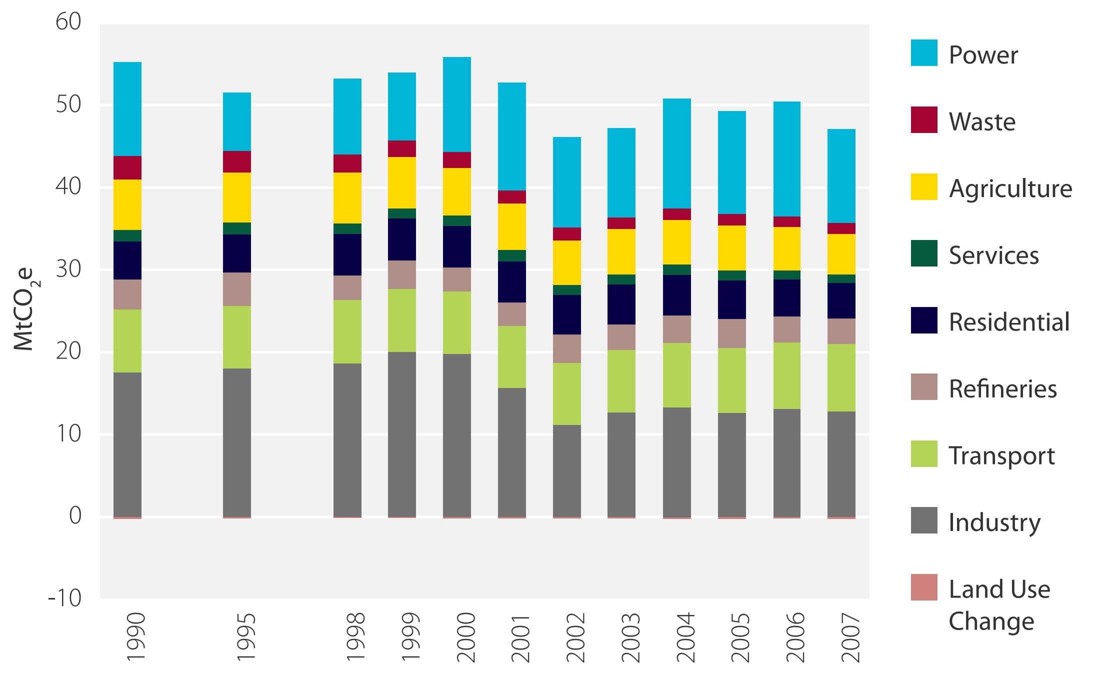
Net GHG emissions in 2007 were 54.5 $MtCO_2e$, 20% below 1990 levels and 7% below the previous year. Excluding power, emissions have fallen 27% from 1990 and 2% in the last year.

- Power station emissions accounted for over a quarter of Scotland's total GHG emissions in 2007. Emissions are up 4% on 1990 levels, although they have dropped 17% since 2006.
- GHG emissions from industry accounted for 16% of Scottish GHG emissions. Emissions in 2007 were down 43% on 1990 levels, and 3% on the previous year.
- Transport emissions accounted for a quarter of the Scottish GHG total. They have grown on average 0.4% per annum since 1990, driven by increasing demand for road transport (which accounts for three-quarters of all transport emissions), and grew by 1% between 2006 and 2007.
- Residential emissions continued on a long-term downwards trend, falling 7% on 1990 levels and 3% on the previous year.
- Emissions from public and commercial services fell by 1% between 1990 and 2007, and dropped by 4% between 2006 and 2007.
- Agriculture emissions were down 21% on 1990 levels, falling 4% between 2006 and 2007.
- Waste emissions were down 54% on 1990 levels, up 1% on the previous year.

Box 1.4 continued

Wales

Figure B1.4b Wales Greenhouse Gas Emissions by UEP sector 1990–2007



Source: NAEI (2009).

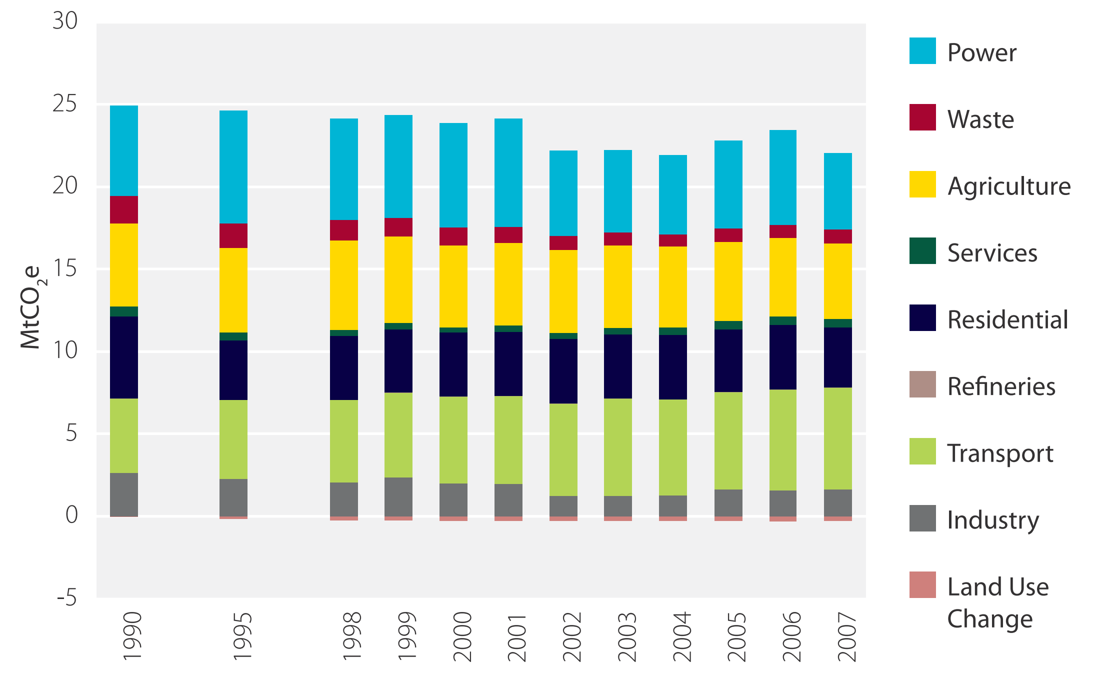
Net GHG emissions in 2007 were 46.8 $MtCO_2e$ – 15% below 1990 levels, 7% below the previous year. Excluding power, emissions have fallen 19% from 1990 and 2% in the last year.

- Power station emissions accounted for a quarter of total GHG emissions in 2007. Emissions in 2007 were comparable to 1990 levels, having dropped by 18% on 2006.
- GHG emissions from industry accounted for over 27% of Welsh GHG emissions. Emissions were down 27% on 1990 levels, and 2% lower than the previous year.
- Transport accounted for 17% of Wales' GHG emissions. Transport emissions have grown on average 0.4% per annum since 1990, driven by increasing demand for road transport (which accounts for three-quarters of all transport), and in 2007 were up 0.7% on the previous year.
- Residential emissions were down 9% on 1990 levels and 6% on the previous year.
- Emissions from public and commercial services fell by 20% between 1990 and 2007, and dropped by 5% between 2006 and 2007.
- Agriculture emissions were down 19% on 1990 levels and down 6% compared to the previous year.
- Waste emissions have more than halved since 1990, although there have been no further significant reductions in the past few years.

Box 1.4 continued

Northern Ireland

Figure B1.4c Northern Ireland Greenhouse Gas Emissions by UEP sector 1990–2007



Source: NAEI (2009).

Net GHG emissions in 2007 were 21.8 $MtCO_2e$ – 12% below 1990 levels, 6% below the previous year. Excluding power, emissions have also fallen 12% from 1990, but by 2% in the last year.

- Power station emissions accounted for over a fifth of total GHG emissions in Northern Ireland in 2007. In 2007, emissions were 15% lower than in 1990 and 19% lower than in 2006, returning to 2003-2004 emission levels.
- GHG emissions from industry accounted for only 7% of Northern Ireland's GHG emissions. Emissions were down 38% on 1990 levels, although up 2% on the previous year.
- Emissions from transport accounted for 28% of Northern Ireland's GHG emissions. They have grown on average 1.9% per annum since 1990 and by 1.4% between 2006 and 2007, entirely driven by increasing demand for road transport which accounts for almost 80% of all transport emissions.
- Residential emissions continued on a long-term downwards trend since 1998, falling 26% on 1990 levels and 7% on the previous year.
- Public and commercial services emissions fell by 25% between 1990 and 2007, and by 3% between 2006 and 2007.
- Agriculture emissions were down 8% on 1990 levels and 3% down on the previous year.
- Waste emissions were down 50% on 1990 levels, but rose by 2% between 2006 and 2007.

Box 1.5 Recent developments in climate change policy and the legislative framework in the Devolved Administrations

Scotland

- The Climate Change (Scotland) Act received Royal Assent on 4th August 2009.
- The Act commits Scotland to reduce its emissions by at least 80% by 2050 compared to 1990 levels, with an interim target for 2020 of a 42% reduction (subject to advice from the Committee).
- In July the Scottish Government published the Climate Change Delivery Plan[5], which identifies the key sectors for abatement in Scotland and the high level measures required in each sector to deliver both a 34% and 42% emissions reduction target by 2020.

Wales

- Wales has set a target to reduce emissions under devolved competence by 3% per year from 2011.
- In June, the Welsh Assembly Government published its *Programme of Action*[4], a consultation on the government's climate change strategy. The consultation sets out in more detail the actions the WAG are proposing to deliver their climate change objectives.
- The final Climate Change strategy will be developed following the consultation and is expected by the end of 2009.

Northern Ireland

- Northern Ireland aims to reduce greenhouse gas emissions by 25% in 2025.
- Northern Ireland has made a number of recent announcements and publications relevant to action on climate change mitigation:

– Draft strategic Energy Framework[6], which proposes new and ambitious renewable electricity and renewable heat targets by 2020.

– Draft Cross Departmental Bioenergy Action Plan[7].

– The Northern Ireland Executive agreed on 30 July to extend the Carbon Reduction Commitment to all NI government Departments regardless of whether they meet the minimum criteria for the scheme.

4 Available at: http://new.wales.gov.uk/consultations/environmentandcountryside/climatechangeaction/
5 Available at: http://www.scotland.gov.uk/Publications/2009/06/18103720/0
6 Available at: http://www.detini.gov.uk/cgi-bin/get_builder_page?page=4861&site=5&parent=149
7 Available at: http://www.detini.gov.uk/cgi-bin/moreutil?utilid=1223

Chapter 2: Implications of the recession and credit crunch for meeting budgets

Introduction and key messages

The credit crunch and the recession have a number of potential consequences for meeting carbon budgets:

- The decline in GDP will reduce emissions which will make it easier to meet the first and possibly subsequent budgets.
- At the European level, the decline in industrial output and energy demand has resulted in a low carbon price and low expectations of future prices which, if this were to sustain, would undermine incentives for investment in low-carbon power generation and measures to reduce emissions in other energy-intensive industry.
- Fiscal stimulus has inspired a debate over how to finance low-carbon measures such as energy efficiency improvement.
- As a result of the banking crisis and fears over borrowing ('credit crunch'), securing finance for required investments in renewable electricity generation has become more challenging.

This chapter assesses the impacts of the current circumstances for meeting carbon budgets. The key messages are:

- It is possible that the first budget could be achieved with very limited or no emissions reduction *effort*. It is imperative, however, that measures are implemented in the context of meeting medium and long term objectives. Any strategy to reduce emissions should therefore be focused on implementation of necessary measures. To the extent that outperformance ensues, this should not be banked in order to sustain incentives for emissions reductions in subsequent budget periods.
- The carbon price is likely to be significantly lower to 2020 than we previously projected. This will have consequences for investments in low-carbon power generation. A range of measures including tightening the EU ETS cap and a UK carbon price underpin should be seriously considered to strengthen incentives for low-carbon investments in the energy-intensive sectors.
- As a result of the credit crunch there is limited finance available for investments in renewable electricity. The Government has partially addressed this through measures in the 2009 Budget. The need for further intervention, however, cannot be ruled out and should be kept under review.

We set out our analysis in four sections:

1. The cost of meeting carbon budgets in a recession
2. The impact of the recession on emissions in the non-traded sector
3. Impacts of the recession on the traded sector and the carbon price
4. Opportunities and challenges for meeting carbon budgets in the current macroeconomic circumstances.

1. The cost of meeting carbon budgets in a recession

In our December 2008 report we estimated that the cost of meeting our Intended carbon budget in 2020 will be less than 1% of GDP. As a result of the recession, HM Treasury now forecast GDP to be lower in 2020 than previously projected. Our key message remains: we expect the cost of meeting the Intended budget in 2020 will still be less than 1% of GDP after accounting for the recession.

We argue that this cost should be accepted given the costs and consequences of doing nothing. The imperative to act now towards meeting long-term objectives remains notwithstanding the recession. We do not therefore consider possible reductions to the level of ambition underpinning carbon budgets in this chapter.

We highlighted the need in the December 2008 report to consider not only aggregate or average costs, but also distributional impacts. In particular, and given our duties under the Climate Change Act, we focused on fuel poverty impacts.

Our analysis showed that higher energy prices required to cover the cost of renewable electricity and heat will exacerbate fuel poverty, but that this will be offset by energy efficiency improvement and the impact that this will have in reducing energy bills. We estimated that these effects largely balance such that achieving the Intended budget would result in a similar level of fuel poverty to now.

Fuel poverty is therefore not a consequence of meeting carbon budgets. It is, however, an important social issue which may have become more pronounced as a result of the recession. The Committee's view is that fuel poverty can and should be addressed through a range of policy interventions including energy efficiency improvements which will be important given that many fuel poor live in inefficient housing (Chapter 5).

2. The impact of the recession on emissions in the non-traded sector

Our economy-wide carbon budgets comprised traded and non-traded sector budgets (Figure 2.1):

- The traded sector includes power generators and other energy-intensive firms covered by the EU ETS.
- The non-traded sector includes anything outside the EU ETS – heat consumption in buildings and industry, transport fuel consumption, land use change and forestry, non-CO_2 emissions from agriculture, waste and industry.

This section focuses on the emissions impact of the recession in the non-traded sector, and in particular on CO_2 emissions (rather than non-CO_2 emissions), as these are more directly affected by economic growth.

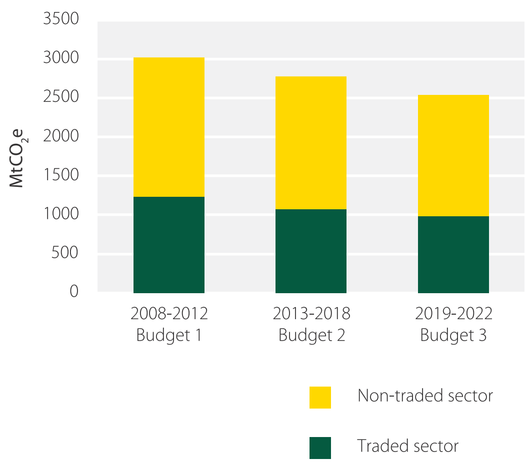
Our recommended non-traded sector budget was designed to require implementation of emissions reduction measures. Emissions are, however currently a function of economic activity, and it is possible that the first budget could now be achieved through emissions reductions due to the recession. This would be a problem given the need to implement measures in order to lay the foundation for meeting subsequent budgets and longer-term targets.

In this section we set out analysis showing the order of magnitude of emissions reduction due to the recession, and implications for the appropriate policy approach. We now consider:

(i) New emissions projections

(ii) Aiming to outperform the first budget.

Figure 2.1 Interim UK carbon budgets, 2008–2022



Source: DECC.

(i) New emissions projections

Assumptions and modelling approach

In order to assess the potential impact of GDP on emissions we have developed new projections based on revised GDP, fossil fuel price and other assumptions:

- The revised GDP forecast incorporates the Government's Budget 2009 assumptions of 0.75% growth in 2008, 3.5% contraction in 2009, recovery starting in 2010 and subsequent annual average growth of 2-2.5% 2014-2022 (Table 2.1);[1] the overall impact of the recession is assumed to be a permanent reduction in GDP of around 6% by 2020 (Figure 2.2).
- We have used the Government's latest fossil fuel price projections.[2] These are slightly higher than those used in our December 2008 report, and are based on a central case assumption that the oil price in 2020 will be around $80/bbl in 2020 (Figures 2.3-2.5).
- We have adjusted emissions reduction due to policy delivery under the Climate Change Programme down in line with current Government estimates, for example to allow for previous double counting of policy impacts (Box 2.1).
- We have also incorporated DECC's updated split between the traded and non-traded sectors reflecting more detailed sub-sectoral calculations.

We have run these assumptions both through the DECC Energy Model and the Cambridge Econometrics model (Box 2.2).

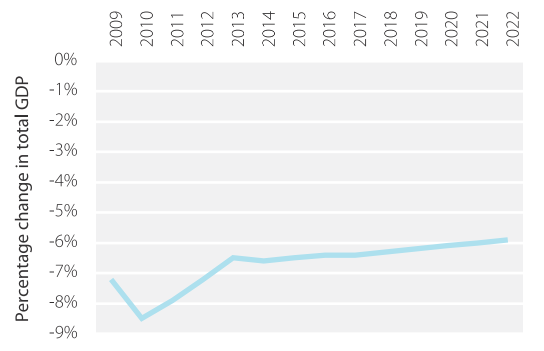
Table 2.1 Central GDP growth forecasts, 2008 and 2009 projections

	Projected growth – consistent with Budget 2008 (%)	**Revised projected growth – consistent with Budget 2009 (%)**
2007 (actual)	3	
2008	2	¾
2009	2 ½	-3 ½
2010	2 ¾	1 ¼
2011	2 ¾	3 ½
2012	2 ¾	3 ½
2013	2 ¾	3 ½
2014	2 ½	2 ½
2015	2 ¼	2 ½
2016-2022	2 ¼	2 ¼

Source: HM Treasury; CCC calculations.
Note: Growth is rounded to one-quarter percentage point.

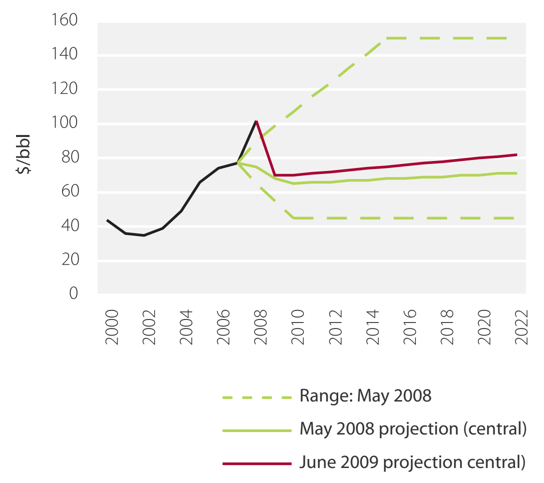
1 HM Treasury (2009), *Building Britain's Future* http://www.hm-treasury.gov.uk/bud_bud09_index.htm
2 DECC (2009) *Communication on DECC Fossil Fuel Price Assumptions*. Note: we have taken Scenario 2 as the central scenario. http://www.berr.gov.uk/files/file51365.pdf

Figure 2.2 Reduction in projected GDP under latest (2009) growth projections, relative to 2008 projections



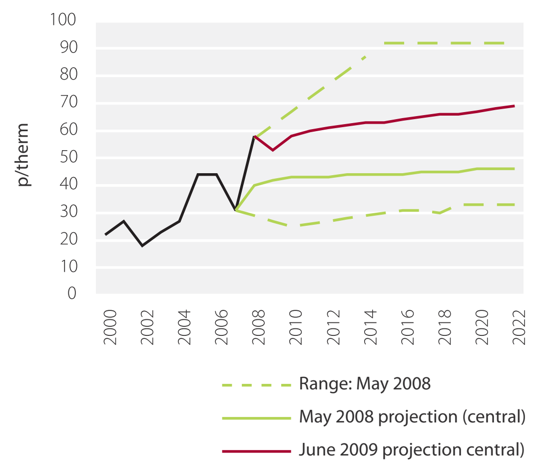
Source: HM Treasury; CCC calculations.

Figure 2.3 Projected annual oil prices ($/bbl) in the 2008 and 2009 projections



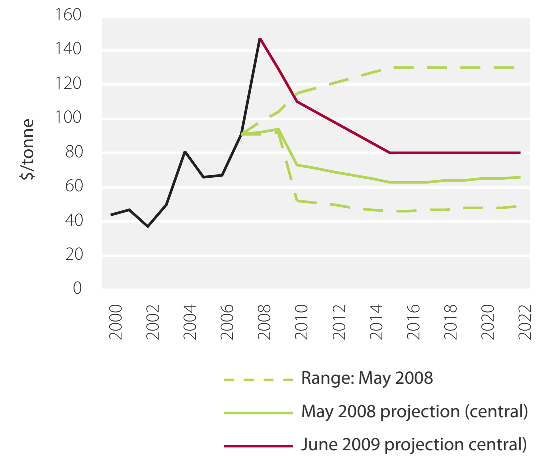
Source: DECC (2009), *Communication on DECC Fossil Fuel Price Assumptions.*

Figure 2.4 Projected annual gas prices (p/therm) in the 2008 and 2009 projections



Source: DECC (2009), *Communication on DECC Fossil Fuel Price Assumptions.*

Figure 2.5 Projected annual coal prices ($/tonne) in the 2008 and 2009 projections



Source: DECC (2009), *Communication on DECC Fossil Fuel Price Assumptions.*

3 DECC (2009), *UK Low Carbon Transition Emissions Projections*, http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

Box 2.1 Adjustments to expected policy savings in the DECC model

Our recommended budgets were based on projections that included official estimates of energy and emissions reductions from policies in place.

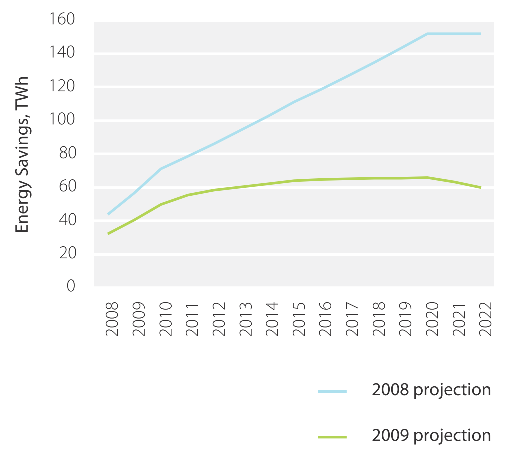
For their latest projections accompanying the Transition Plan[3] the Government revised downwards expected savings from some policies included in the CCC emissions projections. The adjustments relate to the major end-use sectors, primarily residential, and the impacts are significant – overall energy savings are just under 60% lower, by 2020, in the updated projections (Figure B.2.1).

The implications of these revisions (in terms of $MtCO_2$, cumulated over each budget period) are shown in Table B.2.1. The adjustments increase overall direct emissions in the non-traded sector by around 15 $MtCO_2$ in the first budget period, compared with policy savings in the 2008 projections. This partially offsets the fall in non-traded sector emissions due to the recession and updated price assumptions (Figure 2.7).

The adjustments have been made for a number of reasons. Some policies have been re-appraised, based on evidence of policy delivery ex post. For example, in the case of EEC, energy suppliers delivered a lot more compact fluorescent lightbulbs than expected but fewer insulation measures. In other cases the changes reflect different assumptions about 'business-as-usual' energy efficiency savings.

For example, the savings expected from changes to the building regulations in 2002 and 2006 have been scaled back, recognising that some of the efficiency savings would have happened anyway. Finally, a more sophisticated approach has ensured that some double counting due to policy overlaps (e.g. supplier obligations and product policy) has been eliminated.

Figure B.2.1 Energy savings from policies in end-use sectors, 2008 and 2009 projection



Source: DECC Energy Model.
Note: Total electricity, gas, oil and solid fuel saved in residential, industry and service sectors.

Table B.2.1 Increase in emissions due to revision of policy savings, $MtCO_2$

	Budget 1		**Budget 2**		**Budget 3**	
	Direct	**Electricity**	**Direct**	**Electricity**	**Direct**	**Electricity**
Industry (non-traded)	1	0	1	4	2	5
Households	7	1	24	6	46	16
Services	7	0	10	5	12	11
Total	**15**	**2**	**35**	**15**	**61**	**32**

Source: DECC model; CCC calculations.
Note: 'Direct' refers to carbon savings from gas, coal and oil demand. Numbers may not sum to total due to rounding.

Box 2.2 Differences between the Cambridge and DECC models

The Cambridge Econometrics Model (MDM-E3) and the DECC Energy Model both project energy demand and CO_2 emissions on the basis of econometrically estimated relationships. The difference between the DECC and Cambridge model results chiefly from differences in the estimated demand equations, upon which projections are based. Therefore, the models contain differing demand elasticities and in some cases different demand drivers. These result in energy demand for the non-traded sectors in the Cambridge model being more sensitive to changes in economic growth than in the DECC model.

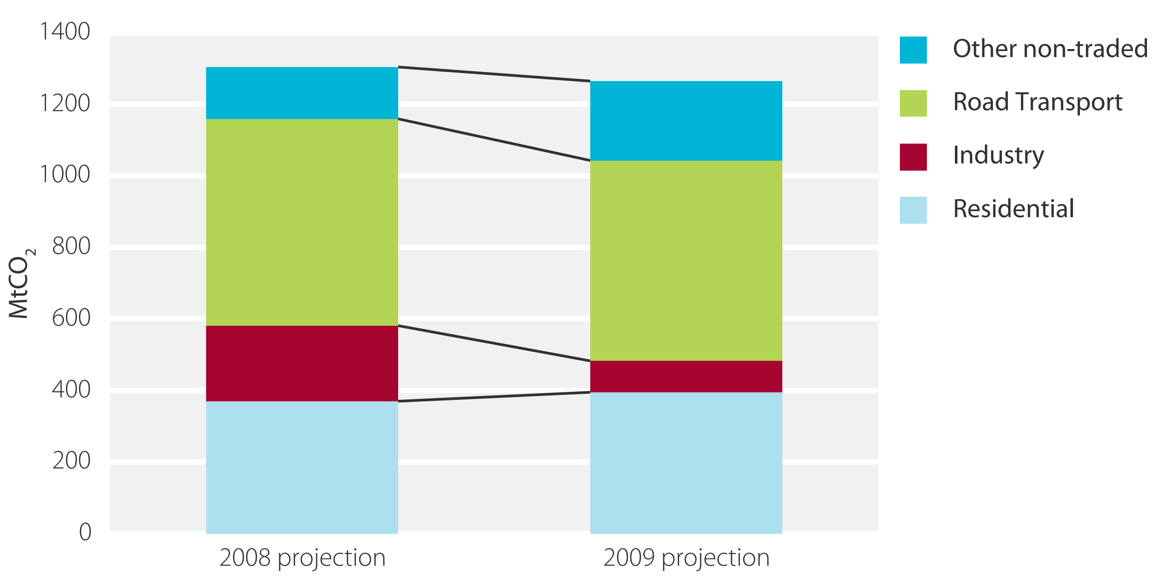
Emissions projections for the non-traded sector

Under the revised assumptions set out above, the DECC Energy Model projects overall non-traded sector CO_2 emissions to be around 40 $MtCO_2$ (i.e. 3%) lower than the previous projections on which the first budget was based (Figure 2.7 and Table 2.2):

- Emissions are around 35 $MtCO_2$ lower in response to falling GDP.
- Emissions are a further 20 $MtCO_2$ lower due to the updated projection of the split between non-traded and traded sectors.
- Offsetting this by around 15 $MtCO_2$ are the revised estimates of what climate change policies are expected to deliver (Box 2.1).

If these lower emissions were to ensue in practice, this would mean that the first budget could be achieved with limited emissions reduction effort (e.g. emissions reductions under CERT would not be required to meet the budget).

Figure 2.6 Projected CO_2 emissions in the non-traded sector for the first budget period (2008-2012), 2008 and 2009 projection



Source: DECC Energy Model.

Table 2.2 Change in projected non-traded sector emissions in the DECC model, 2008 and 2009 projection

	Budget 1
	2008-2012
$MtCO_2$	-40
Percentage change	-3%

Source: DECC; CCC calculations.
Note: shows change in non-traded emissions due to updated assumptions (growth, prices, policy expectations and traded coverage).

Table 2.3 Change in projected non-traded sector emissions in the Cambridge model, 2008 and 2009 projection

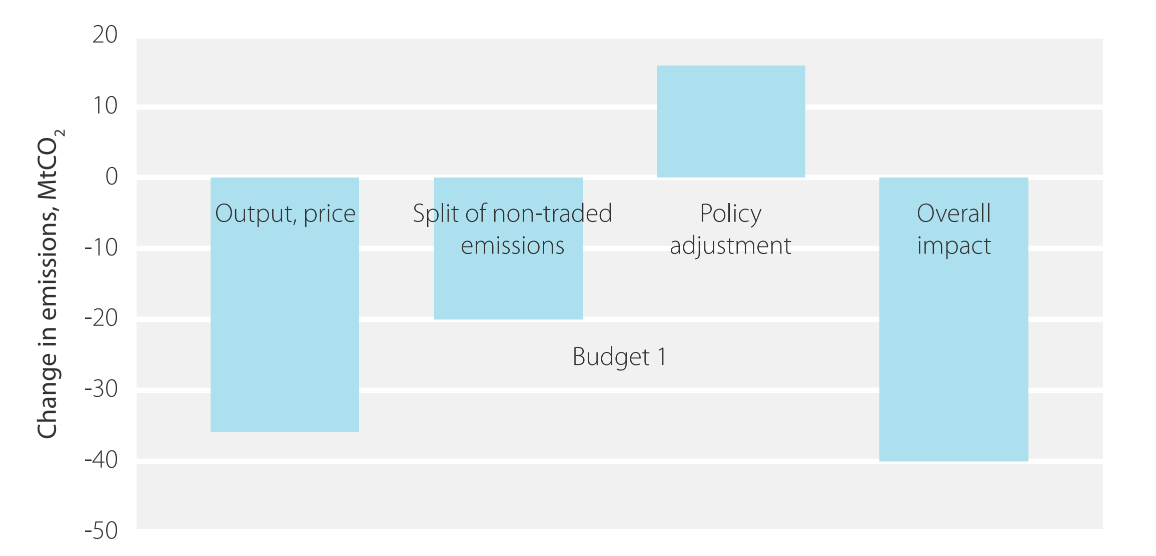
	Budget 1
	2008-2012
$MtCO_2$	-90
Percentage change	-7%

Source: Cambridge Econometrics; CCC calculations.
Note: shows change in non-traded emissions due to updated assumptions (growth, prices, and traded coverage, but not revised policy expectations).

The Cambridge Econometrics model projects that non-traded sector emissions will fall by over 90 $MtCO_2$ (-7%) in the first budget period (Table 2.3) based on new GDP and fossil fuel prices:[4]

- Emissions in transport fall by around 45 $MtCO_2$; this is in contrast to the DECC model, where emissions fall by 19 $MtCO_2$.
- Emissions in the residential sector fall by 32 $MtCO_2$; this is in contrast to the DECC model, where emissions actually increase by 23 $MtCO_2$.
- After adjusting for new estimates of emissions reduction due to lower policy delivery (around 15 $MtCO_2$), overall non-traded projections from the Cambridge Econometrics model are of the order of 75 $MtCO_2$ lower than previously projected (a reduction of 6%).

Figure 2.7 Change in cumulative non-traded emissions in the first budget period, 2008 and 2009 projections



Source: DECC Energy Model; CCC calculations.

4 Cambridge Econometrics (2009) *An Impact Assessment of the Current Economic Downturn on UK CO_2 Emissions.*

Weight should be attached to the projections from the Cambridge model for two reasons:

- The review commissioned by the Committee of the DECC model and carried out by Oxford Economics in the context of our December 2008 report raised questions about the ability of the DECC model to project transport and residential emissions for off-trend GDP growth (in the event of a recession, for example).[5]
- Increasing residential emissions projected by the DECC model in response to declining GDP appears to be counter intuitive; the Committee would expect an emissions reduction as GDP falls.

There is a significant risk that the first budget could therefore be achieved with very limited or no emissions reduction effort.

(ii) Aiming to outperform the first budget

The analysis above suggests that we may no longer need the full implementation of our measures to meet the first budget; and that monitoring only emissions could provide a distorted picture of how the UK is performing relative to medium and long-term challenges. The Committee therefore recommends:

- The focus of emissions reduction strategy should be implementation of underlying measures, rather than using falling emissions *per se* as a measure of success.
- The Government should aim to implement necessary measures and to outperform the first budget by up to 75 $MtCO_2$ (i.e. building in effects of the recession as suggested by the Cambridge Econometrics model) and, in order to preserve incentives for future required emissions reductions, any outperformance should not be banked[6] for use in the second budget period.

We summarise what in our view needs to be achieved in terms of underlying measures to drive emissions reductions consistent with medium/long-term objectives in Chapter 3, and set out our indicators in detail in Chapters 3-6.

The Committee also recommends that the Government reviews its approach to emissions projections with a view to ensuring that these are robust to changes in key economic drivers.

3. Impacts of the recession on the traded sector and the carbon price

We now consider EU level impacts of the recession on the carbon price and implications for incentives to invest in low-carbon technologies in the UK's traded sector.

The Committee's recommended traded sector budget reflected the UK's caps under Phase II and III of the EU ETS. We will not out or underperform this budget as a result of the recession:

- From an accounting perspective, in normal circumstances we will by definition exactly meet the traded sector budget given that the EU ETS cap is binding.
- Falling emissions in the traded sector as a result of the recession would result in the UK selling more or purchasing less EUAs from the rest of Europe to meet a given cap.
- At the EU level, falling traded sector emissions would require less emissions reduction effort to meet a given cap, and would therefore result in a lower carbon price.

In considering the traded sector, the Committee will seek to ensure that investments are made in low-carbon power generation not only to meet the EU ETS cap in 2020 but also to deliver longer-term objectives; we set out our view of required investments and delivery mechanisms in Chapter 4.

5 Oxford Economics (2008) *Review of the BERR Energy Demand Model* http://www.theccc.org.uk/pdfs/Final_Report_Dec_2008.pdf
6 The Climate Change Change Act allows for an unlimited amount of emissions reductions which exceed those budgeted to be banked towards meeting the next budget, subject to advice by the Committee.

The recession across Europe has impacted on output from energy-intensive industries. Emissions from these industries have therefore fallen without the need to improve energy efficiency or switch away from burning coal in power generation. Given that we would not expect this reduction to be offset by increased output or emissions in the period to 2020, there is now less emissions reduction effort to meet the EU ETS cap than was the case prior to the recession (Figure 2.8).

The reduced need for effort would lower the cost of meeting the EU ETS cap in the period to 2020 and therefore could be regarded positively. Given that it is emissions reduction effort that drives the carbon price, however, we would now expect a lower carbon price in the period to 2020 than we projected in our December 2008 report. This is likely to be a problem given that we rely on the carbon price as one of the main levers for delivering low-carbon investment in long-lived assets in the energy-intensive sectors, and hence in preparing for emissions reduction in future.

We assess carbon price impacts of the recession and policy implications as follows:

(i) Recent carbon price movements and drivers

(ii) Policy implications.

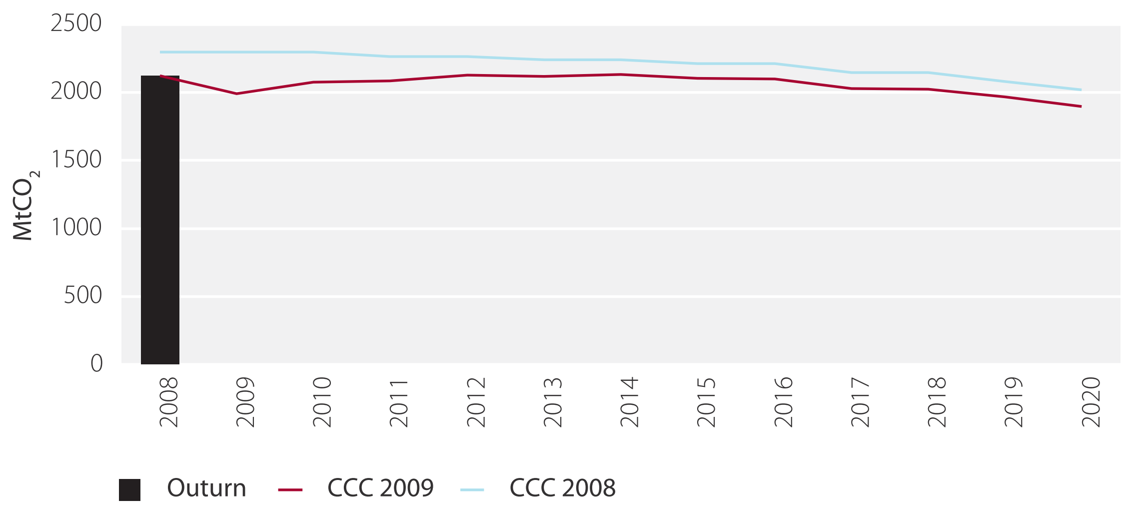
(i) Recent carbon price movements and drivers

In our December 2008 report we projected a carbon price in EU ETS that would increase to €56/tCO_2 (in 2008 prices) in 2020, against an average market price for the first half of 2008 of €24/tCO_2. The carbon price has subsequently fallen to a low of €8/tCO_2, averaging €22/tCO_2 in the second half of 2008 and €13/tCO_2 in the first half of 2009 (Figure 2.9).

There are two areas where changes in fundamentals may have had an impact on the carbon price:

- Output in energy-intensive sectors has fallen as a result of the recession and is expected to remain lower than previously projected. This means less abatement is required to meet the EU ETS cap which is reflected in a lower carbon price.
- The market perception of future fossil fuel prices may have been revised downwards as the market price of oil has fallen from a high of over $140/bbl in July 2008 to around $70/bbl in summer 2009.

Figure 2.8 Change in EU 'business as usual' emissions projections due to the recession



Source: CCC calculations based on PRIMES modelling outputs (2008); Deutsche Bank (2009), *How long is a piece of string?*
Note: Projections do not include aviation emissions. PRIMES estimates are adjusted to take account of the inclusion of a carbon price and the CCC's estimates of savings from the 2020 renewable energy and energy efficiency targets. Deutsche Bank estimates are adjusted to take account of the CCC's estimates of savings from the 2020 renewable energy and energy efficiency targets.

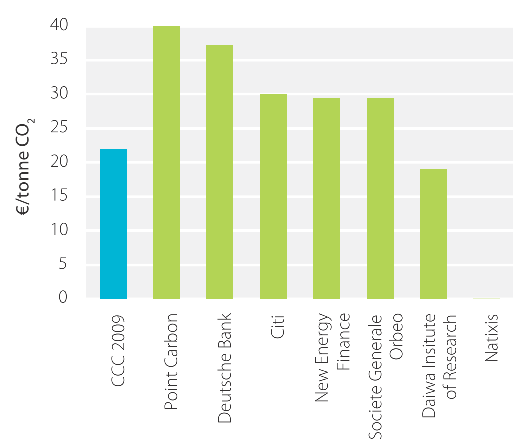
Figure 2.9 Allowance price evolution in the EU ETS 2005-2009

Source: European Climate Exchange (www.ecx.eu).
Notes: Prices are nominal. Phase I prices are for December 2007 settlement. Phase II prices are for December 2009 settlement.

We have used the DECC EU ETS Marginal Abatement Cost Curve Model (i.e. not DECC's UK Energy Model) to develop new projections based on revised assumptions about output and fossil fuel prices, as well as improved estimates of the abatement available in energy-intensive industrial sectors (Box 2.3).

Our new analysis produces a central projection for the carbon price in 2020 of around €22/tCO_2 compared to our previous projection of €56/tCO_2; most market commentators now project a price around or below €30 (Figure 2.10). The fact that these projections are not in line with the carbon prices we expect in the 2020s and beyond (e.g. in excess of €100 by 2030, based on our previous modelling of global emissions trajectories and abatement opportunities) reflects a disconnect between current and future prices (i.e. post 2020) due to uncertainty over longer-term emissions reduction trajectories.

Figure 2.10 Market projections of the EUA price in 2020 since the onset of the recession



Source: CCC modelling; Point Carbon (July 2009); Deutsche Bank (July 2009); Citi Investment Research and Analytics (July 2009); New Energy Finance (July 2009); Societe General Orbeo (May 2009); Daiwa Insitute of Research (February 2009); Natixis (Chief Carbon Economist at Natixis E&I, July 2009).
Note: Inflation rate of 2% was assumed to adjust estimates to real 2008 prices. Point Carbon estimate is a probability weighted value for 2016.

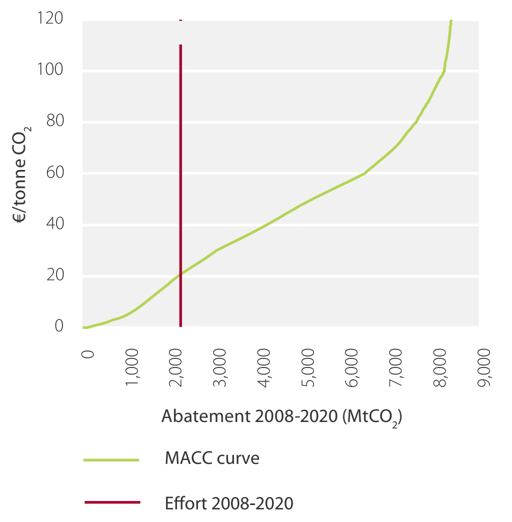
Box 2.3 Carbon price analysis

The DECC EU ETS MACC model estimates a price based on the marginal (most expensive) abatement action required to meet the cap by comparing the effort required with a marginal abatement cost curve (MACC) – Figure B.2.3. The wide range of projections for the various assumptions (e.g. fossil fuel prices, reference emissions) means there is a great deal of uncertainty over the carbon price projections.

Total domestic effort is estimated by looking at the difference between reference case (business as usual) emissions and the EU ETS cap:

- **Reference case emissions:** We have adjusted our estimate of reference case emissions to take account of the impact of the recession. Our estimate of reference emissions is based on projections published by Deutsche Bank,[7] adjusted to take account of the CCC's estimates of savings from meeting the 2020 EU renewable energy target and partially meeting the 2020 EU energy efficiency target (Figure 2.8).

Figure B.2.3 Effort and marginal abatement costs in the EU ETS sectors over Phases II and III



Source: CCC calculations based on CCC assumptions; DECC EU ETS marginal abatement cost curve model.
Note: Prices in €2008. Effort is the difference between business as usual emissions and the cap, net of CDM allowances.

- **Banking:** Because banking of allowances across years is allowed, we have looked at effort across Phases II and III as a whole rather than for any one year or Phase in isolation. Given uncertainty over future caps, we have assumed that the option to bank allowances into Phase IV has no impact on the Phase II and III price.
- **Aviation:** In line with the Directive, all departing and arriving aviation emissions are included from 2012. This increases required abatement effort from our assumptions last year, when in the absence of an agreed position, we only included departing aviation. Reference case emissions for aviation are estimated from outputs of the AERO model.[8]
- **Abatement through the purchase of offset credits:** We assume allowed CDM usage as in the Directive.
- **The cap:** We continue to derive the EU ETS cap from the Directive, and assume that there is a global agreement on emissions reductions and thus that a 30% GHG target applies in the EU.

The cost and quantities of abatement available are estimated using the DECC model of marginal abatement costs in the EU ETS:

- **Fuel switching in the power sector:** The DECC EU ETS MACC model is dominated by abatement achieved through fuel switching, that is, generating from gas-fired stations rather than coal-fired stations. The cost of fuel switching varies according to the efficiencies of the plants involved, but is primarily driven by the relative price of coal and gas. We have used DECC's latest fuel price estimates, based around an oil price of $80/bbl in 2020.[9]

7 Deutsche Bank (2009), *How Long is a Piece of String?*
8 van Velzen, Andre (2006), *Computational results from the AERO model for Impact Assessment of including aviation in the EU ETS*
9 DECC (2009) *Communication on Fossil Fuel Prices*, http://www.berr.gov.uk/files/file51365.pdf

Box 2.3 continued

- **Abatement in the industrial sectors:** The MACC for industry in the DECC model has recently been updated. This has increased the total amount of abatement available across Phases II and III by around 35% and significantly lowered the resulting price estimate.
- **Abatement in aviation:** The model includes no abatement in the aviation sector, which is likely to be a reasonable assumption at lower carbon prices.

Table B.2.3 Summary of key changes in assumptions

Assumption	Compared to estimate used in December 2008 report	Impact on estimated carbon price
Reference case	Lower due to recession	Reduction
Inclusion of aviation	All departing and all arriving aviation included in EU ETS, rather than just all departing	Increase
Fuel prices	Greater differential between projected coal and gas prices	Increase
Industrial abatement	More industrial abatement included in revised MACC	Reduction

(ii) Policy implications

In our December 2008 report we noted that the EU ETS plays a useful role reducing emissions in the period to 2020 at least cost. We also highlighted, however, the need to think beyond 2020 out to 2050, given our 80% target and the long-lived nature of assets in energy-intensive industries. We noted the role that carbon prices might play in signalling the need for investment in low-carbon technology in energy intensive industries and particularly power generation, but questioned whether carbon price signals would be adequate given uncertainty about what the carbon price will be to 2020 and beyond.

The fact that market expectations of future carbon prices are low raises a question over whether we can rely on this mechanism to incentivise investment in low-carbon technology. Carbon price uncertainty is compounded by other uncertainties (e.g. over fossil fuel prices, technology costs, electricity prices) with the result that there are plausible scenarios where incentives for required investment in low-carbon technologies are limited; we set out a detailed analysis of investment in low-carbon power generation given carbon price and other uncertainties in Chapter 4.

The only situation where investments in low-carbon technology would then proceed is if investors attach significant weight to scenarios with a significantly increasing carbon price over the next decade and through the 2020s. We believe that this is currently unlikely for two reasons:

- There is a great deal of uncertainty over what the arrangements will be for determining the carbon price in the 2020s.
- It is difficult to make an investment business case around a price that is currently low but that is projected to increase significantly in 20 years time, particularly where the increase is subject to significant political risk.

We cannot therefore be confident that the EU ETS will deliver the required low-carbon investments for decarbonisation of the traded sector through the 2020s. Given this risk, the Committee recommends that a range of options for intervention in carbon and electricity markets should be seriously considered:

- Ideally EU level action would be taken to increase the carbon price (i.e. the EU ETS cap could be tightened and firmed up beyond 2020, and/or use of offset credits to meet the cap restricted) and to reduce uncertainty (e.g. through introducing auction reserve prices). There is a good opportunity for tightening the EU ETS cap as the EU moves from its 20% to 30% economy-wide emissions reduction targets (i.e. the incremental emissions reduction effort could be focused on the traded sector).
- UK action to underpin the carbon price could provide support for required low-carbon investments. Two options for intervention are a tax that adjusts according to EU ETS price fluctuations to deliver a target carbon price in the UK, or contracts for differences between the Government and investors in low-carbon technology.
- UK action might also be in the form of electricity market intervention (e.g. through a low-carbon obligation, tendering for low-carbon capacity, etc.).

We consider the case for carbon/electricity market interventions in more detail in Chapter 4, where we call on the Government to undertake a review of the range of options for fundamental reform of current market arrangements.

4. Opportunities and challenges for meeting carbon budgets in the current macroeconomic circumstances

The recession and the credit crunch provide both opportunities and challenges for meeting carbon budgets and developing a low-carbon economy. Two of the most significant are:

- The fiscal stimulus packages in response to the recession provided an opportunity to finance measures which would reduce emissions.
- The credit crunch, however, could potentially restrict finance for investments in low-carbon technologies (e.g. wind generation) that are required in the near term to be on track to meeting carbon budgets and to laying the foundations for a green economy in the UK.

(i) Opportunities for meeting carbon budgets through fiscal stimulus

In November 2008 the European Commission set out a European Economic Recovery Plan based on two pillars:

- *Pillar 1:* A substantial injection of purchasing power into the European economy.
- *Pillar 2:* A programme of smart investments including energy efficiency improvement to create jobs and save energy, and investments in low-carbon technologies to boost low-carbon markets of the future.

In February 2009 the Grantham Research Institute (LSE) published a detailed analysis of the case for a 'green' stimulus arguing that:

- green measures could leverage social returns of fiscal stimulus subject to these measures being timely, targeted and temporary (Box 2.4)
- energy efficiency measures best meet the criteria for being included in a recovery plan, and there may be some benefit in measures to encourage consumers to switch to more low-carbon cars (Table 2.4).

We now consider energy efficiency improvement in the UK fiscal stimulus. Our aim is to assess what further measures are required given what was included in the fiscal stimulus.

Energy efficiency improvement in the UK fiscal stimulus

The UK fiscal stimulus in Budget 2009 included various measures to support energy efficiency improvement:

- £100 million to improve the insulation for 150,000 homes in the social sector through the Decent Homes programme in England
- £100 million for the construction of new homes at higher energy efficiency standards
- £100 million of new funding for low-cost loans for energy efficiency measures in small and medium-sized enterprises
- £65 million of new funding for loans to install energy efficiency measures in public buildings.

Box 2.4 The six criteria in the case for a 'green' stimulus, Grantham Research Institute

- Timeliness: Can the measure be implemented soon after the initial shock to demand (i.e. within the first year or so)?
- Long-term social returns: With respect to climate change objectives, will the measure be effective in significantly reducing emissions?
- Positive lock-in effects: Does the measure bring permanent effects to the economy, for example, reducing dependence on high-carbon energy?
- Domestic multiplier/job creation: To what extent will it create jobs, and stimulate the domestic economy?
- Targeting areas with slack: Does it target areas of the economy that are under-utilised – for example, construction in the event of a downturn in the housing market?
- Time limited/reversibility: To what extent will it bring forward investment that would have otherwise been made, but later on?

Source: Grantham Research Institute on Climate Change and the Environment (2009), *An outline of the case for a 'green' stimulus* http://www.lse.ac.uk/collections/granthamInstitute/

Table 2.4 Grantham scoring of measures to tackle climate change, as part of a fiscal stimulus (selected proposals)

Scores: (1= worst, 3 = best)	**Timeliness ('shovel ready')**	**Long-term social return**	**Positive lock-in effects**	**Domestic multiplier /job creation**	**Targeting areas with slack**	**Time-limited/ reversability**
Investment approach: Mixed public / private						
Residential energy efficiency (lofts, etc.) either utility-driven or local authority driven	3	3	2	3	3	3
Energy efficiency measures for public buildings	3	3	2	3	3	3
Boiler replacement programme	3	3	2	3	3	3
Investment approach: Private with incentives						
Lights and appliances, e.g. utility-driven	3	3	2	3	3	3
Renewable heat/fuel switch (e.g. solar, biomass)	3	3	2	3	3	3

Source: Grantham Research Institute (2009), *An outline of the case for a 'green' stimulus.*

Given the attractiveness *in principle* of energy efficiency improvement as part of a fiscal stimulus, and the relatively small proportion of the UK fiscal stimulus accounted for by such measures, we have considered whether further support for energy efficiency might be desirable.

The crucial point for the Committee is that any further fiscal stimulus should be looked at within the context of the close to £9 billion worth of energy efficiency measures currently committed for 2008-11 (Table 2.5), as well as new measures already in train such as the Carbon Reduction Commitment.

The resourcing of energy efficiency is an important issue going forward, but one that can potentially be dealt with by proposed new financing mechanisms, i.e. without further fiscal stimulus (Chapter 5).

Table 2.5 Main energy efficiency programmes and measures

Measures	Main features	Budget
Domestic sector		
Carbon Emissions Reduction Target (CERT)	Obligation on energy suppliers to achieve CO_2 reduction targets in the domestic sector. At least 40% of carbon savings must be in 'priority group' of low income and elderly customers.	£3.2 billion (2008-11)
Community Energy Saving Programme (CESP)	Supplier programme funding of 'whole house' packages in up to 100 low income areas	£350 million (2009-12)
Warm Front	Grants up to a maximum of £6k for the installation of energy efficiency measures in vulnerable private sector households.	£959 million (2008-11)
Decent Homes (thermal element)	Funds measures to increase energy efficiency in social sector homes.	£2 billion (2008-11)
Commercial & industrial sector		
Climate Change Agreements (CCAs) and Climate Change Levy (CCL)	CCAs allow eligible energy-intensive business users to receive up to an 80% discount from the CCL in return for meeting energy efficiency or carbon-saving targets.	£280m (2008-09)
Enhanced capital allowances	100% first year capital allowances for energy-saving investments by the private sector.	£95m (2008-09)
Carbon Trust interest-free loans	Unsecured, zero interest loans up to £400k for companies to undertake energy-saving projects.	£100m (2009-11)
Total		**£2.7 billion (per annum)**

Source: CCC calculations.

Measures to encourage purchase of more low-carbon cars

In the Budget 2009 the Government announced a scrappage scheme under which anybody scrapping a car or van aged ten years old or more would receive £2,000 towards the purchase of a new vehicle.[10] £300 million has been set aside for this scheme which will run from May 2009 until March 2010 or until 300,000 vehicles have been purchased.

We have considered:

- whether this scheme is likely to have a positive emissions impact which will contribute significantly to meeting the first carbon budget
- and whether there is any rationale to continue scrappage beyond the initial period.

The scheme could potentially have a positive impact in reducing emissions given the difference in fuel efficiency of old and new vehicles (Table 2.6).

Our analysis (summarised in Box 2.5) suggests the following conclusions:

- A time-limited scrappage scheme can induce a very small short-term reduction in emissions.
- Future scrappage schemes (if any) should be targeted at lower carbon vehicles (e.g. below a gCO_2/km threshold).
- In particular, scrappage schemes could be used to encourage uptake of new technologies (e.g. electric vehicles).

Going forward, possible scrappage schemes should be assessed in the context of a broader strategy to bring low-carbon vehicles to the market. We set out our vision for transport sector decarbonisation in Chapter 6.

Table 2.6 Emissions intensity of a range of cars

Size	Example Brand	Market Segment	Test cycle efficiency of new cars (gCO_2/km)*		
			1999	2003	2007
Small	Smart Fortwo	A. Mini	144	136	129
	VW Polo	B. Supermini	157	149	143
Medium	Ford Focus	C. Lower Medium	178	167	158
	Toyota Avensis	D. Upper Medium	191	178	169
	Renault Espace	I. MPV	225	200	179
Large	BMW 5-Series	E. Executive	228	213	197
	Mercedes SLK	G. Sports	223	229	224
	Land Rover Discovery	H. Dual Purpose 4 x 4	273	248	229
	Bentley Continental GT	F. Luxury	310	292	263

Source: SMMT.
* Average new car gCO_2/km for cars in each segment.

10 The Government proposes to match a £1,000 reduction in sale price by the vehicle manufacturer, bringing a total saving of £2,000 per vehicle.

Box 2.5 Analysis of the impact of vehicle scrappage scheme

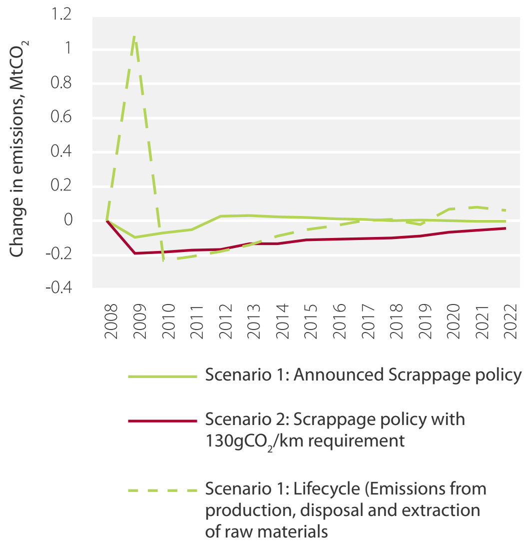
Using the transport Marginal Abatement Cost Curve (MACC) developed by AEA for the analysis in our December 2008 report we simulated two stylised scrappage scenarios:

- Scenario 1: all cars older than nine years are scrapped and replaced by new cars of a similar type (i.e. new small cars replace old small cars, new medium cars replace old medium cars, etc.) for one year only.
- Scenario 2: as Scenario 1, but replacement cars have emissions of 130 gCO_2/km or less (i.e. a large old car cannot be replaced by a new car with emissions above 130 gCO_2/km).

The analysis suggests that the scrappage policy could result in a small and temporary emissions reduction:

- In Scenario 1, net cumulative tailpipe emissions fall by up to around 0.1 $MtCO_2$ over the period to 2020 relative to a situation where there is no scrappage policy (Figure B.2.5).
- This increases to 1.6 $MtCO_2$ in Scenario 2.
- Assessing the impact of a scrappage scheme is further complicated when attempting to take into account lifecycle emissions (i.e. those associated with vehicle manufacture and the disposal and production of fuel). Evidence suggests that these emissions may be of the order 4 tCO_2 per car. Accounting for lifecycle emissions offsets any emissions reduction to 2020 in Scenario 1, and slightly reduces the emissions saving in Scenario 2.
- Preliminary evidence suggests that consumer preferences have been for purchase of more carbon efficient cars with average emissions around 135 gCO_2/km; this is therefore closer to Scenario 2 than 1.

Figure B.2.5 Impact of car scrappage scheme, including lifecycle emissions



Source: CCC calculations.
Note: Emissions from production and disposal are modelled as occurring in the year in which a car is bought, in reality extra cars bought under the scrappage scheme may have been produced in previous years; although this has little impact on the total emissions to 2020.

(ii) Challenges for meeting carbon budgets and building a low-carbon economy in the credit crunch

The global market for environmental goods and services is already worth £3 trillion, and is projected to grow to £4.3 trillion in 2015.[11] The Government sees this as an opportunity and has stated its intention to become a leader in the production of low-carbon goods and services such as offshore wind engineering, low-carbon vehicles, CCS, and financial and consulting services. The Government strategy to achieve this is based around what they have called a new industrial activism (i.e. policies to support development of low-carbon industry).

The credit crunch, however, poses a risk to progress in developing new green sectors, and to meeting carbon budgets, because it is restricting finance available for required low-carbon investments. Renewable generation (specifically wind) and low-carbon vehicle manufacture both require significant near-term investments and could be particularly badly affected by the credit crunch.

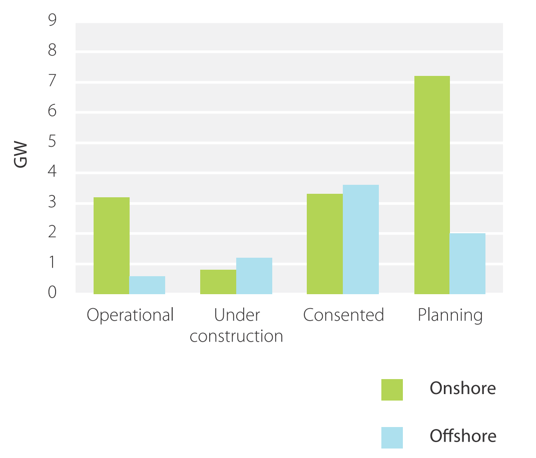
Renewable wind generation

Investment in wind generation is key to necessary decarbonisation of the power sector in the period to 2020 and beyond. We set out our pathways for investment in wind generation in Chapter 4, where we argue that by 2020 an additional 23 GW will be required for the UK to be on track to meeting our 2050 emissions reduction target. In order to achieve what is a very significant increase in wind capacity in 2020 – relative to around 4 GW that is expected to be in operation by the end of 2009 – progress in the near term is required.

There are at least three necessary conditions that must be fulfilled before a wind generation project can proceed:

- the project must have planning approval
- it must have been granted access to the power transmission network
- it must have financing in place.

Figure 2.12 Wind projects according to various stages of development, September 2009



Source: BWEA.

Evidence from the British Wind Energy Association (BWEA) suggests that there are currently around 22 GW of projects at different stages of development, with up to around 7 GW which have planning approval. The implication is that at least a significant proportion of these projects are not proceeding to construction due to a lack of financing.

There are two types of finance for wind projects:

- 'Project finance', where funds are secured on the basis of project cash flows. This is the main mechanism for securing funding for projects sponsored by independent developers.
- 'Corporate finance', where funds are secured based on the credit worthiness of project sponsors rather than project cash flows. This is the main mechanism for securing funding for projects sponsored by large energy companies (via corporate debt, bonds, guarantees, etc.).

In both cases, project economics are key. This is clear in the case of project finance, given that project cash flows provide the security for finance. In the case of corporate finance, project economics will be the determinant of whether sponsors are prepared to accept repayment obligations. There is therefore a question over whether the economics of wind projects remain sound given:

11 Innovas (2009), *Low-carbon Environmental Goods and Services, an industry analysis.*

- Depreciation of Sterling, which is an issue for UK wind projects given that wind turbines are priced internationally.
- Changes in the price of wind turbines due to reduction in global demand (e.g. US demand for wind turbines is significantly down) and commodity price movements.

Even if project economics are sound, there remains a question over whether projects will be able to access finance in the credit crunch. Our discussions with large energy companies, independent developers and investment banks suggest that although corporate finance is available, project finance is very limited, therefore undermining the ability of independent developers to proceed with project implementation.

The package to support renewable electricity investment in Budget 2009 aimed to address both the economic and financial aspects of wind projects (Box 2.6):

- The economics of offshore wind projects has been strengthened by allowing a temporary increase in the ROC multiple, thereby increasing project cash flows.
- The European Investment Bank (EIB) will provide up to an additional £4 billion of finance for energy projects, including renewable projects, £1 billion of which will be part of an intermediated lending scheme targeting onshore wind projects in the UK.

This package is likely to be useful in easing near-term financing constraints, particularly as regards unlocking finance for offshore investments.

Concerns remain, however, that the package does not fully address challenges for independent developers seeking project finance:

- The EIB will lend money to banks who will in turn extend finance to projects, and must therefore accept project risk.
- It is not clear that banks currently have the appetite to accept project risks.

Box 2.6. Details on measures to support wind generation investment

Support to renewable generators is provided in the form of the Renewables Obligation (RO). Eligible generators are issued with Renewable Obligation Certificates (less mature technologies receive multiple certificates) per MWh generated. These are then sold to suppliers who are required to source an increasing amount of electricity from renewable sources. In April 2009, the Government announced plans to increase the number of ROCs from 1.5 to 2 per MWh for offshore wind projects reaching financial close in the next year (falling to 1.75 for those closing the following year, and 1.5 for those closing in 2012-2013). This arrangement allowed a number of key projects to get off the ground, including the London Array (around 1 GW) that were believed to be held back due to financial pressures.

More recently, as part of the £4 billion of new capital from the European Investment Bank (EIB) announced in the Budget, DECC have unveiled an intermediated lending scheme that will generate up to £1 billion of funds, targeted primarily at onshore wind projects. EIB funds will be channelled through existing banks (RBS, Lloyds, BNP Paribas), with the EIB providing up to 50% of debt for qualifying projects, although project risk would remain with banks rather than the EIB.

The Committee therefore recommends that the Government should closely follow the market response to the EIB facility, and consider interim mechanisms to provide comfort to banks (e.g. time-bound guarantees or partial risk guarantees) as appropriate, in order to encourage lending to independent onshore projects.

Looking beyond the near term, there are open questions around both project economics and financial markets and whether current arrangements will secure the level of finance that is required:

- The increase in the ROC multiple is only temporary. Whether future projects would be economically viable at a lower multiple is not currently clear.
- The size of energy company balance sheets may not be sufficiently large to offer guarantees for all of the finance that will be required.

It is necessary, therefore, to keep both project economics and financing conditions under review:

- It may be the case that there should be a continued higher ROC multiple for offshore wind projects, or new ROC rules should be introduced that reduce uncertainty for investors (e.g. indexing of ROC prices on key drivers of cash flow such as the electricity price, load factor, etc.).
- It is likely that increasing amounts of project finance will be required. To the extent that these are not forthcoming in the market, some form of Government intervention might be required.

Difficult financial conditions for new renewable projects, and an overall reduced appetite for risk may not, therefore, be a temporary feature as a result of the recession. At the current stage, therefore, future intervention should not be ruled out (Box 2.7).

Box 2.7. Further measures to support investment in renewable projects

The current RO provides investors with a less certain return than could other forms of intervention (such as feed-in tariffs). Investors are exposed to fluctuations in the electricity price reflecting fossil fuel price and carbon price volatility, and the ROC price itself can vary with the quantity of renewables on the system. Interventions to reduce the risk to developers can help to bring projects forward, particularly at the current time when investors may be more risk averse in the face of the credit crunch.

- In the Renewable Energy Strategy, the Government announced a consultation on the role of a revenue-stabilising mechanism for the RO, that would potentially link the ROC price to the wholesale electricity price.[11] Such a link would provide greater certainty for renewable generators and investors by ensuring revenue is ‘topped up’ when prices are (too) low, and vice versa. In doing so it would provide a more certain return, as received under feed-in tariffs.
- The Government could also step in and offer loan guarantees to investors. This would be like an insurance policy for an investor in the event that a project is unable to service debt repayments. Such loan guarantees typically cover only part of project debt, for a specified time-period. Such a scheme is already in place to encourage lending to UK automotive industry (‘Automotive Assistance Programme’). If correctly designed (i.e. with suitable guarantee pricing and risk coverage) the scheme could be self-financing.
- Green bonds could be a means for increasing long-term finance available for low-carbon investment (e.g. pension fund finance for investment in wind generation). These could be issued by the Government, and regarded as separate from standard bonds given that they would be supported by project cash flows. Alternatively, green bonds could be issued by the private sector, with Government support, either directly (i.e. through financial guarantees) or indirectly (e.g. through providing comfort over the regulatory framework).
- State-owned banks could be directed to finance low-carbon investment (as state-owned banks in other countries have been directed to support national strategic objectives). Alternatively a dedicated Green Infrastructure Bank could be established to raise finance and lend to low-carbon investments.

11 DECC (2009), *Consultation on Renewable Electricity Financial Incentives* http://www.decc.gov.uk/en/content/cms/consultations/elec_financial/elec_financial.aspx

Low-carbon vehicles

Development of low-carbon vehicles is essential for decarbonisation of road transport, both in the UK and globally. The potentially large market for low-carbon vehicles provides an economic opportunity for the UK given that we are currently a significant manufacturer of both vehicles and engines, and therefore have industry expertise upon which to build (Box 2.8).

There are, however, at least two sets of challenges currently facing the industry in moving towards production of low-carbon vehicles:

- The impact of the recession on car demand has raised questions about the availability of funding for innovation.
- The UK car industry is focused on production of large and luxury vehicles with relatively high emissions, and has seen declining levels of R&D.

Nevertheless, recently there have been a number of positive decisions on finance and investment (Box 2.9). The next step should be for the Government to provide an overarching strategy to guide the required industry transition.

A key element of any strategy must be the creation of a market for low-carbon vehicles including electric vehicles and plug-in hybrids; investment is likely to flow elsewhere if market development in the UK lags behind that of other countries. The creation of an early market for electric vehicles is also necessary from the perspective of meeting emissions reduction targets in the first three budget periods and beyond. This will require both price support to cover cost premiums of early electric cars and the development of a charging infrastructure. We set out our views on the appropriate strategic approach to development of a market for electric cars in Chapter 6.

Box 2.8 UK Vehicle Industry

2008 vehicle industry value added in the UK was around £9.5 billion, and directly employed approximately 384,000.

- In 2008, the UK produced around 1.4 million cars, of which around 22% were for the domestic market.
- Production of commercial vehicles was 0.2 million, of which 38% were for the domestic market.
- Production of engines in 2008 was around 3.2 million.

Box 2.9 Progress developing a low-carbon car industry in the UK

- In March 2009 the Government announced that it had put in place guarantees that could unlock European Investment Bank (EIB) loans of up to £1.3 billion for greening of the UK car industry.
- The Government will also provide an additional £1 billion of loan guarantees for projects aimed at improving efficiency but which do not qualify for the EIB loans.
- The Government has established a new Office for Low Emission Vehicles (OLEV) to support the development and roll-out of low-carbon vehicles in the UK.
- In July 2009 it was announced that Toyota will build its new hybrid car in the UK.
- In July 2009 it was announced that Nissan will locate a new battery factory for electric cars in the UK, with discussions ongoing about locating an electric car factory here.

Chapter 3: Emissions reduction scenarios and indicators

In our December report we set out a range of emissions reduction scenarios based on alternative assumptions about Government commitment and policy effort. We showed that there were feasible scenarios for meeting our proposed carbon budgets. In particular, the Government's policies and commitments at the time were sufficient, if successfully implemented, to meet the Interim budget without purchase of offset credits; new commitments would be required to meet the Intended budget through domestic emissions reductions.

In this chapter we set out revised scenarios which reflect:

- New analysis of emissions reduction potential. For example, we have carried out new analysis of the pace at which energy efficiency measures can be feasibly rolled out, and of the scope for emissions reductions through renewable heat.
- New commitments by the Government since the December report was published. Two areas where notable commitments have been made are to try to promote widespread insulation of solid walls and to introduce new policies to tackle emissions reduction potential in agriculture.

The chapter also includes a new framework we will use to monitor progress in meeting carbon budgets. This includes emissions trajectories, not only emissions but also implementation of measures to reduce emissions and the policies required to achieve this.

We argue in the chapter that tracking emissions alone would not be an adequate basis for fulfilling our statutory duty to monitor progress in meeting carbon budgets. This is because there are a number of factors which drive emissions year on year, not all of which would result in sustainable emissions reductions. It is also because many of the measures needed to reduce emissions have long project lead times. Failure to track progress according to different stages of the project cycle could result in a situation where it becomes clear far too late that measures are not being implemented as required.

We therefore complement our emissions reduction scenarios with a set of indicators of progress towards achieving a commensurate level of emissions reduction, including policy milestones and high level incentives that the policy framework should provide.

The main messages in the chapter are:

- Our revised emissions reduction scenarios continue to meet the Interim budget without the need for purchase of offset credits. Meeting the Intended budget would require new commitments from Government or purchase of offset credits.
- The framework of indicators and forward indicators that we set out should not be seen as a concrete plan for meeting budgets which cannot be deviated from. Rather, we envisage a situation where there may be underperformance on some measures and outperformance on others which would on average leave emissions on track to achieve budgets. Our indicators would be useful, however, in highlighting situations where a sufficiently large number of measures are off track that we can no longer be confident that budgets will be achieved. If such situations were to arise, the Committee would then propose remedial measures.
- Policies set out in the UK Low Carbon Transition Plan provide a good foundation for cutting emissions and achieving budgets. It is the Committee's view, however, that there are significant risks for meeting the second and third budgets under the existing framework, and that policy strengthening is required across the power, buildings and industry, and transport sectors.

The chapter is structured in four sections:

1. Revised emissions reduction scenarios
2. The framework for monitoring budgets: indicators and forward indicators
3. Summary of measures to deliver budgets
4. Summary of required policy strengthening to deliver budgets.

It does not include indicators for agriculture or other non-CO_2 gases. It is the Committee's intention to set out a detailed assessment of agriculture emissions in the next progress report to Parliament due in June 2010.

1. Revised emissions reduction scenarios

Emissions reduction scenarios in the December report

In our December report we set out three emissions reduction scenarios which we constructed using a reference emissions projection from which we netted off emissions reductions due to implementation of measures:

- The **Current Ambition** scenario included identified measures that would cost less per tonne than our projected carbon price, and/or which are covered by policies already in place. It also included significant progress towards low-carbon electricity generation and some progress on improving fuel efficiency in new cars. Some policy strengthening would be required to deliver the Current Ambition scenario.

- The **Extended Ambition** scenario incorporated more ambitious but still reasonable assumptions on penetration of energy efficiency improvements and a number of measures which would cost more per tonne than our projected carbon price, but which are important stepping stones on the path to 2050. It was broadly in line with policies to which the Government is committed in principle, but where precise definition and implementation of policy is required. It included, for instance, a significant penetration of renewable heat, more ambitious energy efficiency improvement in cars and some lifestyle changes in home and transport. Delivery of the Extended Ambition would require both strengthening of existing policies and introduction of new policies.

- The **Stretch Ambition** scenario added further feasible abatement opportunities for which no policy commitment was in place, including emissions reduction potential in agriculture, more radical new technology deployment and more significant lifestyle adjustments.

We showed that the Extended and Stretch Ambition scenarios would achieve the non-traded sector Interim budget without the need to purchase offset credits, and the Stretch Ambition scenario would be almost sufficient to achieve the Intended budget. In the traded sector, the Extended and Stretch Ambition scenarios would largely achieve the Interim budget, with the purchase of European Union Allowances (EUAs) from other member states required to meet the Intended budget.

Updated emissions reduction scenarios

We have subsequently revised our scenarios to reflect new reference emissions projections (see Chapter 2), new analysis and new commitments by the Government (Table 3.1). In doing this, we have focused on Extended and Stretch Ambition scenarios, given that the Current Ambition scenario is not sufficiently ambitious to meet budgets, and that Government commitments for measures in the Extended Ambition scenario are closer to becoming policy.

Our new Extended Ambition scenario reflects two main categories of change relative to our December 2008 report:

- The Government has made new commitments (e.g. solid wall insulation)

- Our estimates of emissions reduction potential for existing commitments have changed based on new analysis (e.g. renewable heat).

Updates based on new Government commitments:

- We argued in our December report that there is a significant opportunity for cost effective emissions reduction through solid wall insulation.

We noted, however, that this may be politically difficult to achieve at scale given the disruption which installing solid wall insulation may cause to households. However, in its Heat and Energy Saving consultation, the Government has, suggested that out of 7 million homes receiving a 'whole house package' by 2020, 2 million will be 'hard to treat' homes. We therefore assume that 2 million houses have solid wall insulation by 2020 with a corresponding emissions reduction of 2.7 $MtCO_2$.

- We previously suggested that there is significant scope for agricultural emissions reduction, but included these in our Stretch rather than Extended Ambition scenario given uncertainties over the precise order of magnitude of potential and the absence of a policy framework. More recently, the Government included agricultural emissions reductions in its scenarios set out in the Low Carbon Transition Plan, and committed to introduce a policy framework to unlock emissions reduction potential. We therefore include emissions reduction of 3.3 $MtCO_2$ in our Extended Ambition scenario, which is consistent with the Government's estimate in its central scenario.

- Similarly, in our December report, we included emissions reduction from waste management only in our Stretch Ambition scenario. Consistent with the central scenario set out more recently in the Government's Low Carbon Transition Plan, we now include 0.6 $MtCO_2$ in our Extended Ambition scenario.

Updates based on new analysis

- We have revised emissions reduction trajectories to reflect more detailed analysis over the feasible pace at which measures can be implemented. In the residential buildings sector, for example, where we had previously assumed a straight line emissions trajectory through the first three budget periods, we now assume faster implementation of loft and cavity wall insulation.

- Based on new analysis of renewable heat, we have adjusted our estimate of feasible emissions reduction from renewable heat from 12 $MtCO_2$ to 18 $MtCO_2$ in 2020. This is broadly in line with the Government's Renewable Energy Strategy.

In addition, the Committee has changed its judgement on the issue of speed limit enforcement: it is reasonable to enforce the existing 70 mph speed limit and this is also feasible given average speed controls and in-car speed limiting devices. We have therefore included emissions reduction of 1.4 $MtCO_2$ in our Extended Ambition scenario to reflect enforcement of the 70 mph speed limit.

In total, these changes result in an Extended Ambition scenario which offers an additional 10 $MtCO_2$ emissions reduction potential in 2020 than the same scenario in our December 2008 report.

Our Stretch Ambition scenario is updated in the following ways:

- We noted in our December 2008 report potential for a 2 $MtCO_2$ emissions reduction from early replacement of old inefficient boilers. We did not include this in either our Extended or Stretch Ambition scenario, however, given that there was no clear policy lever to provide incentives for early replacement. We argue in Chapter 5 that early replacement could be included in a whole house approach to energy and carbon efficiency improvement in the residential sector. We therefore include emissions reduction of 1.7 $MtCO_2$ in 2020 from early replacement of boilers in our revised Stretch Ambition scenario.

- Based on new analysis of road pricing, we estimate that emissions reductions of 5.6 $MtCO_2$ in 2020 are available. Good economic rationale exists for introducing road pricing; however we include this in our Stretch rather than Extended Ambition scenario reflecting the political judgements to be made.

With these changes, our Stretch Ambition scenario offers an additional 14 $MtCO_2$ emissions reduction in 2020 relative to the Extended Ambition scenario.

Table 3.1 Revisions to Extended and Stretch Ambition scenarios

	Extended Ambition			Stretch Ambition		
	Abatement potential in 2020 ($MtCO_2$)		Reason for change	Abatement potential in 2020 ($MtCO_2$)		Reason for change
	Dec 2008 Report	This Report		Dec 2008 Report	This Report	
Domestic buildings						
Cavity wall, solid wall and loft insulation	4	6	reflects latest government targets	7	8	reflects latest government targets
Other Insulation Measures	2	1	new estimates of take-up	2	1	new estimates of take-up
Heating Effciency	<1	<1	new estimates of take-up	<1	2	new estimates of take-up
Lights and appliances	5	5	new estimates of take-up	5	6	new estimates of take-up
Lifestyle measures	4	4	unchanged	4	4	unchanged
Zero carbon homes	4	1	revised government estimate	4	1	revised government estimate
Total	19	17		22	22	
Non-domestic buildings and industry						
Total	16	16	unchanged	16	16	unchanged
Renewable heat						
Total	12	18	revised estimates of savings based on work by NERA, in line with RES	15	18	revised estimates of savings based on work by NERA, in line with RES
Road transport						
Biofuels	5	5	revised vehicle-km forecasts	5	5	revised vehicle-km forecasts
Car technology	10	10	revised vehicle-km forecasts, less aggressive uptake of EV and PHEVs	10	10	revised vehicle-km forecasts, less aggressive uptake of EV and PHEVs
Van technology	1	2	revised vehicle-km forecasts, now includes EV and PHEV technology	3	2	revised vehicle-km forecasts
HGV technology	1	1	revised vehicle-km forecasts	1	1	revised vehicle-km forecasts

Table 3.1 continued

	Extended Ambition			Stretch Ambition		
	Abatement potential in 2020 ($MtCO_2$)		Reason for change	Abatement potential in 2020 ($MtCO_2$)		Reason for change
	Dec 2008 Report	This Report		Dec 2008 Report	This Report	
Rail – efficiency measures	1	1	unchanged	1	1	unchanged
Demand – Smarter Choices	3	3	unchanged	3	3	unchanged
Demand – Eco driving – cars	<1	<1	unchanged	1	1	unchanged
Demand – Eco driving – vans and HGVs	1	1	unchanged	1	1	unchanged
Speed limiting (at 70 mph in Extended, 60 mph in Stretch)		1	not included last year	5	3	new information on split of travel across different road types
Road pricing					6	not included last year
Total	22	23		30	32	
Agriculture						
Total		3	not included last year, now reflects government commitment		3	not included last year, now reflects government commitment
Waste						
Total		1	not included last year, now reflects government commitment		1	not included last year, now reflects government commitment
Total	69	79		83	92	

Note: Due to rounding, small changes may not be apparent and figures may not sum to totals.

Comparison of updated scenarios with carbon budgets

Non-traded sector emissions under the Extended Ambition scenario are 11 $MtCO_2$ lower in 2020 compared to the same scenario in the December 2008 report.

Our updated Extended Ambition scenario continues therefore to offer sufficient emissions reduction potential to meet the non-traded sector Interim budget without the need for purchase of offset credits (Figure 3.1), but not the Intended budget.

However, our updated Stretch Ambition scenario does meet the Intended budget in the non-traded sector through domestic effort alone for all years except 2022.

Moving from the Interim to the Intended budget would require either additional commitment from Government or purchase of offset credits.

The Committee will advise on the appropriate level of offset credit purchase as part of our wider advice on moving to the Intended budget once a deal to reduce global emissions has been agreed.

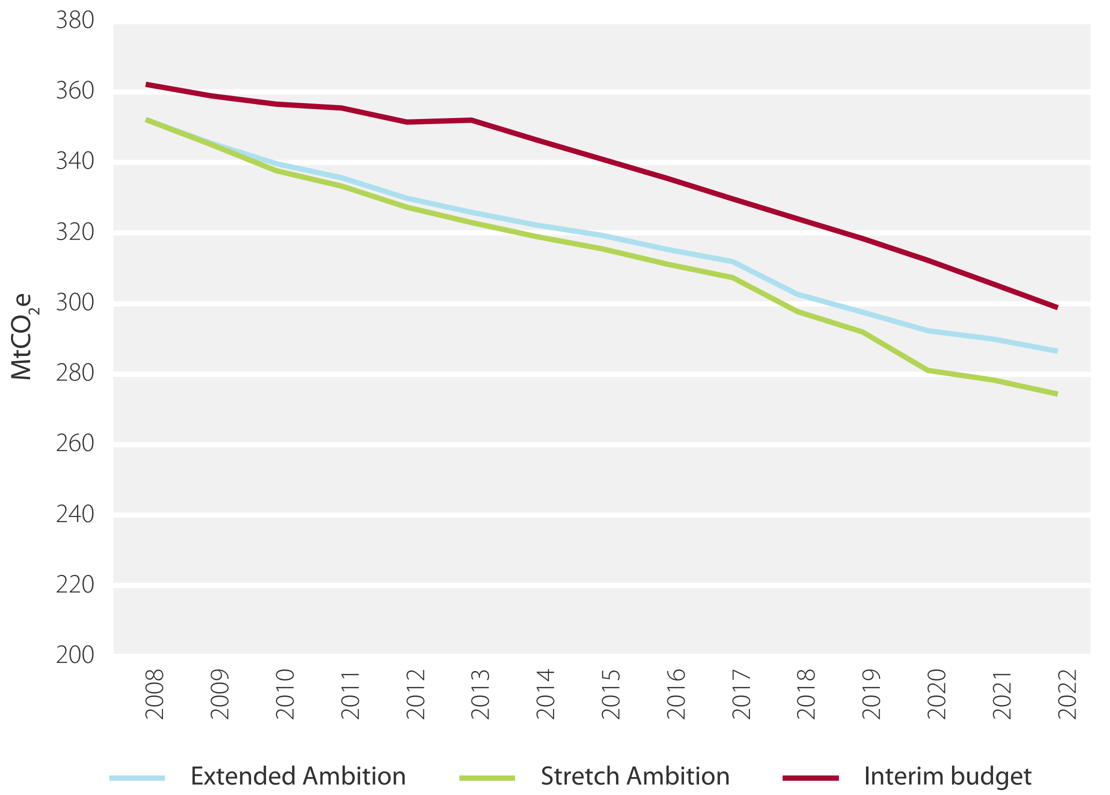
In the traded sector our Extended and Stretch Ambition scenarios offer similar levels of emissions reduction potential as in our December 2008 report. At the same time, our assumptions about coal build in the power sector have been updated with the result that traded sector emissions are now lower. Overall, our Extended and Stretch Ambition scenarios continue to allow the traded sector Interim budget to be met domestically; the Intended budget would not be met though domestic effort alone.

Comparison of revised scenarios with official projections

Economy wide emissions under our Extended Ambition scenario are 24 $MtCO_2e$ lower in 2020 compared with the government's central projection. Non-traded sector emissions are 9 $MtCO_2e$, reflecting different assumptions that we have made about the level of emissions reduction that would be delivered through effective policy (Box 3.1)[1]. We therefore recommend that the Government's level of policy ambition should be increased to reflect our bottom up analysis of emissions reduction potential (e.g. in industry and transport). In order to deliver this ambition, strong incentives will be required to support uptake of measures; we discuss required policy strengthening in Section 4 below and in Chapters 4-6.

1 Our traded sector emissions are lower for two reasons: we have a slightly different split of emissions between the traded and non-traded sectors (chapter 2); we have also assumed a slightly different capacity/generation mix (chapter 4).

Figure 3.1 Emissions trajectories under the Extended and Stretch Ambition trajectories for the non-traded sector versus budget



Source: CCC Modelling.

Box 3.1 Comparison of CCC and Government scenarios for emissions reduction

In 2020, measures in our Extended Ambition scenario save 14 $MtCO_2$ more, and in our Stretch Ambition scenario 27 $MtCO_2$ more, than the Government's central scenario.

In the Extended Ambition scenario this principally reflects:

Buildings and industry (Table B3.1.a)

- A similar level of ambition for domestic buildings
- Higher savings from the commercial and industrial sectors, where we envisage wider roll out of EPCs and DECs, development of a policy framework to deliver increased savings from SMEs and use of existing policy (EU ETS, CCAs and CRC) to deliver all cost-effective potential

Surface transport (see table)

- Greater ambition for delivery of savings from new cars on track to average new car emissions in the UK of 95 gCO_2/km
- Wider roll out of Smarter Choices to towns and cities in the UK
- Enforcement of the 70 mph speed limit

Our ambitions for power sector decarbonisation are similar.

Box 3.1 continued

Table B3.1.a: Comparison of CCC and government emissions trajectories

	Abatement potential in 2020 ($MtCO_2e$)									
	CCC						**Government**			
	Extended Ambition scenario			**Stretch Ambition scenario**			**Included in UK Low Carbon Transition Plan**			**Additional savings identified***
Measure	Non-traded	Traded	Total	Non-traded	Traded	Total	Non-traded	Traded	Total	Total
Buildings & industry										
Measures excluding renewable heat										
Domestic			17			22			18	
Public			2			2			1	
Commercial			7			7			6	
Industry			6			6			3	
CHP			1			1				
TOTAL	15	18	33	18	20	38	10	17	28	
Renewable heat										
TOTAL	13	5	18	13	5	18	10	5	15	
Surface transport										
Biofuels			5			5			7	
Car technology			10			10			8	
Van technology			2			2			2	
HGV technology			1			1			<1	
Rail efficiency measures			1			1			<1	
Bus technology									<1	
Smarter Choices			3			3				1
Eco driving - cars, vans and HGVs			1			2				<1
SAFED for bus drivers									<1	
Speed limiting			1			3				1
Road pricing						6				
TOTAL	24	-1	23	33	-1	32	18		18	3
Agriculture & Waste										
TOTAL	4		4	4		4	4		4	
GRAND TOTAL	56	22	79	67	24	92	42	22	64	3

*Additional savings identified by Government but not included in the Transition Plan

2. The framework for monitoring budgets: indicators and forward indicators

We have demonstrated that successful delivery of our emissions reduction scenarios would achieve the UK's carbon budgets. One approach to monitoring progress would simply be to compare actual emissions with budgets and to say that we are on track if emissions are within budgeted levels, and off track otherwise. We do not, however, accept this approach for two reasons:

- There are many factors which drive emissions, some of which would not result in sustainable emissions reductions. It may be the case, for example, that emissions in a particular year are low due to a mild winter, but that emissions in subsequent years are higher as winters are colder. A current example relates to the economic recession, which will result in falling emissions and may give the impression that we are on track to meet carbon budgets even though there is limited progress on implementation of measures that will be required to meet the second and third budgets; we set out detailed analysis of this issue in Chapter 2.
- Some of the measures which will result in emissions reductions have long lead times (e.g. investment in low carbon power generation); focusing simply on emissions could reveal too late that measures required to meet budgets have not been implemented.

The Committee will therefore fulfil its statutory obligation to monitor progress meeting budgets by considering both emissions and indicators of progress in implementing measures that drive emissions reductions.

In developing our indicators, we have considered various existing indicator frameworks, both generally and in the specific context of climate change (Box3.2). This has informed our framework, which includes emissions, drivers of emissions, forward indicators for these drivers where appropriate, policy milestones, and contextual factors (Figure 3.2):

Headline indicators

- **Emissions.** Our headline indicators include a sectoral breakdown of economy wide emissions to power, buildings and industry, transport.
- **Emissions intensity and demand.** They also include high level indicators of the supply and demand side factors which drive emissions. On the supply side, for example, we have developed trajectories for carbon intensity of power generation and carbon efficiency of vehicles underpinning our emissions reduction scenarios. On the demand side, we have trajectories for electricity and heat demand reduction, and for vehicle miles/passenger miles.

Supporting indicators

- **Implementation indicators.** Each headline indicator is underpinned by a set of indicators which track progress in implementing the measures required to achieve sustainable emissions reduction. We have therefore developed trajectories across the range of measures driving our emissions reduction scenarios. In the power sector, for example, we have trajectories for adding low-carbon power generation capacity. In buildings we have trajectories for roll out of loft, cavity wall and solid wall insulation. In cars, we have trajectories for penetration of electric cars.
- **Forward indicators.** Where appropriate, we have trajectories for forward indicators that we will use to assess whether we are on track to deliver measures as required. In the power sector, for example, delivering the new low-carbon capacity required will require planning applications/decisions to be made, projects to move to the construction phase, etc., a number of years before emissions reductions ensue.
- **Policy milestones.** In order that measures are successfully implemented, the appropriate enabling framework will have to be in place. We therefore include in our framework indicators reflecting key policy milestones and high level aspects of policy design.

Box 3.2 Existing indicator frameworks

Performance information is the information used to measure an organisation's progress towards its objectives. Financial ratios have long been used to measure performance in the private sector. Public sector performance indicators tend to differ – the aims of Government are wider than private organisations, reflected in a wider range of performance measures.

Some established performance frameworks

HM Treasury's 'Choosing the Right Fabric'

HM Treasury publish guidance to departments setting out general principles for producing high quality performance information[1].

This recognises that defining performance measures, setting targets and collecting performance information requires a balance between using the ideal information and using what is possible, available, affordable, and most appropriate to the particular circumstances.

It also recognises that while, ultimately, organisations aim to improve outcomes, measurement can be difficult. Moreover, it is useful to understand how inputs and outputs and associated processes are contributing to outcomes. Hence performance measures need to look at inputs and outputs as well. It's also important to look at performance in context, establishing factors external to Government that affect an outcome.

Logical Frameworks

Logical Frameworks ('logframes') are widely used by development organisations to help strengthen activity design, implementation and evaluation. Guidance is provided by DfID as part of their Tools for Development[2]. Indicators play a crucial role in logframe planning and analysis:

- They specify realistic targets
- They provide the basis for monitoring, review and evaluation
- The process of setting indicators contributes to transparency.

Existing climate change mitigation indicators

A range of climate change mitigation indicators exist.

Government PSAs

Public Service Agreements (PSAs) set out the key outcomes that Government wants to achieve in the next spending period. PSA 27 sets out Government's aim to 'Lead the global effort to avoid dangerous climate change'[3] and is underpinned by six outcome-focused indicators. Two – UK greenhouse gas and CO_2 emissions, and Greenhouse gas and CO_2 intensity of the UK economy – are the most relevant to the Committee's task to monitor progress towards decarbonisation, although published with a lag.

1 HM Treasury, Cabinet Office, National Audit Office, Audit Commission, Office For National Statistics (2001) Choosing the Right FABRIC – A Framework For Performance information. http://www.hm-treasury.gov.uk/d/229.pdf
2 DfID (2003) Tools for Development – A handbook for those engaged in development activity http://www2.dfid.gov.uk/pubs/files/toolsfordevelopment.pdf
3 HM Government (2007) PSA Delivery Agreement 27: Lead the global effort to avoid dangerous climate change. http://www.hm-treasury.gov.uk/d/pbr_csr07_psa27.pdf

Box 3.2 continued

Departmental Strategic Objectives

Government PSAs are underpinned by Departmental Strategic Objectives (DSOs)[4]. These have their own indicators which include some of the drivers of emissions, for example proportion of electricity from renewable sources, average new car CO_2 emissions and annual energy saving from domestic appliance design.

Other Government monitoring data

Other government indicator sets monitor changes in factors relevant to climate change but do not define in detail what success should look like. These include the Government's Sustainable Development Indicators[5] and the UK Energy Sector Indicators published by DECC[6].

Indicators used by the European Commission

The European Commission publish a range of indicators – both for the EU as whole and the individual member states – largely derived from GHG or CO_2 emission statistics[7]. Whilst they capture a wider range of emissions and provide more sector detail than the emissions indicators underpinning the UK's PSA 27, these indicators suffer from the same publication lags.

As part of the EU Energy End-Use Efficiency and Energy Services directive, member states will also be required wherever practicable to measure, verify and report their total energy savings using a harmonised framework which includes a range of energy efficiency indicators[8].

Roadmaps for climate change mitigation

CBI

In April 2009, the CBI set published a set of roadmaps to a low-carbon future for each sector of the economy[9]. Covering both policy and market response, they identified key steps necessary over the next 10 years to drive a 'green' economic recovery, decarbonise the UK economy and secure business buy-in and investment.

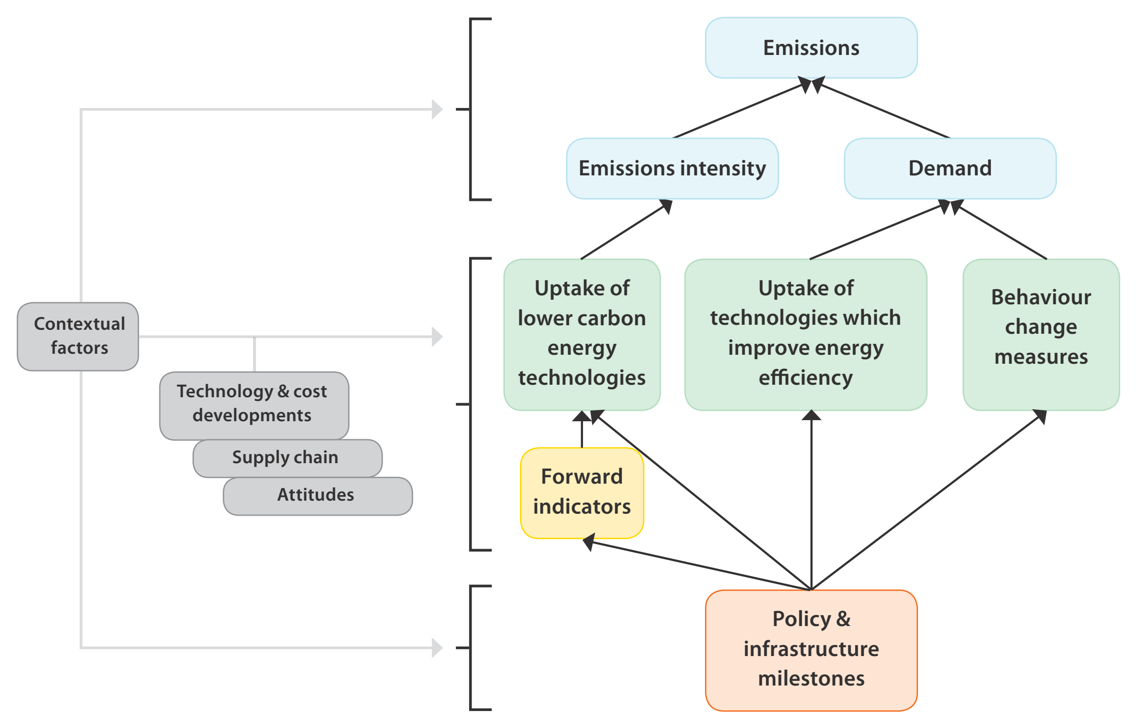
HM Government

The UK Low Carbon Transition Plan included a roadmap for building a low-carbon UK. It set out the Government's plan for reducing emissions and meeting carbon budgets, summarised in a set of timelines for each sector showing the major changes over the next 10 years.

The steps identified in these roadmaps provide milestones and indicators of progress.

4 Defra (2009) Departmental Report 2009. http://www.defra.gov.uk/corporate/about/how/deprep/docs/2009-deptreport.pdf, DECC (2009) Annual Report and Resource Accounts 2008-09. http://www.decc.gov.uk/en/content/cms/publications/annual_reports/2009/2009.aspx, DfT (2009) Annual Report and Resource Accounts 2008-09. http://www.dft.gov.uk/about/publications/apr/ar2009/arra.pdf
5 See http://www.defra.gov.uk/sustainable/government/progress/index.htm
6 See http://www.decc.gov.uk/en/content/cms/statistics/publications/indicators/indicators.aspx
7 See for example http://ec.europa.eu/energy/publications/doc/statistics/part_4_energy_pocket_book_2009.pdf
8 See http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&lg=EN&numdoc=32006L0032
9 CBI (2009) Going the distance: the low-carbon economy roadmap. http://climatechange.cbi.org.uk/uploaded/Roadmap_SummaryDistance.pdf

Figure 3.2 The CCC indicator framework



Key: Headline indicators; Implementation Indicators; Forward indicators; Milestones; Other drivers

Other drivers

There are a number of emissions drivers for which we do not set out indicators in advance but which we will track as part of our monitoring framework. These include drivers for which we would hope to see improvements (e.g. technology costs, supply chain capability etc.) and those which are purely contextual (e.g. GDP, fossil fuel prices, population etc.).

In choosing indicators, we have required that these fulfil a range of criteria. In particular, high quality representative data must be available in timely manner if it is to be useful for monitoring. Where data is not available or does not meet these criteria, we will work with Government to try to address this.

In using indicators, the Committee wishes to make clear that our framework provides an indicative roadmap for emissions reduction rather than a concrete plan which cannot be deviated from. It may be the case, for example, that some indicators are not met, but that there is a good reason for this (e.g. because battery costs for electric cars do not fall as quickly as we envisage), and that there is more achieved on take up of more carbon efficient cars based on conventional technology. The Committee will therefore apply the framework in a pragmatic manner that allows for emission reductions to be lower in some cases and higher in other cases than currently envisaged.

It would not be acceptable, however, to be off track across a range of measures without compensating with outperformance on other measures. If this were to ensue, the Committee would explore scope for remedial actions. The indicator framework is therefore a tool for supporting analysis and assessing progress in meeting carbon budgets and for underpinning an evolving strategy to achieve carbon budgets.

3. Summary of measures to deliver budgets

In this section we provide a summary of our indicators based on our Extended Ambition scenario, for the power sector, buildings and industry and transport; more detailed analysis of these sectors is set out in Chapters 4-6.

Power sector indicators

Power sector indicators include trajectories for emissions, carbon intensity of power generation, investment in low-carbon power generation, and actions required in order that investment proceeds (Table 3.2):

- Our emissions trajectory results in a 53% reduction in emissions by 2020 through retirement of existing coal plant and investment in renewable (primarily wind), nuclear and CCS coal generation.
- Carbon intensity along this trajectory falls from the current average of 540 g/kWh to around 300 g/kWh in 2020.
- Low-carbon generation capacity comprising 27.1 GW total wind, two additional nuclear plants and up to four CCS coal plants, is required to drive this trajectory.
- Forward indicators for delivery of this investment include planning applications/decisions and entry of plant into construction. For example, in order that onshore wind plant comes onto the system in 2020, this must have entered planning two years earlier (three years earlier for offshore) and construction one year earlier (two years earlier for offshore); for nuclear plant, planning project development should start with a seven year lead relative to when capacity is required on the system; etc..

Table 3.2 Power sector indicators

Power		Budget 1	Budget 2	Budget 3
Headline indicators				
Emissions intensity (g/kWh)		509	390	236
Total emissions (% change from 2007)		-15%	-39%	-64%
Generation (TWh)	*Wind*	21	50	98
	Nuclear	58	30	48
	CCS	0	5	11
Supporting indicators				
Transmission				
Agreement on incentives for anticipatory investment for Stage 1 reinforcements		2010		
Implementation of enduring regime for accessing grid		2010		
Transitional OFTO regime in place		2009		
Enduring OFTO regime in place		2010		

Table 3.2 continued

Power		**Budget 1**	**Budget 2**	**Budget 3**
Grid reinforcement planning approval		2011: Scotland Stage 1, Wales Stage 1 (Central), South East	2013: Wales Stage 1 (North), English East Coast Stage 1, South West 2014: Scotland Stage 2	
Grid reinforcement construction begins		2012: Scotland Stage 1, Wales Stage 1 (Central), South East	2014: Wales Stage 1 (North), English East Coast Stage 1, South West 2015: Scotland Stage 2	
Grid reinforcements operational			2015: Scotland Stage 1, Wales Stage 1 (Central), South East 2017: Wales Stage 1 (North), English East Coast Stage 1, South West	2018: Scotland Stage 2
Tendering for first offshore connections under enduring OFTO regime		2010		
Construction of first offshore connections under enduring OFTO regime begins		2011		
First offshore connections under enduring OFTO regime operational		2012		
Planning				
IPC set up and ready to receive applications		2010		
Market				
Review of current market arrangements and interventions to support low-cost, low-carbon generation investment		to begin in first budget period		
Wind				
Generation (TWh)	*Onshore*	13	26	44
	Offshore	8	24	54
Total capacity (GW)	*Onshore*	5.7	10.8	18.0
	Offshore	2.5	7.4	16.6

Table 3.2 continued

Power		**Budget 1**	**Budget 2**	**Budget 3**
Capacity entering construction (GW)	*Onshore*	0.9	1.3	1.5
	Offshore	0.9	1.6	2.6
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		
	Offshore	New planning applications will be expected in line with site leasing		
Average planning period (months)		<12	<12	<12
Nuclear				
Regulatory Justification process		2010		
Generic Design Assessment		2011		
National Policy Statement for nuclear (including Strategic Siting Assessment)		2010		
Regulations for a Funded Decommissioning Programme in place		2010		
Entering planning		first planning application in 2010	subsequent applications at 18 month intervals	
Planning approval; site development and preliminary works begin		first approval and site development and preliminary works begin in 2011	subsequent application approvals, site development and preliminary works at 18 month intervals	
Construction begins			first plant in 2013, subsequent plants at 18 month intervals	
Plant begins operation				first plant in 2018, with subsequent plants at 18 month intervals*
CCS				
Front-End Engineering and Design (FEED) studies for competition contenders completed		2010		
Announce competition winner		2010		

Table 3.2 continued

Power	Budget 1	Budget 2	Budget 3
Second demonstration competition	launch 2010, announce winners 2011		
Quantification of saline aquifer CO_2 storage potential		no later than 2015	
Review of technology and decision on framework for future support		no later than 2016	
Strategic plan for infrastructure development		no later than 2016	
Planning and authorisation approval, land acquisition, and storage site testing completed, construction commences	first demo in 2011	subsequent demos 2012/13	
Demonstrations operational		first demo in 2014, subsequent demos 2015/16**	
First new full CCS plants supported via the 2016 mechanism			2022
Other drivers			
Total demand (TWh), coal and gas prices, nuclear outages *Average wind load factors, availability of offshore installation vessels, access to turbines* *Nuclear supply chain, availability of skilled staff* *International progress on CCS demonstration and deployment* *Planning approval rates and frequency of public inquiries to decisions of Infrastructure Planning Commission*			

* Up to 3 nuclear plants by 2022.
** Up to 4 CCS demonstration plants by 2020.

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022
Key:
Headline indicators Implementation indicators Forward indicators Milestones Other drivers

Buildings and industry indicators

Indicators for buildings and industry include emissions trajectories for residential buildings, non-residential buildings and industry, measures to improve energy efficiency, and increased penetration of renewable heat (Table 3.3):

- Our emissions trajectory for residential buildings has total emissions falling by 29% over the period to 2020, with a 20% reduction in direct emissions and a 53% reduction in indirect (i.e. electricity-related) emissions
- Residential energy demand along this trajectory falls by 16% by 2020.
- Energy efficiency improvement includes insulation of 90% lofts and cavity walls by 2015, with solid wall insulation in around 2 million houses by 2020, and boiler replacement in up to 11 million houses.
- Penetration of renewable heat reaches 12% of total heat supply by 2020 resulting in emissions reduction of 18 $MtCO_2$.
- In the period to 2020, emissions fall by 28% for non-residential buildings and by 16% for industry, underpinned by reductions in energy demand of 7% and 16% respectively.
- All cost-effective emissions reduction potential for public sector buildings covered by the CRC is realised by 2018.

Table 3.3 Buildings and industry indicators

Buildings and Industry		Budget 1	Budget 2	Budget 3
All buildings and industry				
Headline indicators				
*CO_2 emissions (% change on 2007)**	*direct*	-9%	-11%	-15%
	*indirect***	-11%	-28%	-58%
Final energy consumption (% change on 2007)	*non-electricity*	-10%	-18%	-23%
	*electricity (centrally produced)****	-8% (-4%)	-7% (-9%)	-5% (-13%)
Residential buildings				
Headline indicators				
*CO_2 emissions (indicative minimum % change on 2007)**	*direct*	-6%	-18%	-20%
	*indirect***	-11%	-23%	-53%
Final energy consumption (indicative minimum % change on 2007)	*non-electricity*	-6%	-18%	-19%
	*electricity (centrally produced)****	-5% (-5%)	-4% (-4%)	-3% (-3%)
Supporting indicators				
Uptake of Solid Wall insulation (million homes, total additional installations compared to 2007 levels)		0.5	1.2	2.3
Uptake of Loft insulation (up to and including 100mm) (million homes, total additional installations compared to 2007 levels)		2.1	5.3	5.3
Uptake of Loft insulation (100mm +) (million homes, total additional installations compared to 2007 levels)		1.9	4.8	4.8
Uptake of Cavity wall insulation (million homes, total additional installations compared to 2007 levels)		3.5	7.5	7.5
Uptake of Energy efficient boilers (million homes, total additional installations compared to 2007 levels)		4.9	9	12
Uptake of Energy efficient appliances - Cold A++ rated (% of stock)		3%	18%	45%
Uptake of Energy efficient appliances - Wet A+ Rated (% of stock)		22%	53%	82%
Every house offered whole-house energy audit			by 2017	

Table 3.3 continued

Buildings and Industry		**Budget 1**	**Budget 2**	**Budget 3**
Heat and Energy Saving Strategy finalised		2009		
New financing mechanism pilots operate and are evaluated		2011		
Post CERT delivery framework legislation in place		2011		
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				
Non-residential buildings				
Headline indicators				
*CO_2 emissions (indicative minimum % change on 2007)**	*direct*	6%	2%	-3%
	*indirect***	-9%	-22%	-51%
Final energy consumption (indicative minimum % change on 2007)	*non-electricity*	-4%	-8%	-13%
	*electricity (centrally produced)****	-1% (-1%)	-1% (-1%)	-1% (-1%)
Supporting indicators				
Develop policy on SMEs		by October 2010		
Government decision on the following recommendations for EPCs and DECs:		by October 2010		
· All non-residential buildings to have an EPC			by 2017	
· All non-residential buildings to have a minimum EPC rating of F or higher				by 2020
· Roll out of DECs to non-public buildings			by 2017	
All public buildings covered by CRC to realise all cost effective emissions change potential			by 2018	by 2018
Other drivers				
Emissions and fuel consumption by subsector, GVA / GVA vs. GDP for each sub-sector, Electricity and gas prices				

Table 3.3 continued				
Buildings and Industry		**Budget 1**	**Budget 2**	**Budget 3**
Industry				
Headline indicators				
*CO_2 emissions (indicative minimum % change on 2007)**	*direct*	-15%	-2%	8%
	*indirect***	-12%	-35%	-66%
Final energy consumption (indicative minimum % change on 2007)	*non-electricity*	-20%	-21%	-19%
	*electricity (centrally produced)****	-16% (-6%)	-11% (-18%)	-5% (-30%)
Other drivers				
Emissions and fuel consumption by subsector, GVA / GVA vs. GDP for each sub-sector, Electricity and gas prices				
Renewable heat				
Headline indicators				
Renewable heat penetration		1%	5%	12% in 2020
Supporting indicators				
Renewable Heat Incentive in operation		from April 2011		
Other drivers				
Uptake and costs of renewable heat technologies (Biomass boilers, Solar thermal, GSHP and ASHP, District heating)				

* These indicators should be considered jointly. Reductions in total emissions from buildings and industry reflect savings from renewable heat. We do not however set out in advance the split of these savings across sectors. Therefore emissions changes for indiviudal sectors do not assume any savings from renewable heat and reflect a minimum level of change.
** Based on a reference projection net of electricity demand changes whose carbon intensity is assumed to be that of new build gas. Within our modelling of the power sector, emissions from electricity generation are lower than is represented here due to different assumptions about carbon intensity. The indirect emissions shown here are therefore conservative.
*** Figures show percentage changes in total electricity consumption including autogenerated electricity, and in centrally produced electricity only.

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022
Key: Headline indicators Implementation Indicators Milestones Other drivers

Transport indicators

Transport indicators include trajectories for emissions, carbon intensity of cars, travel demand by mode and fuel consumption (Table 3.4):

- In our transport emissions reduction trajectories car emissions fall by 30% compared to 2007 levels by 2020 as lower gCO_2/km offsets rising demand, van emissions rise by 30% (compared to a rise of 18% in our reference projection), and HGV emissions fall by 19% by 2020.
- Carbon efficiency of new cars improves from the current level averaging 158 g/km to 95 g/km in 2020.
- Electric car penetration reaches 240,000 by 2105 and 1.7 million by 2020 and biofuels penetration reaches 10% by 2020.
- Demand for car travel reaches by 418 billion vehicle-km in 2020 as Smarter Choices measures are implemented (compared to 432 billion vehicle-km in our reference projection).

Table 3.4 Transport indicators

Road Transport		Budget 1	Budget 2	Budget 3
Headline indicators				
Direct emissions (% change on 2007)	Total	-11%	-19%	-29%
	Car	-17%	-24%	-37%
	Van	11%	16%	14%
	HGV	-13%	-16%	-19%
gCO_2/km (carbon intensity of a vehicle kilometre)	Car	152	132	104
	Van	247	226	196
	HGV	743	687	639
Vehicle-km billions	Car	421	419	420
Supporting indicators				
Vehicle technology				
New vehicle gCO_2/km	Car	142	110	95 (by 2020)
New electric cars registered each year (value at end of Budget period)		11,000	230,000	550,000
Stock of electric cars in vehicle fleet		22,000	640,000 (240,000 delivered through pilot projects in 2015)	2.6 million (1.7 million by 2020)
Biofuels				
Penetration of biofuels (by volume)		4.5%	7.9%	10.0%
Decision on whether future biofuels target can be met sustainably		2011/12		

Table 3.4 continued			
Road Transport	**Budget 1**	**Budget 2**	**Budget 3**
Demand side measures			
Proportion of drivers exceeding 70mph		0%*	0%
Car drivers who have undergone eco driving training	1,050,000	2,800,000	4,550,000
Smarter Choices – demonstration in a city and development plan for roll out if successful, demonstration in rural areas and demonstration targeting longer journeys	2010		
Smarter Choices – phased roll out to towns	2010		Complete
Development of integrated planning and transport strategy	2011		
Other drivers			
*Fuel pump prices, Fuel duty, Proportion of new car sales that are 'best in class', Proportion of small/medium/large cars, Van and HGV km (vehicle/tonne)**, Petrol/diesel consumption, Surface transport modal split, Average speed of drivers exceeding 70mph*			
*Agreement of modalities for reaching an EU target of 95 gCO_2/km target and strong enough penalties to deliver the target, New Car CO_2 in EU, New Van and HGV gCO_2/km***, Number of EV car models on market, Developments in battery and hydrogen fuel cell technology, Battery costs*			
Successful conclusion of EU work on Indirect Land Use Change/development of accounting system for ILUC and sustainability			
Number of households and Car ownership by household, Cost of car travel vs. cost of public transport, Funding allocated to and percentage of population covered by Smarter Choices initiatives†, Proportion of new retail floorspace in town centre/edge of centre locations, Ratio of parking spaces to new dwellings on annual basis			

* These are the values implied by the estimated savings from speed limiting. CCC recognise that in practice it is impossible to achieve zero speeding. However, as close to zero as practicable is required to achieve the greatest carbon savings.
** We will include van and HGV km travelled in our headline indicators following new work on freight for our 2010 report.
*** We aim to include new van and HGV gCO_2/km in our indicator set as the available monitoring data improves
† Our initial recommendation is for phased roll-out of Smarter Choices to further establish emissions reduction potential. If initial roll-out proves successful, our subsequent recommendation would be for national roll-out. We would then need to monitor population covered and also total expenditure to verify sufficient coverage and intensity. Once national roll-out is underway and suitable data sources are identified, population covered and total expenditure will be included in our set of supporting indicators.

Note: Numbers indicate amount in last year of budget period i.e 2012, 2017, 2022.
Key: Headline indicators Implementation Indicators Milestones Other drivers

4. Summary of required policy strengthening to deliver budgets

The policy framework will be crucial in driving actions to meet indicators and reduce emissions. The policies summarised in the Low Carbon Transition Plan provide a good foundation for required actions.

The Committee notes, however, the broadly flat emissions trend in recent years and the need therefore for a fundamental shift if deep cuts required to meet carbon budgets are to be achieved going forward. Under current policies, it is the Committee's view that significant risks exist for meeting the second and third carbon budgets, and that policy strengthening is necessary across power, buildings and industry and transport sectors.

We now summarise key policy milestones and areas for policy strengthening identified by the Committee, with more detailed discussion presented in Chapters 4-6.

Power sector policy strengthening and milestones

Wind generation. In order to support very ambitious targets for investment in wind capacity, key decisions are required on power transmission access and investment. In particular, a new enduring regime for access that allows connection of new wind generation is required by 2010. Decisions to proceed on least-regrets investments in power transmission to support increased levels of wind generation are required by 2010.

Nuclear generation. The enabling framework for nuclear new build is currently under development. Key outstanding policy milestones include: issuing a national policy statement by 2010; Generic Design Assessment of reactor design completed by 2011; approval of first planning applications by 2011 to allow commencement of construction by 2012/13.

CCS generation. It is important to move forward with CCS demonstration in a timely manner. The first CCS demonstration competition should be concluded according to the schedule announced by the Government in June 2009. The second round of competitions, which in the view of the Committee should cover up to three projects, should commence in 2010 and conclude by 2011. The Government should announce now that a financing mechanism to support roll-out will be put in place following the demonstrations (e.g. no later than 2016). In addition, the Government should provide a very clear signal now that the role for any conventional coal plant remaining beyond the early 2020s would be very limited.

Power market reform. The Committee had previously raised the question whether investors could reasonably be expected to invest in low-carbon technologies under current market arrangements given multiple risks (e.g. over fossil fuel prices, carbon prices, electricity prices, technology costs and performance characteristics, etc.).

Based on a detailed consideration of new analysis, the Committee's view is that there are plausible scenarios where risk-averse investors will revert to investment in gas fired power generation rather than low carbon technologies. This is problematic given the centrality of power sector decarbonisation to decarbonisation in other sectors on the path to meeting the 2050 target.

The Committee therefore proposes that alternative options to strengthen incentives for investment in low-carbon technologies (e.g. carbon price underpin, low-carbon obligation, emissions performance standard, etc.) should be seriously considered. A near term review of these options is required in order that any new arrangements can be introduced on a schedule consistent with the timing of investment decisions to be made early in the second budget period.

Strengthening of policy for buildings and industry

Policy for residential buildings. The supplier-led existing framework for energy efficiency improvement in residential buildings does not provide sufficient incentives for the deep emissions cuts required in this area. A new approach is required. The Government has acknowledged this in its draft Heat and Energy Savings Strategy. The Committee agrees with the high level approach proposed in the Government consultation. The Committee recommends that any policy should be developed in 2010-2011 for implementation from 2012, and should be based on:

- A whole house approach which covers the range of cost-effective measures for energy efficiency improvement and minimises transaction costs for households
- A street by street neighbourhood approach led by national Government, with a delivery role for local government in partnership with energy companies
- An appropriate balance between 'pay as you save' (i.e. loans for energy efficiency improvement which are repaid through cost savings due to lower energy consumption) and subsidised funding recognising that some measures do not save money (e.g. solid wall insulation) and that some groups (e.g. the fuel poor) may not be able to take on loans.

Renewable heat. Our Extended Ambition scenario includes significantly increased renewable heat penetration on the basis that the Government will introduce new policies in this area to meet EU renewable energy targets. The Government has recognised that new policies are required to address barriers to uptake including cost penalties for renewable heat technologies and consumer attitudes reflecting the fact that there is very limited experience of renewable heat in the UK. The Committee welcomes the proposed introduction of a Renewable Heat Incentive on which the Government will consult later in 2009.

Energy efficiency improvement in the non-capped sectors. The Committee has identified significant emissions reduction potential from energy efficiency improvement in non-residential buildings. Not, currently covered by policies for reduction of non-residential emissions (e.g. Climate Change Agreements, the Carbon Reduction Commitment, EU ETS). The Committee agrees with the Carbon Trust that new requirements should be introduced:

- All non-residential buildings to have an EPC in place by the end of the second budget period
- Minimum ratings set for all non-residential buildings (minimum EPC rating of F by 2020)
- Roll-out of DECs to all non-residential buildings.

In relation to SMEs, a first step would be to develop a better understanding of emissions reduction opportunities by getting better information about the current state of the building stock. In this respect, information from Display Energy Certificates (DECs) and Energy Performance Certificates (EPCs) would help inform new policies. There are a range of policy options for SMEs that warrant further consideration including:

- Providing more financial support. Current financial and institutional support provided by the Carbon Trust could be scaled up to cover a larger proportion of the SME population.
- Extending the proposed new approach for the residential sector to cover SMEs. Some progress has already been made in this respect with the large energy companies in the UK entering voluntary agreements with Government to provide energy services to SMEs. There is a question, however, as to whether the voluntary basis of the scheme provides sufficient bite for energy suppliers to actively participate and whether the neighbourhood approach which could motivate households would provide the same incentives for SMEs.

- Mandating implementation of measures. As in the residential sector, regulatory measures may be required to achieve full take up of cost effective emissions reduction potential (e.g. mandating a minimum EPC rating on sale or letting of property, or linking business rates to the EPC rating).

The Government has established a new project that will consider possible new policies to support SME emissions reduction; this will be the first step towards unlocking significant SME emissions reduction potential.

Transport policy strengthening

Policy for new cars. Incentives will be required in order to achieve the ambitious EU targets for carbon efficiency of new cars. These are likely to require both fiscal levers and better information. For electric cars specifically, financial support will be required both to cover cost premiums of early stage designs before battery costs fall, and charging infrastructure cost. The Government's commitment to provide £250 million to support electric car deployment is a very useful start in this respect, although further funding is likely to be required. Government-sponsored pilot projects should aim to achieve 240,000 electric cars on the road by 2015 on the way to 1.7 million by 2020 in order that a critical mass is reached and the electric car option developed to achieve significant market share in the 2020s; design of projects should start now in order to support early implementation.

Roll out of Smarter Choices. Evidence from Sustainable Travel Towns suggests that car travel demand reductions are at the top end of the range that had been suggested in the literature. Based on this evidence, it is the Committee's view that the Government's new Sustainable Travel City should be complemented by phased roll out of Sustainable Travel Towns, and a plan for roll out of Sustainable Travel Cities depending on the experience in the pilot project. There should also be demonstrations focussing on rural areas and on longer journeys.

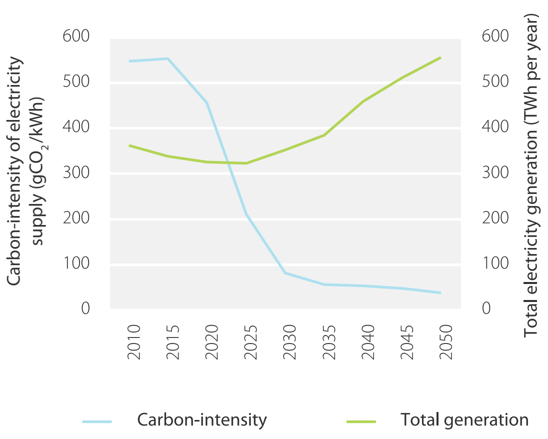
Integrated land use and transport planning. Up to 3 million new houses will be built in the UK in the period to 2020. Analysis suggests that if these were built without regard for transport implications then overall emissions could increase, even if the new houses are zero carbon. For existing developments, there is wide variation in average emissions for cities in the UK and beyond, suggesting that there is scope for emissions reduction through changing land use planning and transport policy. The Committee therefore recommends that the Government should develop an integrated land use and transport strategy designed to fully account for transport emissions.

Chapter 4: Delivering low-carbon power

Introduction and key messages

In our December 2008 report, we set out a range of scenarios to meet our 80% emissions reduction target in 2050. The common theme running through these scenarios was the need for early decarbonisation of the power sector, with the application of low-carbon electricity to transport and heat. We showed therefore that the carbon-intensity of power generation should decline over time, whilst at the same time electricity demand could increase (Figure 4.1).

Figure 4.1 Declining carbon-intensity and increasing generation of electricity to 2050



Source: CCC calculations.

We argued that the economics of wind and nuclear generation are favourable in the context of meeting the 2050 target, and we expressed optimism that carbon capture and storage (CCS) will also be shown to be economically viable. We envisaged emissions cuts in the power sector initially through increasing levels of wind generation in the period to 2020, with deployment of a portfolio of low-carbon technologies – renewables, nuclear and CCS – in the 2020s resulting in a substantially decarbonised electricity system by 2030.

We highlighted the multiple risks associated with the current market arrangements. Specifically, investors are subject to significant uncertainty over fossil fuel prices and technology costs. This is compounded by policy induced risks stemming from carbon price uncertainty and increasing electricity price volatility resulting from high levels of intermittent power generation. Given these risks, we questioned whether current market arrangements would deliver required investments in low-carbon technology.

In this chapter we consider in more detail trajectories for power sector decarbonisation over the first three budget periods. We develop indicators, including forward indicators, setting out what has to happen in order to drive decarbonisation, and against which we will judge progress in reducing emissions when we report annually to Parliament (Box 4.1). We set out our response to the Government's proposals for investment in coal-fired generation. We also present detailed analysis of current market arrangements and our assessment of whether these will provide the right incentives for investment in low-carbon generation.

The main messages from our analysis are:

- Key decisions should be taken over the next two years on power transmission access and investment, and planning approvals should be granted, in order to support investment in around 23 GW of new wind generation capacity by 2020 and up to three new nuclear plants in the first three budget periods.
- We welcome the Government's proposals on coal generation. We recommend, however, that economic viability of CCS should be considered in the strategic context of moving towards our 80% emissions reduction target rather than narrower definitions (e.g. Best Available

Technology) of technical and commercial viability. An early decision (e.g. no later than 2016) on any required financial support for roll-out should be taken to support potentially high levels of investment from the early 2020s. For coal plant without CCS, the Government should provide a very clear signal that this will have a limited role in the 2020s on the way to an 80% cut, whether or not CCS is satisfactorily proven.

- We are not confident that current market arrangements will deliver required investments in low-carbon generation through the 2020s. We propose a set of options for power market intervention to support low-carbon investments and urge that these are seriously considered in the near term.

Box 4.1 Power sector indicators

- Addition of 23 GW of new **wind** generation to reach 27 GW in total by 2020, supported by streamlined planning processes, improved transmission access and an expanded supply chain.
- Addition of up to three new **nuclear** plants by 2022, supported by an improved enabling framework to contain the development timeline.
- Addition of up to four **CCS** (clean coal) demonstration plants by 2020, with financial support provided as required.
- Policy strengthening to support these and future investments:
  - **Market rules** – A review of options for strengthening low-carbon generation investment incentives.
  - **Support for CCS** – A new framework to support investment in CCS generation beyond initial demonstrations.
  - **Grid strengthening** – Timely decisions on transmission network access and investment.

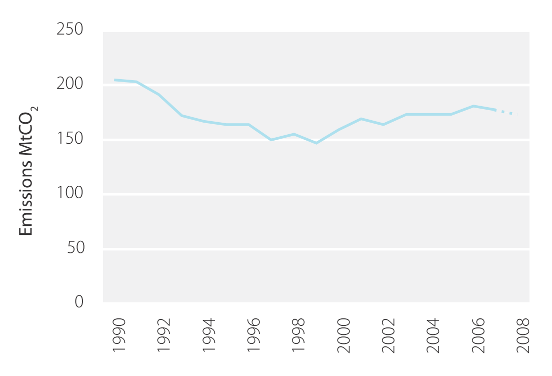
We set out our analysis underpinning these conclusions in seven sections:

1. Power sector emissions trends
2. Scenarios for power sector decarbonisation to 2022
3. Wind generation: indicators and the enabling framework
4. Investment in nuclear new build
5. Demonstration and roll-out of CCS technology
6. Assessment of current power market arrangements and possible interventions
7. Summary of power sector indicators.

1. Power sector emissions trends

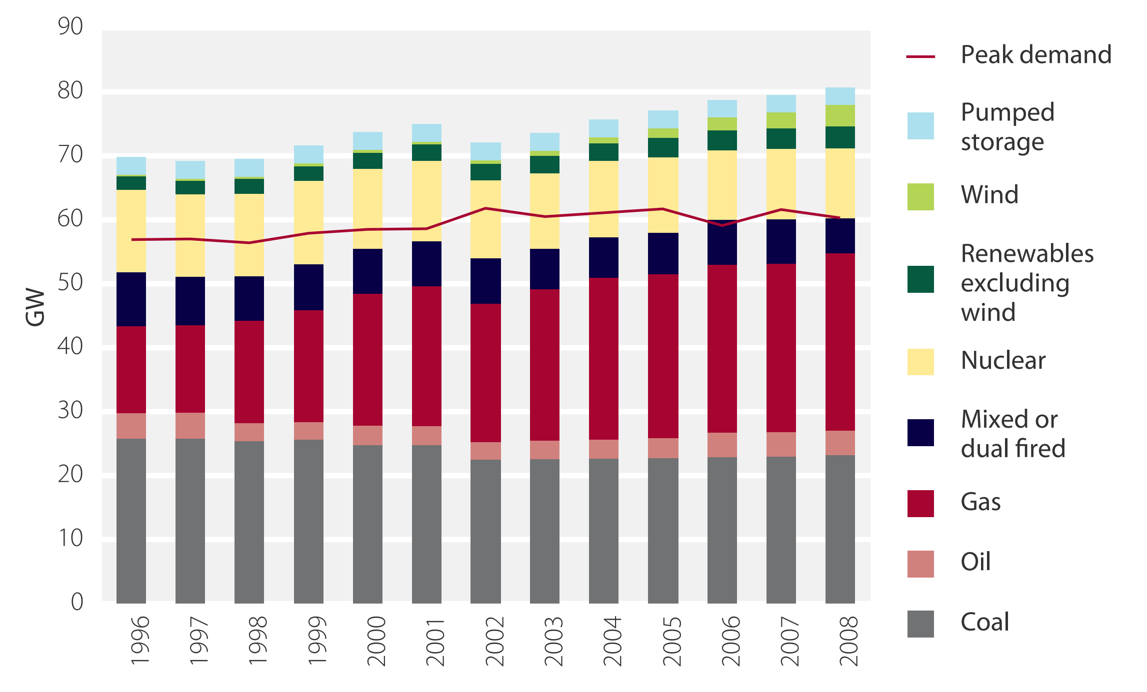
UK CO_2 emissions from power generation fell from 205 $MtCO_2$ in 1990 to 171 $MtCO_2$ in 2008 (Figure 4.2). The main driver of this reduction was the 'dash for gas' through the 1990s when new gas-fired generation capacity replaced existing coal-fired capacity (Figure 4.3), rather than significant increases in low-carbon capacity (which will be needed going forward). More recently progress reducing emissions has reversed.

Figure 4.2 CO_2 emissions (1990-2008) from the power sector



Source: NAEI (2009); DECC (2009); *DUKES*; Table E.1.
Note: 2008 figures are provisional.

Figure 4.3 Installed capacity (1996-2008)



Source: CCC calculations.

In the last year, small increases in the level of renewable power generation have been offset by lower levels of nuclear and increased gas generation (Figure 4.4):

- The share of renewable generation rose from 5.5% in 2007 to 6.2% in 2008, reflecting the addition of new wind capacity to the system.
- There was a decline in nuclear generation in 2008 due to plant outages – specifically two plants (2.3 GW) were closed for the whole of 2008. These plants were brought back on line earlier this year, so nuclear generation was up 17.5% in Q1 2009 compared to the same period in 2008.
- The most recent quarterly data[1] shows that coal has increased in the first period of 2009 compared with a year earlier. Coal generation during Q1 2009 was 12% higher compared to Q1 2008, while gas use declined 22%. Wind generation increased 17% over the same period.

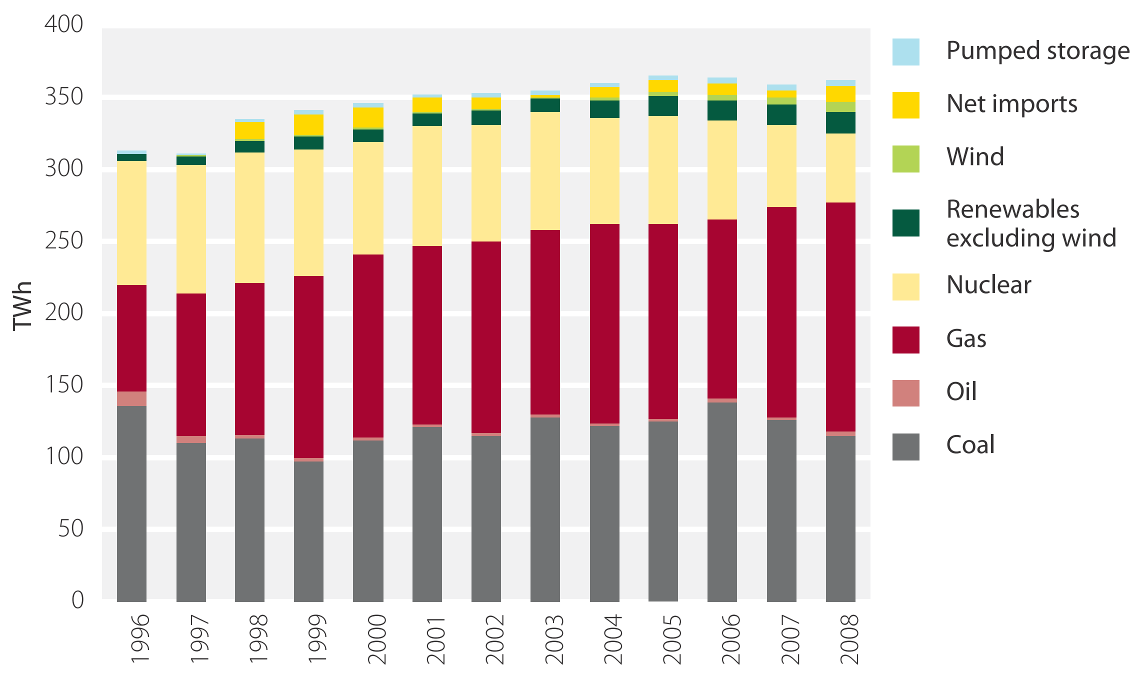
Electricity demand has increased across the period since 1990 (Figure 4.5):

- From 1990 to 2005, electricity demand increased by around 1.6% per annum, driven by growth across all sectors.
- Following a 1.5% fall in demand to 2007, overall demand has been flat to 2008, with a fall in industry demand offsetting increasing residential sector demand.
- The most recent quarterly data suggests that the economic downturn may have intensified this trend into 2009. Overall electricity consumption was 5% lower in the first quarter of 2009 compared with the same period in 2008.

Overall, the emissions intensity of power generation has fallen since 1990, and fluctuated in the last three years:

- The average carbon-intensity of the power sector fell from 770 gCO_2/kWh in 1990 to 527 gCO_2/kWh

Figure 4.4 Electricity generation (1996-2008)



Source: DECC (2009); *DUKES*; Table 5.1, 5.6 and 7.4.
Note: Data for net imports is only available from 1998. Chart begins in 1996 because data for previous years is not available on the same basis.

1 DECC (2009) Energy Trends, June 2009.

in 2005. Intensity increased to 543 gCO_2/kWh in 2007[2] but provisional estimates suggest intensity fell to around 537 gCO_2/kWh in 2008[3].

- The reduction in the 1990s reflects the dash for gas, whilst the short-term trend reflects movements in fossil fuel and carbon prices, demand and availability of nuclear plant.

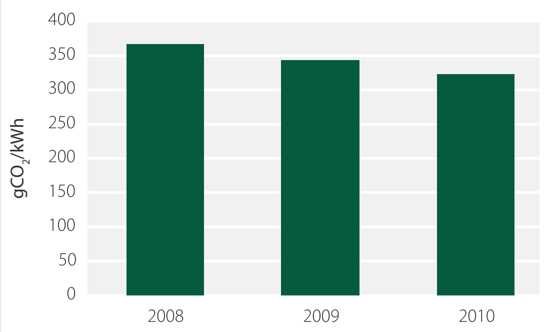
The achievable emissions intensity for the power sector – the least emissions dispatch to meet demand from available capacity – was around 370g/kWh in 2008 (Figure 4.6).

Looking forward we expect the achievable emissions intensity to steadily fall as:

- Just over 2 GW of wind capacity is currently under construction, with an expectation that the majority will be completed and commissioned in 2009 and 2010
- There are no planned nuclear retirements before 2011, and all existing plants are currently online
- No new unabated coal plant is currently under construction, whilst around 4.7 GW of new gas plant is expected to come online over 2009 and 2010.

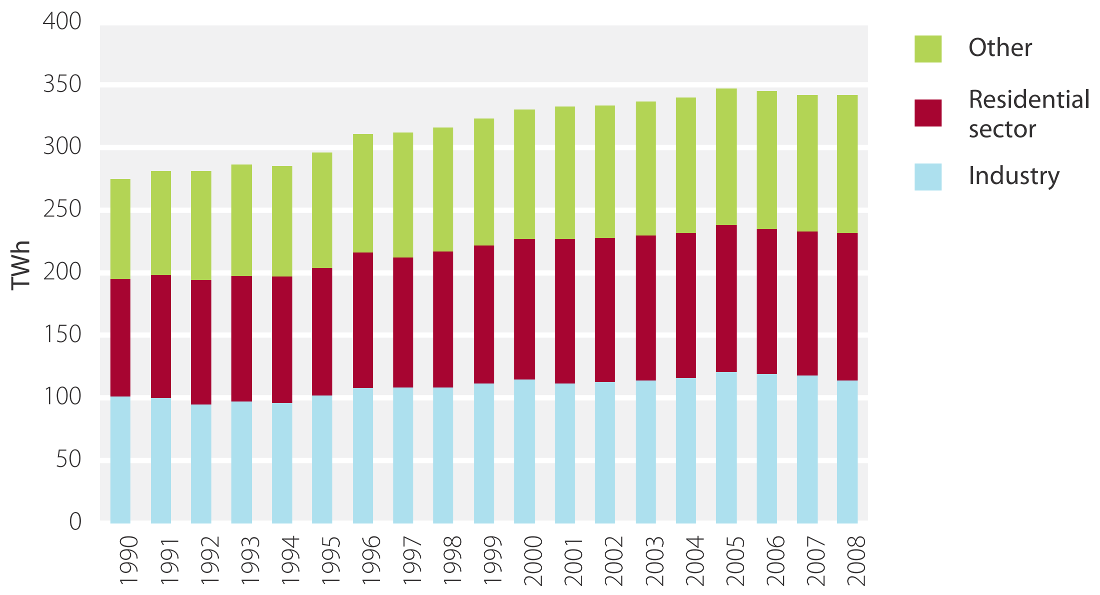
Together we expect these to lead to an achievable emissions intensity of around 320 g/kWh in 2010, whilst outturn intensity and emissions will depend on actual outages and fuel and carbon prices.

Figure 4.6 Estimated achievable emissions intensity



Source: CCC calculations.
Note: Achievable emissions intensity is the minimum average annual emissions intensity that could be achieved in a given year, given the installed capacity, demand and the profile of that demand . Emissions intensity is on an end use basis (includes transmission and distribution losses).

Figure 4.5 Electricity consumption (1990-2008)



Source: DECC (2009); *DUKES*; Table 5.1.2.
Note: Other includes public administration, transport, agriculture and commercial sectors. Does not include energy industry use and losses.

2 Defra/DECC (2009) 2009 guidelines to Defra/DECC's GHG conversion factors for company reporting.
3 2008 figures are based on CCC calculations from DECC (2009), Dukes.

2. Scenarios for power sector decarbonisation to 2022

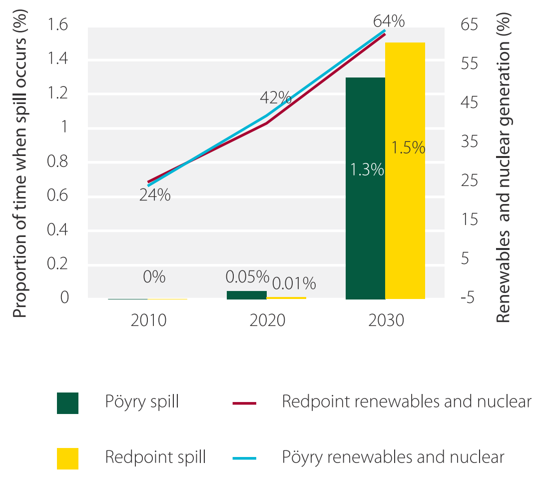
There is an approach to power generation that says emissions from the sector are capped and that we can entirely rely on the market to determine the appropriate path to decarbonisation. This is not, however, an approach that the Committee accepts. Whilst inclusion of the power sector in the EU ETS will deliver the emissions cuts required in the sector to 2020, it will not automatically bring forward the low-carbon investment to deliver required emissions cuts in the 2020s and beyond. This is because the EU ETS cap to 2020 could be met through coal to gas switching without any significant new investment in low-carbon plant, and because the cap beyond 2020 is highly uncertain.

Given the importance of early power sector decarbonisation, we set out in our December 2008 report two scenarios for power sector decarbonisation over the first three budget periods that would put us on track to meeting our longer-term goals:

- The first scenario was based on a high level of renewables consistent with scenarios in the Government's draft Renewable Energy Strategy.[4]
- The second scenario had a slightly lower level of renewables, with three new nuclear plants added to the system during the third budget period. In setting out this scenario, we noted that there are concerns about the long-term sustainability of nuclear waste storage and about the possible implications of a global nuclear power industry for military nuclear proliferation. The Committee recognises that these issues go beyond cost economics alone. The Committee argued, however, that if nuclear is in principle acceptable, then cost economics will argue for a significant role in the generation mix.

The premise for these scenarios was a hypothesis that there may be a tension between high levels of renewables and the economics of nuclear new build. Subsequent modelling, however, does not appear to bear out this hypothesis, and suggests that the projected demand/supply balance is such that there may only be limited periods of excess supply ('spill') even with both high levels of renewable and nuclear new build (Figure 4.7).

Figure 4.7 Spill with high levels of wind and nuclear



Source: CCC calculations based on Redpoint (2009), *Decarbonising the GB power sector*; Pöyry (2009) *Impact of Intermittency*.

High levels of wind generation and nuclear new build are both desirable over the first three budgets:

- Wind generation offers the best opportunity for early decarbonisation of the power sector because it is the only low-carbon technology that is ready for deployment now.
- Nuclear new build is a cost-effective form of low-carbon generation and early entry into the mix will contain the costs of decarbonisation through the 2020s and beyond.

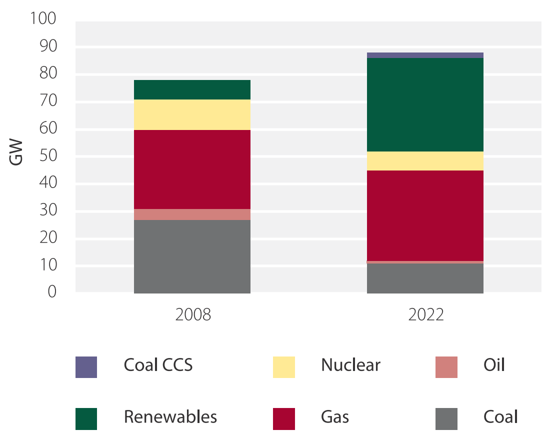
4 BERR (2008) *UK Renewable Energy Strategy consultation.*

We have therefore designed a new indicative scenario which includes both high levels of wind and nuclear new build and which our analysis shows is consistent with being on track to meeting the 80% emissions reduction target:

- The scenario includes addition of 23 GW new wind capacity and four CCS demonstration plants by 2020, with three new nuclear plants by 2022, together with 4 GW of new non-wind renewables (Figure 4.8 and Figure 4.9).
- It does not include the Severn Barrage project, which could deliver low-carbon electricity at reasonable cost but is relatively expensive compared to other low-carbon options currently available and offers limited scope for driving down costs through learning/wider technology deployment. Whilst this project may become an attractive option in the future if other technologies fail to deliver, it is not a clear current priority (Box 4.2).
- Emissions fall by around 50% from 2008 levels to 2020 under this scenario, putting emissions intensity on the path to deep emissions cuts required by 2030 and beyond to meet the 80% economy-wide emissions reduction objective in 2050 (Figure 4.10 and Figure 4.11).

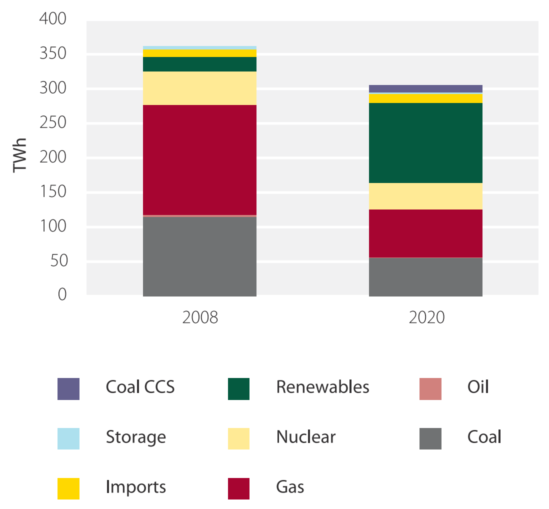
We include this scenario in our economy-wide Extended and Stretch Ambition scenarios (Chapter 3). We will use it pragmatically to provide a high level assessment of progress in reducing power sector emissions. To achieve this scenario, however, there is a set of required measures around the enabling framework and project development and implementation. We now turn to a detailed consideration of these measures for wind, nuclear and CCS generation.

Figure 4.8 CCC scenario for capacity mix in 2020 compared to actual capacity mix in 2008



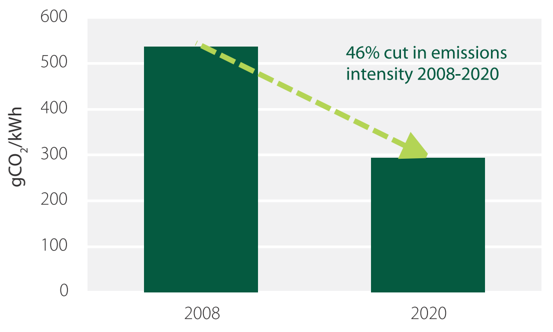
Source: DECC (2009); *DUKES*; Table 5.7 and 7.4 and CCC.
Notes: Capacity is on nameplate basis. Renewables in 2020 are made up of 27 GW of wind and 7 GW of other renewables.

Figure 4.9 CCC scenario for generation mix in 2020 compared to actual generation mix in 2008



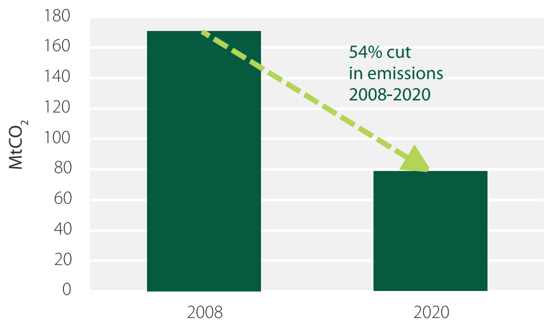
Source: DECC (2009); *DUKES*; Tables 5.6, 7.4 and 5.1 and CCC.

Figure 4.10 Emissions intensity in 2020 under CCC scenario compared to 2008



Source: CCC calculations based on DECC (2009); *DUKES*; Tables 5.1, 5.6, 7.4 and E.1.

Figure 4.11 Emissions in 2020 under CCC scenario compared to 2008



Source: CCC calculations based on DECC (2009); *DUKES*; Table E.1.

Box 4.2 Severn Tidal Power

The Government is currently investigating a number of options to use the tidal range (the height difference between low and high tide) in the Severn estuary to generate electricity. The feasibility study will make recommendations in 2010 after further technical, environmental, and economic analysis and a second public consultation. A smaller barrage could be completed in time to contribute towards the 2020 renewable energy target, whilst a large barrage would take longer.

The Committee has made its own assessment as to whether or not a Severn barrage should be pursued. In doing so we have considered:

- The cost per kWh of low-carbon electricity generated, relative to other options available to decarbonise the power sector.
- The potential of investment in a barrage to drive learning, and to bring down the future cost of generating low-carbon electricity.

Cost

In the context of a commitment to power sector decarbonisation, an option to deploy a barrage in the early 2020s should be compared with other low-carbon generation options available for deployment from the early 2020s, i.e. other renewables, nuclear and CCS.

A tidal barrage would be highly capital intensive and would have a much longer life than most other technologies in the power sector (around 120 years, compared to around 40 years for a nuclear power plant, and 20 years for a wind farm). The choice of discount rate is therefore critical. Given we are considering societal choices about alternative low-carbon technologies, we have used a social rather than commercial discount rate in comparing these technologies.

The figure below shows the levelised costs for a barrage compared to other technologies. It abstracts from the need to back up plant which cannot be relied upon to generate in the peak. It is therefore favourable both to the barrages and wind generation, which require significant back up.

We have looked at two barrages: the Cardiff-Weston barrage – the largest barrage being studied in detail by Government, and the Shoots barrage – the most cost-effective of the barrages being investigated further by Government.[5] Figure B.4.2 shows that the costs for these options are at the high end of the range for all low-carbon technologies.

5 DECC (2009) *Partial impact assessment of Severn tidal power shortlisted schemes.*

Box 4.2 continued

Learning

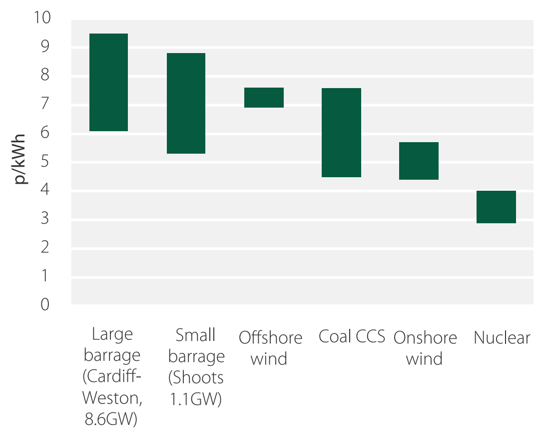
A key part of the rationale for the Government's renewables target, is to encourage investment in emerging low-carbon technologies and thereby drive the costs down. However, in contrast to technologies such as offshore wind, and other marine technologies such as tidal stream and wave, there is likely to be little scope for learning from the construction of a barrage in the Severn estuary. Firstly, the technology has already been proven (in La Rance in France a 240 MW barrage has operated since the 1960s). Secondly, the Severn resource is exceptional. There are only a handful of sites in the world where tidal range could be introduced on a comparable scale.

Conclusions

A Severn barrage would generate electricity at a low enough cost that if other options were not available it could form part of a clearly affordable low-carbon strategy. However, it currently appears more costly than the leading low-carbon alternatives, whilst investment in a barrage is not likely to drive down the future costs of generating low-carbon electricity. Investing in a barrage is therefore not clearly attractive if these alternatives are available.

However, we note that nuclear, CCS and other renewables carry their own delivery risks, and the option of constructing a barrage at the Severn in future should therefore be kept open. As such, even if building a smaller barrage or lagoon proves more cost-effective it may not be desirable to proceed with this option if it rules out the addition of a large barrage in the future.

Figure B4.2 Levelised cost at social discount rate for low-carbon technologies built in 2020



Source: CCC calculations based on DECC (2009), *Partial impact assessment of Severn tidal power shortlisted schemes*; IPCC (2005) *Special report on CCS*; DECC capital and operating cost assumptions.
Note: Lower ranges for the barrages are based on no requirement for compensatory habitat and 15% optimism bias on costs. Upper ranges are based on 2:1 requirement for compensatory habitat and 66% optimism bias on costs.

3. Wind generation: indicators and the enabling framework

This section sets out our indicators for wind generation, against which we will judge progress in our annual reports to Parliament. It covers the various stages of the project cycle for investment in wind generation (Figure 4.12). It presents a scenario for investment in wind generation consistent with our overall power scenario outlined above and with the Government's ambition for renewable electricity as set out in its Renewable Energy Strategy, and critical factors in realising this scenario. It sets out departures from this scenario under alternative assumptions about different stages of the project cycle. It also considers access rules and investment in power transmission required to support renewable investment.

We now consider:

(i) Scenarios for investment in wind generation

(ii) Power transmission investments and access rules

(iii) Summary of wind generation indicators.

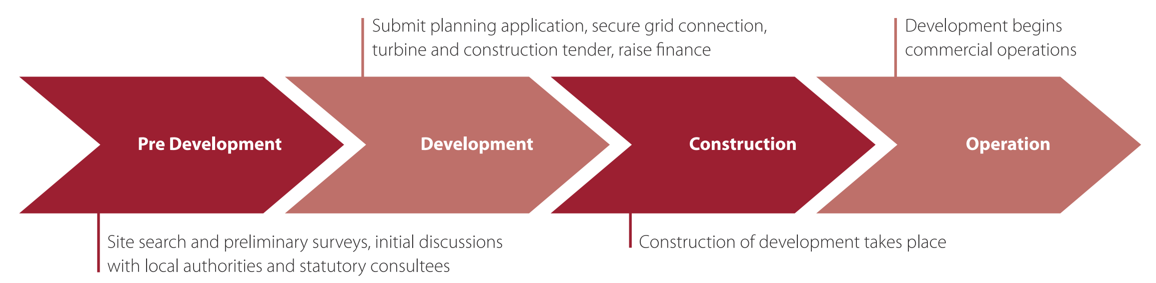
(i) Scenarios for investment in wind generation

High feasible investment

In developing our high scenario for feasible investment in wind generation, we have considered:

- Current wind capacity in the pipeline at different stages of the project cycle.
- Time required for project development (planning, gaining access to the grid, and securing finance – Box 4.3).
- Time required for construction (Box 4.4).
- Barriers to project implementation (e.g. supply chain constraints).

Figure 4.12 The project cycle for a wind development



Source: Pöyry Energy Consulting (2009) *Timeline for wind generation to 2020 and a set of progress indicators.*

Box 4.3 Constraints within development phase

In order to proceed, a project must have planning approval, transmission access, finance and a turbine contract:

- Planning approval has historically often been slow (e.g. taking up to several years), resulting in projects being delayed or cancelled. Recent planning reforms are aimed at reducing the planning period and increasing approval rates (Box 4.5).
- The UK grid is currently constrained in areas with wind generation potential. This has resulted in access being delayed ten or more years in some cases. Recent reforms are aimed at providing access for any project that is ready to proceed.
- Accessing finance has become more challenging as a result of the credit crunch. In particular, there has been limited project finance available to independent developers. A combination of finance from the European Investment Bank with possible Government support should address this issue (Chapter 2).
- Until recently, there was limited availability of turbines for new wind generation projects. Supply constraints have eased, however, as the global recession has reduced turbine demand, potentially allowing increased turbine supply to the UK (Box 4.6).

Box 4.4 Construction of a wind farm

Onshore: In our analysis, we have assumed construction takes one year. Activities include installation of a substation, laying of turbine foundations, erection of turbines and the commissioning and testing of turbines.

Offshore: We have assumed a two year construction period. Activities include installation of the offshore substation, laying of subsea export cable, installation of steel foundations, securing of transition piece (to enable access to wind farm) and turbine installation.

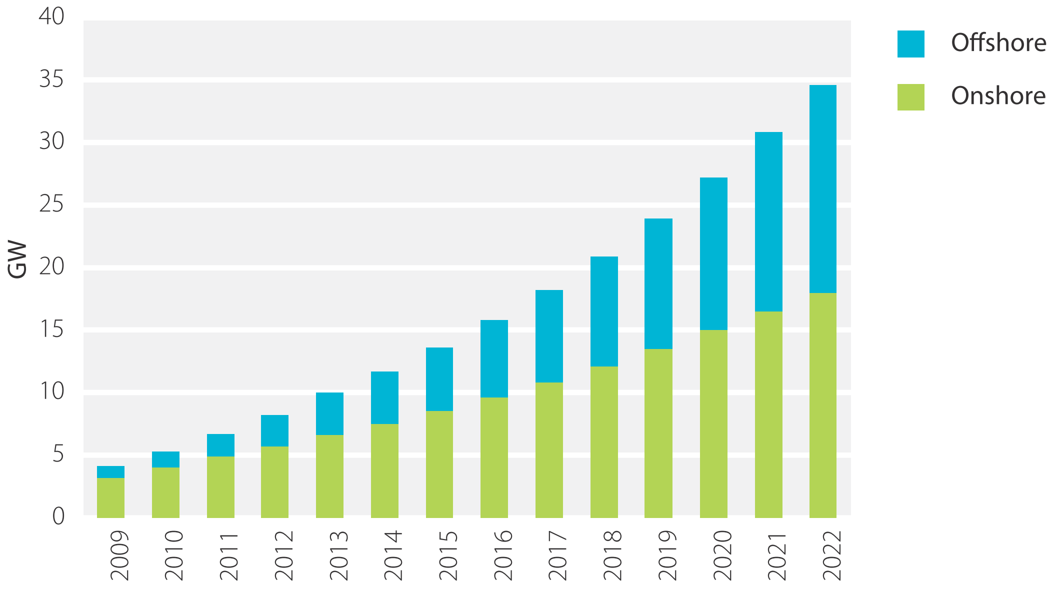
Allowing for all these factors and drawing on analysis carried out for us by Pöyry Energy Consulting, we estimate that it would be feasible to add up to 23 GW of new wind capacity by 2020 (i.e. to reach 27 GW in total given the 4 GW currently on the system – Figure 4.13):

- This comprises an additional 12 GW onshore and 11 GW offshore.
- Onshore wind is added along a reasonably smooth trajectory at an annual average rate just under 1 GW to 2014, rising to 1.5 GW by 2020.
- Offshore wind is added at the rate of under 1 GW per year in the near term, rising to almost 2 GW per year by 2020.

Delivering this level of investment is contingent on four key factors:

- Planning system reform reduces the planning period and increases the approval rate (Box 4.5).
- Renewables have access to a power transmission network without bottlenecks; we discuss issues around power transmission in the next section.
- The supply chain adjusts to accommodate over a threefold expansion in annual installation capability for both onshore and offshore generation. This will require, for example, the UK accessing ten additional offshore installation vessels, costing between £50-150 million each and with up to a three year procurement period (Box 4.6).
- Projects are able to secure finance. We discuss financing of renewable projects in the current macroeconomic context in Chapter 2.

Figure 4.13 Operational wind capacity in the high feasible scenario



Source: CCC modelling based on Pöyry Energy Consulting (2009), *Timeline for wind generation to 2020 and a set of progress indicators*.

Box 4.5 Getting planning approval

Evidence from the British Wind Energy Association (BWEA) suggests that it took on average 14 months for the relevant Local Planning Authority (LPA) to determine onshore projects under 50 MW, as opposed to the statutory timescale of 16 weeks. Applications that go to appeal (around a quarter) take an average of 26 months.[6] For larger onshore projects (over 50 MW) the average time from application to the Secretary of State to decision is around 25 months, with those going to inquiry (around 15% in England, 30% in Scotland) taking a further 10 months. Large offshore projects are usually determined within 21 months.[7]

The Planning Act 2008 introduces new rules to simplify the consent procedure for large energy projects (defined as Nationally Significant Infrastructure Projects), including wind but also transmission infrastructure. A suite of National Policy Statements (NPSs) will establish the national case for infrastructure development, including renewables.

The Act establishes the Infrastructure Planning Commission (IPC), to take over decisions on major infrastructure applications. This means onshore projects 50 MW or above will seek approval from the IPC along with offshore installations over 100 MW. The IPC must have regard for the relevant NPS when considering applications, and have a legal duty to determine the application within a set time period (around nine months). The new process places a greater onus on developers to consult with interested parties before an application is submitted, which is also expected to reduce the risk of inquiry and improve the approval rate.

6 BWEA (2008), *State of the Industry Report*.
7 Pöyry Energy Consulting (2009), *Timeline for Wind Generation to 2020 and a set of Progress Indicators*.

Box 4.5 continued

For onshore projects below 50 MW (around 40% of capacity currently awaiting approval) the Renewable Energy Strategy sets out a number of reforms being taken forward to speed up and improve the approval rate for such projects, including:

- Increased funding for LPAs
- Performance agreements between developers and LPAs on timescales
- A requirement for each Devolved Administration to assess the potential for renewable electricity and heat, as the basis for a level of ambition for deployment by 2020.

Box 4.6 Supply chain constraints

The onshore market is relatively more mature than offshore, where the barriers are generally considered more severe.

The key supply chain issues for offshore generation are:

- Turbine technology is at an early stage of development, and the market for turbine supply is very limited,
- The market for subsea cables – of which around 7,700 km will be required for Round 3 projects – is undeveloped,
- There are currently only two installation vessels available to install wind turbines in the UK – with up to 12 needed by 2020.

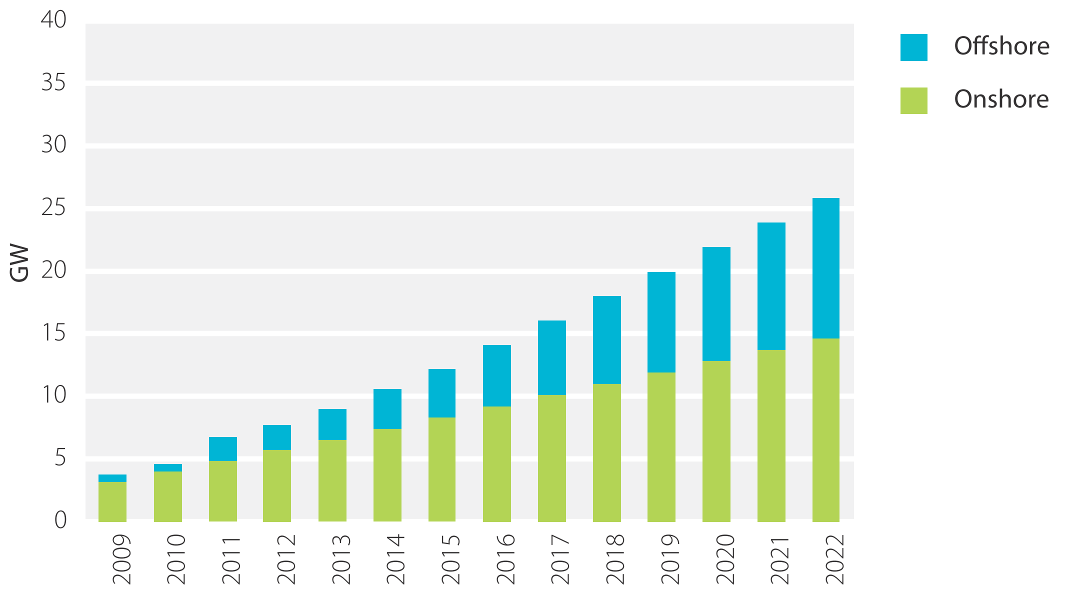
Supply chain constraints can potentially be eased through provision of clear signals on the level of ambition for offshore wind and supporting delivery mechanisms (e.g. continued financial support).

Departures from high feasible investment

We have also developed alternative scenarios to highlight outcomes under alternative assumptions about key drivers:

- With even higher growth in supply chain capability (e.g. such that up to 2 GW of onshore wind and 3 GW of offshore wind could be added annually by 2020) we estimate that up to 29 GW of capacity could be added (split 14/15 GW on/offshore), with total capacity reaching just over 33 GW by 2020.
- We estimate that just 18 GW of new capacity could be added by 2020 (22 GW in total), if the planning period and approval rate is around equal to the historical average and the supply chain capability is around half of that in the maximum feasible investment scenario (Figure 4.14). This is split 10 GW onshore and 8 GW offshore.
- We have explored a further scenario, where supply chain capability fails to expand beyond 2010, together with further prolonged planning periods and poor approval rates, strenuous conditions for raising finance and some constraints on the transmission network. In this scenario, as little as 13 GW of new capacity is added (17 GW in total), split 8 GW onshore and 5 GW offshore.

Figure 4.14 Operational wind capacity in the alternative scenario



Source: CCC modelling based on Pöyry Energy Consulting (2009), *Timeline for wind generation to 2020 and a set of progress indicators.*

Summary of scenarios

The high feasible scenario we have developed in our bottom-up analysis of wind generation is consistent with the scenario presented in Section 2 above. The bottom-up analysis suggests that it is challenging but feasible to add the levels of wind capacity required to be on track to meeting our 80% emissions reduction target in 2050 and to meet the Government's ambition set out in its Renewable Energy Strategy. The analysis also highlights the risk that if improvements to the planning system and growth in the supply chain are insufficient there will be a consequent shortfall in wind investment relative to our scenario. Even with reduced planning periods and supply chain growth, delivering more ambitious scenarios will require a number of measures to be implemented for power transmission.

(ii) Power transmission investments and access rules

It is crucial that the power transmission network is developed in a way to support a significant increase in the level of wind generation. The current network has limited capacity, with severe bottlenecks in some areas where there is wind resource (e.g. there is limited capacity from north to south Scotland and from Scotland to England), and a very limited offshore network. Onshore and offshore transmission investments will therefore be required as a matter of urgency.

The onshore transmission network

In the context of developing a strategy for renewable energy, an Electricity Network Strategy Group (ENSG) jointly chaired by DECC and Ofgem and comprising power generators and transmission owners has been formed. The ENSG has carried out analysis of required transmission investments to support increased wind generation, and has identified a set of 'least regrets' investments (i.e. where there is a high degree of confidence that these investments will not turn out to be stranded – Figure 4.15)[8]. Implementation of these projects is a necessary condition for delivering the scenarios for wind generation investment that we set out above.

In order that these projects proceed, they must be approved by Ofgem. Currently Ofgem has agreed in principle that these projects can proceed and be included in National Grid's regulated asset base. There is ongoing discussion about the return on investment that will be allowed, and the risks that National Grid will accept (e.g. cost overrun, lower demand than currently anticipated). This is a matter for Ofgem and National Grid, and possibly the Competition Commission if these two parties cannot come to agreement. The key issue for the Committee is the timing of approval, which should ideally be early in 2010, with planning permission granted by the new Infrastructure Planning Commission before the end of 2011, in order that project implementation can commence as required in 2012 (Figure 4.16).

The offshore transmission network

Up to £15 billion of investment will be required to develop the offshore transmission network to eventually support up to 40 GW of offshore wind generation, should all the resource currently identified in the Crown Estate and Scottish Territorial Waters be taken up.

A new regime to govern this investment was introduced under the Energy Acts 2004 & 2008 whereby there will be competitive tendering (run by Ofgem) for the right to build and operate offshore transmission networks, with National Grid – as System Operator – providing strategic oversight to ensure that these networks are developed in a coherent manner.

Offshore grid investments will be tendered in two categories:

- Tendering for the first 'transitional' projects started in June 2009. A licensed Offshore Transmission Owner (OFTO) should be in place to operate the existing offshore transmission network by 2010.
- Tendering for the construction of the first projects under the enduring regime will start in June 2010, for construction to start in 2011 and complete in 2012/13. It is currently envisaged there will be annual tendering rounds.

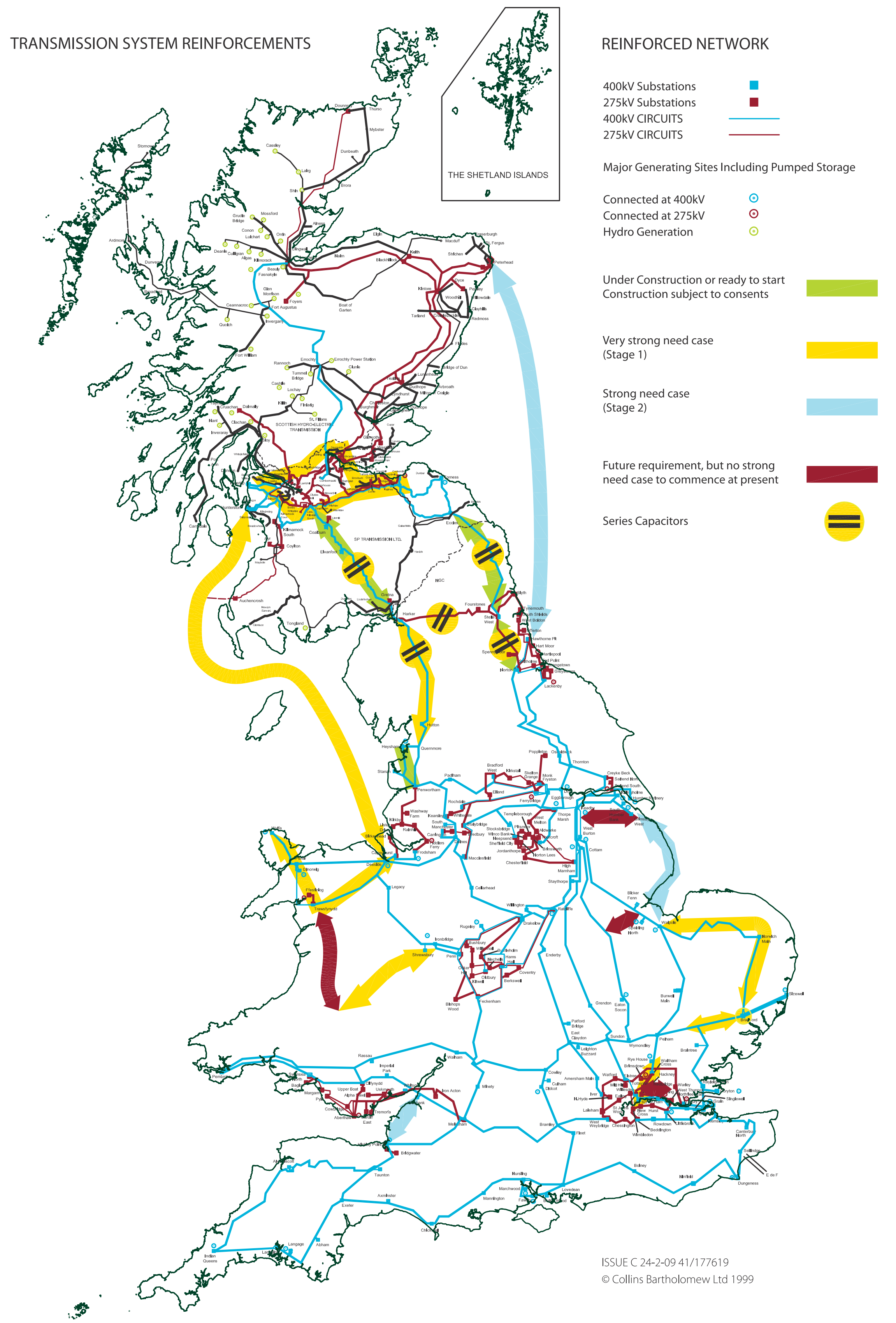
These schedules underpin the envisaged addition of 11 GW offshore capacity by 2020 in our high feasible investment scenario, and the Committee will therefore focus on achieving milestones in the schedules as part of annual monitoring of progress reducing emissions (Figure 4.17).

Transmission access

It will inevitably be the case that there will continue to be transmission network bottlenecks in the near term given the lead time for transmission investment projects. An interim arrangement is in place to ensure that renewable capacity is able to gain access to the network even where this is capacity constrained. There are a number of alternatives for replacing the interim arrangements, and which differ on distributional grounds (e.g. whether or not incumbent generators are paid compensation for not generating – Box 4.7); the choice between these mechanisms goes beyond the remit of the Committee. An important issue for the Committee, however, is the timing of this choice; an enduring mechanism that allows network access to wind generation should be in place by mid-2010 in order to support delivery of our scenarios for investment in wind generation.

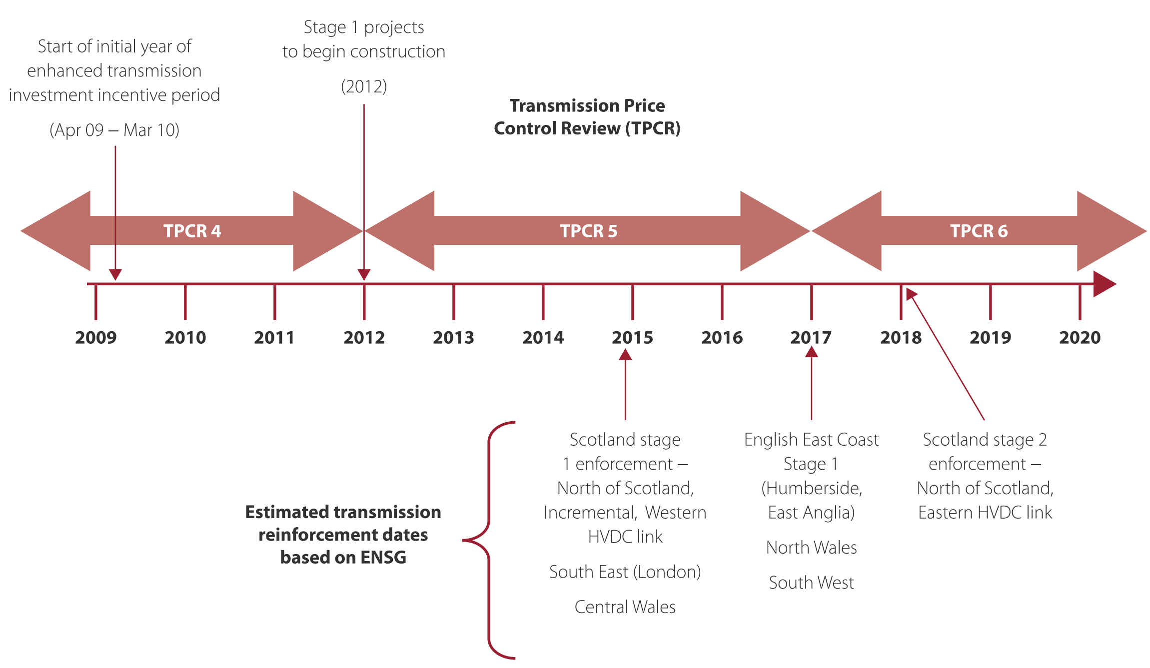
8 ENSG (2009) *Our Electricity Transmission Network, A Vision for the Future*, http://www.ensg.gov.uk/assets/1696-01-ensgvision2020.pdf

Figure 4.15 Stage 1 and 2 transmission reinforcements recommended by ENSG



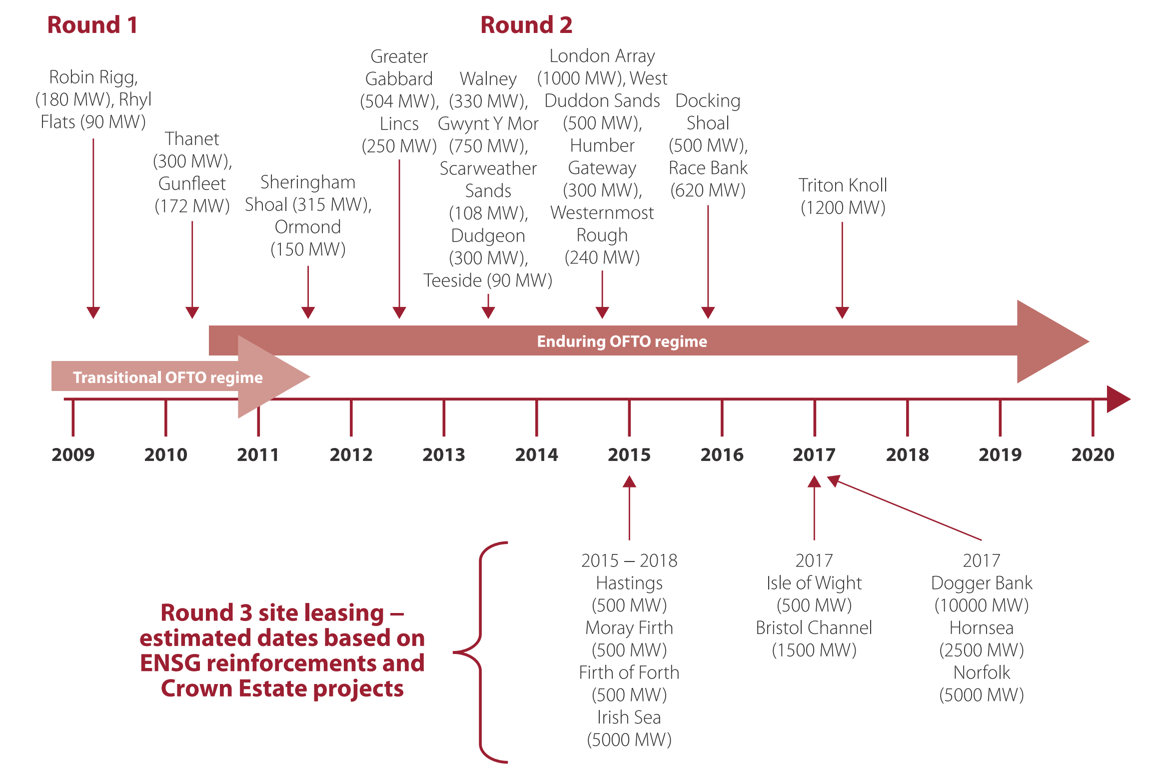
Source: ENSG (2009), *Our Electricity Transmission Network, A Vision for the Future.*

Figure 4.16 Timeline for investments in transmission capacity, onshore



Source: Pöyry Energy Consulting (2009), *Timeline for wind generation to 2020 and a set of progress indicators*; ENSG (2009), *Our Electricity Transmission Network, A Vision for the Future.*

Figure 4.17 Indicative timeline for offshore capacity



Source: BWEA, DECC, Crown Estate, Pöyry Energy Consulting (2009), *Timeline for wind generation to 2020 and a set of progress indicators*; ENSG (2009), *Our Electricity Transmission Network, A Vision for the Future*, Crown Estate.
Note: Due to space, not all Round 2 projects are shown

Box 4.7 Rules for accessing the grid

The 2008 Transmission Access Review (TAR) set out the need for grid access reform. A range of models have been put forward, broadly falling into two categories:

- 'Connect and Manage' as under the interim arrangements, whereby generators are offered a fixed connection date ahead of necessary reinforcements. Any constraints on the network are managed by the System Operator (National Grid).
- Auctioning – unlike Connect and Manage (where incumbent generators will effectively be paid for not generating in the event of a bottleneck), auctioning would require the removal of existing rights, and reallocation via an auction.

In August 2009, the Government published a consultation seeking views on the options, and their implementation.

(iii) Summary of wind generation indicators

The indicators against which we will monitor progress cover all stages of the project cycle, together with the supply chain and power transmission. We will therefore not only be able to make an assessment of whether there is sufficient investment in new wind capacity, but whether there is likely to be sufficient investment given progress in the drivers of investment. Our indicators include:

- The number and type of planning applications made for wind generation projects, time taken to process applications and approval rates.
- The number of wind generation projects commencing and completing construction, along with the time taken and any barriers faced.
- Key stages for development and implementation of the transmission investments identfied by the ENSG.
- Key milestones for development of the enabling framework (e.g. agreement of an enduring regime for transmission network access).

We set out the indicators underpinning our high feasible investment scenario in Table 4.1.

Table 4.1 Table of indicators – wind

Wind	2008	2009	2010	2011	2012
Headline indicator					
Total generation (TWh)	**7.6**	**9.7**	**13.4**	**16.8**	**20.9**
Onshore	5.8	7.0	9.0	11.0	12.9
Offshore	1.8	2.7	4.3	5.9	8.0
Supporting indicators					
Project cycle					
Total installed capacity (GW)	**3.4**	**4.1**	**5.4**	**6.7**	**8.2**
Onshore	2.8	3.2	4.0	4.9	5.7
Offshore	0.6	0.9	1.3	1.8	2.5
Additional capacity (GW)	**0.9**	**0.7**	**1.3**	**1.3**	**1.5**
Onshore	0.7	0.4	0.8	0.9	0.9
Offshore	0.2	0.3	0.5	0.5	0.7
Capacity entering construction (GW)	**1.0**	**1.4**	**1.5**	**1.8**	**1.7**
Onshore	0.5	0.9	0.8	0.9	0.9
Offshore	0.5	0.5	0.7	0.9	0.9
Average planning period (months) onshore/offshore, all sizes	**various***	**<12 months**			
Capacity entering planning (GW)	**2.3**	There are currently around 9 GW of projects awaiting planning consent (7 onshore and 2 offshore), as well as just under 7 GW that have planning consent but are not yet in construction (3.2 onshore and 3.6 offshore)**.			
Onshore	1.4				
Offshore	0.8				
Transmission					
Transmission policy					
Implementation of enduring regime for accessing grid			■ (green)		
Agreement on incentives for anticipatory investment for Stage 1 reinforcements			■ (green)		
Transitional OFTO regime in place		■ (green)			
Enduring OFTO regime in place			■ (green)		
Onshore transmission reinforcement dates					
Scotland Stage 1 (North, Incremental and Western HVDC link)				■ (red)	■ (yellow)
Scotland Stage 2 (North, Eastern HVDC link)					
Wales Stage 1 (Central)				■ (red)	■ (yellow)
Wales Stage 1 (North)					
English East Coast Stage 1 (Humberside, East Anglia)					
South East (London)				■ (red)	■ (yellow)
South West					
Offshore transmission reinforcement dates					
First offshore connections under enduring OFTO regime			■ (red)	■ (yellow)	■ (green)
Moray Firth, Firth of Forth, Hastings, Irish Sea					
Dogger Bank, Hornsea, Norfolk, Isle of Wight, Bristol Channel					
Other drivers					
We will also be monitoring qualitative indicators including average load factors, planning approval rates and frequency of public inquires to decisions of Infrastructure Planning Commission, availability of offshore installation vessels and supply of turbines to the UK market.					

Key:
■ (red) seek and gain planning permission ■ (yellow) in construction ■ (green) in operation

Source: CCC calculations, Pöyry Energy Consulting (2009) *Timeline for wind generation to 2020 and a set of progress indicators*, BWEA UK Wind Energy Database (UKWED), RESTATS Planning database.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	25.7	**30.5**	**35.6**	**43.6**	**50.5**	**58.2**	**66.8**	**76.3**	**86.8**	**98.0**
	14.8	16.8	19.0	23.5	26.5	29.7	33.1	36.8	40.4	44.1
	10.9	13.6	16.6	20.1	24.0	28.6	33.7	39.6	46.4	53.8
	9.9	**11.7**	**13.6**	**15.8**	**18.2**	**20.9**	**23.9**	**27.2**	**30.8**	**34.6**
	6.6	7.5	8.5	9.6	10.8	12.1	13.5	15.0	16.5	18.0
	3.4	4.2	5.1	6.2	7.4	8.8	10.4	12.2	14.3	16.6
	1.8	**1.8**	**1.9**	**2.2**	**2.4**	**2.7**	**3.0**	**3.3**	**3.6**	**3.8**
	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.5
	0.9	0.9	0.9	1.1	1.2	1.4	1.6	1.8	2.1	2.3
	1.8	**2.1**	**2.3**	**2.6**	**2.9**	**3.2**	**3.6**	**3.8**	**3.8**	**4.1**
	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.5	1.5
	0.9	1.1	1.2	1.4	1.6	1.8	2.1	2.3	2.3	2.6

Going forward we expect at a minimum new planning applications required towards the end of the second budget period, or sooner in the event of low approval rates for the current stock. For offshore, we will expect a schedule in line with site leasing (e.g. for Round 3, projects entering planning in 2012/13 for operation from 2015 onwards.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
			■							
		■	■			■				
			■							
	■	■			■					
	■	■			■					
			■							
	■	■			■					
	■	■	■							
			■	■	■					

Key:
Headline indicators Implementation indicators Forward indicators Milestones Other drivers

Notes: *For example, BWEA found average period for onshore <50 MW was 14 months for determination by LPA (for those not going to appeal), and 26 months for those going to appeal (around 30%). From a sample, Eversheds (on behalf of Pöyry) found onshore 100 MW+ took around 25 months for determination by the Secretary of State, and Offshore (<100 MW) around 21 months. **BWEA Statistics, September 2009

4. Investment in nuclear new build

Our scenario for decarbonisation of the power sector includes up to three new nuclear plants by 2022. In this section we consider what has to happen in order that the first of these plants comes onto the system in 2018, differentiating between development of an enabling framework and project development/implementation.

Development of an enabling framework

Planning has been a particular problem for past investment in nuclear power in the UK, with planning approval of the Sizewell B project taking around six years. Going forward, this period will have to be reduced both to contain costs of nuclear development and to ensure that investment occurs in a timely manner without compromising due process. In this respect, the Government is making progress on a number of fronts:

- Regulatory Justification of nuclear new build will be completed by early 2010.
- A National Policy Statement (NPS) outlining the importance of nuclear new build in the context of energy strategy will be published by Spring 2010. The NPS will also set out the policy framework within which the Infrastructure Planning Commission (IPC) will make its decisions (see Box 4.6 above).
- A Strategic Siting Assessment pre-approving sites for nuclear new build will be completed in April 2010.
- Generic Design Assessment of reactor designs is due to be completed by mid-2011, leaving only some site specific aspects for further regulatory approval.
- Regulations for a Funded Decommissioning Programme covering back-end waste and decommissioning costs is expected to be in place by 2010.

Project development/implementation

Key aspects within the project cycle are the time taken for approval of a planning application, and the construction period for new plant:

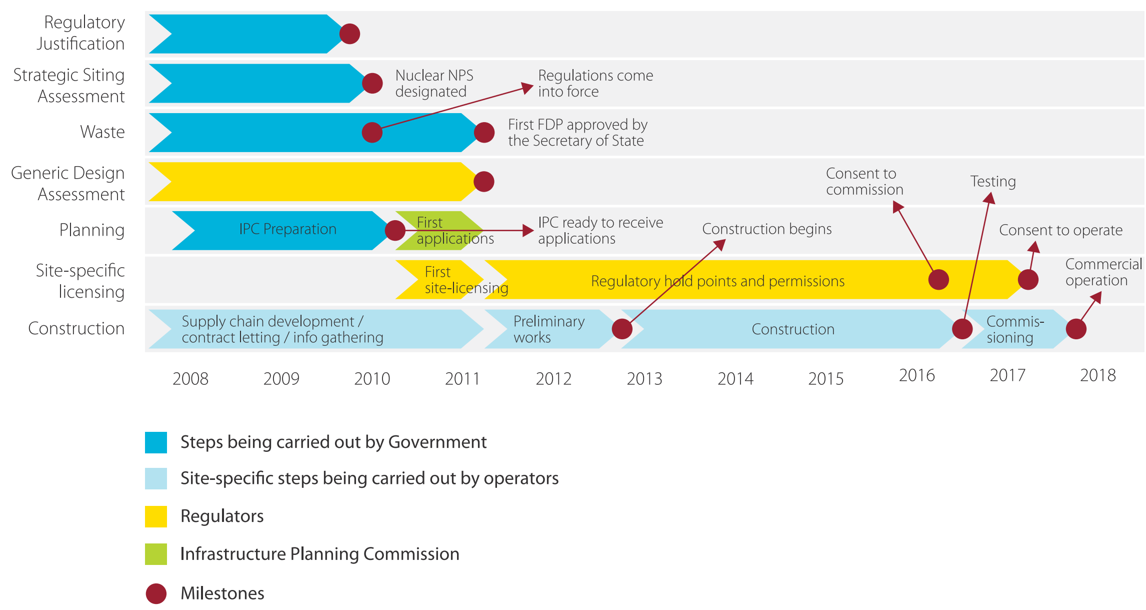
- The current expectation is that it would take the new IPC around nine months to approve a planning application.
- The Government has suggested a period of six and a half years from planning consent to commercial operation (covering site preparation, construction and testing).

Nuclear timelines and risks

Timelines for the enabling framework and project development together define our forward indicators for nuclear power (Figure 4.18). We currently expect the first planning application to be made in 2010, with approval by 2011, which would result in a completed plant by 2018 under a five year assumed construction period with one and a half years for site development. The Government's assumption, which we accept, is that plants could subsequently be added at 18 month intervals.

There are a number of risks to successful implementation related to regulation and planning. For example, the IPC might not function as intended, or the regulations for the Funded Decommissioning Programme may not be in place by 2010 as currently envisaged. In addition, the new regulatory framework may be subject to judicial review and subsequent change. Successful implementation will also require that there is an adequate supply chain, and that there continue to be sufficient numbers of specialist trained staff. We will actively monitor risks around the enabling framework and project implementation; we will cover both of these aspects as part of our wider monitoring exercise.

Figure 4.18 Nuclear timeline



Source: CCC based on DECC (2009), *Indicative timeline for first new nuclear power stations.*
Note: NPS – National Policy Statement, FDP – Funded Decommissioning Programme, IPC – Infrastructure Planning Commission.

5. Demonstration and roll-out of CCS technology

We highlighted in our December 2008 report the importance of carbon capture and storage (CCS) fossil generation both for decarbonisation of the UK power sector and for achieving required global emissions cuts. We also highlighted uncertainty over technical and economic aspects of CCS when applied at scale to a power station, and stressed the need to demonstrate this technology. We argued that there is no role for conventional coal generation through the 2020s on the path to an 80% emissions reduction target in 2050, and argued that this should be signalled by the Government to investors.

In this section, we set out our indicators for CCS demonstration and subsequent roll-out both through retrofit of existing plant and application to new plant. We also revisit our position on investment in conventional coal in light of the Government's response to our proposals.

There is an issue over the appropriate role for CCS in gas generation. Analysis in our December report showed that there is a longer term role for unabated gas generation reflecting lower emissions intensity and a potential role as back-up generation. The clear priority is therefore for early application of CCS to coal generation. The Committee will further consider viability of gas CCS as part of its advice on the fourth budget, to be published in 2010.

We consider in turn:

(i) Indicators for CCS

(ii) The framework for investment in conventional coal generation.

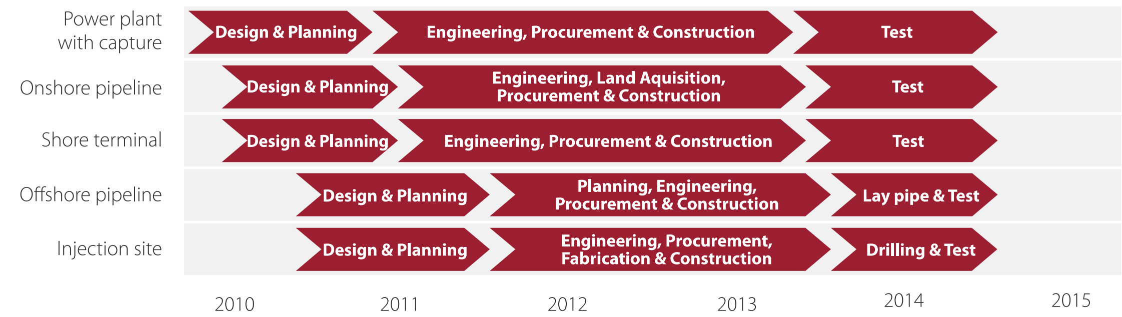
(i) Indicators for CCS

CCS demonstrations in the UK

In June 2009, the Government set out a new framework for CCS demonstration under which there will be up to four demonstration projects operational in the UK before 2020.

- The first demonstration project will be awarded funding under a competition to be concluded in 2010.

Figure 4.19 Project cycle for CCS demonstration



Source: Pöyry Energy Consulting (2009), *Carbon Capture and Storage: Milestones to deliver large-scale deployment by 2030 in the UK.*

- The Government's stated objective is that the first plant should begin operation in 2014, which would require (Figure 4.19):

– Front-End Engineering and Design (FEED) studies are undertaken in 2010

– the Competition winner is announced by the end of 2010

– by the end of 2011 each of planning and authorisation approval, land acquisition, and storage site testing is complete, and construction should have started

– the period for construction and testing of generation and transport/storage infrastructure is three years.

- A subsequent competition could in principle be launched and concluded in 2010, covering one or more projects with plants coming onto the system in 2015 or 2016.

The Committee welcomes this new framework and will use it as a basis for assessing progress in future reports to Parliament. In particular, we will focus on timely conclusion of the first competition and subsequent milestones towards having a plant in operation in or before 2015, and timely commencement of a second competition.

There are a number of questions around design of a second competition:

- How many projects should be included (one or more)?
- What technologies should this include (e.g. pre- and/or post-combustion)?
- What is the relative benefit of demonstrating CCS on existing versus new plant?
- How quickly can the competition process be completed?

We have not attempted to answer these questions in detail but have, however, taken a high-level view based on the imperative to get a critical mass of CCS in operation at the earliest opportunity:

- The second competition should follow as soon as possible after the first (e.g. in 2010), with the aim to reach operation soon after the plant financed under the first competition (e.g. in 2015 or 2016).
- It should award support to more than one plant in order to maximise learning and the probability of success, provided that there is a sufficient number of competitive bids.
- It should allow a range of technologies applied to both new and existing plant with a view to developing a portfolio of options for roll-out going forward.
- It should allow proposals based on shared infrastructure and oversized pipes to highlight scope for cost savings due to economies of scale.

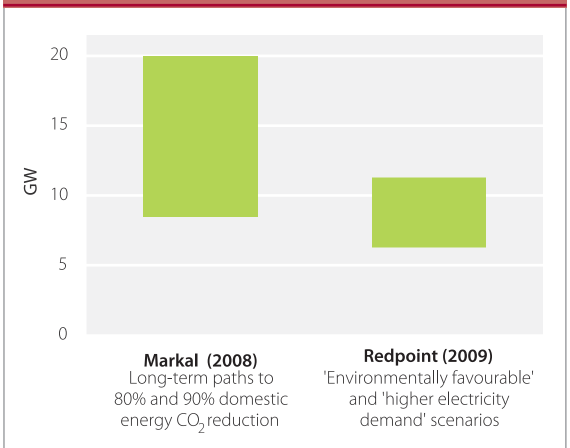
We will therefore use commencement in 2010 and conclusion in 2011 of a second competition designed along the high level principles set out above as a benchmark in our future progress reports.

From demonstration to deployment

We commissioned Pöyry Energy Consulting to help us develop a timeframe for post-demonstration roll-out of CCS, and approached this both from top-down and bottom-up perspectives:

- The top-down approach draws on modelling of power sector decarbonisation in the 2020s for our December report, which included up to 20 GW of CCS plant being added to the power system by 2030, depending on evolution of electricity demand and the levels of investment in nuclear and renewables (Figure 4.20). It assumes maximum feasible construction of 2.5 GW annually based on historical evidence of past power generation investment in the UK (Box 4.8). It therefore requires roll out of CCS to start in the early 2020s in order to keep open the option of delivering the levels of CCS deployment indicated in this scenario.
- The bottom-up approach recognises that the first demonstration project should be on the system in 2014 or 2015, with the second phase of demonstrations operational in 2015 and 2016. A decision on roll-out could then be taken as early as 2016, which with a period of five or six years for design, planning and construction would allow additional CCS to come on the system at significant scale from the early 2020s.

Figure 4.20 Ranges of CCS deployment by 2030 across core modelling runs



Source: CCC based on AEA (2008), *MARKAL-MED model runs of long-term carbon reduction targets in the UK*; Redpoint (2009) *Decarbonising the GB power sector*

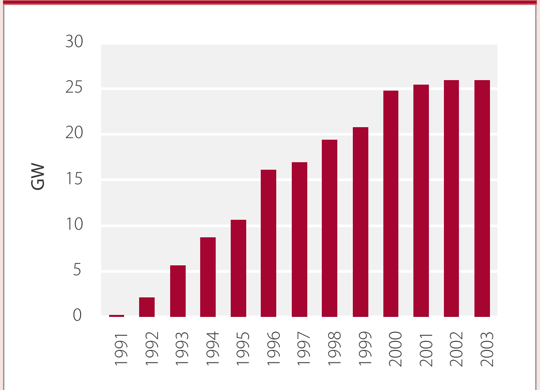
Box 4.8 Feasible build assumptions for CCS

Analysis for the CCC by Pöyry Energy Consulting suggests that it may be possible to deploy 20 GW of CCS plant by 2030 if:

- roll-out were to start in the early 2020s
- build rates of around 2.5 GW per year were achievable.

A historical comparison suggests that it would be very challenging to achieve such high build rates. A build rate of around 2.5 GW per year was sustained for gas CCGT plant in the 1990s, during the 'dash for gas'. But it must be recognised that CCS is both more risky and more technically challenging, comprising not only a thermal power plant, but also CO_2 capture, transportation and storage.

Figure B4.8 Cumulative additions to CCGT capacity (1991-2003)



Source: Pöyry Energy Consulting (2009) *Carbon Capture and Storage: Milestones to deliver large-scale deployment by 2030 in the UK.*

It is the view of the Committee therefore that the aim should be to roll out CCS from the early 2020s subject to technical and economic viability being demonstrated. A key milestone on this path is an early decision on a financing mechanism to support roll-out following demonstration plants coming into operation both in the UK and internationally (e.g. no later than 2016).

CCS infrastructure

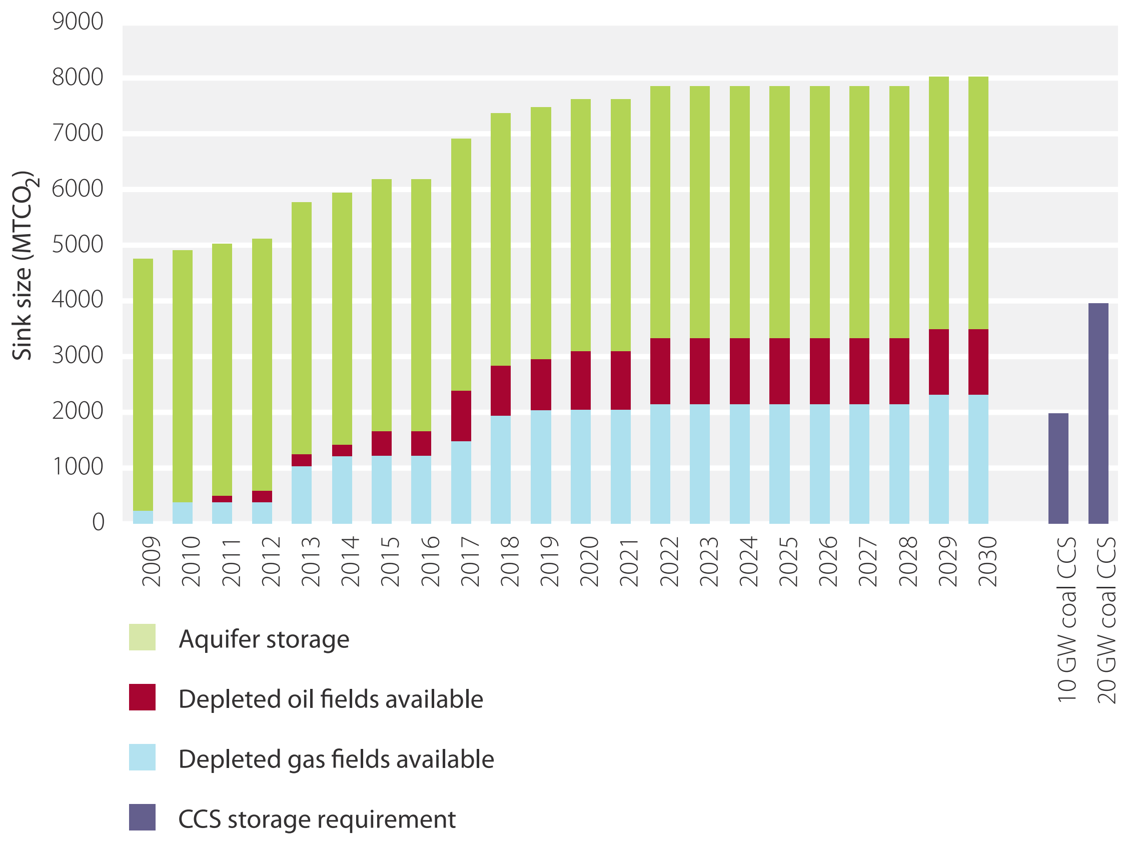
There will be some infrastructure in place by the time any decision is made to roll out CCS. This will not, however, be of sufficient scale to support levels of investment envisaged under our power sector scenarios. There is therefore a question over the appropriate approach to developing infrastructure to support roll-out.

Part of any approach will have to be a view on what type of infrastructure might be required. Analysis by Pöyry suggests that in order to support CCS deployment of 20 GW, a range of storage options would be required, with physical testing of saline aquifers, which are less well characterised than depleted oil and gas fields, an important near-term objective (Figure 4.21).

There is also a question over whether development of infrastructure should be market based (i.e. where energy companies develop their own infrastructure), or whether a more strategic approach (e.g. based on a statutory monopoly) is required. The issue here is whether energy companies could reasonably be expected to coordinate and exploit economies of scale (e.g by oversizing pipes and granting shared access).

It will be important that there is a clear strategic plan and regulatory framework for infrastructure development in place no later – and ideally sooner – than any decision to roll out CCS. As part of monitoring progress in CCS therefore, the Committee will track progress in early development of a strategic plan for infrastructure development.

Figure 4.21 Availability of CO_2 storage capacity



Source: Pöyry Energy Consulting (2009), *Carbon Capture and Storage: Milestones to deliver large-scale deployment by 2030 in the UK*.
Note: CO_2 storage requirements for CCS deployment based on the full lifetime output of a single generation of new-build coal CCS plants.

(ii) The framework for investment in conventional coal generation

In our December report we presented analysis that suggested there is no role for unabated coal-fired generation beyond the 2020s on the way to an 80% emissions reduction in 2050, which is borne out in new modelling that we have commissioned from Redpoint Energy (Figure 4.22).

We considered whether we could rely on the carbon price to signal this to investors and concluded that the signal is unlikely to be sufficiently robust. We argued that any investment in conventional coal generation should only be allowed for an interim period and should be made on the full expectation that CCS would be retrofitted.

We proposed an approach that would require that:

- Coal-fired power stations cannot be built beyond a certain date without CCS (say 2020)
- Those built before that date will be given a deadline for retrofitting CCS (say in the period 2020-2025)
- Or plants which choose not to retrofit should be allowed to generate for a very limited number of hours.

In April 2009 the Government responded with a proposed approach:

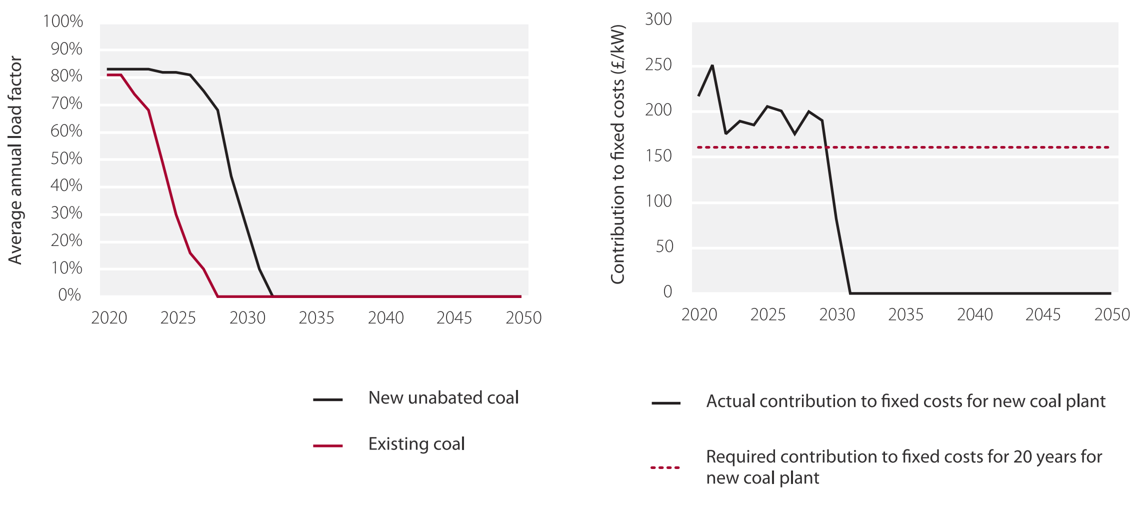
- Any investment in new coal-fired power generation would have to be at least part fitted with CCS.
- The remainder of plant built will have to be retrofitted with CCS if this is regarded as proven under a review to be carried out in 2020.
- If the review in 2020 does not regard CCS as proven, operation of any plant that is not retrofitted could be limited.

The Committee broadly welcomes the Government's proposals which will support development of CCS technology.

We are concerned, however, whether the proposed framework would lead to appropriate application of CCS technology in a timely manner:

- In particular, we envisage a situation post-demonstration where the carbon price is insufficient to cover CCS costs, but where deployment is desirable given the strategic importance of decarbonising the power sector and the potential to further reduce CCS costs through learning. It is not clear that CCS would be regarded as proven in these circumstances under the Government's proposals.

Figure 4.22 Projected load factors and profitability for conventional coal



Source: CCC calculations based on Redpoint (2009), *Decarbonising the GB power sector* to 2030 and assumed carbon price above €100t/CO_2.

- There is a long lag between when the first demonstration plant is scheduled to be up and running (2014) and the proposed timing for the review (2020), which is particularly problematic given the lead-times of five or six years for a CCS plant and the need to roll out CCS from the early 2020s.

We are also concerned as to whether the proposals give a strong enough signal that for any plant not fitted with CCS there will be little or no role further into the 2020s; the fact that there will be a review does not ensure an expectation that the generation would be severely limited.

Given our concerns, we therefore recommend that:

- Whether CCS is deemed proven should not be judged only on the basis of the carbon price. Rather it should be considered in the wider context of power sector decarbonisation required both in the UK and internationally, and on the basis of UK and international evidence.
- To the extent that retrofit might be considered desirable in this context but would require additional support over and above what is likely to be provided by the carbon price, investors should be given comfort now that a mechanism would be introduced to provide this support.
- Such a mechanism should be introduced no later than 2016 to support roll-out once the first demonstration plants become operational. Some decisions on regulation and financing structure could be made in advance of this date.
- The Government should make it absolutely clear now that whether or not CCS can be deemed economically viable any conventional coal plant still operating unabated beyond the early 2020s would only generate for a very limited number of hours. Such a statement should be complemented by a review (e.g. in 2020) to determine the precise level and timing of such a limit.

6. Assessment of current power market arrangements and possible interventions

In this section we assess whether current electricity market arrangements will deliver sector objectives:

- Power generation should be substantially decarbonised by 2030
- Security of supply should be maintained, with the risk of power outages kept to very low levels
- Electricity should be produced in a way that minimises costs and be delivered at affordable prices to consumers.

Our assessment is based on analysis of private and social risks associated with investment in low-carbon technology, and detailed modelling of the UK power system carried out for us by Redpoint Energy and Pöyry Energy Consulting. We set the analysis out as follows:

(i) Investment risks under current arrangements

(ii) Modelling approach and results

(iii) Conclusions and next steps.

(i) Investment risks under current arrangements

Current arrangements were designed for a different set of circumstances where there was excess capacity and where it was envisaged that any new investment would probably be in gas-fired generation (Box 4.9). Going forward, however, there is an emerging capacity deficit which must be addressed through investment in low-carbon generation on the path to meeting the 80% emissions reduction target.

Box 4.9 Existing market arrangements

The market for electricity is governed by a complex set of regulatory arrangements (BETTA – British Electricity Trading and Transmission Arrangements) within which electricity is traded between generators and suppliers or large consumers.

BETTA contains a number of forward markets covering months and years ahead. It also includes a balancing market, which operates close to real time and allows matching of demand and supply.

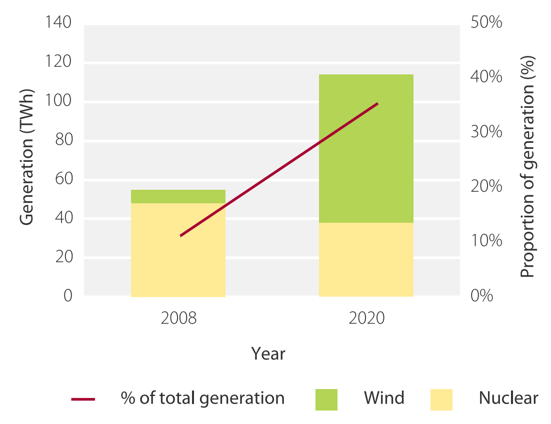
Prices in the balancing market reflect either the cost of the last plant dispatched or, where the system is capacity constrained, willingness to pay of suppliers or large energy consumers. Balancing market prices are very 'peaky', reflecting short run marginal cost much of the time, and rising to very high levels when capacity is constrained and demand reductions are therefore required.

Prices in forward and retail markets are smoothed, and therefore do not reflect volatility in the balancing market. Trends in balancing market prices are however reflected in forward and retail prices. Gas price increases, or system capacity constraints, will result in increased balancing, forward and retail prices.

The power system that we have committed to create will be characterised by increasing amounts of intermittent and inflexible generation operating with very low short run marginal costs (Figure 4.23, Figure 4.24). Under current arrangements, the electricity price in this system would be increasingly peaky (i.e. low for much of the time and very high for a small number of time periods – Figure 4.25); this price volatility would compound uncertainty associated with the volatile EU ETS price (Chapter 2).

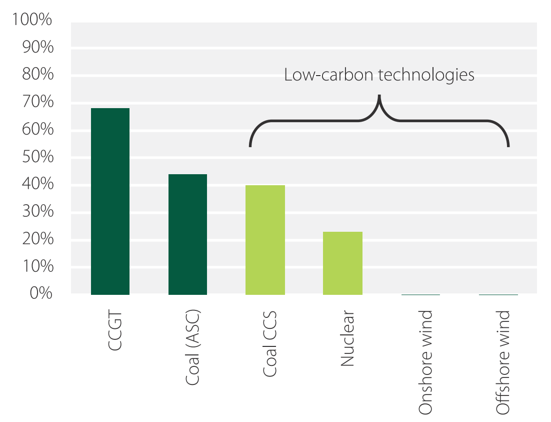
These two sources of policy uncertainty exacerbate a potential problem caused by a mismatch between private and social risk under current arrangements:

Figure 4.23 Generation from intermittent and inflexible plant 2008 and 2020 in CCC scenario



Source: CCC and DECC (2009); *DUKES*; Table 5.6 and 7.4.

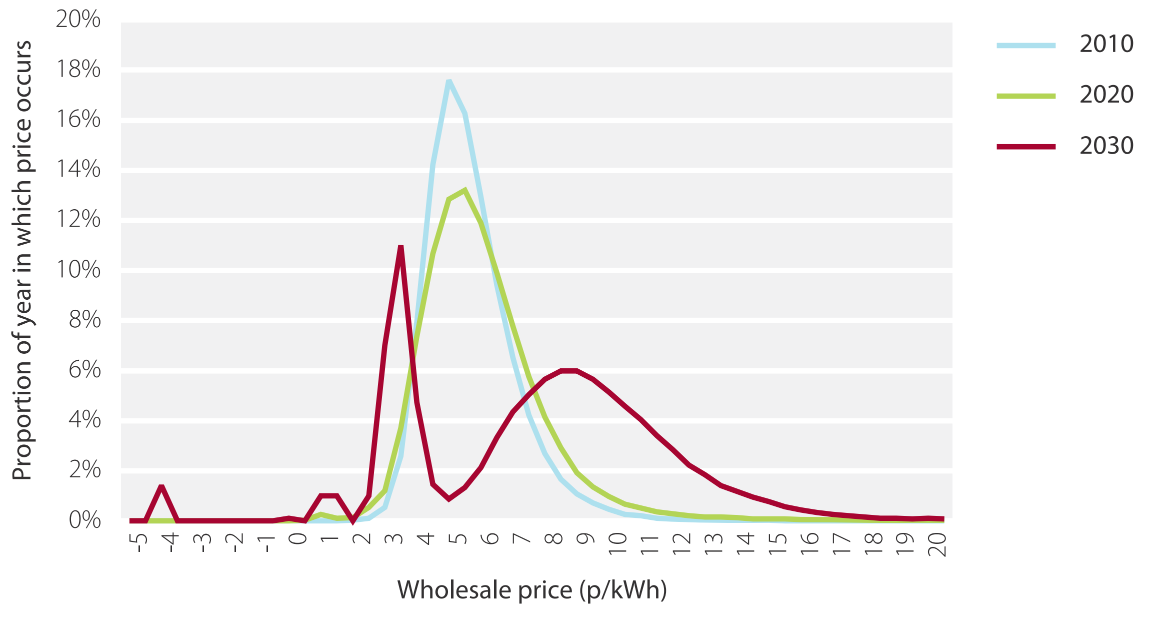
Figure 4.24 Short run marginal cost as a proportion of long run marginal cost for a range of technologies



Source: CCC calculations based on Redpoint (2009), *Decarbonising the GB power sector* and SKM (2008) *Growth scenarios for UK renewables generation and implications for future developments and operation of the electricity network.*
Note: Costs refer to plants built in 2020.

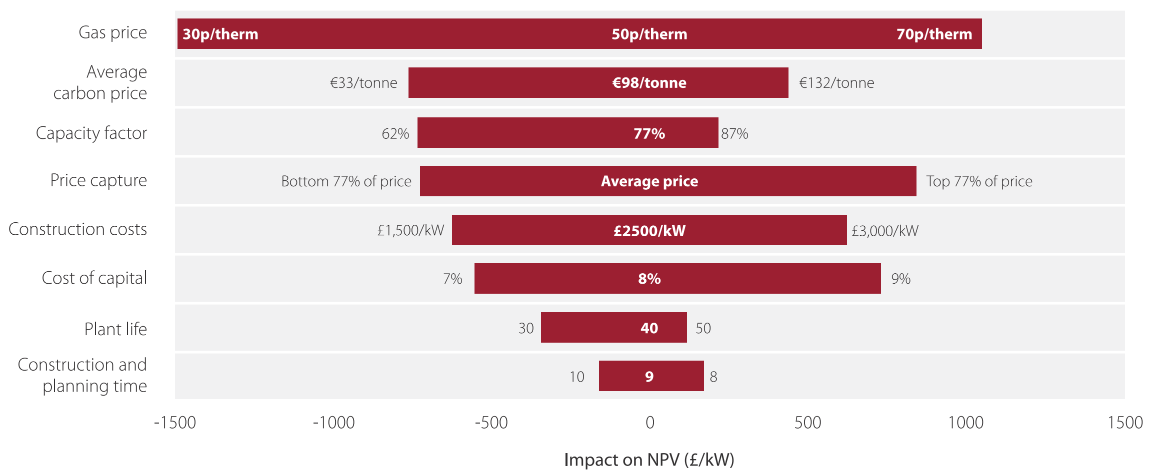
- A private investor in a low-carbon technology (e.g. nuclear) is subject to fossil fuel price risk, carbon price risk, electricity price risk, and technology cost risk (Figure 4.26).

Figure 4.25 Price density functions for 2010, 2020 and 2030



Source: Redpoint (2009), *Decarbonising the GB power sector.*
Note: By 2030, generation is made up of 34% renewables and 28% nuclear.

Figure 4.26 Relative importance of uncertainties faced by nuclear investors



Source: CCC calculations, based on the analysis presented in CBI (2009), *Decision time*; Redpoint (2009) *Decarbonising the GB power sector.*

- For a society committed to power sector decarbonisation, the only relevant risks are those associated with the costs of the low-carbon technology (i.e. risks associated with capital and fuel costs and operational characteristics of that technology).

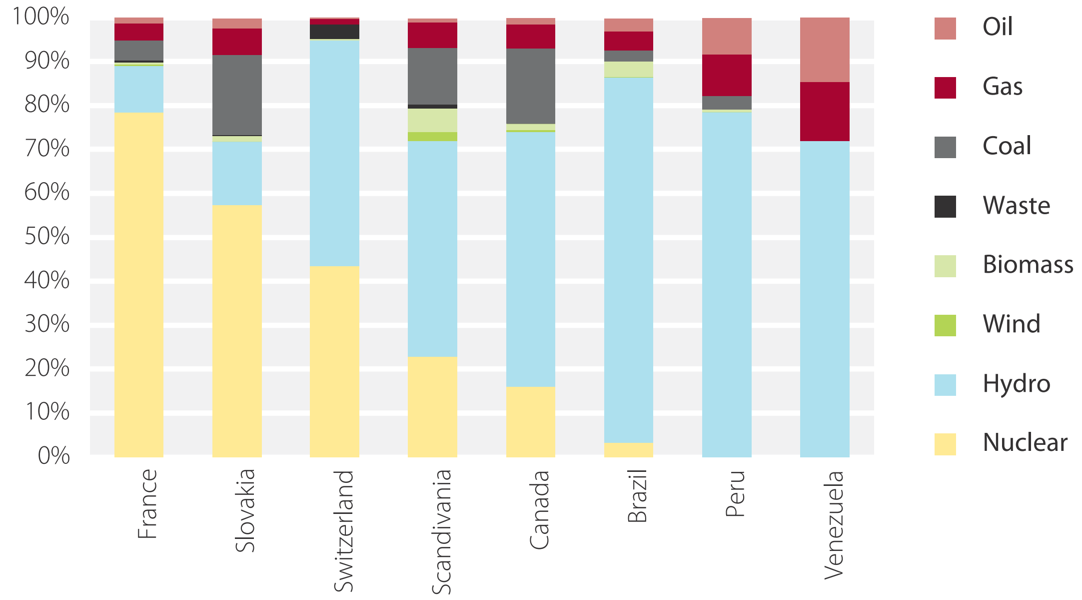
Given this mismatch there is a danger that private investors will tend towards investing in gas-fired power generation rather than the low-carbon generation which is required, and that this will jeopardise meeting carbon budgets and/or increase the costs of doing so. We note that no other country has relied on a fully liberalised electricity market of the type that we have in the UK to deliver investments in low-carbon generation (Box 4.10).

Box 4.10 International experience of incentivising investment in low-carbon generation

Several countries already source over 70% of their power generation from low-carbon sources (Figure B4.10)[9]. For these, investment has typically only occurred with substantial government intervention, even where markets have subsequently been liberalised:

- Several of these countries benefit from a large hydro resource. Hydro has very different technical and economic characteristics to wind and nuclear, and is more comparable to thermal plant: though it has low marginal costs, it has a high opportunity cost, is flexible and can be run at peak times. However, even where the main source of electricity is hydro, investment has relied on government intervention – markets in Canada and Venezuela are still dominated by state-owned firms, whilst most major hydro plants in Brazil and Peru were built prior to market reforms.
- In France, Slovakia and Switzerland over 80% of generation is provided by state-owned companies, with government having directed investment to reach high levels of nuclear capacity. France has the highest level of non-hydro low-carbon generation, with 78% of generation from nuclear, which has been adapted to load follow (i.e. is more flexible than current UK capacity) and benefits from good interconnection with the rest of Europe, allowing it to export electricity at times of low domestic demand.
- The integrated Scandinavian electricity market (Nordpool) has been liberalised and has a high level of low-carbon generation. However, most of the investment in low-carbon, capital intensive plant happened before liberalisation and was driven by state-owned utilities. Investment in renewables has continued since liberalisation, incentivised by a range of interventions to the market including taxes and tax rebates, investment support schemes, feed-in tariffs and obligations.

Figure B4.10 Generation mix in predominantly low-carbon electricity markets (2006)



Source: International Energy Agency www.iea.org

9 We do not cover Costa Rica, Columbia or Iceland due to lack of data.

(ii) Modelling approach and results

Having identified a risk mismatch, we commissioned Redpoint Energy to explore the implications by simulating investment scenarios which model variation in:

- Parameters that determine the economics of generation investment (e.g. electricity demand, fossil fuel prices, levels of intermittent generation – Box 4.11)
- Investor behaviour (e.g. the extent to which investors perceive levels of risk to be higher, the way that carbon price expectations are formed – Box 4.12).

Box 4.11 Summary of Redpoint scenarios

Redpoint modelled around 30 scenarios for the CCC. A core scenario was based on environmentally favourable conditions (a carbon price consistent with a global deal, low electricity demand and successful delivery of 32% renewable generation by 2020). The rest of the scenarios varied either exogenous conditions (e.g. commodity prices), policy choices (e.g. restricting wholesale price peaks), investor behaviour (e.g. perception of risk and foresight on the carbon price – Box 4.12), or a combination of one or more of these factors. The most important of the scenarios are summarised in the below table. Detailed descriptions of the full set of scenarios are set out in the Redpoint study[10].

Table B4.11 Modelled scenarios

Scenario	Description	Modelled with alternative investor behaviours
Environmentally favourable conditions	Fuel prices based on DECC scenario 2[11] Carbon price consistent with global deal (€120 in 2030)	Yes
Peak price constraint	Wholesale electricity prices are restricted in the modelling from peaking above £500/MWh	No
More renewables	Target of 36% of generation in 2020, reflecting maximum feasible use of UK resource	Yes
Reduced interconnector flexibility	A reduction of export capability at times of high wind output simulating a higher correlation between wind output in GB and the continent	Yes
High fossil fuel prices	Fuel prices based on DECC scenario 4	No
Low fossil fuel prices	Fuel prices based on DECC scenario 1	No
Less successful energy efficiency policy	0.6% growth in electricity demand per year	No
Low EUA prices	EUA prices reaching only €45 by 2030	Yes

10 Redpoint (2009) *Decarbonising the GB power sector.*
11 DECC (2009) *Communication on Fossil Fuel Prices.*

Box 4.12 Summary of investor behaviour scenarios in the Redpoint modelling

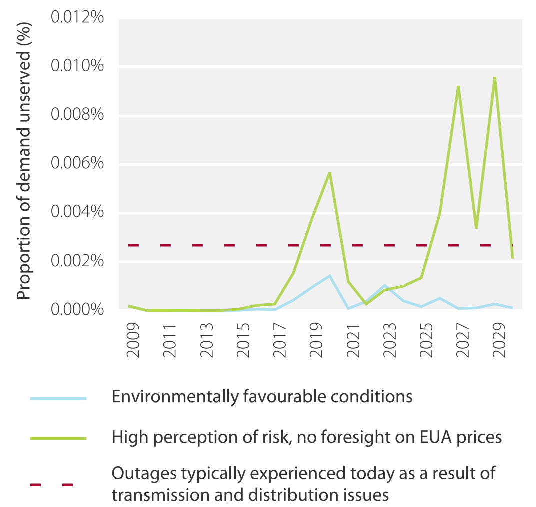
In order to take account of the fact that investors will not always behave as 'textbook' economic agents, we asked Redpoint to model a number of alternative investor behaviours. These were looked at alone, and in combination.[12]

Table B4.12 Summary of alternative investor behaviours

	Central behaviour	Alternative behaviour	Rationale for scenario
Foresight on EUA prices	Investment decisions made on the basis of ten year forward look on EUA price.	Investment decisions based on in-year EUA price.	It is very difficult for investors to make an investment case on the expectation of a high EUA price in ten years' time. There is anecdotal evidence that the current price is often used in investment decisions as a best estimate of the future price.
Hurdle rates required for investment	Hurdle rates determined in Redpoint modelling – around 10% for low-carbon technologies, slightly lower for CCGT and coal.	3% added to hurdle rate in each scenario.	Risk averse investors will require a premium when faced with multiple market risks.

The analysis suggests that across the range of scenarios, and with sufficiently high prices in peak periods to which investors respond, security of supply in terms of unserved demand due to generation shortage should not be an issue (Figure 4.27). Where market risks are perceived to be high, investors revert to investment in (relatively low risk) gas-fired generation. This finding is consistent with analysis underpinning the 2006 Energy Review and 2007 Energy White Paper, which focused on security of supply in the period to 2016 and concluded that the market would fill the emerging capacity deficit with gas-fired generation.

Figure 4.27 Expected energy unserved due to generation shortage



Source: Redpoint (2009), *Decarbonising the GB power sector.*

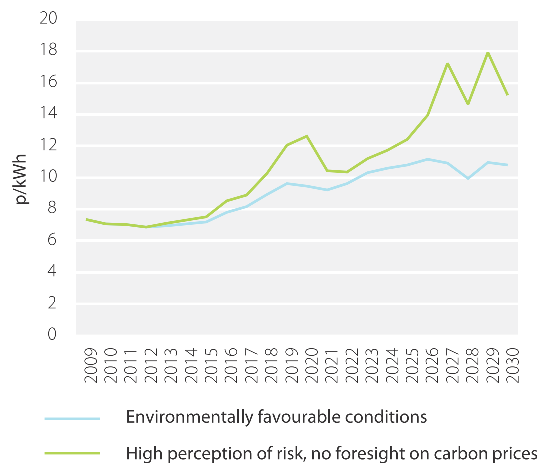
12 Full results available in the supporting research paper: Redpoint (2009) *Decarbonising the GB power sector*

The analysis suggests, however, that under current arrangements there are risks of unnecessarily high prices for consumers and that required decarbonisation will not be achieved (Box 4.13):

- Even where current arrangements function ideally, gas-fired generation will continue to set the electricity price most of the time. Electricity prices will increase over time as the carbon price increases, and low-carbon generators will capture significant rents. Increasing prices are likely to be problematic from fuel poverty and wider political economy perspectives and could rise much less significantly under a different set of arrangements where gas-fired generation did not continue to determine the return for all generators (Figure 4.28).
- There are plausible scenarios where investors favour investment in gas-fired rather than low-carbon generation. This is likely to ensue where investors require higher returns in response to risks that are induced by the current arrangements, and/or where investments are made on the basis of prevailing carbon prices rather than an assumption of increasing carbon prices. These scenarios lead to lock-in to high-carbon assets and failure to make sufficient progress with decarbonisation by 2030, unnecessarily high system costs/prices, and loss of any security of supply benefits associated with generation from low-carbon sources rather than imported gas (Figure 4.29).

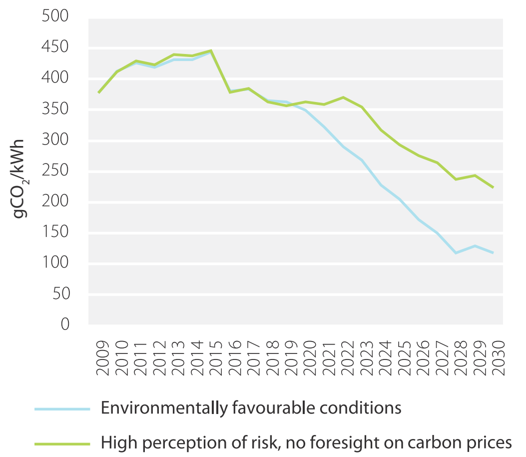
In addition to commissioning the Redpoint modelling, we joined a multi-client study by Pöyry Energy Consulting which simulated investment scenarios using a different power sector model. In line with the Redpoint analysis, Pöyry analysis suggests that with high levels of wind generation, returns for investors will become far less certain under current market arrangements and investment incentives will be undermined, particularly for low-carbon technologies (Box 4.14).

Figure 4.28 Wholesale cost to consumers under alternative scenarios



Source: Redpoint (2009), *Decarbonising the GB power sector.*
Note: These prices exclude VAT, transmission and distribution costs, and the costs of energy efficiency policies.

Figure 4.29 CO_2 intensity of generation under alternative scenarios



Source: Redpoint (2009), *Decarbonising the GB power sector.*
Note: Emissions intensity is not adjusted for losses during transmission and distribution.

Box 4.13 Summary of Redpoint modelling results

The key results of the Redpoint modelling for decarbonisation, security of supply and prices are[13]:

- **Decarbonisation:** In the core scenario emissions intensity falls to around 120 gCO_2/kWh by 2030. However, if the carbon price only reaches €45/tonne (rather than €120/tonne) then intensity only falls to 260 gCO_2/kWh. Even with a higher carbon price, if this is not foreseen by investors and they have a high perception of risk then only 220 gCO_2/kWh is achieved. High risk perception is especially damaging as it biases against (capital intensive) nuclear and CCS.
- **Security of supply:** Capacity margins are lowest where decisions are based on the current (not future) carbon price, and where the perception of risk is high, delaying investment and resulting in unserved energy peaking at around 30 GWh per year. Even in this scenario, levels of unserved energy are not much higher than those typically experienced today as a result of transmission and distribution outages.
- **Prices:** Even in scenarios where over 60% of generation is coming from low-marginal cost plant by 2030, CCGT plant continues to set the price most of the time. As such, rising commodity and EUA prices lead to very high consumer prices in 2030 (and large rents to low-carbon generators) in all scenarios. Prices are highest where the perception of risk is higher, and where there is a lack of foresight on the EUA price, as investment is made in high-carbon assets which then prove very expensive to run.

Table B4.13 Key results of Redpoint modelling

	Standard perception of risk, foresight on EUA price	**Higher perception of risk, investment based on current EUA price**
Decarbonisation by 2030	~120 gCO_2/kWh in 2030	~220 gCO_2/kWh in 2030
Security of supply	Annual unserved energy peaks at 0.001% of demand	Annual unserved energy peaks at around 0.003% of demand
Wholesale cost to consumers	11p/kWh in 2030	15p/kWh in 2030

13 Full results available in the supporting research paper: Redpoint (2009) *Decarbonising the GB power sector*

Box 4.14 Summary of Pöyry Energy Consulting analysis

The CCC joined several key players in the power sector (including National Grid and three of the 'big six' energy companies) in funding Pöyry Energy Consulting's investigation into the challenges large-scale investment in wind might pose for the electricity market to 2030[14].

Pöyry's study examined historical wind patterns, taking hourly data for eight years from 36 different locations across the UK and Ireland. These data were used to generate forecasts of wind power output and to estimate the resulting impact on the electricity market for a number of scenarios to 2030. A core scenario was based on a very high assumed level of wind investment (33 GW installed by 2020 and 43 GW by 2030) alongside modest demand growth and significant investment in new nuclear. Additional scenarios varied other factors such as the level of interconnection.

Key findings of the study were as follows:

- While thermal plant and interconnectors appear able to deal with the dynamic requirements of a significant level of wind output, the running regime of thermal plant is likely to change dramatically, with much more irregular output patterns and lower average load factors. Frequent fluctuations in load may mean greater maintenance requirements or shorter lifetimes for thermal plant.
- Wholesale electricity prices fall but become much more volatile with high levels of wind generation. The distribution of prices becomes more extreme with some periods of negative prices and some periods of very high prices. By 2030, many plants earn a significant part of their annual return over a few periods per year. Meanwhile, average prices fall.
- More interconnection can help the physical management of the system, but is not a sufficient solution of itself.

Pöyry conclude that power stations built now will face a future of far lower and more uncertain load factors and dramatically increased uncertainty of revenues. They argue that the price spikes needed to reward the risks for investment in peaking plant are likely to stretch the market design to the utmost. Investors are unlikely to believe that price spikes will be allowed to occur and volatile prices greatly increase the risks of operation and dampen economic signals to new investors.

(iii) Conclusions and next steps

Risks under current arrangements

Power sector decarbonisation by the early 2030s is central to cutting emissions more generally (e.g. through the application of low-carbon electricity to cars and vans, etc.). Given the importance of moving to a low-carbon electricity system at affordable cost, the Committee believes that we should not accept the significant risks and costs associated with the current market arrangements.

We therefore strongly recommend that a range of options for power market intervention are seriously considered. New arrangements would replace current interim support for selected technologies. They should cover the full range of low-carbon generation technologies for the 2020s, and be designed to increase confidence about power sector decarbonisation, cut the costs of achieving this, and address any concerns about security of supply.

Options for market intervention

The options which we believe could potentially improve on the current market arrangements in delivering low-cost, low-carbon generation investment include (Box 4.15):

- Measures to strengthen the carbon price signal (e.g. underpinning the carbon price at the EU or UK level, extending the Climate Change Levy exemption to all new low-carbon sources)

14 Pöyry Energy Consulting (2009) *Impact of Intermittency*

- Measures to provide confidence over the price received by low-carbon generation (e.g. feed-in tariffs for low-carbon generation, tendering for low-carbon capacity)
- Measures to ensure investment in low-carbon capacity (e.g. a low-carbon obligation, possibly as part of a wider capacity obligation, or an emissions performance standard).

These options have not previously been assessed in the UK. The Committee recommends that they should now be seriously considered given the new context, in which the UK has committed to cut emissions by 80% in 2050, and where decarbonisation of the power sector in the period to 2030 is vital in achieving this goal.

Transitioning from current arrangements

Our analysis shows that we require significant investment in low-carbon generation from now over the next 20 years and beyond to 2050. We expect that this investment will initially be mainly in wind generation (over 20 GW), with investment in up to around 3 GW of new nuclear plant and 2 GW of CCS coal by 2020, and around an additional 20 GW of low-carbon generation capacity in the period 2020-2030.

The risks that we have identified adversely impact cost and viability of investment in nuclear and CCS, and may increase the costs of wind investment required to meet EU targets. In assessing the appropriate timing of possible interventions, we have considered the timing of decisions to invest, the time likely to be required to introduce any intervention, and the need for near term investment in gas-fired generation:

- Working back from when investments should ideally come on line, and given long project lead times, decisions to proceed with investment in low-carbon generation for the 2020s will have to be made in the relatively near term (e.g. during the second carbon budget period).
- Detailed design of a market intervention could require a lengthy process. We note that it took several years each to move from the old power pool to the New Electricity Trading Arrangements (NETA), and from NETA to the current British Electricity Trading and Transmission Arrangements (BETTA).
- Our extensive discussions with a wide range of industry stakeholders – energy companies, analysts, academics – suggest a strong consensus that current arrangements will not deliver a low-carbon power generation system through the 2020s, and that changes to the current arrangements are both required and inevitable. In these circumstances, a failure to review current arrangements may be perceived as creating more uncertainty by postponing introduction of inevitable change.
- A new global agreement to reduce emissions and the EU response could have implications for the carbon price which in turn could change the power sector investment climate for the period to 2020 and beyond.
- There is a significant amount of gas-fired generation currently in the pipeline that we expect to move forward and replace coal-fired capacity that will come off the system before 2016 and therefore maintain near-term system security (Table 4.2). These investments will be required whatever new mechanisms are introduced, and should be provided with appropriate comfort in the context of any review.

The Committee's judgement in balancing these concerns is that a comprehensive review of the current market arrangements should be carried out in the near term. This should reflect any implications of Copenhagen for EU targets, the carbon price and UK carbon budgets. It should be designed to address adequately concerns for current investment in gas-fired generation. Any delay in moving forward with a review as soon as is practical following Copenhagen will jeopardise prospects for successfully decarbonising the power sector in the 2020s.

Box 4.15 Potential power market interventions

The below table briefly describes a set of market interventions which could help support investment in low-carbon generation capacity. These range from measures which could be introduced relatively quickly, and would entail minimal change over the current system (such as extending the exemption for renewables from the Climate Change Levy to other new build low-carbon generation) to measures which would mean a much greater level of government intervention (such as introducing a system of tendering for low-carbon capacity). The measures listed here are not necessarily mutually exclusive or exhaustive.

The CCC does not yet have a view on which measure would best tackle the risks posed by the current market structure, but believes that all should be seriously considered in the near term.

Table B4.15 Potential power market interventions

Measures	Description
Measures to strengthen the carbon price signal	
Extend exemption from Climate Change Levy (CCL) to all new low-carbon generators	The CCL is a 0.4p/kWh levy on the supply of electricity to industry, commerce, agriculture, public administration and other services. Renewable generation is already largely exempt. This exemption could be extended to new nuclear and new CCS.
Carbon price underpin	The carbon price faced by the power sector could be prevented from falling below a certain level, for example by setting an auction reserve price at the EU level or using a carbon tax or contracts for difference to set a minimum carbon price for the UK.
Measures to provide confidence over the price received by low-carbon generation	
Feed-in tariffs for low-carbon technologies	Feed-in tariffs would guarantee a price for a fixed period for electricity generated by new low-carbon generators.
Tenders for low-carbon capacity	An agency could competitively tender for investment in low-carbon capacity, offering successful bidders long-term contracts free of commodity price risks.
Measures to ensure investment in low-carbon capacity	
Emissions performance standard	An emissions performance standard would entail regulation to specify a maximum emissions intensity (g/kWh) of generation. This could be introduced at firm or installation level.
Low-carbon obligation	An obligation could be placed on UK suppliers to source an increasing proportion of their electricity from low-carbon sources to ensure the required investment in low-carbon generation is undertaken. It could also be set to up to require that generators have sufficient installed capacity to meet the peak load of the customers they serve, plus a reserve margin.

Table 4.2 Current power sector projects in the pipeline

	Under construction	With planning consent (all have TEC), but not yet under construction	Total
Fuel type	**GW**	**GW**	**GW**
Coal	0	0	0
Gas	5.1	7.5*	12.6
Nuclear	0	0	0
Wind	2.1	6.9	9.0
Other renews	0.1	0.4	0.5
CHP	0	0	0
Interconnector	1.2	0	1.2
Total	**8.5**	**14.8**	**23.3**

* Includes 0.8 GW Hatfield project whose turbines will operate initially on natural gas, switching to coal IGCC with CCS as and when that part of the plant is operational.
Source: CCC calculations based on DECC, BWEA (September 2009) http://www.bwea.com/statistics/
Note: Transmission Entry Capacity (TEC) is a Connection and Use of System Code term that defines a generator's maximum allowed export capacity onto the transmission system. Wind data is measured on an installed capacity basis.

7. Summary of power sector indicators

Our indicators of progress for the power sector include (Table 4.3):

- Power sector emissions and emissions intensity
- Low-carbon capacity deployment (e.g. trajectories for adding onshore and offshore wind generation)
- Forward indicators to assess progress delivering capacity (e.g. amounts of onshore and offshore wind capacity entering and completing planning and under construction)
- Underpinning indicators required to deliver progress (e.g. planning approval rates and times, supply chain capability)
- Policy milestones for required enabling frameworks (e.g. early decisions on transmission network access and investment).

Table 4.3 Power sector indicators

Power		Budget 1	Budget 2	Budget 3
Headline indicators				
Emissions intensity (g/kWh)		509	390	236
Total emissions (% change from 2007)		-15%	-39%	-64%
Generation (TWh)	*Wind*	21	50	98
	Nuclear	58	30	48
	CCS	0	5	11
Supporting indicators				
Transmission				
Agreement on incentives for anticipatory investment for Stage 1 reinforcements		2010		
Implementation of enduring regime for accessing grid		2010		
Transitional OFTO regime in place		2009		
Enduring OFTO regime in place		2010		
Grid reinforcement planning approval		2011: Scotland Stage 1, Wales Stage 1 (Central), South East	2013: Wales Stage 1 (North), English East Coast Stage 1, South West 2014: Scotland Stage 2	
Grid reinforcement construction begins		2012: Scotland Stage 1, Wales Stage 1 (Central), South East	2014: Wales Stage 1 (North), English East Coast Stage 1, South West 2015: Scotland Stage 2	
Grid reinforcements operational			2015: Scotland Stage 1, Wales Stage 1 (Central), South East 2017: Wales Stage 1 (North), English East Coast Stage 1, South West	2018: Scotland Stage 2

Table 4.3 continued

Power		Budget 1	Budget 2	Budget 3
Transmission continued				
Tendering for first offshore connections under enduring OFTO regime		2010		
Construction of first offshore connections under enduring OFTO regime begins		2011		
First offshore connections under enduring OFTO regime operational		2012		
Planning				
IPC set up and ready to receive applications		2010		
Market				
Review of current market arrangements and interventions to support low-cost, low-carbon generation investment		to begin in first budget period		
Wind				
Generation (TWh)	*Onshore*	13	26	44
	Offshore	8	24	54
Total capacity (GW)	*Onshore*	5.7	10.8	18.0
	Offshore	2.5	7.4	16.6
Capacity entering construction (GW)	*Onshore*	0.9	1.3	1.5
	Offshore	0.9	1.6	2.6
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		
	Offshore	New planning applications will be expected in line with site leasing		
Average planning period (months)		<12	<12	<12

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022

Key
Headline indicators Implementation indicators Forward indicators Milestones Other drivers

Table 4.3 continued

Power	Budget 1	Budget 2	Budget 3
Nuclear			
Regulatory Justification process	2010		
Generic Design Assessment	2011		
National Policy Statement for nuclear (including Strategic Siting Assessment)	2010		
Regulations for a Funded Decommissioning Programme in place	2010		
Entering planning	first planning application in 2010	subsequent applications at 18 month intervals	
Planning approval; site development and preliminary works begin	first approval and site development and preliminary works begin in 2011	subsequent application approvals, site development and preliminary works at 18 month intervals	
Construction begins		first plant in 2013, subsequent plants at 18 month intervals	
Plant begins operation			first plant in 2018, with subsequent plants at 18 month intervals*
CCS			
Front-End Engineering and Design (FEED) studies for competition contenders completed	2010		
Announce competition winner	2010		
Second demonstration competition	launch 2010, announce winners 2011		
Quantification of saline aquifer CO_2 storage potential		no later than 2015	
Review of technology and decision on framework for future support		no later than 2016	
Strategic plan for infrastructure development		no later than 2016	

Table 4.3 continued

Power	Budget 1	Budget 2	Budget 3
CCS continued			
Planning and authorisation approval, land acquisition, and storage site testing completed, construction commences	first demo in 2011	subsequent demos 2012/13	
Demonstrations operational		first demo in 2014, subsequent demos 2015/16†	
First new full CCS plants supported via the 2016 mechanism			2022
Other drivers			
Total demand (TWh), coal and gas prices, nuclear outages *Average wind load factors, availability of offshore installation vessels, access to turbines* *Nuclear supply chain, availability of skilled staff* *International progress on CCS demonstration and deployment* *Planning approval rates and frequency of public inquiries to decisions of Infrastructure Planning Commission*			

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022
* Up to 3 nuclear plants by 2022.
† Up to 4 CCS demonstration plants by 2020.

Key:
Headline indicators · Implementation indicators · Forward indicators · Milestones · Other drivers

Chapter 5: Reducing emissions in buildings and industry

Introduction and key messages

Our December 2008 report identified a major opportunity for reducing emissions in buildings and industry through energy efficiency improvement. The report noted barriers to uptake of measures, differentiating between technical emissions reduction potential (i.e. if there were no barriers to uptake) and realistically achievable emissions reductions given an assessment of barriers and the way that these are or could be addressed by policies in place or that could be introduced.

We also considered renewable heat in the context of the UK's commitment to a 15% renewable energy target for 2020 and discussed the contribution it could make to meeting longer term emissions reduction objectives.

We presented a high level assessment of the policy framework, and questioned whether this currently provides sufficiently strong incentives for uptake of measures in the residential sector and across non-capped sectors in commerce and industry. We noted the absence of and need to develop a new framework to support renewable heat deployment.

In this chapter, we do four things:

- We revisit our assessment of potential for residential energy efficiency improvement. We focus both on the pace at which emissions reductions can be realistically achieved, and the incentive framework that will unlock the emissions reduction potential, including a discussion of the Government's draft Heat and Energy Saving Strategy for residential buildings published in February 2009.
- We present new analysis of renewable heat which extends our previous work by considering a wider range of technologies and setting out new renewable heat scenarios.
- We present scenarios for non-residential buildings, and set out high level policy options that could unlock the significant potential in this area.
- We set out indicators against which we will make future assessments of progress in reducing emissions from buildings and industry (Box 5.1).

Box 5.1 Key Indicators

Residential sector:

- installations of loft and cavity wall insulation (10 million lofts and 7.5 million cavity walls insulated by 2015)
- solid wall insulation (2.3 million by 2022)
- replacement of old boilers (12 million non-condensing boilers replaced by 2022)
- increase in stock penetration of A+ rated wet (82% by 2022) and A++ cold appliances (45% by 2022).

Renewable heat: 12% penetration by 2020, resulting in emission reductions of 18 $MtCO_2$.

Non-residential buildings: minimum EPC rating of F or higher by 2020.

The main messages in the chapter are:

- A new framework for accelerating residential emissions reductions is required. This should include *whole house* and *neighbourhood* approaches, with strong leadership from central government and an important role for local government. Complementary financial incentives and regulatory measures are also likely to be required to overcome the significant barriers that exist despite the cost-effectiveness of most energy efficiency measures.
- Increased deployment of renewable heat should aim at meeting carbon budgets in the most cost-effective way and developing a portfolio of options for possible deployment in the 2020s on the way to meeting longer term emissions reduction goals. This should include biomass boilers and combined heat and power (CHP), air source and ground source heat pumps, and biogas. In our analysis, we have assumed the Government's suggested renewable heat share of 12% by 2020, but recognise that this could be very expensive at the margin.
- It is crucial that the public sector emissions reduction potential is unlocked, because this can make an important contribution to meeting carbon budgets; encourage behavioural change among users of public sector buildings; stimulate the low carbon supply chain; and underpin government credibility in leading a wider emissions reduction programme. By 2008, all cost-effective emissions reduction potential should be realised for buildings in the central government estate and for other public sector buildings covered by the Carbon Reduction Commitment.
- A new framework to incentivise emission reductions by SMEs should be introduced. Options to be considered might include an extension of the new residential sector delivery model and mandating certain measures to improve energy efficiency. In order to support any new policy, more widespread requirements for energy audit and certification of non-residential buildings should be introduced.

We set out the analysis that underpins these messages in five parts:

1. Emissions trends in buildings and industry
2. A framework for energy efficiency improvement in residential buildings
3. Scope for reducing emissions through the deployment of renewable heat
4. Emissions reductions in non-residential buildings and industry
5. Indicators for buildings and industry.

1. Emissions trends in buildings and industry

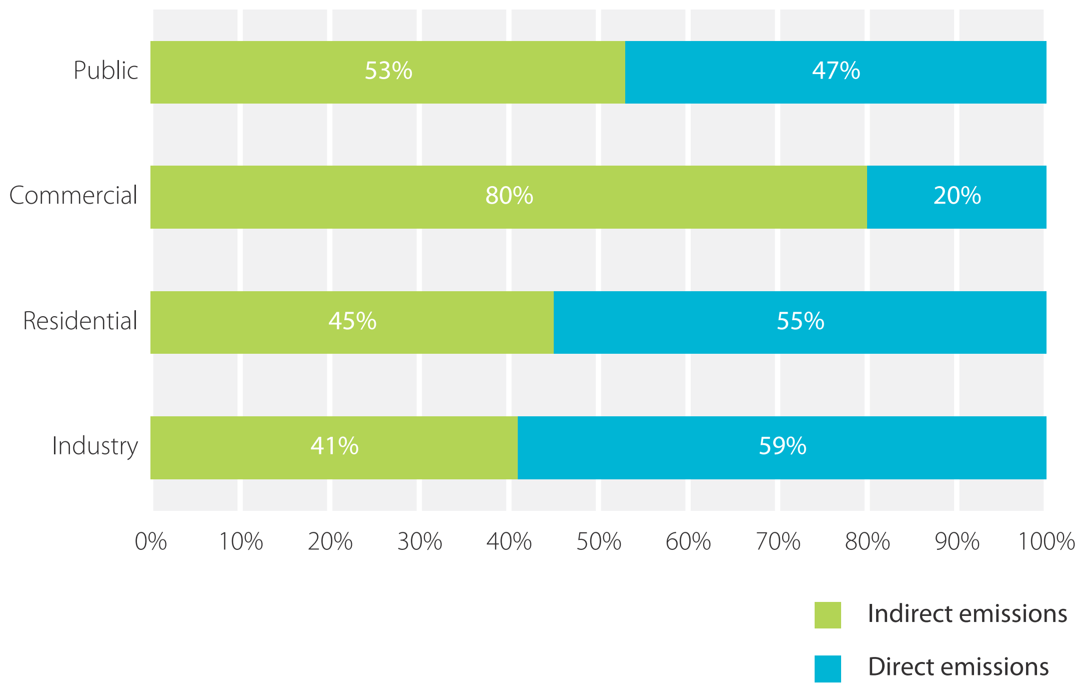
Total emissions in buildings and industry

Homes, non-residential buildings and industry are responsible for around two-thirds of total UK CO_2 emissions. Direct emissions (e.g. due to burning of fuel for heat) account for 51% of total buildings and industry emissions and indirect emissions (mainly electricity related) for 49%. The split between direct and indirect emissions varies between sectors, with the commercial sector having the highest proportion of indirect emissions, whilst in industry direct emissions dominate (see Figure 5.1).

Total emissions from buildings and industry have fallen significantly since 1990 (see Figure 5.2), although emission reductions have slowed more recently, particularly as regards indirect emissions:

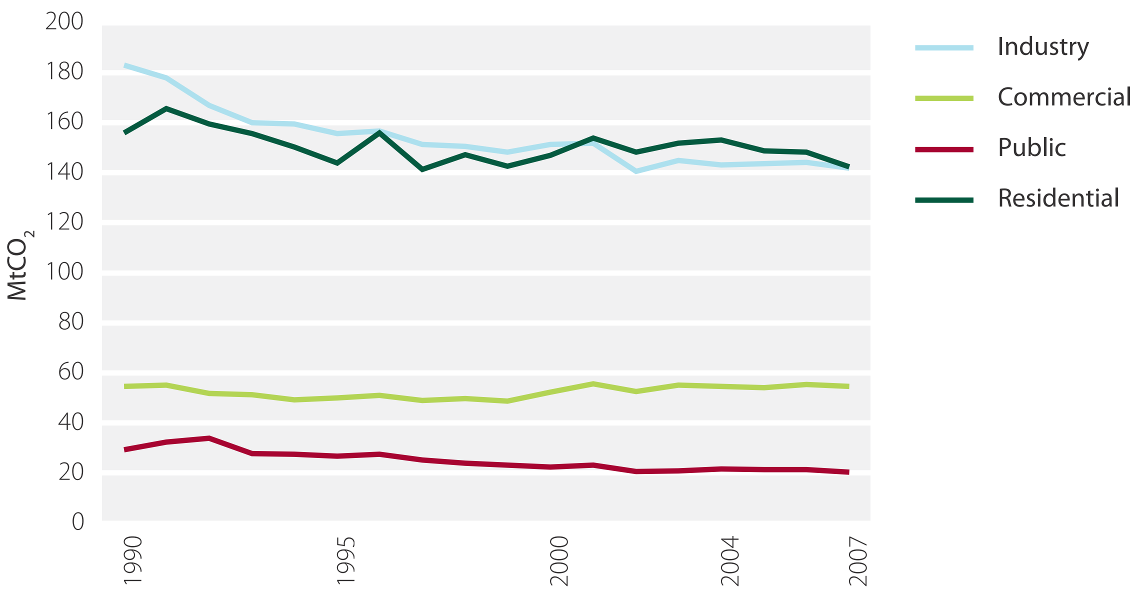
- Emissions in these sectors fell by 15% over the period 1990 to 2007, with direct emissions falling 14% and indirect emissions falling 16%.
- Between 2003 and 2007 emissions fell by 4%, driven by reduced direct emissions, while indirect emissions were broadly flat.
- Provisional estimates suggest that direct emissions from buildings and industry in 2008 were broadly the same as in 2007, as was electricity consumption.

Figure 5.1 Direct and indirect emissions from energy use by sector in 2007



Source: NAEI (2009).

Figure 5.2 Emissions from energy use in buildings and industry by sector 1990-2007



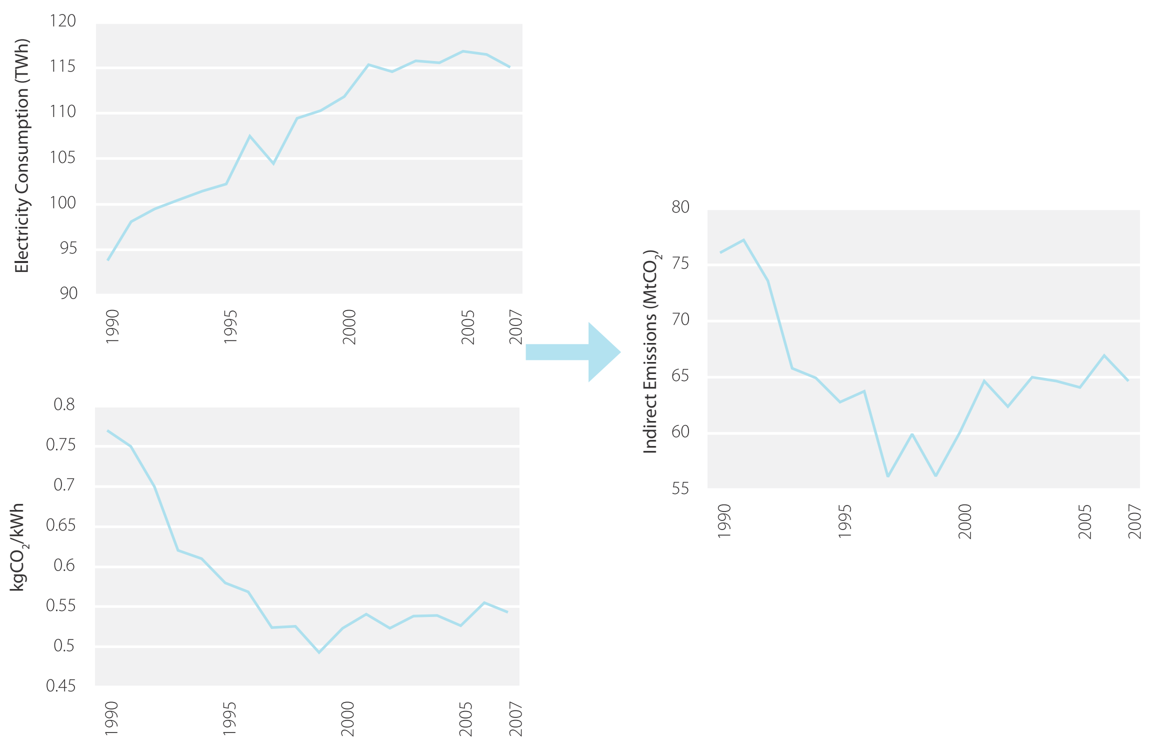
Source: NAEI (2009).

Residential emissions

Residential emissions have fallen since 1990. However, while there was a substantial drop in the first five years of the period, over the last 12 years, emissions have fluctuated.

- Overall, residential emissions fell by 9% between 1990 and 2007. This was driven mainly by falling indirect emissions in the 1990s as a result of the switch from coal to gas power generation (Figure 5.3).
- Between 2003 and 2007, residential emissions fell by 6%.
  - This was underpinned by an 11% reduction in direct emissions between 2003 and 2007, at least partially as a result of reduced demand due to increased energy prices.
  - Residential indirect emissions were broadly flat between 2003 and 2007.
- Provisional 2008 emission and energy consumption data shows:
  - Direct residential emissions increased by 5%, driven by a 3% increase in fuel consumption in the winter of 2007/08.
  - Electricity consumption increased by 2% over the same period.

Figure 5.3 Electricity consumption, carbon intensity and indirect emissions from residential buildings 1990-2007



Source: DECC (2009), *Energy consumption in the UK*; Defra (2009) *Guidelines to Defra's GHG conversion factors for company reporting and NAEI (2009).*

Public sector emissions

Public sector emissions reductions over the period since 1990 have resulted mainly from fuel switching rather than energy efficiency improvement or reduced energy consumption:

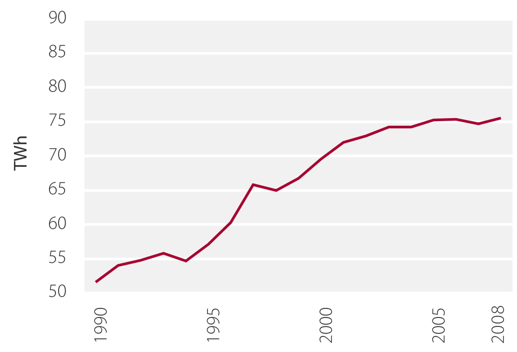
- Public sector emissions fell by 30% over the period 1990 to 2007 due to a greater use of lower carbon fuels with overall energy consumption remaining largely flat.
- In the period 2003 to 2007, emissions fell by 2% due to a 5% reduction in direct emissions. Indirect emissions over this period were broadly flat.
- Preliminary data suggests that the level of direct public sector emissions in 2008 was broadly similar to 2007.

Commercial emissions

Commercial emissions have not fallen since 1990, with the impact of falling carbon intensity in electricity generation offset by increased electricity consumption:

- Commercial emissions are around the same levels as in 1990 and stayed broadly constant between 2003 and 2007.
- Indirect emissions currently make up approximately 80% of commercial sector emission, having grown by 2% between 1990 to 2007 and by 2% between 2003 to 2007, with increased electricity demand more than offsetting falling carbon intensity of power generation over the period since 1990 (see Figure 5.4).
- Provisional data suggests that commercial sector direct emissions in 2008 remained around the level for 2007.
- The retail sector, hotel and catering and warehouses currently account for the largest proportion of energy consumption and emissions in non-residential buildings (see Figure 5.5).

Figure 5.4 Commercial sector electricity demand 1990 to 2008



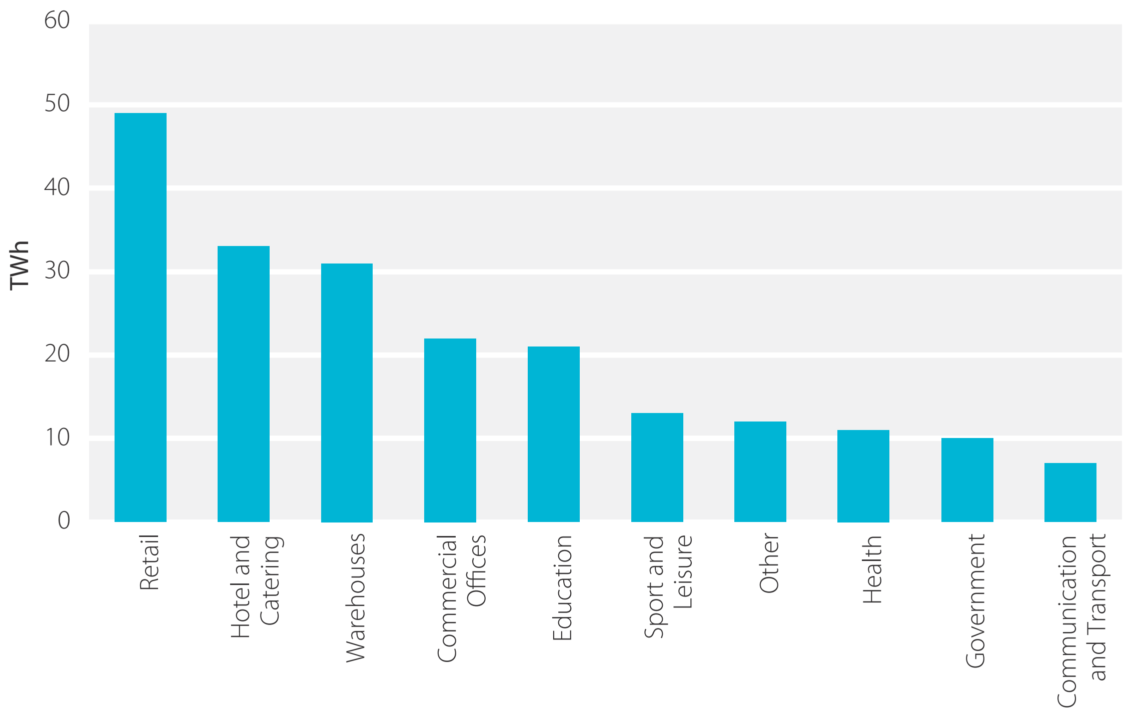
Source: DECC (2009), *Energy consumption in the UK*

Industrial emissions

Industrial emissions fell significantly in the period since 1990, although less so in recent years, due to fuel switching and industry restructuring:

- Industrial emissions fell by 22% between 1990 and 2007, due to direct emissions reductions from the decline of heavy industry and fuel switching. Indirect emissions fell slightly as a result of improved carbon intensity of power generation.
- More recently, emissions fell by only 2% in the period 2003 to 2007.
  - Direct emissions fell by 5% from 2003 to 2007, due to the changing structure of the UK industrial sector and the use of less carbon-intensive fuels in industrial production.
  - Indirect emissions increased by 3% over the same period, as electricity demand growth offset any energy efficiency improvement.
- Provisional 2008 data suggests that direct emissions fell by 4% relative to 2007, while electricity consumption fell by 3%, both of which reflect declining production due to the recession.

Figure 5.5 Public and commercial energy consumption by sub-sector in 2007



Source: DECC (2009); *Energy consumption in the UK.*

2. A framework for energy efficiency improvement in residential buildings

In our December 2008 report we set out a range of measures for improving energy efficiency and reducing emissions in 2020.

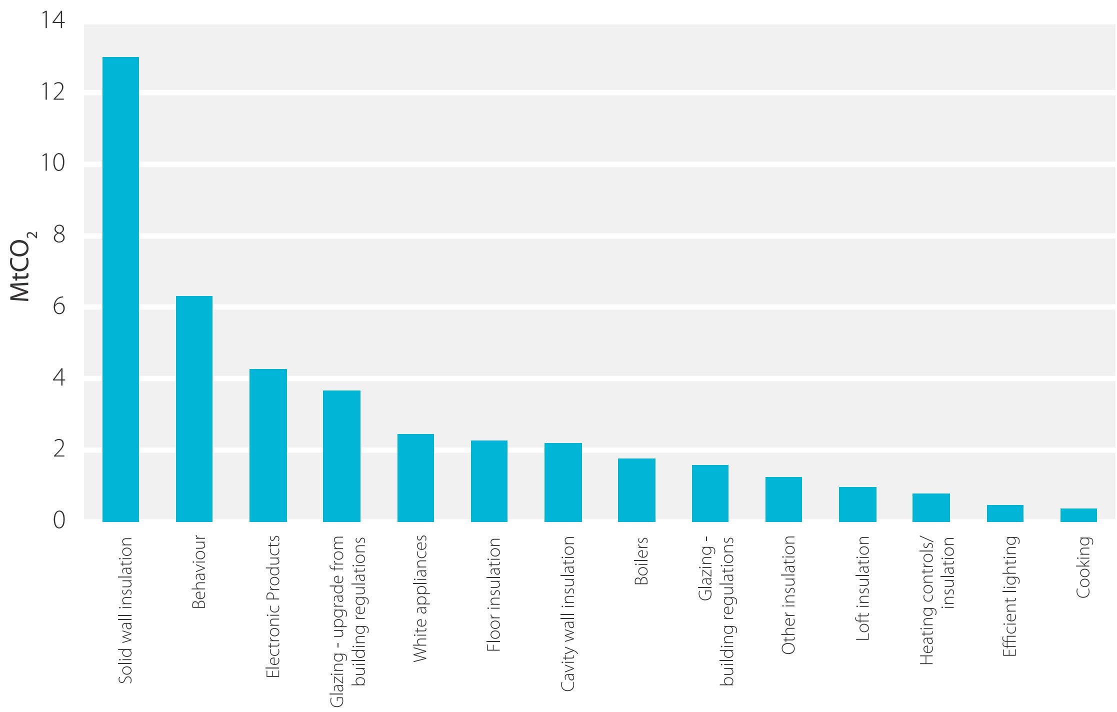
We started with a reference scenario that included emissions reductions expected to ensue from energy efficiency improvements under the Government's Climate Change Programme (CCP) 2006, including:

- 2 $MtCO_2$ from loft insulation.
- 3 $MtCO_2$ emissions reduction from cavity wall insulation.
- 7 $MtCO_2$ from replacement of old inefficient boilers with new efficient condensing boilers.

We then carried out a detailed assessment of remaining emissions reduction potential over and above what was expected from the CCP (Figure 5.6). We estimated potential for a further:

- 1 $MtCO_2$ from loft insulation.
- 2 $MtCO_2$ from cavity wall insulation.
- 17 $MtCO_2$ from more difficult measures including solid wall insulation, under-floor insulation and upgrade of glazing above building regulation levels.
- 2 $MtCO_2$ from early replacement of condensing boilers.
- 8 $MtCO_2$ from more efficient lights and appliances.
- 6 $MtCO_2$ from lifestyle change including turning the thermostat down by 1 degree C and using appliances on efficient cycles.

Figure 5.6 Technical potential from domestic energy efficiency measures in 2020



Source: CCC (2008).

We noted that emissions reductions were unlikely to be achieved under the existing policy framework, which – based on a preliminary assessment – the Committee viewed as providing insufficient incentives to address barriers to uptake of measures.

This chapter considers barriers to uptake and the way that these might be addressed in more detail, drawing on new analysis that we commissioned from Element Energy. We first focus on supply side barriers, which could constrain potential for uptake in the near term. We then move to an assessment of demand side barriers and the way that these are or could be addressed by the policy framework. Given an assessment of supply and demand side barriers, we set out indicators based on what the Committee believes is achievable, and against which future progress reducing emissions should be judged.

We therefore consider in turn:

(i) Supply side barriers to rolling out energy efficiency measures

(ii) The policy framework for energy efficiency improvement

(iii) Indicators and scenarios for residential emissions reductions.

(i) Supply side barriers to rolling out energy efficiency measures

In our December 2008 report, we made a general assumption that measures to improve energy efficiency could be rolled out on a straight line basis. In order to explore the validity of this assumption, we commissioned Element Energy to carry out detailed analysis of feasible implementation given supply and demand side barriers.

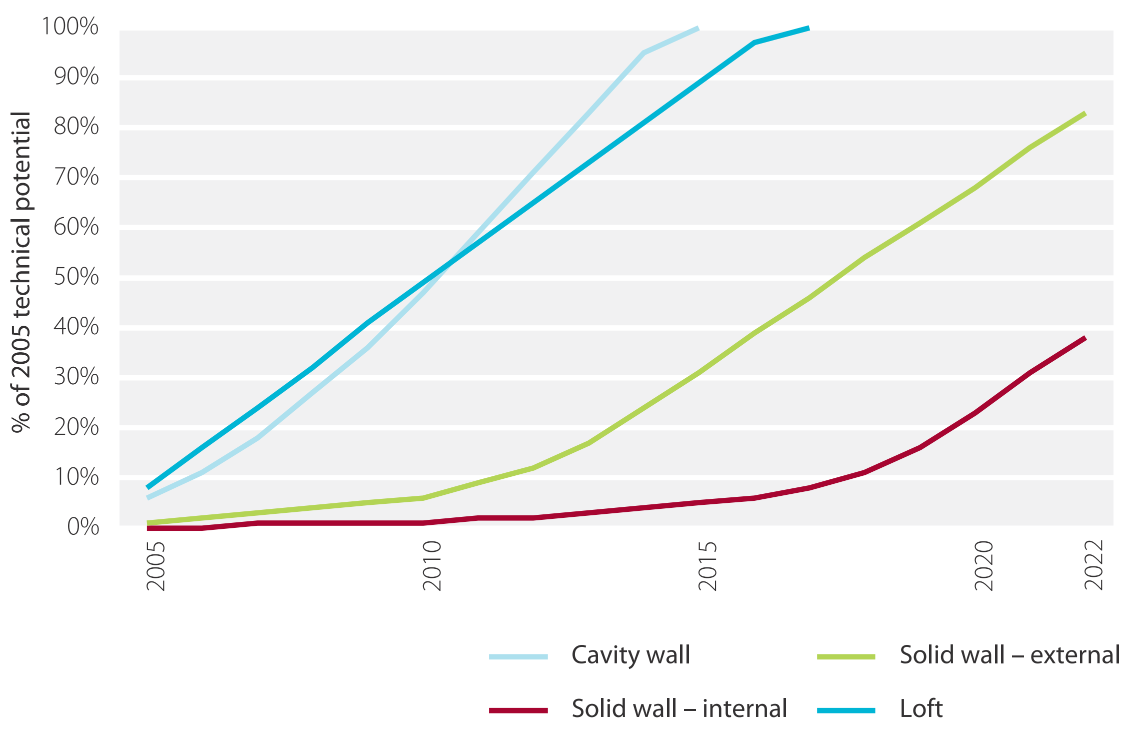
Element Energy's analysis and our consultation with key industry players suggest that there is currently adequate industry capacity to support very ambitious rolling out of loft and cavity wall insulation. For other measures where current capacity is lower (e.g. solid wall insulation) the lead time for industry expansion is relatively short (see Figure 5.6), although training and skills gaps need to be addressed, especially for more difficult measures such as external wall insulation.

The Committee therefore believes that the Government's targets for rolling out energy efficiency improvements as set out in the draft Heat and Energy Saving Strategy (HESS) are achievable based on a consideration of supply side constraints only. These targets include:

- All lofts and cavity walls will be insulated where practicable by 2015.
- By 2020, 7 million homes make more substantial changes such as solid wall insulation.
- All homes to have received by 2030 a 'whole house' package including all cost-effective energy saving measures, plus renewable heat and electricity measures as appropriate.

The Element Energy analysis suggests, however, that targets are highly unlikely to be met under current policies given demand side constraints on uptake of energy efficiency improvements.

Figure 5.7 Insulation measures – percentage of 2005 technical potential realised under supply only constraint



Source: Element Energy (2009).

(ii) The policy framework for energy efficiency improvement

The current policy framework

The main policy for delivering residential energy efficiency improvement is the Carbon Emissions Reduction Target (CERT). This was introduced in 2008 as the successor to the Energy Efficiency Commitment and will run until the end of 2012. CERT works by setting targets for energy supply companies to implement measures in homes that will reduce emissions, with failure to meet targets resulting in fines. Initially, a target of 154 $MtCO_2$ of lifetime savings was agreed but this was extended to 185 $MtCO_2$ in 2009.

Under CERT, energy companies offer measures to consumers free or at discounted rates, spreading associated costs across their customer base. Forty per cent of measures are targeted at a 'Priority Group' comprising people over age 70 and those on benefits.

In its first year of operation, CERT delivered half of the target for the period to 2012. A significant part of this reduction (31%) was achieved by sending customers free compact fluorescent light bulbs. There are no checks in place, however, to ensure that customers actually use these bulbs. Given the risk that bulbs are not used and therefore not actually reducing emissions, the government will not count mailing of bulbs to consumers against CERT targets after January 2010, although subsidising the sale of bulbs in shops will continue to be credited.

In our December 2008 report, we expressed our confidence that CERT will deliver on easy measures such as energy efficient light bulbs. However, we questioned whether it was appropriately designed for the much bigger challenges associated with full roll-out of measures around changing the fabric of buildings, particularly where these measures are potentially costly and disruptive (e.g. widespread solid wall and floor insulation). This is borne out by the data from CERT's first year of operation when only 8,600 solid wall insulation measures were delivered. Initially, the government suggested that the scheme might deliver 150,000 solid wall measures between 2008 and 2011.

CERT operates in England, Wales and Scotland. In addition, the Devolved Administrations have introduced their own energy efficiency policy levers, generally with a strong emphasis on combating fuel poverty (Box 5.2).

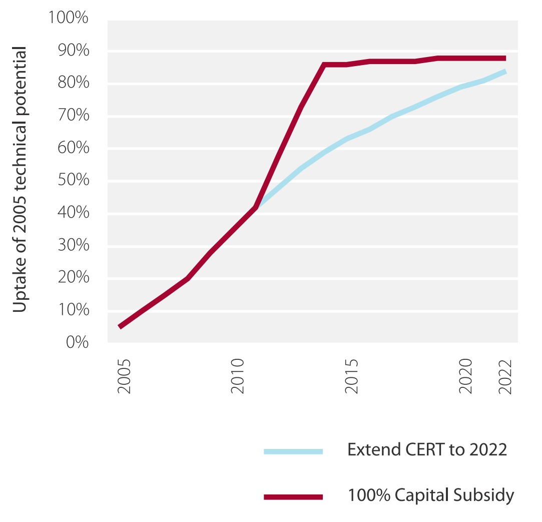
Likely uptake of measures under the current policy

The results of the analysis commissioned by the Committee reinforces our concerns about the effectiveness of CERT. The work is based around statistical analysis of survey data which is then used to simulate household response under various policy levers. The results suggest that even with full subsidisation of upfront cost, there might only be limited uptake of cost-effective energy efficiency improvement measures to 2020.

- Even with full capital grants, uptake rates for lofts are projected to be not more than 88% of total potential (Figure 5.8), and for cavity walls not more than 72% (Figure 5.9). This reflects the underlying survey data upon which the Element Energy simulations are based, and which suggest that up to 30% of the population are not currently interested in energy efficiency improvement even when this is free.
- Uptake of solid wall insulation is projected to be in the range of 7% of total potential under current CERT incentives, with full capital grants resulting in uptake of no more than 47%, reflecting a lack of willingness to take up this disruptive measure (Figure 5.10).

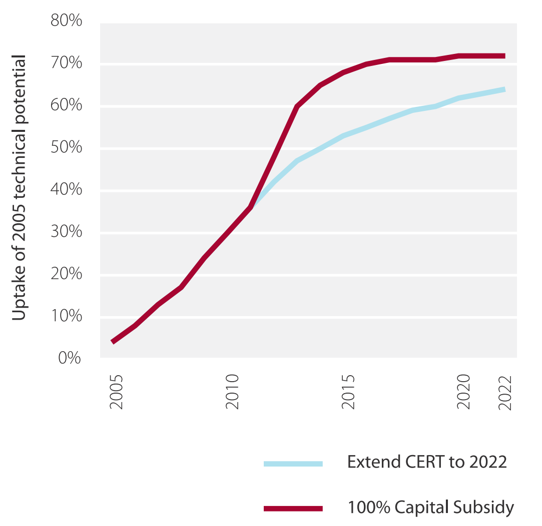
Across the full range of cost-effective measures, Element Energy's analysis suggests that less than half of emissions reduction potential through energy efficiency improvement would be achieved if there was a CERT extension to 2022. In broad terms, this bears out our previous assessment that the current policy is not well designed to address the range of barriers to energy efficiency improvement (lack of information, hassle factor, lack of willingness to implement measures, etc.). A new policy is therefore required.

Figure 5.8 Uptake for different measures under alternative scenarios – loft insulation



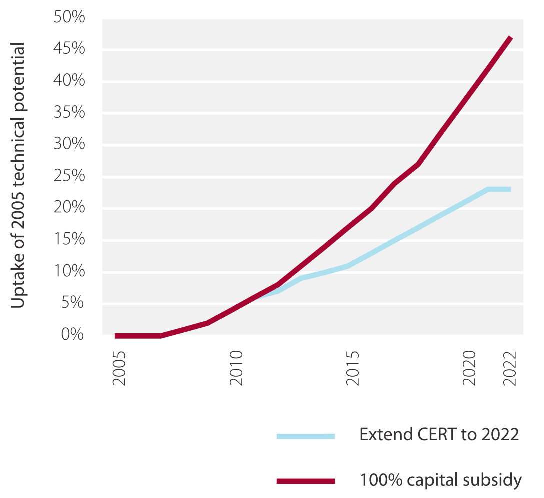
Source: Element Energy (2009).

Figure 5.9 Uptake for different measures under alternative scenarios – cavity wall insulation



Source: Element Energy (2009).

Figure 5.10 Uptake for different measures under alternative scenarios – solid wall insulation



Source: Element Energy (2009); CCC analysis.

Government proposals for a new policy framework

Recognising the importance of energy efficiency improvement in meeting carbon budgets, together with limitations of the current policy, the Government proposed a new approach in its draft Heat and Energy Saving Strategy published in February 2009 and to be finalised by December 2009.

This new policy framework is based on three pillars:

- **A whole house approach**, under which a comprehensive energy audit of each house is carried out, identifying the full range of measures for low-carbon refurbishment. These can then be delivered in 'one hit' or through incremental improvement. Ideally, the company performing the audit acts as a one-stop shop for the household, arranging financing and implementation of measures.
- **A neighbourhood approach**, under which whole house packages are rolled out on an area basis (i.e. street by street), and where there are examples of successful implementation (Box 5.3).

Box 5.2 Devolved Administrations energy efficiency programmes

Wales

The Home Energy Efficiency Scheme (HEES) is a Welsh Assembly Government funded initiative aimed at making homes in Wales warmer, healthier and more energy efficient. The HEES grant provides a package of heating and insulation improvements up to the value of £3600. The Welsh Assembly Government is planning to restructure HEES to target the most inefficient properties and those most in need of support as part of the Fuel Poverty Strategy consultation.

The Heads of the Valleys Low Carbon Zone is a new area-based scheme supported by the Welsh Assembly and local authorities. Over a 15 year period, the programme will install energy efficiency measures and microgeneration units into 40,000 socially owned homes, with an emissions reductions target of 140,000 tCO_2.

Scotland

The new Energy Assistance Package was launched in April 2009 and is supported by a budget of £60m in 2009/10. The package includes energy efficiency advice, income maximisation and energy tariff checks, and, for eligible households, help with standard and enhanced physical measures to improve energy efficiency of the home. Enhanced physical measures are targeted at those most likely to be fuel poor and can include newer technology such as air source heat pumps.

The Scottish Government has also introduced a new area-based 'Home Insulation Scheme' to increase the take up of energy advice and insulation measures in selected areas. It is managed by the Energy Saving Trust, and is supported by £15m of Scottish Government funding with additional funding being sought from other partners. The scheme will target almost 100,000 houses in 10 council areas in its first year and is focused on measures such as loft and cavity wall insulation.

Northern Ireland

Instead of CERT, Northern Ireland has been operating the Energy Efficiency Levy Programme (EELP) since 1997, run by the Utility Regulator. The EELP is not a legal obligation on suppliers; instead a levy is charged per customer and is available to all suppliers wishing to promote energy conservation projects. The EELP was introduced to implement energy efficiency schemes for domestic and non-domestic customers but since 2002, the majority of the funding (80%) has been targeted at alleviating fuel poverty. It has recently been rebranded as the Northern Ireland Sustainable Energy Programme (SEP).

Box 5.3 Area-based (neighbourhood) schemes: Kirklees

'Kirklees Warm Zone' is the largest free insulation scheme in operation in the UK. The three year scheme, which started in March 2007, aims to roll out free insulation to all 171,000 properties in the Council's area. The principal insulation measures are cavity wall insulation and loft insulation top-up to 300mm, resulting in an average SAP improvement of 6 points.

The scheme has a budget of £20 million over a three year period, funded by Kirklees Council, Scottish Power, National Grid and the Regional Housing Board. It systematically targets households, first by mail and then by up to three door knocks. Evidence suggests that word of mouth has been important in promoting take up.

By June 2009, over a third of households targeted had been insulated. The other two thirds of households either already had insulation or were not suitable (30%) or were not interested (6%) or contact had not yet been made (26%); these latter two categories will be targeted in a "mop up" phase. For those households which have been insulated, costs are around a third lower than if a street by street approach had not been used.

- **New financing mechanisms**, which involve consumers taking long-term loans to finance upfront costs of energy efficiency improvements, rather than these costs being spread across the customer base of energy companies. One proposal is to attach the loan to the property, so that both costs and benefits are passed on to the next owner.

The Committee has considered this proposed approach against five criteria set out in our December 2008 report which effective policies should meet: (i) provide information which increases awareness of potential, (ii) strongly encourage households to take action, (iii) reduce hidden costs associated with undertaking measures to improve energy efficiency, (iv) improve financial incentives for action through provision of implicit or explicit subsidies, (v) require action through direct regulation where this is the most appropriate policy lever.

Whole house approach

The whole house approach meets the first three of these criteria, providing information, encouraging households to take action and reducing hidden costs. The Committee therefore supports a whole house approach applied to the full range of cost-effective measures (i.e. that cost less per tonne of CO_2 saved than the projected carbon price) to improve energy efficiency (loft and cavity wall insulation, solid wall insulation, early scrapping of old inefficient boilers, etc.) together with measures to support lifestyle change including installation of heating controls (e.g. thermostatic valves on radiators) and smart meters (Box 5.4), and possibly investment in renewable heat.

Neighbourhood approach

In considering the neighbourhood approach, the Committee has noted three important findings from the social research evidence base put together by Defra, DECC and the Energy Saving Trust:

- **Community based approaches.** Defra survey evidence suggests that a majority of people are keen to act on climate change (either because they are concerned about this directly, or want to save money, avoid waste, etc.) subject to caveats that this should not significantly disrupt current lifestyle (e.g. through restricting mobility). People are concerned, however, that their individual impact will be limited. Community based action is therefore desirable so that people can see how their action together with that of others will make a difference. Beyond a critical mass, people will join community based action simply to conform to social norms even though they may not necessarily want to act on climate change.

- **Government leadership.** The majority of respondents in Defra surveys say that they are looking for the Government to provide a lead on tackling climate change, and that they would be prepared to act if the Government were to act first. The current situation is one where people do not generally perceive energy efficiency improvement in homes to be a top government priority, and so do not make it their own priority. A stronger signal from Government through actively leading and participating in taking forward implementation of measures to improve energy efficiency would therefore raise confidence that measures to improve energy efficiency will be successfully implemented.

Box 5.4 Heating controls

Turning down thermostats is probably the easiest and cheapest way to achieve substantial CO_2 reductions. In our December 2008 report, we estimated that turning down thermostats by 1ºC could reduce emissions by 5.5 $MtCO_2$ annually.

Lack of effective heat controls is currently a barrier to unlocking this potential:

- Industry evidence suggests that around 10 million homes lack some or all standard heating controls (such as programmable timers, room thermostats and thermostatic radiator valves).
- Analysis for the Market Transformation Programme suggests that a substantial proportion of householders do not set and use their controls correctly.

Accelerated roll-out of heating controls as well as smart meters under a whole house approach would provide opportunities for households to save energy and reduce bills.

- **Role for energy companies.** Evidence from the Energy Saving Trust questions how trusting the population is of energy companies, suggesting that only 10% of those surveyed consider energy suppliers trustworthy and impartial when providing advice on how to save energy. Energy companies may not therefore be well placed to lead on what in many respects is a fundamental social transformation (e.g. to mobilise communities, change attitudes and behaviours) required to achieve widespread implementation of buildings fabric measures, and may be better placed to focus on delivery within a government led framework.

A neighbourhood approach *led by government*, aimed at transforming social attitudes, could therefore better meet the second criterion for effective policy than the current situation where the lead is with energy companies.

The Committee recommends that such a neighbourhood approach is adopted. At a high level this should involve central government providing leadership and strategic guidance, for example through a new office tasked with taking forward the new energy efficiency commitments (similar to the Office for Renewable Energy Deployment). Local government would have a key delivery role, building on the trust relationships that it has already established with households and taking advantage of its local housing stock knowledge. Implementation would be in partnership with energy companies and other appropriate commercial organisations, building on their delivery experience.

It is not for the Committee to comment on detailed design of an implementing framework for the neighbourhood approach. We note, however, that whilst 130 out of 150 local authorities have signed up to National Indicator 186 committing them to per capita CO_2 reductions, the majority have no experience of running major energy efficiency programmes. Given the radical change that would be required in order for local authorities to play a leading role in promoting energy efficiency improvement, strong levers including possible statutory instruments may be required in order to secure adequate political and financial commitment.

Complementary regulatory measures for the private rented sector need to be seriously considered as this sector is likely to be less responsive to the neighbourhood approach or pay-as-you save models, given split incentives for landlords and tenants.

More generally, to the extent that some owner occupied households may not respond to the neighbourhood approach, regulatory measures may also need to be considered (e.g. requiring a minimum energy efficiency rating as part of major renovation or upgrade or as a condition of sale, linking council tax or stamp duty to energy efficiency rating).

New financing mechanisms

Energy bills are currently around £35 more than they otherwise would be to reflect costs associated with CERT. Going forward, costs associated with the new delivery model will be substantially higher than those for CERT as more expensive measures are implemented:

- A recent study for Consumer Focus[1] suggested that a retrofit programme aiming to improve all properties in England to EPC bands B and C (currently only 6% of properties) would cost on average around £7,000 per house. It would also reduce annual fuel bills by an average of 46%.
- Evidence from a trial of the whole house approach by Drum Housing Association in Petersfield suggests that in the least efficient properties costs could be as high as £38,000 per house for a *full* range of measures (including solar water heating and PV).
- Estimates for annual investment needs for a ten year low-carbon refurbishment programme vary from £5 billion to £15 billion (UK Green Building Council: £5-15 billion, Climate Change Capital: £7.9 billion, Consumer Focus: £15 billion[2]).

1 Consumer Focus (2009) *Raising the SAP*. http://www.consumerfocus.org.uk/media/viewfile.aspx?filepath=1_20090513110418_e_@@_FuelpovertyproofingcostpubMay09final.pdf&filetype=4
2 UK Green Building Council (2009) *Pay as you save*. http://www.ukgbc.org/site/document/download/?document_id=670
Climate Change Capital (2009) *Delivering Energy Efficiency to the Residential Sector*. Briefing Note.

Box 5.5 Solid Wall Insulation

Solid wall insulation has the highest potential of any of the domestic energy efficiency measures. In our December 2008 report we calculated a reduction potential of 13 $MtCO_2$ in 2022 from 7 million houses at a cost of £5/tCO_2.

More recent work carried out by Element Energy for us suggests that we had previously underestimated the capital costs of solid wall insulation and that this increases the abatement costs to around £17/tCO_2. In other words, whilst solid wall insulation is still cost effective relative to our projected carbon price, it will take longer to pay for itself in energy savings.

Only around 17,000 retrofit solid wall installations are undertaken per year (mostly in the social sector) given limited incentives in the current framework. At this rate, only 15% of existing solid wall properties will be insulated by 2050. The Committee's view, however, is that this could be significantly accelerated if new incentives were to be introduced around a whole house/neighbourhood approach. The Government will propose a framework to support measures such as extensive solid wall insulation as part of its Heat and Energy Saving Strategy, to be published in late 2009. We will consider the effectiveness of the proposals in our 2010 progress report.

Current annual spending by government and energy suppliers on residential energy efficiency programmes is just over £2 billion, therefore implying a large funding gap.

Government proposals to move towards individual charging are partially motivated by concerns over distributional issues that would arise under continued socialisation of costs. For example, passing on costs of rolling out solid wall insulation (Box 5.5) for all seven to eight million houses with solid walls in the UK would have a significant impact across the whole population (i.e. 25 million households), most of which would have no offsetting energy bill reductions.

Evidence from Germany suggests that it is possible to generate high demand for energy efficiency improvement, the situation we would hope to create here through the whole house – neighbourhood approach. In Germany, significant uptake for more expensive and disruptive measures has been achieved through individual charging, while in the UK a new 'Pay-as-you-save' model is to be trialled (Box 5.6).

Box 5.6 Financing Whole House refurbishment

1. Germany's 'Energieeffizient sanieren' programme

Germany's 'Energy Roadmap 2020' has the aim of making Germany the most energy efficient country in the world. A major energy efficiency refurbishment programme is underway which covered 780,000 properties between 2006 and 2008. Its key features are:

- Implementation of measures is generally voluntary; the exception is loft insulation which has been made mandatory.
- Households are expected to make a financial contribution to the installation of measures.
- This is complemented by Government funding of €2.4 billion per year to support a range of measures but the programme has not subsidised CFLs.
- Households receive grants covering up to 17.5% of costs, or loans of up to €75,000 are provided at subsidised interest rates.
- Loans also include a cash-back scheme of up to 12.5% depending on the energy efficiency standard achieved.
- The most favourable terms are available when combinations of measures are implemented together (i.e. for a whole house approach).
- Separate grants and subsidised loans for renewable heat technologies, as well as a feed-in tariff for microgeneration and subsidies for CHP and district heating systems.

2. Pay-as-you save

This concept is based on spreading the cost of low-carbon refurbishment over a long period of time, across different owners. A UK Green Building Council Task Group[3] evaluated the concept in 2009 at the request of the Government and proposed the following model:

- An accredited low energy refurbishment provider develops a 'whole house' energy improvement plan.
- The provider uses finance from a third party to cover the upfront costs of the work.
- An obligation to repay is linked to the property over an extended period of time; this would require legislation to allow local authorities to create a PAYS Local Land Charge.
- Repayments are calculated to be less than the savings that will be made on the fuel bills.
- Billing could be through council tax or electricity bills.
- At change of tenure the benefit and the obligation to pay is transferred to the new householder
- The whole scheme is underwritten by Government to reduce financing risk.

The proposal is to fund upfront costs of up to £10,000 which would provide annual savings of £50 to £200. To drive mass-scale take up beyond environmentally aware households, the proposal notes that strong incentives may be necessary such as stamp duty or council tax rebates, reduced VAT rates or cash-back.

3 http://www.ukgbc.org/site/document/download/?document_id=670

In moving towards individual charging, however, the Government's proposals do not meet the fourth criterion for effective policy, to strengthen financial incentives through providing implicit or explicit subsidies. This is problematic for a number of reasons:

- Some measures do not result in a net cost saving in the short to medium term even with low cost long-term finance. The best example of this is solid wall insulation, which is unlikely to be taken up without at least some subsidy.
- More generally, the Element Energy analysis suggests that there is likely to be a significant decline in uptake as individual charging is substituted for grant funding.
- Consumer research carried out by the Energy Saving Trust suggests many people are unwilling to take on long-term loans for energy efficiency even if these will result in a net cost saving.
- In the German example cited above, individual charging is on the basis of subsidised loans and complemented with grants and mandation.
- More than 40% of the fuel poor live in hard-to-treat homes where solid wall and other expensive measures are required (Figure 5.11). The fuel poor are less well placed to pay for energy efficiency improvements than the non-fuel poor.

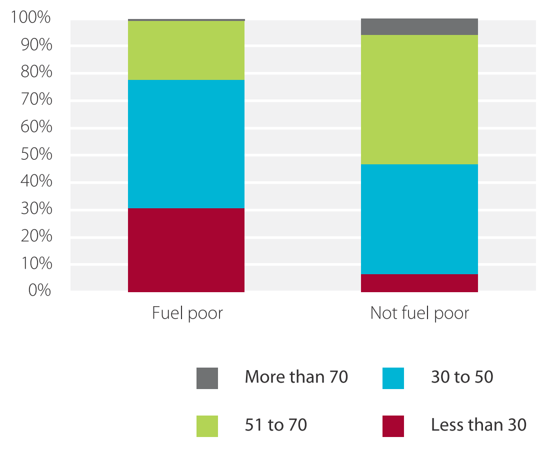
Therefore an element of financial support should be maintained under the new arrangements, both in general and targeted to the fuel poor, in order to provide sufficiently strong incentives for uptake. This would probably best be achieved through ongoing socialisation of some costs (i.e. a hybrid of the current system and the Government's proposals) to provide free measures for the fuel poor and subsidised measures for the population more generally.

(iii) Energy efficiency and fuel poverty

Financial support targeted at energy efficiency improvement for vulnerable households can help to reduce fuel poverty. It cannot, however, fully alleviate this problem, which will be exacerbated by higher energy prices due to increased levels of relatively costly renewable electricity and renewable heat.

In our December 2008 report, we argued that there may be scope to address fuel poverty through the introduction of rising block tariffs (RBTs) – where a subsidised price is charged for consumption to cover basic needs, and a higher price for any additional consumption – which may also incentivise energy efficiency. We commissioned the Building Research Establishment (BRE) to model the potential impact of RBTs using a model of the housing stock, household income and energy consumption.

Figure 5.11 SAP ratings of fuel poor versus non-fuel poor households



Source: BRE (2009), *An Investigation of the effect of rising block tariffs on fuel poverty.*
Note: SAP is the Government's Standard Assessment Procedure for energy rating of dwellings. The rating is on a scale from 1 to 120, with higher ratings denoting better energy efficiency.

The BRE analysis suggests that on average, the fuel poor require more energy to adequately heat their homes than those households not in fuel poverty. This is partly because the fuel poor live in relatively energy inefficient houses. It is also because the fuel poor – comprising around 50% pensioners – also spend a lot of time at home, and therefore require relatively high levels of heating (Figure 5.12).

Given that the fuel poor have relatively high energy requirements, the introduction of RBTs would increase average bills for the fuel poor whilst having a negligible overall impact on the number of households in fuel poverty.

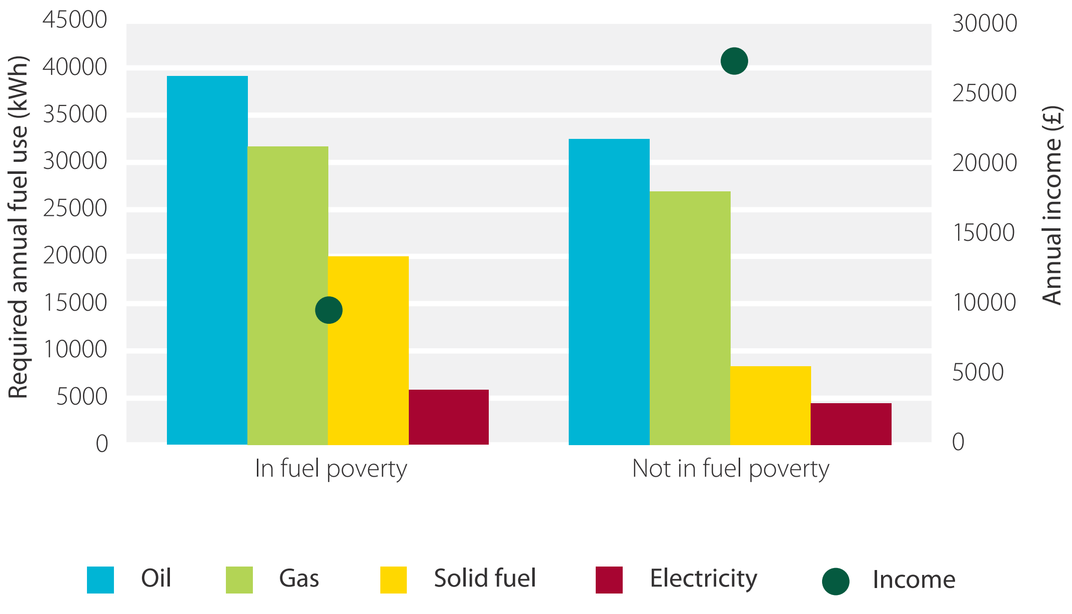
Therefore RBTs should not be introduced until fuel poverty has been addressed through targeted energy efficiency improvement and other fuel poverty policy measures.

(iv) Indicators and scenarios for residential emissions reductions

Our residential buildings indicators – against which we will judge future progress reducing emissions – focus on a number of key measures to improve energy efficiency (lofts, cavity walls, solid walls, boilers and appliances). The indicators are based on our Extended Ambition scenario. For some measures, we have also outlined a more ambitious 'Stretch' scenario which could provide additional emission reductions.

In setting out trajectories for these measures, we assume that a new policy with high powered incentives is introduced. This would require a high level decision in 2009 with detailed proposals and measures to be developed in 2010-2011 for implementation from 2012.

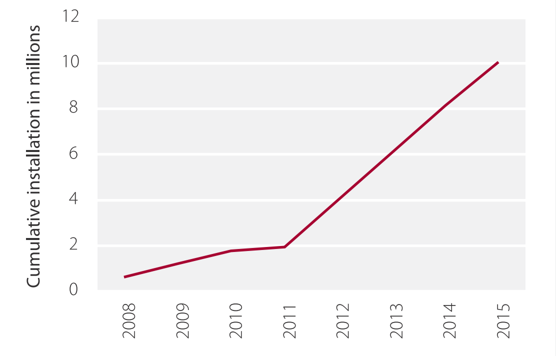
Figure 5.12 Average required use of each fuel (where used) in households in fuel poverty compared to households not in fuel poverty



Source: BRE (2009), *An investigation of the effect of using block tariffs on fuel poverty.*

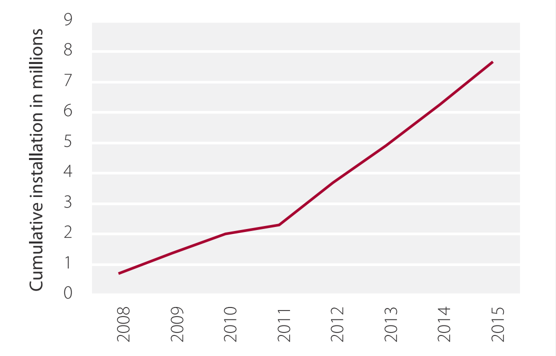
We assume that the new policy delivers the Government's ambition as set out in the draft Heat and Energy Saving Strategy to insulate all lofts and cavity walls by 2015 (where practicable). We assume this applies to 7.5 million unfilled cavity walls and 10 million under-insulated lofts by 2015 (Figure 5.13 and Figure 5.14[4]). To achieve the 2015 target will require a significant scaling up of installation numbers from what is currently being delivered under CERT.

Figure 5.13 Roll-out of loft insulation



Source: CCC analysis.

Figure 5.14 Roll-out of cavity wall insulation



Source: CCC analysis.

For solid walls, we assume implementation begins to accelerate significantly in 2012 from the current very low levels as a new policy is introduced. In our Extended Ambition scenario we assume that 2.3 million properties will have solid wall insulation installed by 2022; this is in line with the level of ambition set out in the draft Heat and Energy Saving Strategy. In our Stretch Ambition scenario, we assume that there are 3.3 million solid wall insulations by 2022 (i.e. around 40% of total technical potential).

We make the following assumptions on roll-out of other key measures to reduce residential emissions:

- By 2022, 12 million older boilers are replaced (either at the end of their lives, or through early replacement under a whole house approach) by new efficient condensing boilers or more efficient emerging technologies (such as fuel cell micro-CHP). In the Stretch scenario, we assume 16 million boilers will be replaced.
- By 2022, the proportion of A+ rated wet appliances increases from the current 15% of stock penetration to 82%, with the proportion of A++ cold appliances increasing from the current 0% to 45%, both in line with what is envisaged under the Government's Market Transformation Programme[5] and the EU Framework Directive for the Eco-design of Energy Using Products (EuP). This would require a move to a situation where almost all new appliances sold are the most efficient rating. New policies might therefore be required to support what is a step change relative to the current status (e.g. lower tax rates for more efficient appliances, as have recently been introduced in Italy).

4 This includes lofts which currently have insulation levels below 125 mm and will be topped up to 270 mm as specified in the building regulations. Top ups for the 7 million lofts that currently have 125 mm or more could provide a small additional saving (0.3 $MtCO_2$).
5 Market Transformation Programme 2009 figures are currently unpublished and subject to revision post-consultation.

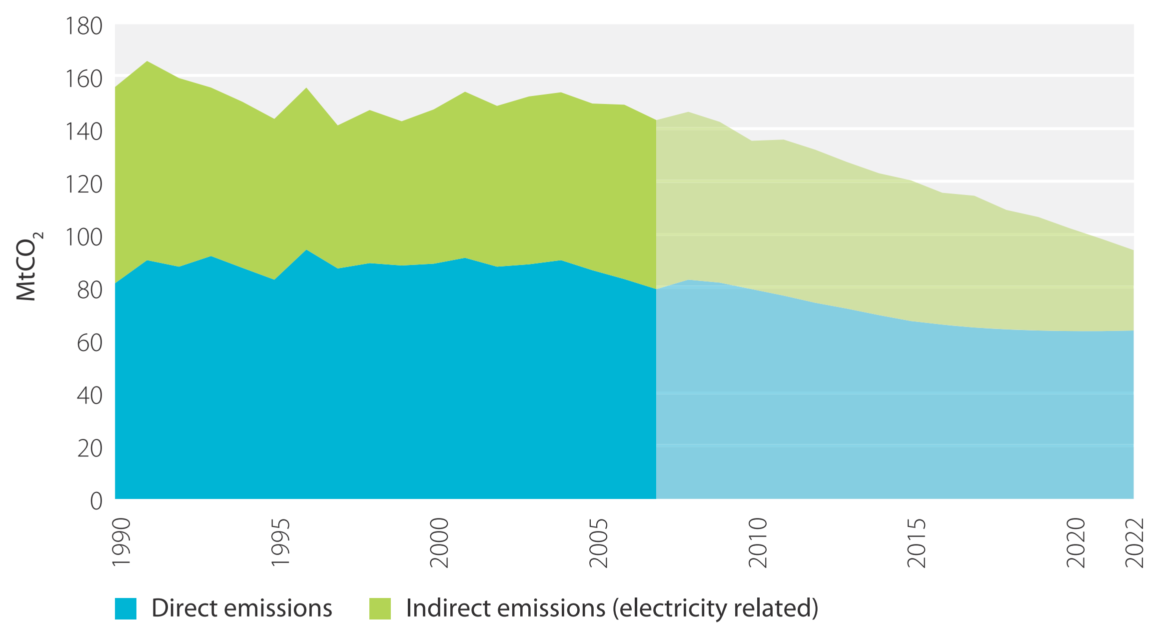
- We also estimate around 4 $MtCO_2$ savings from energy efficiency improvements to consumer electronic products (including reduced stand-by consumption). However, data on the energy performance of these products is currently inadequate and we have therefore not chosen any indicators for these products. We will return to this issue in future reports as data improves.
- In addition, we assume that every household will have been offered a whole house energy audit by the end of the second budget period, to facilitate take up of the 7 million whole house energy packages the government has committed to by the end of 2020.

Successful implementation of these measures would:

- Reduce residential sector emissions by 35% from 140 $MtCO_2$ in 2007 to 92 $MtCO_2$ in 2022, with direct emissions falling by 20% and indirect emissions falling by 53% (Figure 5.15).

We will collect data on these indicators from a range of sources, although we envisage that the bulk of data will come from CERT and the post-2012 delivery model, which should track implementation of specific measures. In our future reports to Parliament, we will then use this indicator framework to assess trends in residential emissions, the extent to which these are falling as required for meeting budgets and the extent to which underlying measures are being implemented both to meet budgets and to be on the path to meeting longer term targets (see Table 5.1).

Figure 5.15 Residential emissions trajectory under the extended ambition scenario 1990-2022



Source: CCC analysis.

3. Scope for reducing emissions through deployment of renewable heat

Currently heat accounts for nearly 50% of final energy consumed in the UK and almost 50% of CO_2 emissions. Residential buildings account for 54% of heat consumption, commercial and public buildings for 16% and industry for 30%. However, industry is responsible for around 50% of heat related CO_2 emissions. This is due to greater use of carbon-intensive fuels such as oil in order to generate the high temperatures required for process heat.

There is a need to increase renewable heat in the UK from the current level of less than 1% of total heat demand (equivalent to 7.7 TWh), in order to both reduce emissions and meet the EU 15% renewable energy target by 2020.

In our December 2008 report, we set out an Extended Ambition scenario resulting in emission reductions from renewable heat of around 12 $MtCO_2$ in 2020. The scenario was characterised by increased use of biomass with some solar thermal water heating. We did not consider air source heat pumps or biogas in detail.

This section sets out our new analysis which considers a wider range of technologies (e.g. air source heat pumps). It also sets out a high level overview of what a framework to support uptake of renewable heat might include, and presents renewable heat scenarios which will provide a benchmark for assessment in our future progress report.

This section therefore considers:

(i) Analysis of renewable heat technologies

(ii) Overview of the policy framework for renewable heat deployment

(iii) Renewable heat scenarios.

(i) Analysis of renewable heat technologies

In order to better understand technical and economic aspects of renewable technologies, we commissioned NERA to analyse where specific technologies are best applied, their cost effectiveness, and any barriers to uptake. The NERA analysis is focused on biomass (boilers and district heating), heat pumps, biogas, and solar thermal heating (Box 5.7). It does not include assessment of biomass CHP; the Committee recognises that there may be significant potential for carbon saving from this technology (e.g. based on preliminary results from a new AEA technology study for DECC) and will consider this further as part of its work programme for 2010.

Biomass boilers. Biomass can be used in both residential and non-residential sectors, with a technical potential (i.e. if there were no barriers to uptake) to abate 42 $MtCO_2$ by 2022. Costs range from £20-£80/tCO_2 for industrial boilers and £60-200/tCO_2 for residential boilers. The range of costs reflects different applications, types of boilers and heat load sizes, as well as the type of fuel replaced, and is based on an assumption that feedstock prices remain at current levels.

- Biomass boilers have become more common in new developments as they often provide the cheapest option to meet renewable energy targets.
- Biomass boilers and CHP plants could potentially substitute for some of the use of oil in industry to produce steam and process heat.
- In the residential sector, biomass boilers are more suitable in non-urban areas, both because they can substitute for more carbon intense fuels in off-gas grid homes, and there are fewer space constraints and air quality considerations compared to some urban areas. There are currently around 4.3m homes without connection to the gas grid.

Box 5.7 Description of renewable heat technologies

Biomass: refers to any organic matter derived from plants or animals, which is then combusted. Currently, biomass is mainly used in power generation (especially co-firing) due to incentives under the Renewables Obligation. However, in recent years smaller scale boiler systems and combined heat and power (CHP) plants have become more common. Biomass boilers usually operate on wood chip or pellets, while the often larger CHP plants burn virgin or waste wood.

Biogas: organic material is fermented to be broken down into methane and CO_2. This biogas can then be burned in a generator or a CHP plant, or upgraded to biomethane for injection into the gas grid. Sources of biogas include landfills, sewage treatment processes and purpose built anaerobic digesters (AD).

Air source heat pump (ASHP): extracts heat from the outside air in the same way that a fridge extracts heat from the inside. There are two types of ASHPs: an air to water heat pump heats water through under floor heating and radiators and an air to air heat pump delivers warm air.

Heat pumps need electricity to operate the compressor. The Coefficient of Performance (COP) measures how much electricity is needed per unit of heat produced.

Ground source heat pump (GSHP): extracts heat from the outside ground to heat water and air. As the temperature found in the ground is relatively stable throughout the year, a GSHP is more efficient than an air source heat pump.

Solar thermal: harnesses the heat from the sun to produce hot water via a solar collector. Although the solar thermal system performs better under direct sunlight it can also produce energy on a cloudy day.

- Analysis commissioned by DECC from E4Tech[6] indicated that there is enough sustainable biomass to support 7% penetration relative to total heat demand in 2020. The EU has consulted on a sustainability scheme for biomass feedstocks under the European Renewable Energy Directive which has received widespread support.
- The upfront cost of a commercial biomass boiler ranges from £37,000 for a 110kW size boiler to £678,000 for a 1,600kW size boiler.
- In the residential sector, upfront boiler costs are around £4,000–£11,000 for a boiler ranging in size from 12kW to 18kW. Cost savings could reach over £400 per year where biomass replaces electric heating.
- Biomass CHP plants can provide both heat and electricity. Analysis by Pöyry for DECC[7] suggests that the CO_2 saving per unit could be a third higher for CHP units than for individual or community biomass boilers.

Air source heat pumps (ASHPs). ASHPs may be used in buildings with vent or wet (i.e. with radiators) heating systems. There is technical potential for air source heat pumps to save 16 $MtCO_2$ by 2022 costing from less than zero (£-40) to £55/tCO_2 in the non-residential sector and over £300/tCO_2 in the residential sector. The range of costs reflects which type of fuel is displaced, energy efficiency of the building, and size of application.

- ASHPs work well in vent heating systems, and their flexibility to be used in reverse for air conditioning in summer has produced high penetration rates in the commercial sector. The upfront cost of a commercial air source heat pump is around £30,000 for a 55kW unit and £183,000 for a larger 300kW unit.
- In the residential sector, ASHPs are most suitable for under floor heating systems in highly efficient new houses.

6 E4Tech (2009) *Biomass supply curves for the UK.* http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx
7 Pöyry (2009) *The potential and costs of district heating networks.* http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/distributed_en_heat/district_heat/district_heat.aspx

- For existing houses, ASHPs will often require larger radiators and upgraded insulation to operate effectively, thus substantially increasing the cost.
- The upfront cost of a residential heat pump is £4,000-£23,000. Current cost savings per year vary from £50 (when replacing gas heating) to £700 (when replacing electric heating).

Ground source heat pumps (GSHPs). These are most suitable for the residential sector, with scope for technical abatement potential of 6 $MtCO_2$ and costing £5-200/tCO_2. The range of costs reflects different ground conditions and installation costs. Bore holes are usually more expensive than horizontal trench installation.

- As with ASHPs, GSHPs are most cost-effective in well insulated new homes.
- They tend to be more suited to non-urban areas, where space is less of a constraint for installing the ground loops. In some urban areas, more expensive bore hole applications are an option.
- The Energy Saving Trust estimates that upfront costs of a residential GSHP system range between £7,000-£13,000, with annual cost savings between £160 (if replacing an oil-fired heating system) and £840 (for electric heating).
- Both ASHPs and GSHPs have seen rapid penetration in a number of countries in recent years (Box 5.8)

Box 5.8 Countries with high heat pump penetration

Rising fossil fuel prices combined with government financial support have facilitated rapid market growth of both ASHPs and GSHPs in many EU countries. In 2008, sales in the eight European countries with the highest heat pump penetration (Austria, Finland, France, Germany, Italy, Norway, Sweden and Switzerland) increased by 46% to 576,000. Sales were highest in France, almost doubling to 130,000.

- France introduced income tax rebates for heat pumps in 2005 which offer 50% subsidy of the capital cost of the equipment.
- In Sweden, grants are available up to a maximum of €3,300 for installation of various renewable technologies including heat pumps. Rapid growth in heat pumps has driven the reduction in use of heating oil by more than 50% in the last 15 years. Strong market competition has lead to considerable price reduction and almost half of all single family houses now have a heat pump installed.
- In Switzerland, heat pumps accounted for 78% of heating systems in new homes in 2008. A range of subsidies are available from energy suppliers and some local authorities. By 2020, the Swiss government expects the number of heat pumps to triple and deliver a 8% reduction in CO_2 emissions.
- Germany has implemented the largest GSHP project in Europe with 21 boreholes serving 383 new houses and flats in a development near Cologne.

Biogas. This is produced by the anaerobic digestion (AD) of agricultural and food wastes. Biogas is best used either directly in CHP plants or, once upgraded to biomethane, injected into the gas grid.

- Estimates for the abatement potential from biogas vary considerably:
  - Work by NERA for the CCC indicates that by 2022 annual emissions reductions potential from biogas is just over 1 $MtCO_2$ (5.7 TWh).
  - The NERA estimate of potential is close to the estimates in our December report based on analysis of agriculture and waste commissioned from the Scottish Agricultural College and Eunomia respectively.
  - DECC's Renewable Energy Strategy suggests that there is technical potential for biogas production of around 10-20 TWh per year (saving around 2-4 $MtCO_2$ per year).
  - Estimates by E4tech for DECC and by Ernst and Young for National Grid[8] suggest that there is a much higher technical potential, with scope for annual emissions reductions of 8-22 $MtCO_2$ by 2030.
- The Committee accepts that there may be more potential available than suggested by the NERA analysis and will consider this as part of further work on heat decarbonisation in the context of developing advice on the fourth budget (2023-27), in which we will also draw out any implications for the first three budget periods.
- NERA estimate that biogas costs around £12/tCO_2 saved, largely driven by capital costs for AD and the cost of upgrading biogas for grid injection.
- Current penetration of biogas is very low in the UK, reflecting the absence of a support mechanism for burning of biogas in CHP or grid injection. This contrasts to Germany, where a comprehensive support mechanism for biogas currently results in emissions reductions of 8 $MtCO_2$ annually (mainly through biogas CHP), and a target for grid injection for 2020 that would result in emissions cuts of a further 9 $MtCO_2$.

Solar thermal. This has technical potential for use in residential water heating and supplementing central heating, where it could result in emissions reductions of 6 $MtCO_2$ in 2022 at a cost ranging from £670-£1,350 /tCO_2 in the residential sector. This range for costs, driven by size of system and location, makes solar thermal the least cost-effective renewable heat technology.

- Solar thermal has the potential to supply on average up to a third of household hot water demand and a smaller proportion of household heat demand. In the summer, up to two-thirds of hot water needs can be met by a solar thermal system.
- It is more cost effective in better insulated and more water efficient new homes.
- According to the Energy Saving Trust, upfront costs for a solar water heating system are £3,000-5,000.
- Annual cost savings for solar thermal are £65 if displacing gas and £95 if displacing electricity.[9] Low annual cost savings mean that the shortest payback period is over 30 years.
- Solar thermal penetration in the UK is around 50,000 units. This contrasts to Germany, where significant financial support has resulted in installation of 1.25 million units.

8 National Grid (2009) *Potential for renewable gas in the UK.*
http://www.nationalgrid.com/NR/rdonlyres/E65C1B78-000B-4DD4-A9C8-205180633303/31665/renewablegasfinal.pdf
http://www.nationalgrid.com/NR/rdonlyres/9122AEBA-5E50-43CA-81E5-8FD98C2CA4EC/32182/renewablegasWPfinal1.pdf
9 Based on displacing gas in a three bedroom semi-detached house.

Summary of technical potential for renewable heat

In summary, the NERA analysis suggests that there may be scope to reduce emissions by up to 85 $MtCO_2$ in 2022 through increased penetration of renewable heat (Figure 5.16).

Most potential comes from the use of biomass in industry, although there is scope for application of all technologies considered in residential and commercial buildings. From an economic perspective, each of biomass, air source heat pumps and biogas has applications that are cost effective when considered against a £40/tCO_2 benchmark, with savings from ASHPs available for less than zero cost in some applications.

It is, however, very important to differentiate between technical potential and what is realistically achievable. The gap between technical and realistic potential will be driven by the policy framework and the way that this addresses the range of barriers to uptake.

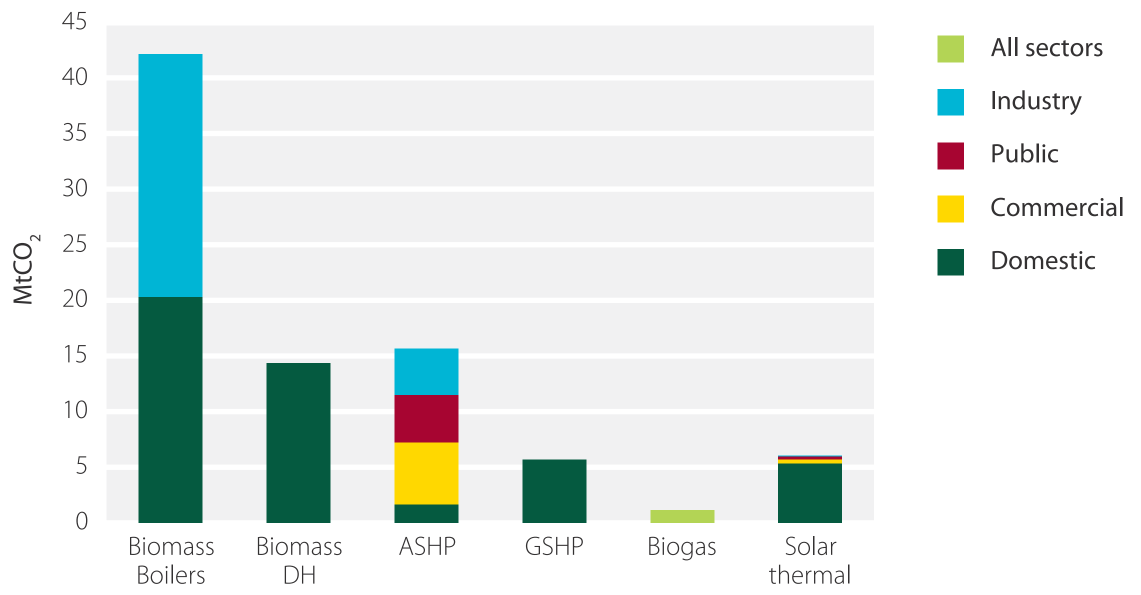
(ii) Overview of the policy framework for renewable heat deployment

Principles for a renewable heat support framework

NERA's analysis of costs suggests that financial support for renewable heat will be required, with the level of support varying according to technology:

- There is currently no carbon price in the heat sector except for the 10% of households and the large proportion of non-residential buildings using electric heating. The financial support provided for renewable electricity by the EU ETS price is absent where gas is the heating fuel.
- If households and businesses are to invest in renewable heat, they will have to be given financial incentives. Preliminary estimates for DECC suggests that financial support required to meet its 12% renewable heat target is in the range £2.7 billion to £4 billion per annum in 2020.

Figure 5.16 Renewable heat market potential by technology, by sector in 2022



Source: NERA (2009).

- The level of the financial incentive should be a function of cost effectiveness. The range of cost effectiveness from £12/tCO_2 for biogas to £20/tCO_2 for some biomass up to £1,350/tCO_2 for solar thermal suggests that different levels of support are required for different renewable heat technologies.
- Financial incentives should allow flexibility over the mix of renewable heat technologies (e.g. to allow more biogas than suggested by the NERA analysis and to allow for CHP).
- Financial incentives should encourage efficient resource allocation (e.g. use of biogas in CHP or grid injection rather than use in inefficient gas turbines, energy efficiency measures rather than over-sizing heat pumps).

Consumer attitudes to renewable heat will also have to change if there is to be significant growth in penetration in the residential sector. This will require strong encouragement from Government, provision of information, and measures to reduce transaction costs (e.g. hassle costs). Sustainability and other environmental concerns (e.g. air quality) also need to be addressed.

Given that the barriers to uptake of renewable heat are similar to those for energy efficiency, renewable heat might usefully be included as part of the whole house/neighbourhood approach discussed above. There may be particular scope to appeal to that part of the population (i.e. up to around 20%) identified as being 'positive greens' in Defra's segmentation model, and those households currently not connected to the gas grid. There is therefore a potentially significant opportunity for uptake of renewable heat in the residential sector if the right incentives are put in place.

In the commercial and industrial sectors, financial incentives will be crucial in determining the level of uptake. There may be scope here to leverage any incentives provided through a tailored mechanism by including renewable heat in any future revisions to existing schemes to improve commercial and industrial energy efficiency improvement (e.g. Climate Change Agreements, the Carbon Reduction Commitment).

Government proposals

The Government's proposed framework for renewable heat is set out in the UK Renewable Energy Strategy 2009. This includes a Renewable Heat Incentive (RHI) which will provide guaranteed payments to householders and businesses using renewable heat, to be implemented from April 2011. Government will consult on the design of the RHI towards the end of 2009.

(iii) Renewable heat scenarios

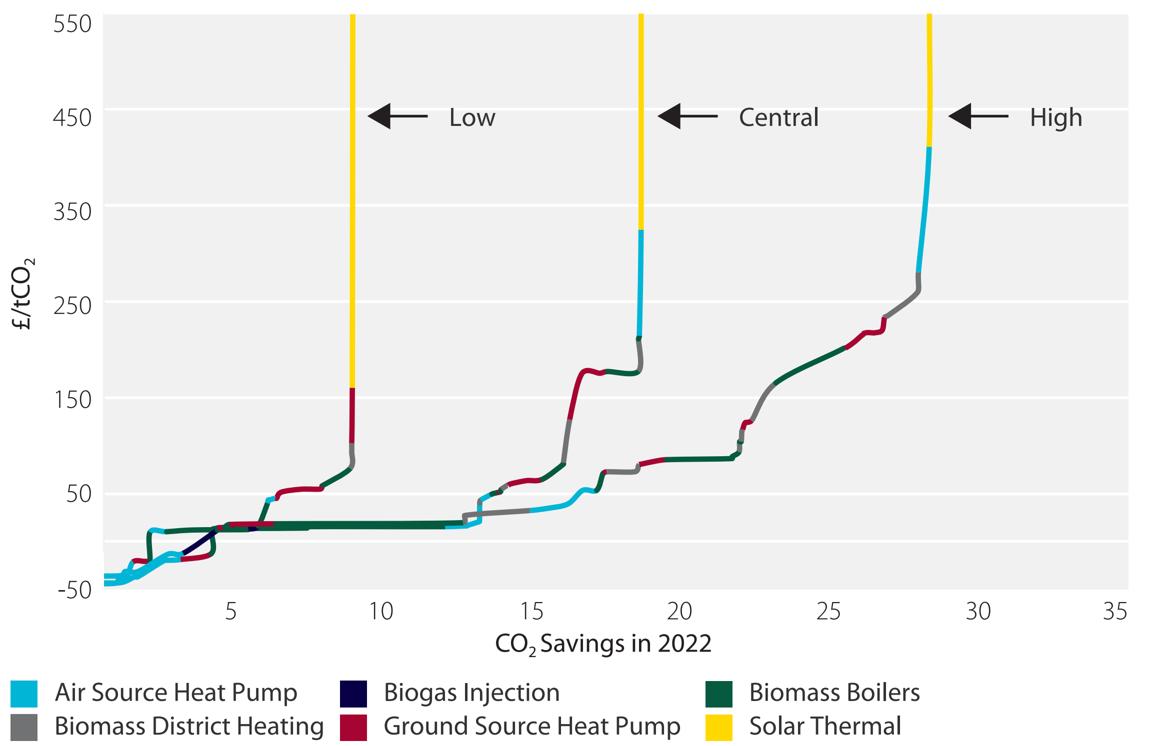
We asked NERA to develop a range of scenarios for uptake of renewable heat to reflect various levels of policy ambition in terms of both financial support and effort to change attitudes, together with supply chain response. Their low, central and high scenarios model emissions reductions in 2022 of 10 MtCO_2, 20 MtCO_2 and 31 MtCO_2 (Figure 5.17).

The central scenario is close to the DECC renewable heat scenario of 24MtCO_2 that we included in the December 2008 report. It differs in composition, however, substituting some industrial biomass, air source heat pumps and biogas for residential biomass. Figure 5.17 shows the emissions reductions by 2022 under the central scenario for each technology with biomass boilers projected to contribute around a third of total abatement (i.e. 7 MtCO_2).

Nearly all the abatement potential available under £100/tCO_2 involves the displacement of electric, oil or solid fuel heating. It is less attractive to displace natural gas with renewable technologies given its relative cheapness. With gas accounting for 80% of residential heat supply this explains why abatement potential in the residential sector below £100/tCO_2 is less than half of that available in industry.

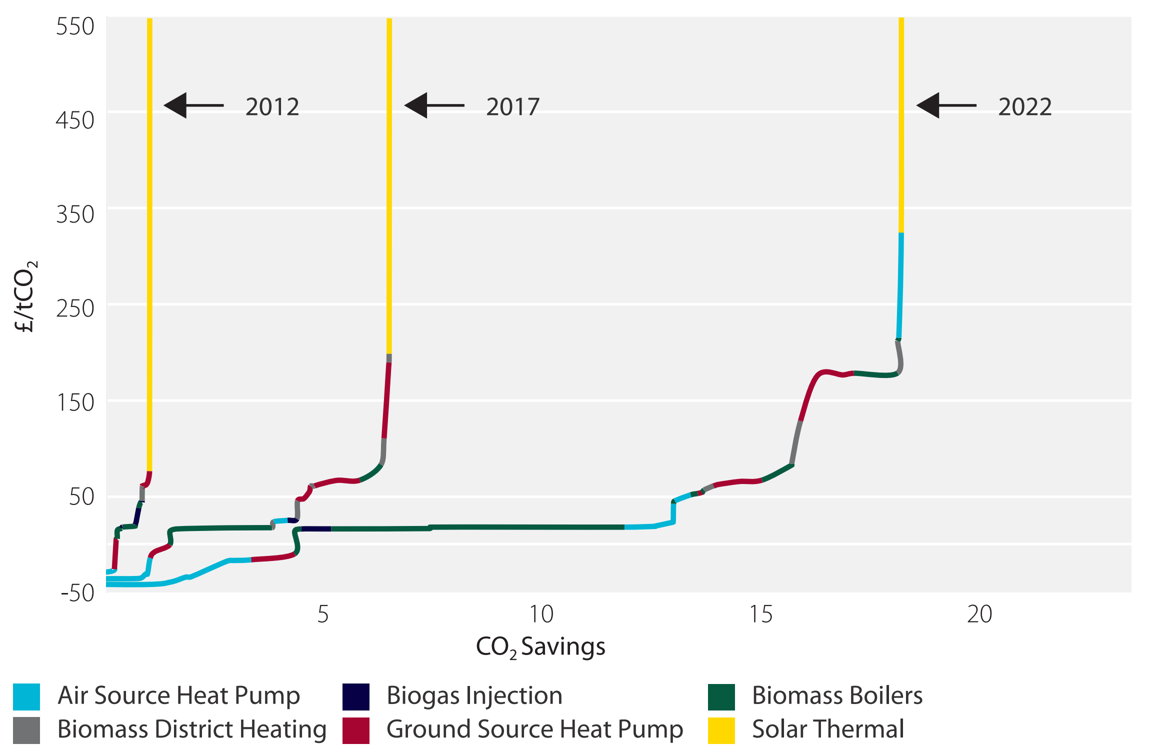
DECC uses a similar scenario in its Renewable Energy Strategy to show that a 12% penetration of renewable heat by 2020, in conjunction with an increase in renewable electricity generation and biofuels in transport, would achieve the 15% renewable energy target required in the EU context.

Figure 5.17 MACC for low, central and high scenarios in 2022



Source: NERA (2009).

Figure 5.18 MACC showing penetration in the central scenario over time



Source: NERA (2009).

It is reasonable to have a stretching target for renewable heat by 2020 because:

- This would make a very useful contribution to achieving the non-traded sector budget.
- The mix of technologies required to achieve high penetration would provide a portfolio of options for more wide-scale deployment in the 2020s.

We have assumed the Government's 12% heat share by 2020 for our Extended Ambition scenario and will use penetration rates over time towards the 12% as the basis for assessing progress in reducing emissions through renewable heat deployment (Figure 5.18).

However, we note that such a stretching target would be very expensive at the margin (e.g. costing hundreds of pounds per tonne of carbon saved). Slightly reducing the level of effort could therefore have a significant cost impact without undermining the contribution of renewable heat to meeting the non-traded sector budget.

We will not set out in advance indicators for the appropriate mix of technologies, given uncertainty over technical and economic characteristics and consumer attitudes. We will, however, seek to ensure overall target levels of penetration are achieved through a mix of technologies including biomass, heat pumps and biogas.

The appropriate path for decarbonisation of heat through the 2020s and beyond is currently unclear:

- There are uncertainties around availability of biogas and sustainable biomass.
- Innovation to improve performance and reduce costs may change the attractiveness of heat pumps.
- Depending on progress to improve energy efficiency there could be a significantly larger pool of houses where heat pumps could potentially be used.
- The consequences of increased electric heating for the power system – generation, transmission and distribution – are not well understood.

It is likely that the path will probably include a mix of biomass, heat pumps and biogas (e.g. with biomass/biogas used by industry, heat pumps used in the residential sector) and an approach based around developing a portfolio of options to 2020 is therefore justified.

For the period beyond 2020, the Committee will consider the appropriate path and pace of heat decarbonisation in more detail in the context of developing its advice on the level of the fourth budget, to be delivered to the Government by the end of 2010.

4. Emissions reductions in non-residential buildings and industry

We consider emissions reductions in non-residential buildings and industry in six parts:

(i) Technical emissions reduction potential

(ii) Emissions reductions in capped sectors

(iii) Emissions reductions in public sector buildings

(iv) Emissions reductions in uncapped sectors

(v) The role of EPCs and DECs

(vi) Indicators for non-residential buildings and industry.

(i) Technical emissions reduction potential

In our December 2008 report our analysis suggested that there is technical potential for emissions reduction through energy efficiency improvement costing less than £40/tCO_2 in non-residential buildings of approximately 14.5 MtCO_2.

- Improving the efficiency of heating and cooling buildings could save over 5 MtCO_2 in 2020.
- Better management of energy (from motion sensitive lights to optimising heating temperatures and timing) could save over 8 MtCO_2 in 2020.
- Use of more efficient lights and appliances has the potential to reduce emissions by around 1.5 MtCO_2 in 2020.

In industry, there is technical potential of 7 $MtCO_2$ available at zero or negative cost in 2020, through a range of measures around improvements in the efficiency of electrical machinery, heat generation, insulation and heat recovery.

As part of the analysis for this report, we asked Element Energy to provide their assessment of emissions reduction potential from non-residential buildings and industry. Their analysis suggested a similar order of magnitude of emissions reduction potential from non-residential buildings, but that emissions reduction potential from industry may be significantly higher than we had previously estimated. We are therefore confident that we have the right order of magnitude of emissions reduction potential for non-residential buildings. For industry, we regard our previous estimate as a lower bound on potential emissions reductions.

(ii) Emissions reductions in capped sectors

Approach in the December 2008 report

The December 2008 report distinguished between those sectors that are covered by a cap versus those where there is no cap. Capped sectors are covered by one of three schemes:

- The Carbon Reduction Commitment (CRC), which covers large non-energy intensive companies (e.g. supermarket chains) and public sector buildings (e.g. universities, hospitals).
- Climate Change Agreements, under which energy intensive industries are exempted from the Climate Change Levy subject to agreeing to improve energy efficiency/cut emissions.
- The EU ETS, which caps emissions from energy intensive industry at the European level.

Our approach was to assume that these schemes are effective in unlocking cost-effective emissions reductions – defined as costing less than our projected carbon price – and that realistically achievable emissions reduction potential from capped sectors is therefore 8 $MtCO_2$ in 2022.

Future work of the Committee

The Committee has been asked by the Government to advise on what the appropriate arrangements are for the second phase of the CRC running from 2013 to 2018. As part of this review, the Committee will consider:

- The appropriate cap for the second phase, given underlying emissions reduction potential
- The role of the CRC in providing incentives for renewable electricity and heat
- Complementary measures to support emissions reductions. The range of options here includes providing firms with better information about emissions reduction opportunities and how these can be addressed, to mandating installation of light and heating controls.

The Committee will report back on the CRC in 2010.

Further work is also required on more radical technology innovations that could result in deep emissions cuts in the energy intensive sectors. In particular, the application of Carbon Capture and Storage (CCS) technology to industries such as iron and steel, cement and refining may offer significant potential for reducing emissions.

The Committee acknowledges the potential importance of introducing new technologies to the energy-intensive sectors both for meeting carbon budgets and in the context of meeting longer term emissions reduction objectives. The Committee will consider opportunities for the use of new technology in industry in the context of providing its advice to Government on the fourth carbon budget (2023-2027) in 2010 as required under the Climate Change Act.

(iii) Emissions reductions in public sector buildings

The public sector comprises a range of institutions including central government, local authorities, schools, universities and hospitals which together account for 6% of emissions from buildings and industry. We estimate that the emissions reduction potential in this sector is around 2.5 $MtCO_2$ by 2022.

There are currently a number of initiatives aimed at reducing public sector emissions:

- The central government estate has established a target to reduce emissions in central government offices by 30% in 2020 relative to 1999/2000. Interim targets established in the context of agreeing departmental carbon budgets aim to achieve a 17% cut in emissions by 2010/11, with DECC committing to reduce its buildings emissions by 10% in 2009/10.
- Around 25% of local authorities have signed up to National Indicator 185 which requires them to report on reducing their emissions.
- The Greater London Authority is currently designing a facility that will provide financial and other support to London local authorities and public sector institutions seeking to reduce emissions.
- Emissions from central government departments, larger local authorities (including state schools), the NHS and large universities are covered by the CRC.
- The devolved administrations have made various commitments and have supporting programmes to improve energy efficiency (Box 5.9).

Both the Sustainable Development Commission and the Carbon Trust have stressed the importance of public sector emission reductions. They can:

- make an important contribution to meeting carbon budgets
- stimulate the low-carbon supply chain
- support behavioural change among users of public sector buildings.

Box 5.9 Devolved Administrations public sector energy efficiency targets

Northern Ireland

The following targets have been set for the public sector estate:

- Increase buildings' energy efficiency in terms of kWh of fuel and electricity used per square metre of building floor area by 15% by 2010/11, relative to a base year of 1999/2000;
- Reduce absolute CO_2 emissions from fuel and electricity used in buildings by 12.5% by 2010/11, relative to a base year of 1999/2000; and
- Reduce electricity consumption by 1% annually from 2007 to 2012 against the base year of 2006/07.

Scotland

The Scottish Government published a Carbon Management Plan in May 2009 that identified a range of carbon reduction projects that will contribute towards a 20% reduction in carbon emissions from a baseline of 2007/08 by 2014 which equates to a saving of almost 4 $ktCO_2$. These projects include building specific and organisational changes to help achieve the target.

Wales

The Welsh Assembly Government and Welsh local authorities are currently in the process of developing a carbon management plan in partnership with the Carbon Trust.

More generally, Government and local authorities cannot be credible leading a programme to reduce emissions without cutting their own emissions. The Committee therefore considers that all cost-effective emissions reduction potential (e.g. heating controls and energy efficient boilers) in central and local government buildings and public sector buildings covered by the CRC should be realised by 2018 (i.e. within 8 years, which is comparable with periods envisaged for widespread roll-out of measures in the residential sector and the end of the first capped phase of the CRC). We will monitor progress towards achieving of this objective in our annual progress reports.

(iv) Emissions reductions in uncapped sectors

SME emissions and emissions reduction potential

Our analysis presented in the December 2008 report suggested that around 45% of technical emissions reduction potential in non-residential buildings and industry comes from sectors which are currently not capped. We stated that this could realistically deliver 7 $MtCO_2$ under our extended scenario by 2022, which equates to 90% of the technical potential available at a cost less than £40/tCO_2.

This potential includes around 1.2 million Small & Medium Enterprises (SMEs), two-thirds of which employ less than five people. SMEs are extremely diverse, ranging from self-employed individuals working at home, to corner shops, restaurants and hotels, offices, garages and small manufacturers (Box 5.10)

Our approach in setting out achievable emissions reductions for non-capped sectors was to provide a range, with the top end of the range corresponding to an assumption that new policies with high powered incentives (providing information, encouragement, reducing hassle costs, providing financial support, etc.) are introduced and are successful in unlocking emissions reduction potential.

Box 5.10 Type of SMEs that receive assistance from the Carbon Trust

The Carbon Trust helped SMEs achieve reductions of 300,000 tCO_2 in 2007-08, which realised energy savings of £45m. Below are some examples of the type of SMEs the Carbon Trust has assisted:

Under the Carbon Trust's energy efficiency loan scheme, a Norfolk timber pallet manufacturer was awarded £100,000 to install energy efficiency equipment. It is estimated that the company has realised annual savings of £32,741 and 174 tCO_2.

A manufacturer of injection moulded plastic items received an £8,000 interest free loan to install motor controllers on the injection moulding machines. This has reduced the machines' electricity use by nearly 20 per cent, a saving of more than £5,000 a year.

A community centre in Manchester applied for an interest free loan of £7,025 to replace an old boiler more than 30 years old. The new boiler has reduced the centre's energy bill from £5,000 to about £3,600, while enabling reductions in emissions of nearly 4 tCO_2 per year.

An independent school in Essex received an interest free loan of £7,000 to install a new mechanised cover for its heated swimming pool. This reduced the annual cost of heating the pool from £8,500 to £6,500.

Policy levers for reducing SME emissions

The current policy framework for addressing SME emissions reductions is aimed at providing information and financial support:

- The Carbon Trust provides information on emissions reduction opportunities and interest free loans for energy efficiency improvement.
- The Enhanced Capital Allowance scheme provides businesses with 100% first year tax relief on capital expenditure on 61 different energy saving technologies.

The Carbon Trust is only able, however, to reach a very small proportion of SMEs, and the majority of emissions reduction potential remains and is likely to remain locked unless new policies are introduced. This is important given the large number of SMEs that do not consider energy a priority as it comprises a small proportion of total costs.

Options for new policy include:

- **Providing more financial support:** Current financial and institutional support provided by the Carbon Trust could be scaled up to cover a larger proportion of the SME population. It is not clear, however, whether this could ever lead to widespread uptake of measures for firms where reduction of energy costs is not currently a priority.
- **Extending the new residential sector delivery model to cover SMEs:** This would remove the barriers associated with taking up energy efficiency measures in the SME sector, namely lack of knowledge, expertise and finance. Some progress has already been made in this respect with the large energy companies in the UK entering voluntary agreements with Government to provide energy services to SMEs. There is a question, however, as to whether the voluntary basis of the scheme provides sufficient bite for energy suppliers to actively participate and whether the neighbourhood approach which could motivate households would provide the same incentives for SMEs.
- **Mandating implementation of measures:** As in the residential sector, regulatory measures may be required to achieve full take up of cost-effective emissions reduction potential (e.g. mandating a minimum EPC rating on sale or letting of property, or linking business rates to the EPC rating).

The Government has established a new project that is considering possible new policies to support SME emissions reduction. This is a crucial project given the magnitude of emissions reduction potential and the lack of a current policy framework, and we will continue to focus on this area going forward.

(v) The role of EPCs and DECs

Under the EU Energy Performance of Buildings Directive (EPBD), it is mandatory for all commercial and public buildings to have an Energy Performance Certificate (EPC) which assesses the energy efficiency of the building as an asset upon sale or letting. In addition, public buildings with a floor space over 1,000 square meters require a Display Energy Certificate (DEC) which shows the actual energy use of the building and associated CO_2 emissions over a 12 month period.

Already issued EPCs and DECs show that there is significant potential for emissions reductions:

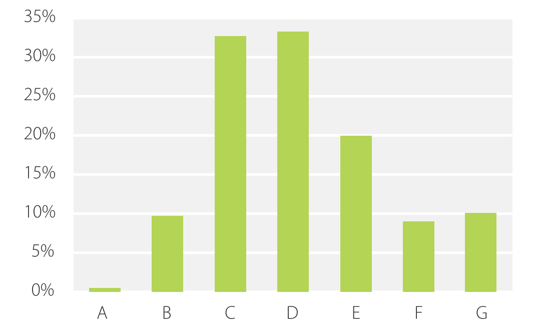
- Of the 115,000 buildings that had been issued an EPC by September 2009, 9% of these had the lowest G rating, suggesting scope for improved energy performance through cost-effective measures such as heating controls and energy efficient boilers (Figure 5.19).
- Of the 29,546 DECs lodged by August 2009, around 18% were given the lowest G rating, accounting for around 27% of total emissions. In comparison, C rated buildings, which were around 16% of the total, accounted for only 8.5% of emissions (Figure 5.20).

EPCs and DECs are therefore potentially useful in providing more transparency on emissions reduction opportunities in buildings and industry. Current usefulness is restricted, however, given limited coverage under the EU legislation; this has been a particular issue for the Committee in moving to a new property without a rating and where there is no obligation for the landlord to get one (Box 5.11).

The Committee therefore agrees with the Carbon Trust that new requirements should be introduced:

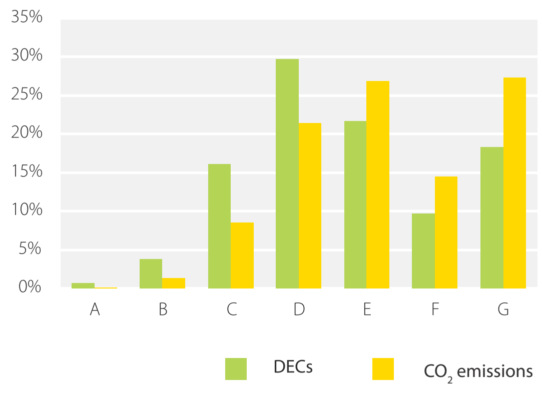
- All non-residential buildings to have an EPC in place by the end of the second budget period.
- Set minimum ratings such that all non-residential buildings have an EPC rating of F or higher by 2020. This should be achievable at a relatively low cost.

Figure 5.19 Distribution of EPCs by ratings by September 2009



Source: CLG (2009).

Figure 5.20 Distribution of DECs by ratings by August 2009



Source: CLG (2009).

- Roll-out DECs to all non-residential buildings by the end of the second budget period. This will give owners and users of buildings a better understanding of their CO_2 emissions. For smaller buildings, automated DECs could be an option so as to minimise the administrative burden on small firms.

This would:

- increase transparency which in itself could catalyse emissions reductions (e.g. where it is clear that a building has a poor EPC or DEC rating, this could put pressure on the landlord to undertake energy efficiency improvement).
- give a better understanding of where emissions reduction potential lies and form the basis for further policy to cut emissions (e.g. linking fiscal mechanisms to minimum ratings).
- allow effective monitoring of progress in reducing emissions via implementation of underlying measures.

Box 5.11 The CCC's experience in obtaining a DEC

In May 2009, the CCC moved office to a privately owned building near Victoria Station in London. Under the DEC guidelines, where a building is partly occupied by a public authority or a relevant institution with a floor space of at least 1,000m^2, the authority or institution is responsible for displaying a DEC and having a valid advisory report. Although the floor space we occupy is less than 1,000m^2 we wanted a DEC. However, given that we share common services such as water and heating with other occupants in the building, we had to rely on the landlord to obtain a DEC for the whole building. As there is no legal requirement for a private landlord to obtain a rating he declined our request to obtain one on a voluntary basis. We have since acquired an EPC with an E rating for the floor space we occupy. We are planning to implement the recommendations that are within our control such as adding daylight linked dimming to the existing lighting scheme. However, the measure that would offer the biggest saving as identified by the audit, the replacement of the heating boiler with a condensing one, is the responsibility of the landlord. We will continue discussions with our landlord to explore further energy efficiency options.

(vi) Indicators for non-residential buildings and industry

In setting out indicators of progress reducing emissions in non-residential buildings and industry we would ideally proceed as for residential buildings (i.e. set out trajectories for implementation of individual measures). However, for the time being we have decided against this approach:

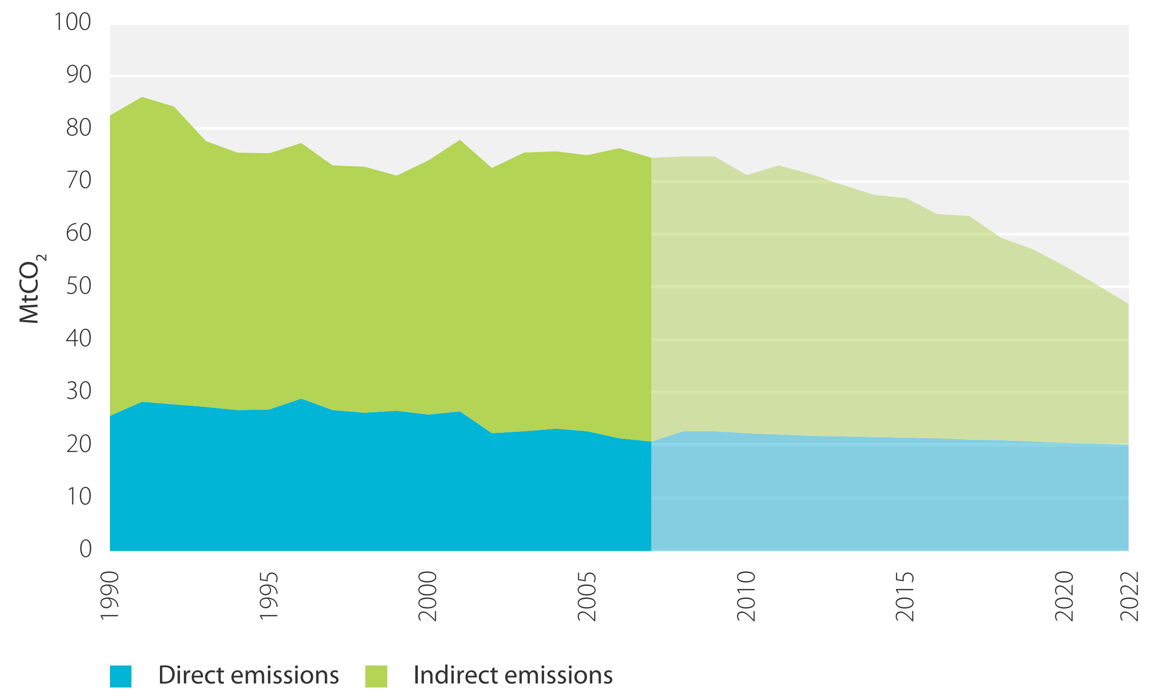
- There are numerous measures for reducing industry emissions. As much of industry is covered by the EU ETS, there are a set of cost-effective measures that we would expect to happen. We have therefore not set out individual indicators for industry but we may develop them in the future.
- There are no comprehensive sources of data for the implementation of key measures. We have recommended above that the evidence base for buildings emissions is improved (e.g through rolling out EPCs and DECs).

Therefore, in the near term we will base our monitoring framework on achieving the Extended Ambition emissions trajectory. The scenario includes all cost-effective emissions reduction potential from both capped and non-capped sectors.

It therefore assumes that effective policies are introduced for the non-capped sectors. The Committee believes that policies should be introduced, and will therefore use the Extended Ambition scenario as the benchmark for what the Government should seek to achieve (Figure 5.21).

In understanding the path of actual emissions relative to these trajectories, we will draw on any available evidence from EPCs and DECs and other sources (e.g. the Carbon Trust). When EPCs and DECs are rolled out more widely, we will revisit the issue of indicators and set out trajectories for implementation of measures and improvement of EPC/DEC ratings as appropriate.

Figure 5.21 Non-residential emissions trajectory under the extended ambition scenario 1990-2022



Source: CCC analysis.

5. Indicators for buildings and industry

Our indicators of progress for the buildings and industry sectors (Table 5.1) include:

- CO_2 emissions and final energy consumption figures for residential and non-residential buildings and for industry. We will monitor both direct and indirect emission and consumption figures.
- For the residential sector, we will monitor the installation of a range of energy efficiency measures (solid wall, cavity and loft insulation, uptake of new boilers and efficient wet and cold appliances).
- For all sectors we have listed policy milestones necessary to deliver progress (e.g. legislation for a post-CERT delivery framework).
- For renewable heat, we will monitor emissions reductions from renewable heat penetration.

Table 5.1 Buildings and industry indicators

Buildings and Industry		Budget 1	Budget 2	Budget 3
All buildings and industry				
Headline indicators				
CO_2 emissions (% change on 2007)*	direct	-9%	-11%	-15%
	indirect**	-11%	-28%	-58%
Final energy consumption (% change on 2007)	non-electricity	-10%	-18%	-23%
	electricity (centrally produced)***	-8% (-4%)	-7% (-9%)	-5% (-13%)
Residential buildings				
Headline indicators				
CO_2 emissions (indicative minimum % change on 2007)*	direct	-6%	-18%	-20%
	indirect**	-11%	-23%	-53%
Final energy consumption (indicative minimum % change on 2007)	non-electricity	-6%	-18%	-19%
	electricity (centrally produced)***	-5% (-5%)	-4% (-4%)	-3% (-3%)

Table 5.1 continued

Buildings and Industry	Budget 1	Budget 2	Budget 3
Supporting indicators			
Uptake of Solid Wall insulation (million homes, total additional installations compared to 2007 levels)	0.5	1.2	2.3
Uptake of Loft insulation (up to and including 100mm) (million homes, total additional installations compared to 2007 levels)	2.1	5.3	5.3
Uptake of Loft insulation (100mm +) (million homes, total additional installations compared to 2007 levels)	1.9	4.8	4.8
Uptake of Cavity wall insulation (million homes, total additional installations compared to 2007 levels)	3.5	7.5	7.5
Uptake of Energy efficient boilers (million homes, total additional installations compared to 2007 levels)	4.9	9	12
Uptake of Energy efficient appliances - Cold A++ rated (% of stock)	3%	18%	45%
Uptake of Energy efficient appliances - Wet A+ Rated (% of stock)	22%	53%	82%
Every house offered whole-house energy audit		by 2017	
Heat and Energy Saving Strategy finalised	2009		
New financing mechanism pilots operate and are evaluated	2011		
New financing mechanism budgeted and legislation in place if necessary	2011		
Post CERT delivery framework legislation in place	2011		
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			

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022
* These indicators should be considered jointly. Reductions in total emissions from buildings and industry reflect savings from renewable heat. We do not however set out in advance the split of these savings across sectors. Therefore emissions changes for individual sectors do not assume any savings from renewable heat and reflect a minimum level of change.
** Based on a reference projection net of electricity demand changes whose carbon intensity is assumed to be that of new build gas. Within our modelling of the power sector, emissions from electricity generation are lower than is represented here due to different assumptions about carbon intensity. The indirect emissions shown here are therefore conservative.
*** Figures show percentage changes in total electricity consumption including autogenerated electricity, and in centrally produced electricity only.

Key: Headline indicators | Implementation Indicators | Milestones | Other drivers

Table 5.1 continued				
Buildings and Industry		**Budget 1**	**Budget 2**	**Budget 3**
Non-residential buildings				
Headline indicators				
CO_2 emissions (indicative minimum % change on 2007)*	direct	6%	2%	-3%
	indirect**	-9%	-22%	-51%
Final energy consumption (indicative minimum % change on 2007)	non-electricity	-4%	-8%	-13%
	electricity (centrally produced)***	-1% (-1%)	-1% (-1%)	-1% (-1%)
Supporting indicators				
Develop policy on SMEs		by October 2010		
Government decision on the following recommendations for EPCs and DECs:		by October 2010		
· All non-residential buildings to have an EPC			by 2017	
· All non-residential buildings to have a minimum EPC rating of F or higher				by 2020
· Roll out of DECs to non-public buildings			by 2017	
All public buildings covered by the CRC to realise all cost effective emissions change potential				by 2018
Other drivers				
Emissions and fuel consumption by subsector, GVA / GVA vs. GDP for each sub-sector, Electricity and gas prices				
Industry				
Headline indicators				
CO_2 emissions (indicative minimum % change on 2007)*	direct	-15%	-2%	8%
	indirect**	-12%	-35%	-66%
Final energy consumption (indicative minimum % change on 2007)	non-electricity	-20%	-21%	-19%
	electricity (centrally produced)***	-16% (-6%)	-11% (-18%)	-5% (-30%)
Other drivers				
Emissions and fuel consumption by subsector, GVA / GVA vs. GDP for each sub-sector, Electricity and gas prices				

Table 5.1 continued

Buildings and Industry	Budget 1	Budget 2	Budget 3
Renewable heat			
Headline indicators			
Renewable heat penetration	1%	5%	12% in 2020
Supporting indicators			
Renewable Heat Incentive in operation	from April 2011		
Other drivers			
Uptake and costs of renewable heat technologies (Biomass boilers, Solar thermal, GSHP and ASHP, District heating)			

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022
* These indicators should be considered jointly. Reductions in total emissions from buildings and industry reflect savings from renewable heat. We do not however set out in advance the split of these savings across sectors. Therefore emissions changes for individual sectors do not assume any savings from renewable heat and reflect a minimum level of change.
** Based on a reference projection net of electricity demand changes whose carbon intensity is assumed to be that of new build gas. Within our modelling of the power sector, emissions from electricity generation are lower than is represented here due to different assumptions about carbon intensity. The indirect emissions shown here are therefore conservative.
*** Figures show percentage changes in total electricity consumption including autogenerated electricity, and in centrally produced electricity only.

Key: Headline indicators Implementation Indicators Milestones Other drivers

Chapter 6: Reducing surface transport emissions through low-carbon cars and consumer behaviour change

Introduction and key messages

In our December 2008 report, we considered scope for transport emissions reduction through reductions in carbon intensity of vehicles and changes in consumer behaviour. Our analysis suggested that there is scope to cut surface transport emissions by up to 32 $MtCO_2$ in 2020, with most of the reduction potential coming from road transport.

We argued that there is significant scope for reducing the carbon intensity of vehicles (including cars, vans and Heavy Goods Vehicles (HGVs)) through improving efficiency of conventional combustion engines, non-powertrain measures such as low rolling resistance tyres and gear shift indicators, and increased use of sustainable biofuels. A major part of our transport story was the increasing importance of full electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) in the second and third budget periods. We argued that it is important to develop the option for wide-scale deployment of electric vehicles in the 2020s, and projected that up to 20% of cars purchased in 2020 could be electric or plug-in hybrid. We also argued that there should be a major focus placed on developing a framework for van CO_2 at European and UK levels.

Our analysis of scope for emissions reductions through changed consumer behaviour focused on better journey planning and modal shift ('Smarter Choices'), eco-driving (e.g. gentle braking and acceleration and travelling without excess weight), and driving within the speed limit. The emissions reduction potential that we identified through consumer behaviour change was of the same order of magnitude as potential through reducing carbon intensity of vehicles.

In this chapter we consider transport emissions trends and progress in reducing emissions. We review developments in the EU framework and implications for the carbon intensity of new cars. We set out more detailed analysis for electric cars, focusing on market readiness, likely costs over time and the need for price support and charging infrastructure. We also review further the opportunity for changing consumer behaviour based on the latest evidence from the Sustainable Travel Town pilots. In addition, we consider the scope for emissions reduction through introduction of road pricing, and potential for emissions reductions through integrating land use and transport planning. We combine all of this analysis in a set of indicators for the surface transport sector against which we will assess future progress in reducing emissions (Box 6.1).

We do not consider the evolving EU framework for van emissions reductions. A draft framework has been developed by the EC, and we will comment on this in our June 2010 report to parliament.

The main messages in the chapter are:

- The UK should aim to converge on the EU trajectory for average new car emissions by 2015 and aim for a new car average of 95 gCO_2/km by 2020 in the wider context of meeting carbon budgets for the non-traded sector. Achieving this will require deployment of the full range of low-carbon options: improved fuel efficiency of combustion engines, non-powertrain measures, increased hybridisation and increasing numbers of electric cars/plug-in hybrids.

Box 6.1 Summary of transport indicators

Indicators include:

- Falling carbon intensity of new cars to 95 gCO_2/km in 2020 from the current 158 gCO_2/km.
- 240,000 electric cars and plug-in hybrids delivered through pilot projects by 2015, and 1.7 million by 2020.
- 3.9 million drivers trained and practicing eco-driving by 2020.
- Policy strengthening to include:
  - Support for electric cars and plug-in hybrids. A comprehensive strategy for rolling out electric cars and plug-in hybrids, including a funded plan for charging infrastructure, and large-scale pilots starting at the end of the first carbon budget period.
  - Smarter choices. Phased roll-out across the UK to encourage better journey planning and more use of public transport.
  - Integrated land-use and transport planning. A new strategy to ensure that land-use planning decisions fully reflect the implications for transport emissions.

- The Government should complement financial support committed for electric car purchase with charging infrastructure for up to 240,000 electric cars and plug in hybrids by 2015 on the way to 1.7 million cars in 2020.
- New evidence from the Sustainable Travel Towns suggests that Smarter Choices initiatives which aim to encourage people to travel on public transport and to better plan journeys can have a significant emissions reduction impact. The Government's recently announced Sustainable Travel City pilot is a positive step in rolling out Smarter Choices. This should be buttressed with a comprehensive plan for more widespread roll out to towns and cities.
- The large programme of home building over the next twenty years and possible increase in transport emissions through out of town developments poses a risk to meeting budgets. Significant land use change over the next decades offers an opportunity to change trip patterns and travel modes. In order to mitigate risks and take advantage of opportunities, the Government should develop an integrated planning and transport strategy, and ensure that planning decisions fully account for transport emissions.

We set out the analysis that underpins these conclusions in five parts:

1. Transport emissions trends
2. The EU framework and UK new car emissions
3. Demonstration and deployment of electric cars
4. Emissions reductions from changing transport consumer behaviour
5. Integrated land use and transport planning
6. Summary of transport indicators.

1. Transport emissions trends

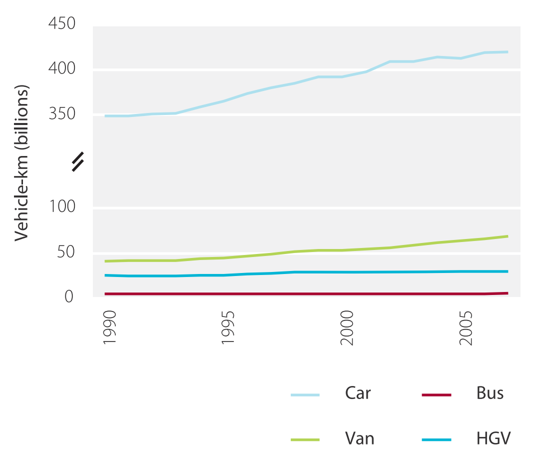
Total surface transport emissions

Transport demand in the UK has increased steadily between 1990 and 2007 (Figure 6.1), and domestic transport emissions have increased 11% over this period, and now account for over 131 $MtCO_2$. The overall trend in emissions is illustrated in Figure 6.2.

Emissions from cars

Demand for passenger car travel (measured in vehicle-km) increased by 20% between 1990 and 2007, on a trend growth path of 1% per annum, though growth was slightly lower (0.4%) in 2007 (Figure 6.3). The Department for Transport's (DfT) provisional estimates suggest that car travel fell by 0.6% in 2008 and by a further 0.8% (1.5% on an annualised basis) in the first two quarters of 2009. We would expect demand to decline as a result of the recession, and – absent new demand management policies – we would expect growth to return to trend as the recession ends.

Figure 6.1 Transport demand by mode 1990–2007



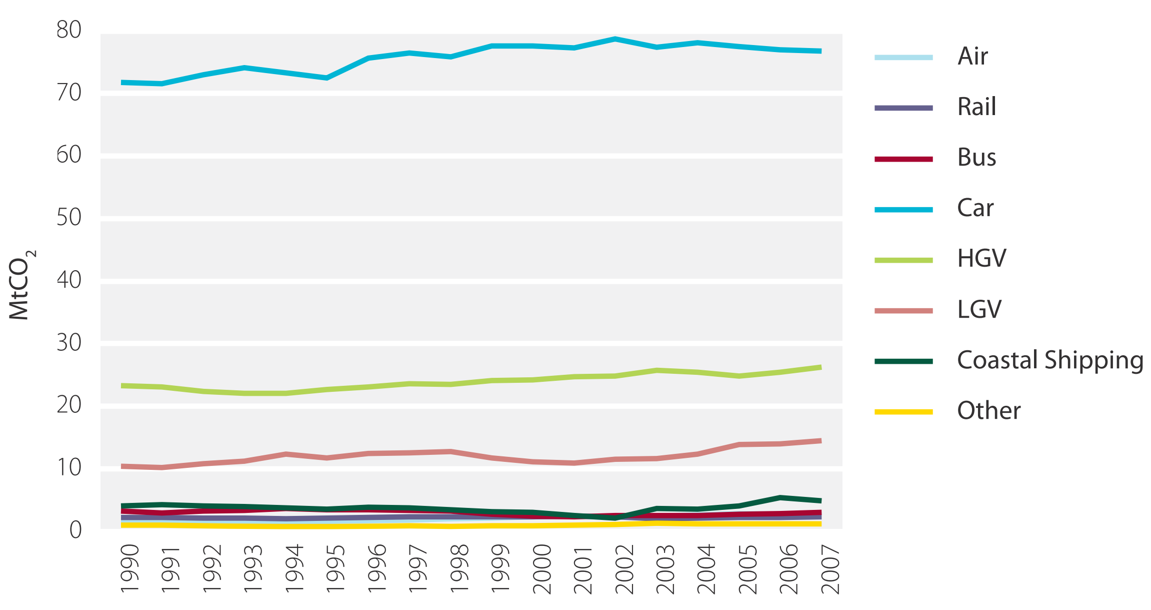
Source: Dft (2008), *Transport Statistics Great Britain*; Table 7.1; Dft (2009), *Road Traffic and Congestion in Great Britain Q1 2009*; Data is uplifted to include NI.
Note: Data for 2008 is provisional.

Demand growth has been offset by falling carbon intensity of cars, which declined by 11% between 1990 and 2007 (Figure 6.3), and was driven by lower carbon intensity of new cars (Figure 6.4). Carbon intensity reduction has been achieved through the EU Voluntary Agreements to reduce new car emissions, supported by measures aimed at raising customer awareness and differentiation of both company car taxation and Vehicle Excise Duty (VED) by carbon intensity. As a consequence of rising demand offset by increasing fuel efficiency, total car CO_2 emissions have increased by around 7% between 1990 and 2007, remaining relatively flat since 2000.

Emissions from vans and HGVs

Vehicle-km travelled by vans have grown very rapidly (a 71% increase 1990-2007), with growth of 4.6% in 2007 (Figure 6.5). DfT's provisional estimates suggest that van traffic fell by 0.4% in 2008 and again very slightly (0.1% on an annualised basis) in the first two quarters of 2009. However, unlike cars, there is no consistent long-term decline in the carbon intensity of vans. Carbon intensity decreased around 22% between 1990 and 2001 but in 2007 was slightly higher than 2001 levels, despite a decline of 1.3% in 2007 compared to 2006. As a consequence of rising demand with limited improvements in fuel efficiency, total van CO_2 emissions have increased by around 40% between 1990 and 2007.

Figure 6.2 Transport CO_2 by mode (by source) 1990 – 2007



Source: NAEI (2009).

Over the long term, HGV traffic has grown, with vehicle-km up 18% since 1990, but with a roughly flat trend more recently, and a slight increase (0.8%) in 2007 (Figure 6.6). Tonne-km have continued to increase, by 3.8% in 2007 (Figure 6.7), increasing total emissions from HGVs by 3.3% in that year. DfT's provisional estimates suggest that HGV traffic fell by 2.4% in 2008 and by a further 4.4% (8.7% on an annualised basis) in the first two quarters of 2009. Carbon intensity has decreased somewhat between 1990 and 2007 (by 4.3% measured in vehicle km and 11.2% measured in tonne-km). As a consequence of rising demand with limited improvements in fuel efficiency, total HGV CO2 emissions have increased by around 13% between 1990 and 2007.

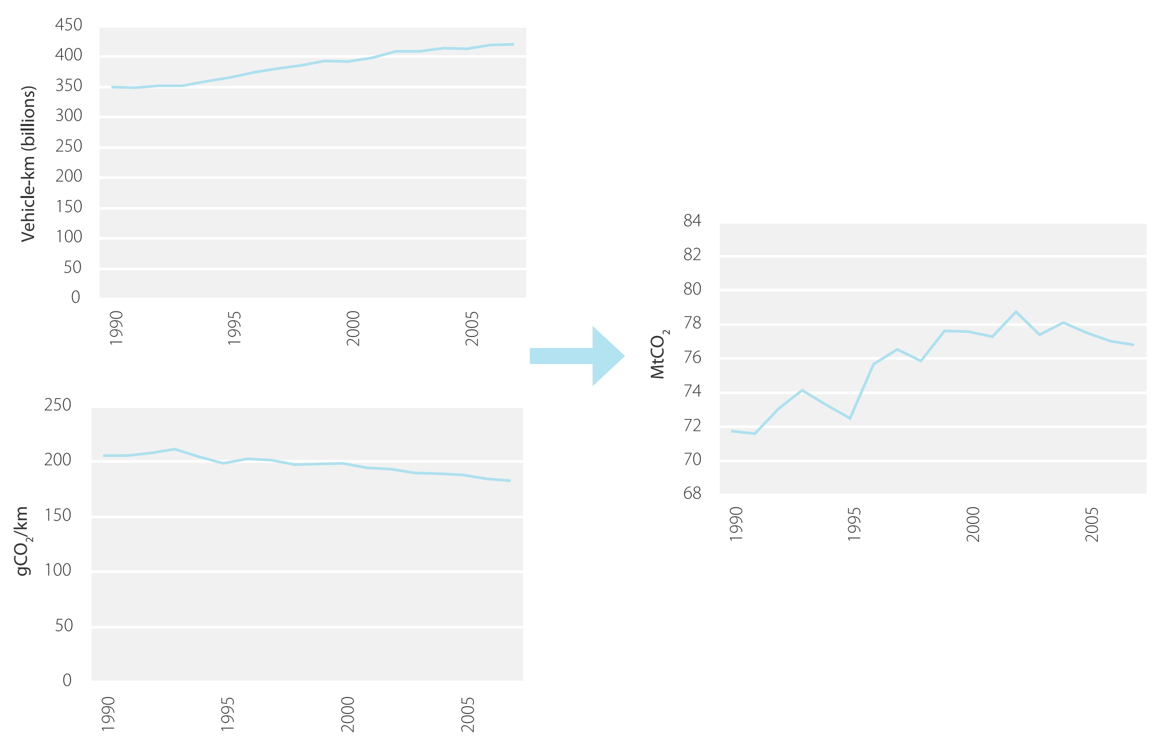
Emissions from bus and rail

Both bus and rail demand have increased in recent years:

- Bus vehicle-km, although relatively stable historically, increased by 4.2% in 2006 and 6.5% in 2007 (Figure 6.8). Total bus emissions have decreased by around 8% between 1990 and 2007.
- Rail passenger-km, after declining to the mid 1990s, are now on a strong upward path, increasing by 6.1% in 2006 and 6.4% in 2007 (Figure 6.9). Total rail emissions have increased by around 4% between 1990 and 2007.

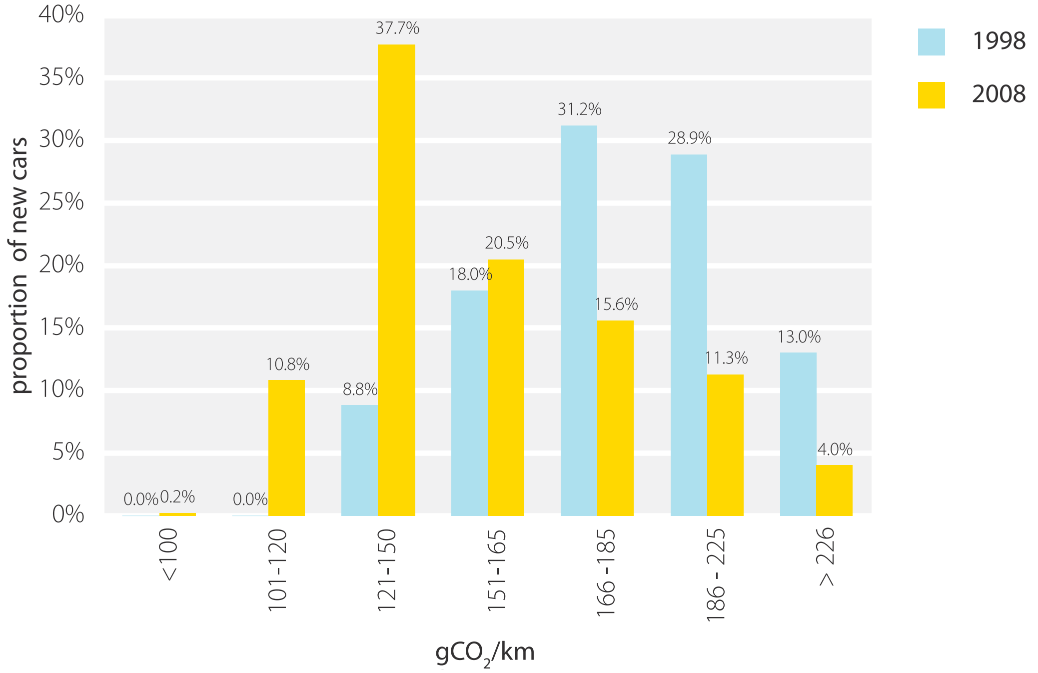
The demand for bus and rail travel is now increasing faster than the demand for car travel. Policies to encourage a shift from passenger car travel to public transport, discussed in Section 4, would be expected to support further increases in demand for bus and rail travel.

Figure 6.3 Historical trends in vehicle km, CO_2 and gCO_2/km for cars 1990 – 2007



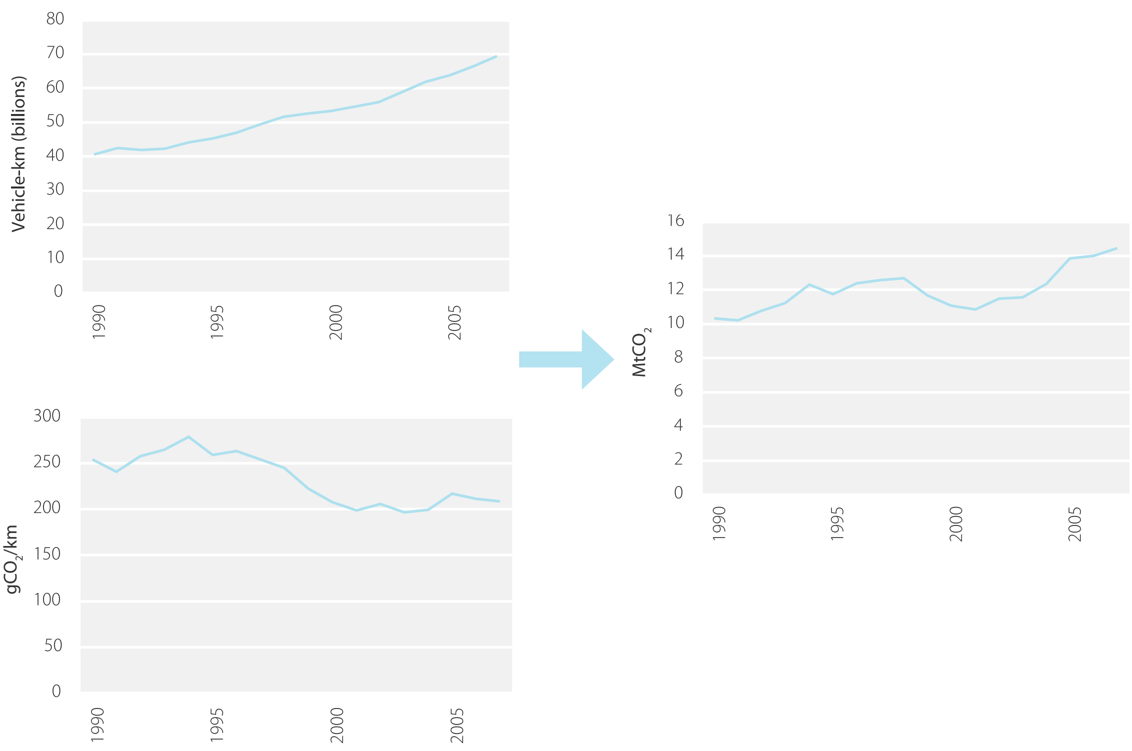
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.4 New car sales by VED band, 1998 and 2008



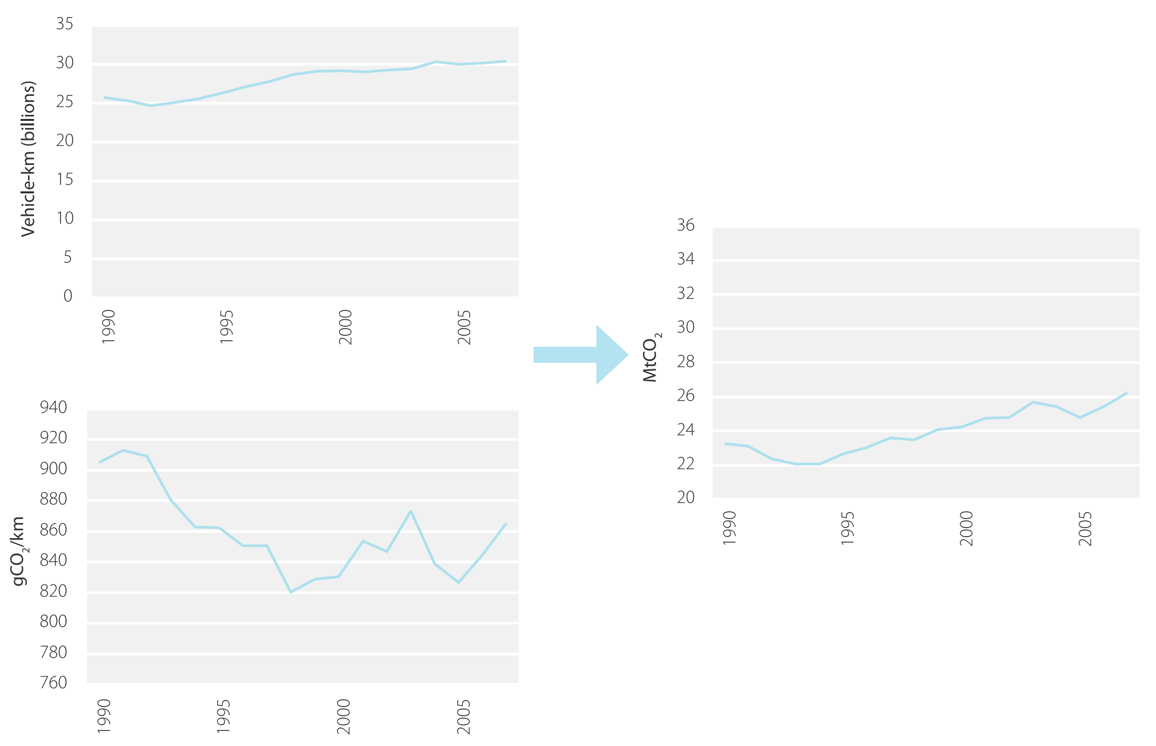
Source: Society of Motor Manufacturers and Traders (SMMT) (2009).

Figure 6.5 Historical trends in vehicle km, CO_2 and gCO_2/km for vans 1990 – 2007



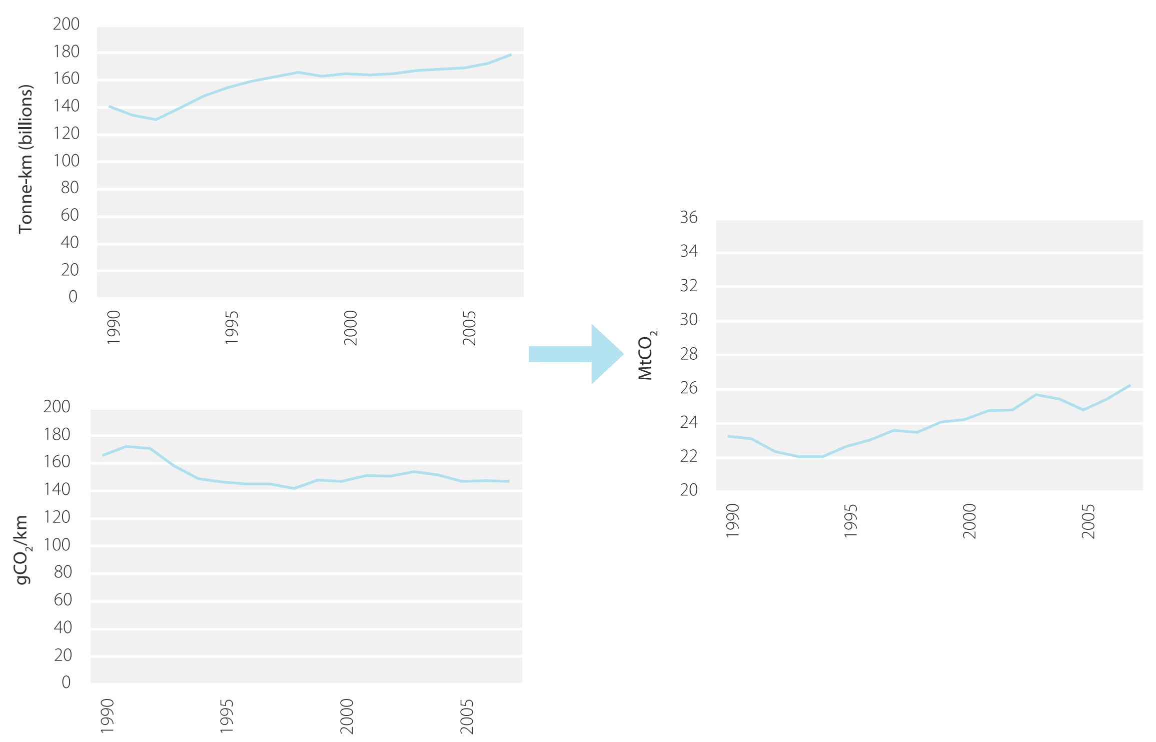
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.6 Historical trends in vehicle km, CO_2 and gCO_2/km for HGVs 1990 – 2007



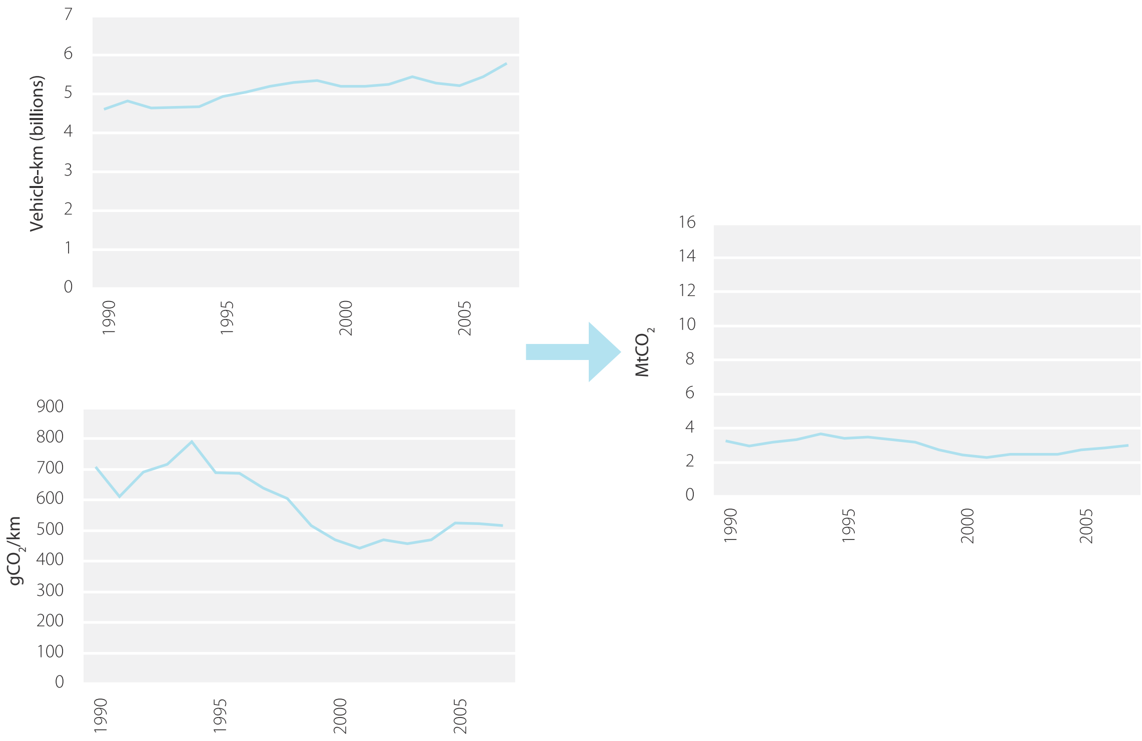
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.7 Historical trends in tonne-km, CO_2 and gCO_2/tonne-km for HGVs 1990 – 2007



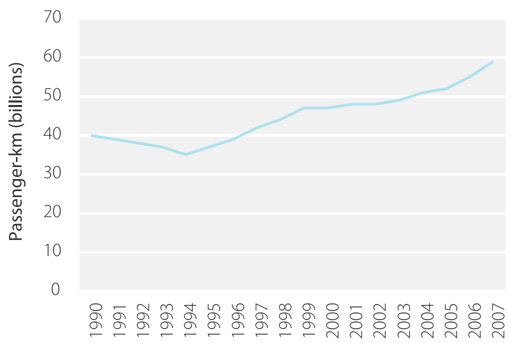
Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.8 Historical trends in vehicle km, CO_2 and gCO_2/km for buses 1990 – 2007



Source: DfT (2008), *Transport Statistics Great Britain*; Table 7.1; NAEI (2009).

Figure 6.9 Historical trends for rail passenger kilometres 1990 – 2007



Source: DfT (2008); Transport Statistics Great Britain; Table 1.1; uplifted to include NI.

2. The EU framework and UK new car emissions

The EU framework

In April 2009 a new EU framework for reducing car emissions was agreed (Box 6.2). This framework sets a legally binding target to reduce average new car emissions across Europe from the current level of 153.5 gCO_2/km to 130 gCO_2/km by 2015. In addition, there is a commitment that emissions will be further reduced to 95 gCO_2/km by 2020. The framework is weaker than originally envisaged in the sense that the 130 gCO_2/km target was originally proposed for 2012, but stronger in the sense that the ambitious target for 2020 has been introduced. It is envisaged that emissions reductions will be achieved through increasing fuel efficiency of cars, and the introduction of new technologies (e.g. electric cars). In parallel, the EU has set targets for increased use of renewable fuels and sustainable biofuels.

Delivering EU targets in the UK

In our December report, we set out an Extended Ambition scenario for UK car emissions that would achieve 95 gCO_2/km by 2020 (Figure 6.10).

Emissions reductions in the Extended Ambition scenario are driven by:

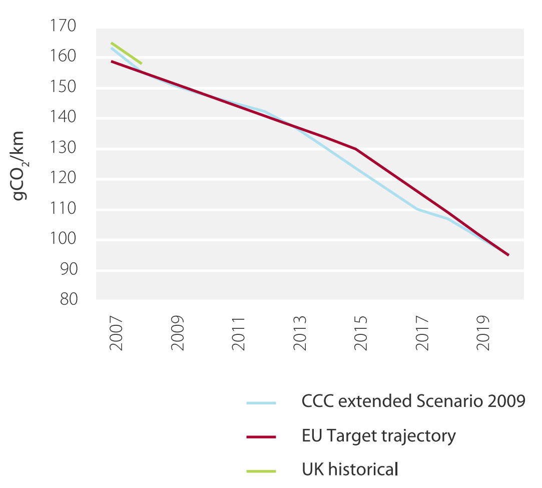
- Replacing old cars with new ones that have more efficient conventional combustion engines.
- Increasing uptake of hybrid cars from the first budget period.
- Increasing uptake of electric cars and plug-in hybrid vehicles in later budget periods.
- Incorporation of non-powertrain measures such as improved aerodynamic design, low rolling resistance tyres and gear shift indicators.
- Increased use of biofuels.

Box 6.2 EU New Car Framework

European legislation on the emissions from new passenger cars was officially adopted in April 2009. This legislation includes a 2015 emissions target for new cars, penalties for non-compliance with this target, and a 2020 target:

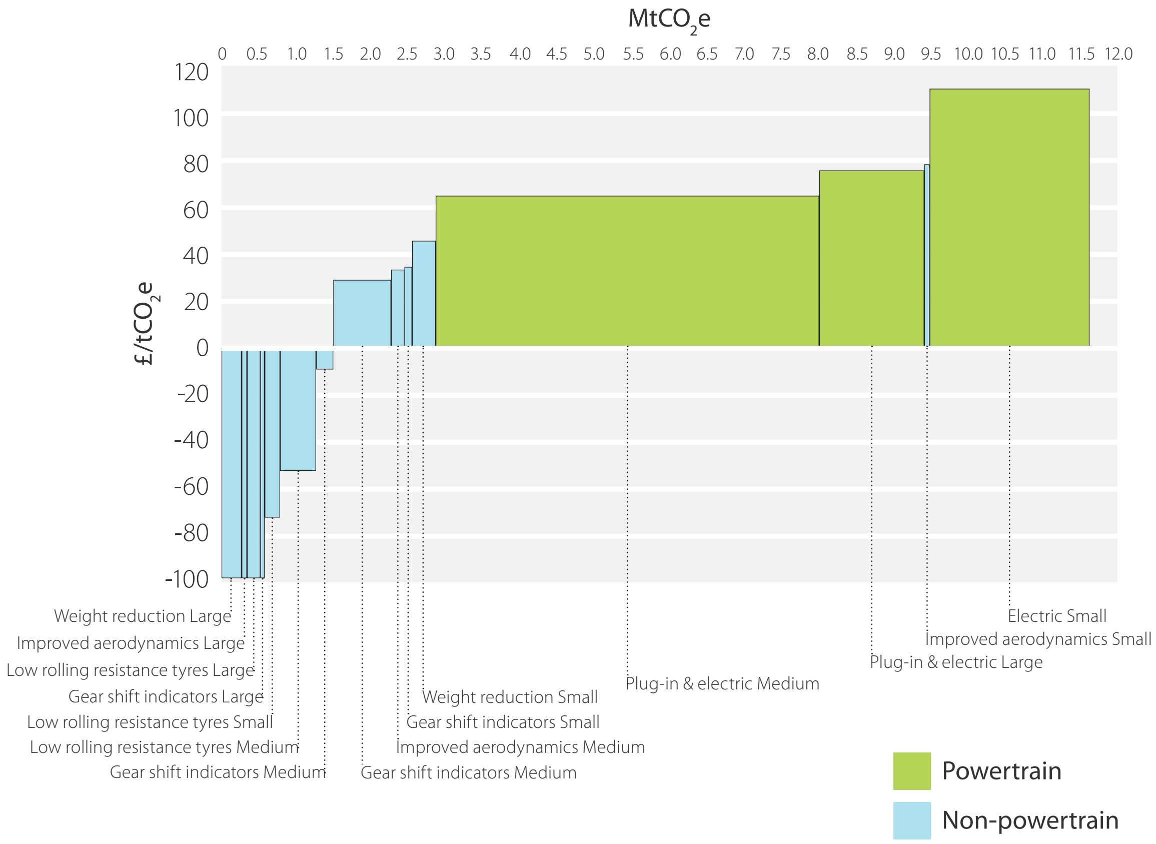
- The legislation stipulates that the average emissions of the new car fleet in the EU should be no more than 130 gCO_2/km in 2015. Measures which are or will be mandatory under other EU legislation such as gear shift indicators, tyre pressure monitoring systems and biofuels do not count towards meeting this target.
- Each manufacturer will be given an individual target and penalties if this is not achieved. Until 2018 the penalty will be €5 for each car sold for the first gCO_2/km over the target, €15 for the second gCO_2/km, €25 for the third gCO_2/km, and €95 for each subsequent gCO_2/km. From 2019, each gCO_2/km over the target will cost €95.
- A target of 95 gCO_2/km has been defined for 2020, with the target and modalities for reaching it to be confirmed before 2013.

Figure 6.10 Average new car emissions in the Extended Ambition scenario and trajectory under the revised EU framework



Source: SMMT (2009), *New Car CO_2 Report 2009*; CCC Modelling.

Figure 6.11 Extended Ambition scenario marginal abatement cost curve, 2020



Source: CCC Modelling.
Note: Does not include biofuels.

Our analysis suggested that several measures, particularly non-powertrain measures, are available at negative cost (i.e. ongoing operating cost reductions more than offset any upfront costs – see Figure 6.11. For measures that come at some cost (e.g. introduction of electric and plug-in hybrid cars), these can be justified in the context of economy-wide efforts to reduce emissions and achieve carbon budgets, and laying foundations for deep emissions cuts in transport through the 2020s.

Average emissions in the UK in 2008 were around 158 gCO_2/km compared to the EU average of 153.5 gCO_2/km. It is the view of the Committee that the UK should aim to converge on the EU average emissions trajectory by 2015 and meet the 95 gCO_2/km target in 2020, both through the technology measures in our Extended Ambition scenario and through change in customer choice (e.g. customers buying best-in-class or smaller cars), in order that transport makes an appropriate contribution to meeting the second and third carbon budgets.

It is also the view of the Committee that the UK should aim to meet EU average standards through delivering the full range of measures in the Extended Ambition scenario, including through critical mass penetration of electric cars / plug-in hybrids by 2020. Our rationale is that electric cars currently appear to be the most viable option for reducing transport emissions through the 2020s, and that demonstration in the years to 2020 will provide the option of full scale roll-out in the 2020s.

Policy levers for delivering EU targets

In our December report, we set out a range of policy levers to encourage purchase of lower carbon cars, each of which is likely to have an important role to play in delivering EU targets:

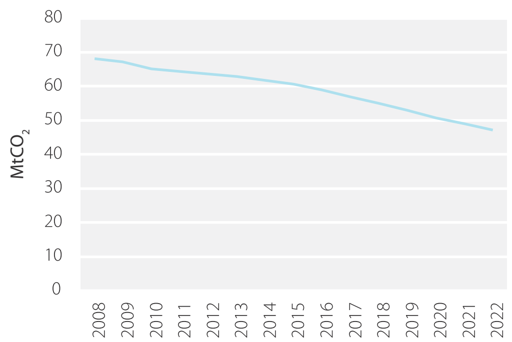
- **Price levers.** The EU framework includes penalties for manufacturers not meeting targets for new car efficiency. These penalties will encourage manufacturers to develop and market lower carbon vehicles. It is likely that penalties will be reflected in pricing policy, with relatively lower prices charged to encourage uptake of lower carbon cars.
- **Fiscal levers.** There is scope to influence car purchase behaviour through both Vehicle Excise Duty (VED) and fuel duty. Evidence from the UK and other countries such as France and the Netherlands suggests that measures to change relative purchase price according to carbon intensity (e.g. through higher first year VED for more carbon intense vehicles) can be effective in encouraging uptake of lower carbon vehicles, more so if higher VED is charged in every year (i.e. not just the first). Evidence also suggests that fuel duty is a potentially powerful lever in encouraging purchase of lower carbon cars (e.g. a 10% increase in petrol prices through a fuel duty increase could result in a 4% decrease in fuel used per kilometre, achieved in part via choice of more efficient cars).
- **Better information and awareness raising.** The EU framework recognises that car purchase decisions could be influenced by information at the point of sale, and requires that dealers display information on fuel efficiency and CO_2 emissions. We reviewed the evidence on the impact of better information and advertising campaigns aimed at promoting fuel efficiency in our December report, where we concluded that these alone are unlikely to result in significantly changed car purchase behaviour, but they are still likely to have an important role to play as part of a package of mutually supporting measures.

Indicators for car carbon intensity

We will consider four sets of indicators in future monitoring of progress towards reducing carbon intensity:

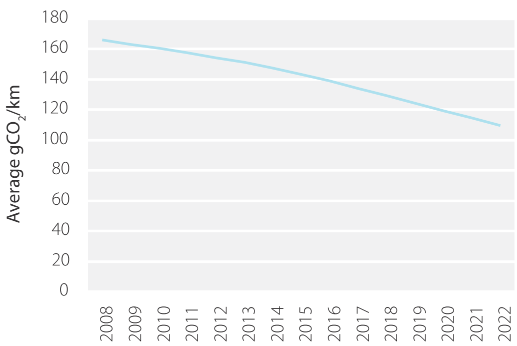
- **Car emissions.** Our benchmark for car emissions will be the emissions trajectory under our Extended Ambition scenario (Figure 6.12).
- **Carbon intensity of car travel.** Our Extended Ambition scenario requires the carbon intensity of car travel to fall over time; our benchmark will be the trajectory implied by our Extended Ambition scenario, where average emissions in 2020 are 116 gCO_2/km (Figure 6.13) across the car fleet.

Figure 6.12 Emissions trajectory for cars in the Extended Ambition scenario



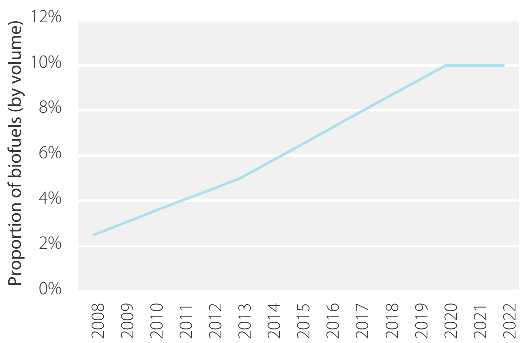
Source: CCC Modelling.

Figure 6.13 Carbon intensity of car travel in the Extended Ambition scenario



Source: CCC Modelling.

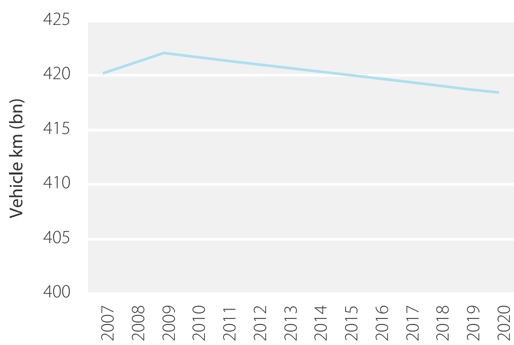
Figure 6.14 Proportion of fuel sold on forecourts that is biofuel



Source: RFA.

- **Average emissions of new cars.** Given that our Extended Ambition scenario is driven by reductions in carbon intensity of new cars, it will be important to monitor whether the full potential for carbon intensity reduction is being realised. We will therefore monitor new car emissions against the trajectory for new car emissions underpinning our Extended Ambition scenario, with average emissions falling to 95 gCO_2/km in 2020 (Figure 6.10).
- **Biofuels penetration.** Our Extended Ambition scenario includes penetration of sustainable biofuels to levels consistent with proposals in the Gallagher Review (Figure 6.14). We will monitor biofuels penetration against a trajectory starting at the current 2.5% (by volume) penetration and rising to 10% penetration in 2020, provided the review of the Renewable Transport Fuel Obligation (RTFO) in 2011-12 confirms that this target can be met through the use of sustainable biofuels exclusively.
- **Car kilometres travelled:** Emissions are determined both by carbon intensity and kilometres travelled. We will therefore monitor kilometres travelled relative to the trajectory underpinning our Extended Ambition emissions scenario.

Figure 6.15 Vehicle-km trajectory for cars in the Extended Ambition scenario



Source: CCC.
Note: Includes impact of demand side measures, see section 4(ii).

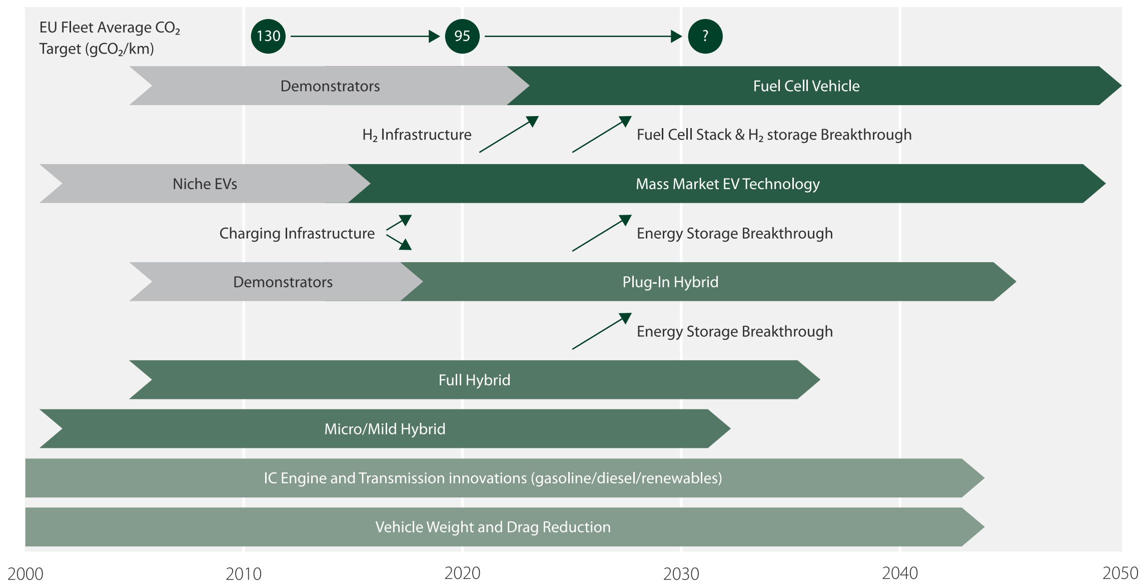
In addition to these indicators, there is a set of variables which may be important determinants of whether the Extended Ambition scenario is reached. These include:

- The proportion of new cars purchased that are the most efficient in class (i.e. proportion of small cars that are most efficient, proportion of medium cars that are most efficient, etc.).
- The size mix of new cars purchased (i.e. the balance of small/medium/large cars).
- The uptake of non-powertrain measures such as gear shift indicators and low rolling resistance tyres.
- The proportion of hybrids in the mix.

All available low-carbon car technologies (from improved vehicle efficiency, to non-powertrain measures to increasing hybridisation) are likely to play a role but there are myriad combinations of these variables which would deliver the Extended Ambition scenario for new car emissions. From the Committee's perspective, the key is to achieve this scenario, rather than to achieve it in a particular way (e.g. through increased hybrid penetration rather than a change in the car size mix). We therefore propose to track these variables as part of our monitoring framework rather than set out indicators in advance for how they should evolve.

We adopt a different approach, however, for electric and plug-in hybrid cars (for the rest of this chapter and where not otherwise specified we will often use the generic term electric car to indicate both battery electric cars and plug-in hybrids). These are potentially very important given limits to carbon intensity reduction based on conventional technology. It will be important, therefore, to achieve a critical mass of electric cars over the first three budget periods. This would contribute to meeting the second and third carbon budgets and would provide the option for possible roll-out in the 2020s. This approach has been endorsed by the Government in its Low-Carbon Transition Plan, where a high level timeline towards increasing levels of electric cars is set out (see Figure 6.16). We now turn to detailed analysis of electric cars, for which we will set out indicators against which we will monitor future progress.

Figure 6.16 Vehicle R&D roadmap



Source: New Automotive Innovation and Growth Team (2009), *An Independent Report on the Future of the Automotive Industry in the UK.*

Box 6.3: Carbon intensity of electric vehicles

An electric vehicle uses around 0.2 kWh/km. Given that the current carbon intensity of electricity production in the UK is around 515 gCO_2/kWh, an electric car is currently a low-carbon car, producing just over 100 gCO_2/km. Some conventional cars are capable of a better carbon performance than this even when accounting for emission from production of fuel; however, as the carbon intensity of electricity falls towards zero, electric cars will reach 0 gCO_2/km. Conventional internal combustion engines will never be able to achieve such a low level of emissions.

3. Demonstration and deployment of electric cars

At least two sets of barriers to electric and plug-in hybrid car development and uptake currently exist:

- Cost and performance characteristics of electric cars may make these unattractive relative to conventional alternatives.
  - Battery technology is at an early stage of development. Cost is therefore relatively high, range is constrained for electric cars (but not for plug in hybrids), and charging times are long.
  - Electric cars will be relatively expensive for an initial period, with a significant upfront price premium over conventional alternatives.
  - Range constraints may make electric cars unattractive relative to conventional vehicles.
- There are likely to be cheaper alternatives for meeting the EU targets in 2020 which do not rely on radical changes to the powertrain, such as advanced diesel engines combined with weight reductions, improved aerodynamics and other efficiency improvements. It would be cheaper for manufacturers to focus on these options which could deliver significant reductions in carbon intensity over the next decade, even though by themselves they do not offer opportunities for further, deeper decarbonisation in the 2020s.

These barriers need not, however, be prohibitive given appropriate policies. There is an important role, for example, in providing price support for purchase of electric cars, and charging infrastructure to address range constraints. This section considers barriers to uptake of electric cars in more detail and appropriate responses by Government to facilitate development of an electric car market. It is structured in four parts:

(i) Market readiness of electric cars

(ii) Electric car costs and price support

(iii) Electric car charging infrastructure

(iv) Scenarios and indicators.

(i) Market readiness of electric cars

Currently there are no electric cars and plug-in hybrids commercially available in the UK market that are substitutes for cars using conventional technology. Although some electric vehicles are available, these are limited to niche markets and are not type approved cars (e.g. the G-Wiz, which is a small vehicle, formally termed a 'quadricycle'). Going forward, however, a number of electric cars and plug-in hybrids that could potentially substitute for conventional cars are under development and likely to come to market in the next few years (Table 6.1).

In tandem with technology development, various business models to support purchase of electric cars and address some of the key barriers to the uptake of electric cars (particularly those relating to battery costs and reliability) are being developed. These include:

- **Battery leasing.** By retaining ownership and liability for the battery the manufacturer removes a significant element of the financial risk for consumers (both in terms of risk of failure and of uncertainty about depreciation and residual value of the battery) as well as helping consumers face the high upfront cost associated with electric cars. It has been reported that Nissan will offer battery leasing with purchase of their electric car, the Leaf.

- **Mobile phone-style transportation contracts.** This is the business model being pursued by Better Place, which plans to offer a range of EV models via packages that will provide access to a network of charging points and battery swap stations (owned, along with the batteries, by the company) (Box 6.10). The intention is that this would combine the benefit of battery leasing with infrastructure provision and greater flexibility for the consumer.
- **Vehicle leasing.** The natural extension to battery leasing is to use a vehicle leasing business model to further reduce risk and minimise upfront costs. Vehicle leasing is currently being pursued by Mitsubishi as the initial business model for the i-MiEV electric small car, which is due to become available in the UK by the end of 2009.
- **Car clubs.** The 'car club' business model could be a viable means of introducing the public to electric vehicle technology, thereby addressing what may be a key barrier in early years in terms of lack of familiarity and negative attitudes to the technology. Norwegian company Th!nk (which produces niche volume electric vehicles) is exploring scope for using this route to promote electric vehicles.

These business models will be useful in helping to support uptake and, in particular, addressing concerns about high up-front costs and range limitations of electric cars. They will require, however, complementary measures including price support and development of charging infrastructure if electric cars are to be attractive to consumers.

(ii) Electric car costs and price support

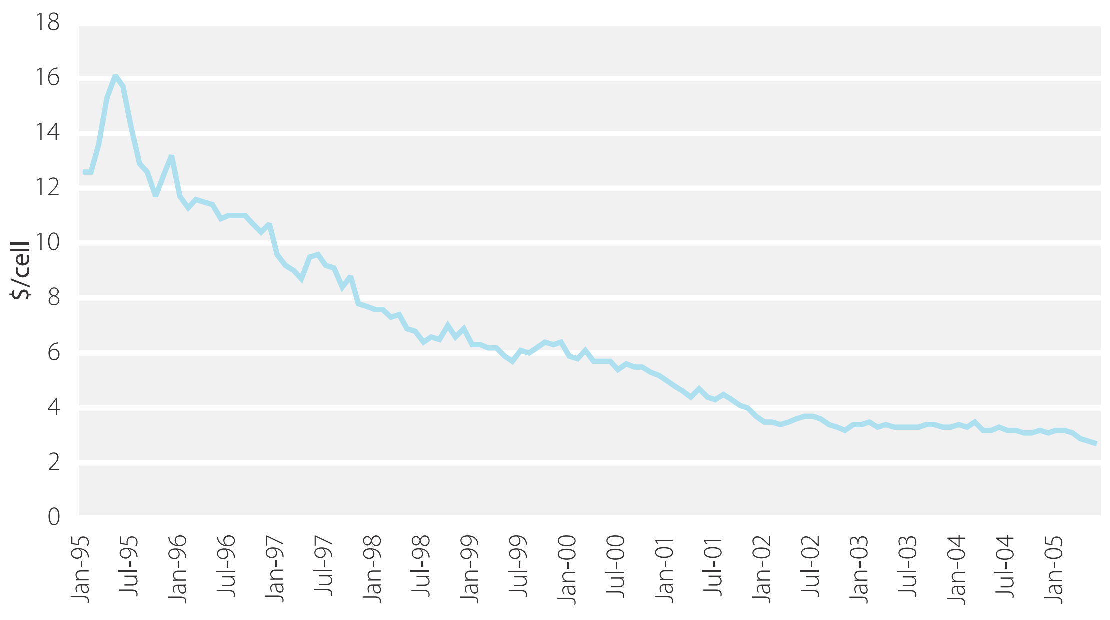
Electric car purchase cost premiums

The purchase cost premium for electric and plug-in hybrid cars derives almost wholly from battery costs. There is a trade off between battery cost and range, with disproportionately large and expensive batteries required to support increasing range. The cost premium for electric cars will therefore reflect this, with a bigger premium for cars with longer range. We estimate, for example, that battery costs for the Mitsubishi i-Miev will be around $13,000 to support a range of 80 miles, whereas the battery costs for a Tesla Roadster will be around $42,000 to support a range of 220 miles.

Although the cost of operating electric cars is significantly less than that for conventional cars – when fuel duty is accounted for in the operating cost of conventional cars – the operating cost saving for electric cars will not be sufficient in the early years to offset the higher purchase cost. At least for an interim period, electric cars will therefore be more expensive than conventional cars on a lifecycle basis, and specifically if the likelihood of a battery replacement during the lifetime of the car is factored into the calculations.

As for any new technology, however, there is scope for significant cost reductions as production levels increase, cumulative research and development commitments rise, and manufacturing scale is increased. The cost of lithium-ion laptop batteries, for example, fell 75% over the period from 1995-2005 (Figure 6.17). In the case of electric car batteries, research that we commissioned from AEA Technology suggested there is scope for cost reduction up to around 70% relative to the cheapest batteries currently available (Box 6.4).

Figure 6.17 Cost of Japanese manufactured lithium-ion laptop battery cells 1995-2005



Source: High Power Lithium; IIT (2009).

Table 6.1 Examples of EVs and PHEVs currently under development

Vehicle manufacturer/ model name	Planned date available on the market	Planned production volume	Retail price information
Mitsubishi i-MiEV (EV)	2009 (Japan, UK); rest of EU (2010).	2,000 vehicles globally in 2009, rising to 10,000 in 2010	Will only be available for lease, but Mitsubishi has quoted a current notional retail price of £35,000, dropping to below £20,000 by end of 2010.
Nissan Leaf (EV)	End 2010	Unknown	£10,000 to £15,000 for the car – batteries will be leased separately
Peugeot iOn (EV)	2011	10,000 in 2011 (estimate)	Unknown, but likely to be similar to Mitsubishi i-MiEV
Toyota Prius PHEV (PHEV)	2010 (initial release limited to selected fleet users), 2012 (series production)	Unknown	US$48,000 (£34,000)
Chevrolet Volt/ Vauxhall-Opel Ampera (General Motors) (PHEV)	2010 (US) 2011 (EU) 2012 (UK)	Initial production volumes range from 10,000 to 60,000 cars per year	US$40,000 (£28,000)
Tesla Roadster (EV)	2008 in USA Autumn 2009 in UK	Unknown, but by the beginning of April 2009, 320 cars had been sold and delivered to customers	£87,000 to £94,000

Source: AEA (2009b); Nissan press release, 2 August 2009;
AutoblogGreen (2009) http://green.autoblog.com/2009/07/05/toyota-will-launch-series-production-phev-prius-in-2012/

Regional availability	Other information
UK, Japan, EU, possibly USA.	SMMT category A (mini-car) UK will be one of the lead markets for the i-MiEV, with 200 vehicles available for lease here in 2009. Mitsubishi has also announced a joint venture with Peugeot whereby the i-MiEV will be rebadged as a Peugeot for EU markets. Vehicle range: 100 miles per charge
USA, Japan, EU, UK	SMMT category B (supermini) To be produced in conjunction with Nissan's parent company Renault. Vehicle range: 100 miles per charge
EU	SMMT category A (mini-car) Vehicle will be heavily based on Mitsubishi i-MiEV – Mitsubishi and Peugeot have signed a Memorandum of Understanding (MoU). Citröen (part of the same PSA group as Peugeot) are also offering electric conversions of the C1 in UK via its partner the Electric Car Corporation. Vehicle range: unknown
EU, USA, Japan	SMMT category C/D (lower/upper medium) Electric-only range will be limited to a maximum of 12 miles, reflecting the small battery capacity that will be fitted to this vehicle. Currently undergoing trials in the UK in a partnership between Toyota and EDF Energy.
EU, USA, Australia, Japan	SMMT category C/D (lower/upper medium) Vehicle range: Electric-only range will be 40 miles. Will be fitted with 16 kWh lithium-ion batteries. Petrol engine capable of 4.7 litres/100 km. Combination of petrol engine and electric motor anticipated by General Motors to return 40 gCO_2/km. General Motors' current financial problems might have an impact on whether or not this vehicle can be brought to market.
US, EU, UK	SMMT category G (specialist sports) Electric sports car designed around the chassis layout of the petrol-engine Lotus Elise sports car. Battery capacity: 53 kWh. Vehicle range: up to 244 miles per charge Recharging time: 3.5 hours (240 Volts)

Box 6.4 Potential battery cost reductions

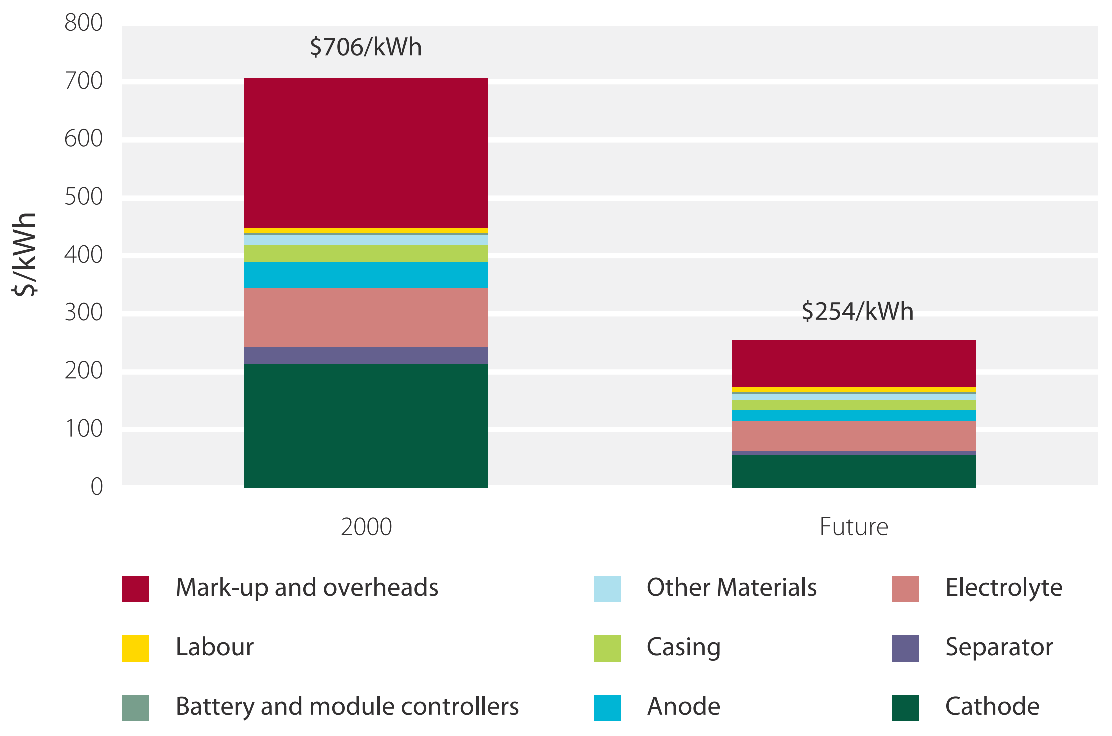
Lithium ion batteries are widely believed to be the most promising technology for electric powered vehicles. However, current battery costs of around \$800/kWh (\$28,000 for a 35kWh battery required by a medium car) will have to fall to make electric vehicles a viable mass market product.

Various analyses (e.g. Argonne National Laboratories (2000)[1], Electric Power Research Institute (2005)[2], and The California Air Resources Board Independent Expert Panel (2007)[3]) suggest that there is scope for significant battery cost reduction to \$200-300/kWh through a range of innovations including:

- Technological advances, particularly relating to innovation which would allow the cathode material to be switched from a cobalt compound to a manganese compound.
- Moving to mass production (100,000s/year) and exploiting economies of scale in the production of parts and of the whole battery.
- Learning effects, which increase efficiency in the manufacturing process.
- Recovery of research and development costs.

The figure below, taken from the Argonne analysis, is broadly indicative of where scope for battery cost reduction lies. This scope for reduction is reflected in the EUROBAT target to reduce battery costs to €300/kWh by 2020.[4]

Figure B6.4 The effect of the 'usable range ratio' on the contribution of electric cars



Sources: Argonne National Laboratories (2000), *Cost of Lithium-Ion Batteries for Vehicles*.

1 Argonne National Laboratories, Center for Transportation Research (2000). *Costs of Lithium-Ion Batteries for Vehicles*.
2 Electric Power Research Institute (2005). *Batteries for Electric Drive Vehicles – Status 2005: Performance, Durability, and Cost of Advanced Batteries for Electric, Hybrid Electric, and Plug-In Hybrid Electric Vehicles*.
3 Kalhammer et al (2007). *Status and prospects for Zero Emissions Vehicle Technology: Report of the Air Resources Board Independent Expert Panel*.
4 EUROBAT (2005). *Battery Systems for Electric Energy Storage Issues: Battery Industry RTD Position Paper*.

If these battery cost reductions can be achieved, the purchase cost premium declines to the point where this no longer outweighs the operating cost saving of electric cars. This analysis suggests, therefore, that price support for electric cars is likely to be required for an initial period, although cost reduction should allow for this to be phased out as penetration increases.

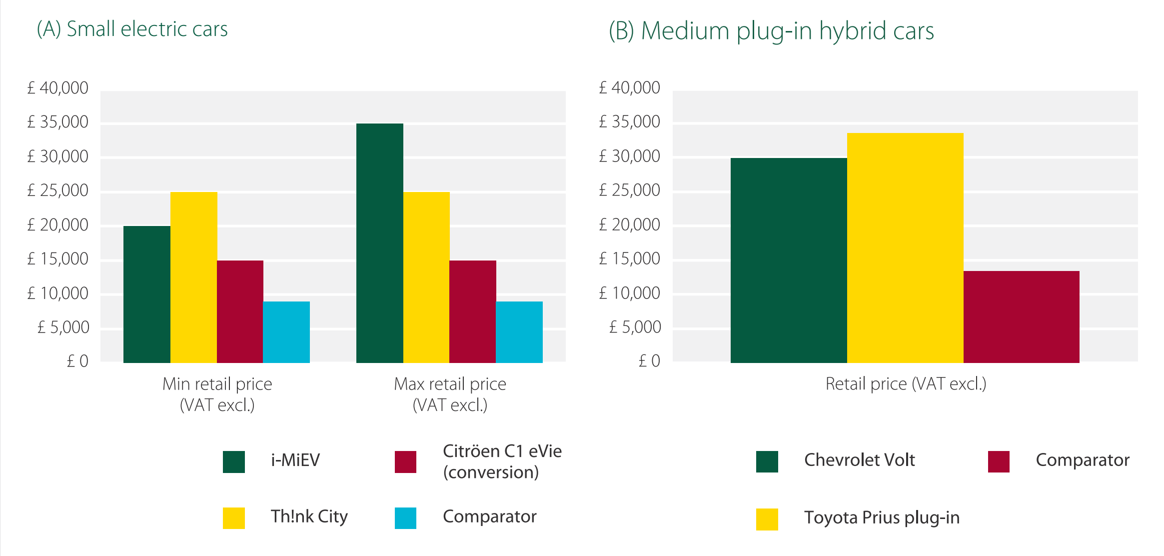
Price support required to offset purchase cost premium

One approach to determining required price support is simply to say that this should offset in full any purchase cost premium of electric cars. Required support would then initially range from £6,000 – £20,000 (Figure 6.18), falling to £1,000 – £7,000 by 2020. Total price support to reach cumulative penetration in the UK of 1.7 million in 2020 – consistent with our (revised) Extended Ambition scenario for electric cars set out below – would be up to £9 billion.

This approach does not, however, allow for the fact that operating costs of electric cars are significantly lower than operating costs for conventional cars. It may be thought of providing an upper bound for required support on the assumption that consumers are myopic (i.e. they fully discount electric car operating cost savings).

An alternative approach is to assess the purchase cost premium of electric cars net of any operating cost savings. Discounting under an assumption that consumers are rational economic agents (i.e. that they discount operating cost savings at their cost of capital) provides a lower bound on the level of price support.

Figure 6.18 Expected purchase price premium for representative early electric and plug-in hybrid cars compared to comparable cars



Source: AEA (2009a), *Review of cost assumptions and technology uptake scenarios in the CCC transparent MACC model.*

This is a lower bound because evidence suggests that consumers are somewhere between the extremes of myopic and rational economic agents in their car purchase behaviour, valuing but over-discounting cost savings. In addition, behavioural theories suggest individuals are likely to be resistant to purchasing electric cars rather than conventional cars given uncertainty and concerns over performance (Box 6.5).

Under an assumption that consumers are rational economic agents, required price support ranges from £1,500 – £7,000 per car initially (depending on the electric car model and the year of introduction), with declining support required over time and no support required beyond 2018. Total price support required to support roll out of electric cars in the UK in line with our Extended Ambition deployment scenario before costs fall to the break-even level would be around £800 million (Box 6.6).

What in practice is the appropriate level of price support will be determined by the way that consumers weight current versus future costs and by the way in which – price premium aside – they value performance characteristics of electric versus conventional cars.

Box 6.5 Influences on car purchasing behaviour: findings of a recent report by Ecolane

In 2008 Ecolane reviewed for DfT the evidence from a number of recent attitudinal research studies on car purchase behaviour. The evidence suggests that purchase decisions are essentially a two-stage process driven in the first instance by a choice of size/body type and available budget, after which secondary factors (which may include running costs and fuel economy) are accounted for. The weight attached to fuel economy, however, reflects heavy discounting due to:

- Consumers' lack of confidence in published miles per gallon (mpg) figures and/or belief that improved mpg compromised safety or performance.
- The complexity of fuel economy calculations, which involve multiplying fuel costs (in pence per litre) by fuel economy figures (in miles per gallon) to derive a fuel cost (in pence per mile).
- The low extent to which underlying pro-environmental attitudes affect vehicle choice.

This evidence (and evidence on the effects of incentive schemes introduced in the US and in the EU) bring Ecolane to conclude that an economic incentive equivalent to at least £1,100 per year would be required to significantly alter car-consumer choice (i.e. switching to an alternative fuel or a smaller engine) while a one-off incentive at the time of purchase (with a £10 per gCO_2/km gradient) would achieve the same effect more efficiently.

Ecolane's report does not focus specifically on attitudes towards electric vehicles, but their explanations for the attitude-behaviour gap (which include factors such as resistance to change) suggests that their conclusions may apply more strongly to the purchase of electric vehicles.

Source: Ecolane (2008). *Review of Attitudinal Influences on Car Purchasing Behaviour.*

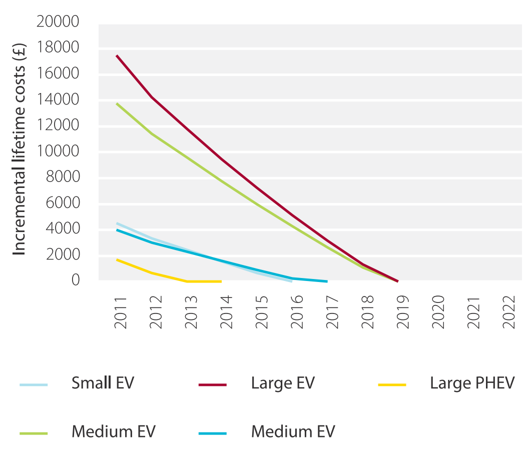
Box 6.6 CCC estimates of the required subsidy to cover lifetime cost differential of electric cars

We calculated required upfront price support by comparing lifetime costs (i.e. purchase and running) of conventional cars, plug in hybrids (PHEVs) and electric cars (EVs). We based our analysis on the following assumptions, which reflect our assessment of the available evidence (e.g. drawing on work for us by AEA and from other sources):

- A small EV has a 16kWh battery, a medium EV has a 35kWh battery and a large EV has a 53kWh battery. A medium PHEV has a 14kWh battery and a large PHEV has a 20kWh battery.
- The costs of a battery are assumed to fall over time, from $1,000/kWh[5] in 2009 to $285/kWh in 2020 in line with the goals set by EUROBAT (2005).
- Batteries are assumed to require replacement after eight years with a probability declining from 100% in 2009 to 10% in 2020.
- Capital costs for conventional car engines and electric motors are consistent with TNO (2006) and work done for the CCC by AEA[6]. An electric motor is less expensive than a conventional engine.
- The cost of petrol is consistent with pump prices based on DECC central projections for fossil fuel prices. The cost of electricity is also based on DECC projections. Per kilometre an electric car uses 1.6-2.7p worth of electricity (0.16-0.28 kWh/km), whilst a petrol car uses 6-14p worth of fuel.
- Small, medium and large cars travel 11,000, 14,000 and 18,000 km per year respectively for 12 years.

Future costs are discounted at 7% to reflect the real cost of borrowing. The figure below shows the upfront support required under these assumptions to negate lifecycle cost differences between conventional and electric/plug in hybrid vehicles; required price support ranges from £2,000-£18,000 initially, with no price support required from as early as 2014.

Figure B6.6 Estimated incremental cost of different types of EV and PHEV compared to a conventional car



Source: CCC Modelling.
Note: Modelling shows estimated incremental costs for years where cars of a particular type may not be available.

The total price support required before EVs and PHEVs break even depends on the pace at which these are rolled out. In our Extended Ambition scenario (see section 3(iv) below) 450,000 vehicles would be sold before EVs and PHEVs break even, and would therefore require price support of around £800 million (the number of vehicles sold each year multiplied by the price support required in that year). A Monte Carlo analysis of required support which allows for uncertainty in battery costs, discount rates, distance travelled and the size of the battery suggests a median value for required price support of £500 million, with a first and third quartile value of £150 million and £1.5 billion respectively. Analysis based on linking battery cost reduction to volume of EVs and PHEVs sold rather than time suggests required price support of around £1 billion.

5 Arup (2008). *Investigation into the Scope for the Transport sector to Switch to Electric and Plug-in Hybrid Vehicles.*
6 AEA (2009a). *Review of cost assumptions and technology uptake scenarios in the CCC transport MACC model.*

It should be noted that all these calculations assume that conventional fuels continue to be taxed at current levels, thus providing an additional implicit subsidy for use of electricity as a transport fuel; the Committee's view is that these implicit and explicit subsidies for electric cars are justified to develop what is likely to be a key technology for decarbonising transport in the 2020s.

Measures to address over-discounting of electric car operating cost savings

There are at least three levers which can be used to encourage purchasers to attach appropriate weight to operating cost savings of electric cars:

- Consumers can be encouraged to consider both purchase costs and operating costs more fully through provision of information about operating cost savings and lifecycle costs of electric versus conventional cars.
- Business models such as battery leasing turn some purchase costs into operating costs, thus eroding the purchase cost premium for electric cars.
- To the extent that heavy discounting may reflect concerns about electric car performance, these can be addressed through ensuring that appropriate infrastructure is in place and demonstrating that this addresses concerns over range limitations.

We concluded in our December report that better information alone is unlikely to result in changed purchase behaviour, but is still likely to have an important role to play as part of a package of mutually supporting interventions. Together with new business models, it is reasonable to assume that better information could mitigate over-discounting of operating cost savings by consumers. These measures would only be effective, however, if consumer confidence in electric cars can be increased, which crucially depends on the introduction of a charging infrastructure; we consider the design of charging infrastructure in Section 2(iii) below.

The UK Government's price support package

In April 2009 the Government announced a support package for developing an electric car market. From 2011 this will provide up to £2,000 to £5,000 per car up to a total amount of £230 million. Whilst this is a useful contribution to developing the electric car market, but that some flexibility is likely to be required over the time for disbursing support, and further support over and above this initial amount is likely to be required:

- The price support per car is of the order of magnitude that our analysis suggests is likely to be required if purchasers fully value operating cost savings of electric cars. It is comparable to the level of price support being offered in other countries (Table 6.2).
- This level of price support combined with measures that spread some purchase costs over time may be sufficient to encourage uptake of electric cars.
- It is possible that stronger incentives may be needed in early years (e.g. higher price support – e.g. £10,000 per vehicle for the first 25,000 vehicles sold – might be required to encourage early stage take up); this type of tapered structure should be considered further.
- Overall our analysis suggests that cumulative support significantly above the initial £230 million already committed will be required (Box 6.6).

It is not imperative that new funding is committed now given uncertainty over how costs will fall in coming years. The Committee's view, however, is that the likely need for extra funding should be acknowledged, and that this issue should be revisited at the appropriate time to determine exactly what level of funding for purchase incentives in combination with other levers such as fuel duty is required.

Table 6.2 Upfront price support offered for low-carbon vehicles in a number of countries

Country/Vehicle Details	Price Support		
	Value of support in currency of origin	Value of support in £ (approximate)	Value of support as % of total vehicle price
Canada: (Federal rebates for vehicles 5.5l/km, e.g. Toyota Prius 1.5 l, Honda Civic Hybrid, 1.3l and additional provincial rebates for plug in electric and hybrid vehicles)	C$2,000 / C$3,000	£1,115/£1,675	
Belgium: (vehicles with emissions up to 105 g CO_2/km)	€4,350	£4,000	20% to 40%
Ireland: (Hybrid and Flexi-Fuel – first registration)	€2,500	£2,300	Up to 15%
Sweden: (Hybrids with emissions less than 120g CO_2/km, electric cars – less than 37 kWh)	10,000 SEK	£850	Up to 5%
France: (Class A, vehicles under 100g CO_2/km)	€2,000	£1,850	Up to 15%
France: (Class A+, vehicles under 60g CO_2/km)	€5,000	£4,700	Up to 25%
USA: (Plug-in electric, batteries of at least 4kWh)	$2,500	£1,700	Up to 8%
USA: (Plug-in electric, gross vehicle weight up to 10,000 lbs)	$7,500	£5,250	Up to 20%
USA: (Plug-in electric, gross vehicle weight up to 14,000 lbs)	$10,000	£6,800	
USA: (Plug-in electric, gross vehicle weight between 14,000 lbs and 26,000 lbs)	$12,500	£8,500	
USA: (Plug-in electric, gross vehicle weight over 26,000 lbs)	$15,000	£10,160	
Japan: (Nissan Hypermini – electric car)	¥940,000	£5,040	27%
Japan: (Mitsuoka CONVOY88 – electric car)	¥210,000	£1,125	24%
Japan: (Zero Sports Elexceed RS – Hybrid)	¥380,000	£2,040	19%
Japan: (Toyota Prius – hybrid)	¥210,000	£1,125	10%
Japan: (Honda Civic Hybrid)	¥230,000	£1,240	11%

Source: AEA (2009b), *Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric vehicles.*

(iii) Electric car charging infrastructure

If people are to purchase electric cars, they will have to feel confident that these will be able to meet their needs. It is likely that initial range for electric vehicles would be 60-100 miles, possibly increasing to 250 miles over time. Even the limited range for initial models would be sufficient to cover the majority of trips currently made in the UK, suggesting that range constraints need not be a prohibitive factor in electric car uptake (Box 6.7).

In purchasing cars, however, it is likely that consumers would look for a range beyond their daily driving distance given concerns about batteries running out mid-journey ('range anxiety') and given the need to make infrequent longer journeys. This suggests that there may be a market for plug-in hybrid vehicles as primary/only cars, and electric vehicles as primary or second cars:

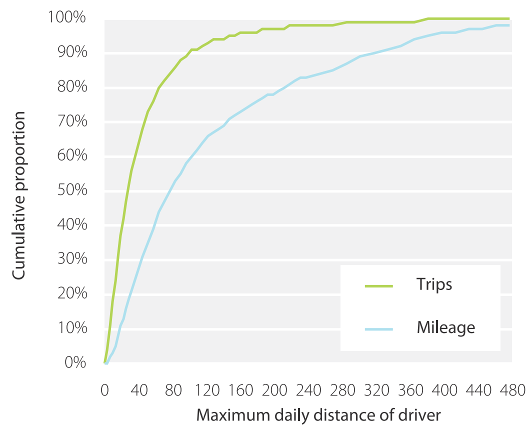
- Plug-in hybrids are subject to the same range constraints as conventional cars. A household purchasing a primary conventional car with the capability for occasional long journeys might equally choose a plug-in hybrid.
- Electric vehicles are potentially subject to the same range constraints as conventional cars depending on the charging infrastructure. In particular, where there is fast charging public infrastructure or battery exchanges (see below), range should not be an issue even for longer journeys (Box 6.8).

Box 6.7 Typical driving distances

The typical daily driving distance of many car users is well within the indicative range of 160 km (100 miles) for a new electric car.

The figure below presents analysis derived from work commissioned from Element Energy.[7] It uses data from 13,390 individuals who had recorded trips as a car driver in the 2006 National Travel Survey. The data records the typical maximum daily distance of each driver[8] and the figure below shows this plotted against the cumulative proportion of total trips taken by all drivers and the cumulative proportion of total distance driven. This tells us that 96% of trips are made by drivers who normally travel no more than 160 km a day, whilst 73% of kilometres driven are undertaken by drivers who normally travel no more than 160 km a day.

Figure B6.7 Cumulative contribution to total number of trips and total mileage as a function of car drivers' maximum daily driving distance



Source: Element Energy analysis based on the National Travel Survey (2006).

This analysis suggests that an electric vehicle with a range of 160 km would, in principle, be sufficient for drivers who undertake 95% of total car trips and 73% of aggregate car-kms. It also suggests that a plug-in hybrid car with an electric range of 64 km (40 miles) would be able to cover 80% of all trips in electric mode, although this only amounts to 44% of total distance driven, due to the large proportion of short trips. Such a vehicle would, however, additionally be able to drive the first 64 km of longer trips in electric mode.

7 Element Energy (2009), *Strategies for the uptake of electric vehicles and associated infrastructure implications*.
8 This does not mean that the driver *never* exceeds this distance, but that their usual driving pattern does not exceed this.

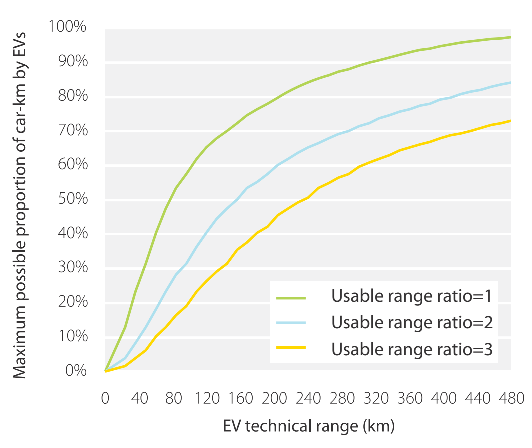
Box 6.8 Technical and utilised range of electric vehicles

Based on an indicative range for an electric vehicle of around 160 km (100 miles), the technical range of an electric vehicle would be sufficient for the normal driving patterns of many drivers as discussed in Box 6.7.

However, survey evidence[9] shows that, at least to date, users of electric vehicles are generally unwilling to utilise more than a third to a half of the vehicle's technical range. Possible explanations for this behaviour include a cautious approach to new technology and a lack of publicly available charging infrastructure that meets their needs.

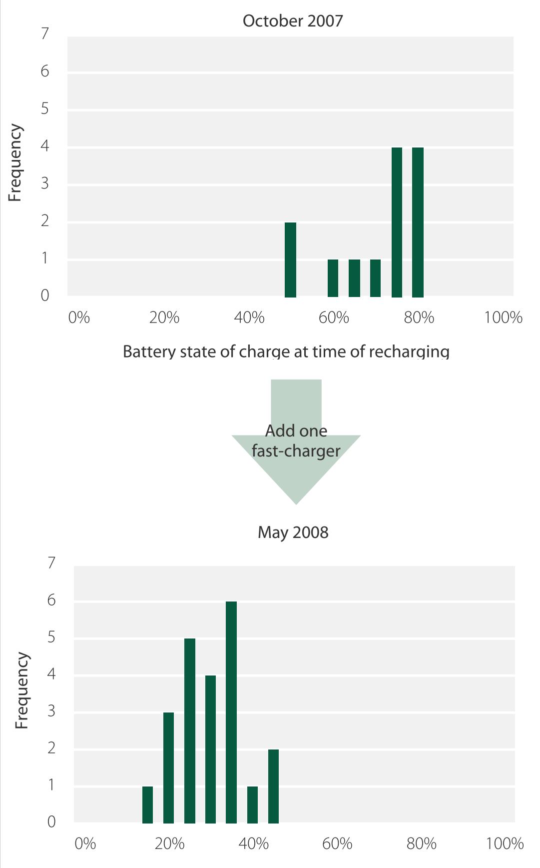
The effect of this unwillingness to use the full technical range of a vehicle is that the 'usable range ratio' – the ratio of the vehicle's technical range to the range utilised by the user – is relatively high, at 2-3, bringing down the potential contribution of an EV with 160 km technical range to 36-51%.

Figure B6.8a The effect of the 'usable range ratio' on the contribution of electric cars



Source: Element Energy analysis, based on data from the National Travel Survey.
Note: The 'usable range ratio' is the ratio of the technical range of a vehicle to the range that a user is actually willing to use. A ratio of 2 implies that a user is only willing to utilise 50% of the vehicle's technical range.

Figure B6.8b The impact on utilised range from the installation of a fast charging point, evidence from Japan



Source: Tokyo Electric Power Company (Tepco), relating to the operation of Tepco's own fleet of EVs. Fast-charger is rated at 45 kW.

There is a potentially important role for public charging/battery swap infrastructure to reduce this ratio, so enabling electric vehicles of a given technical range to be suitable for a much greater proportion of car drivers.

The figure above shows such an effect within the electric vehicle fleet of the Japanese utility Tepco. The addition of a fast-charging station reduced the amount of energy left in the battery at the point of recharging from 50-80% to 20-50% of its capacity, implying a substantial increase in the utilisation of the vehicles between charges.

9 Element Energy (2009), *Strategies for the uptake of electric vehicles and associated infrastructure implications*.

- Second cars are typically used for shorter journeys within the range for electric cars without fast charging public infrastructure or battery exchanges. The many households currently using second cars might equally choose electric cars. Currently 42% of car-owning households have more than one car.

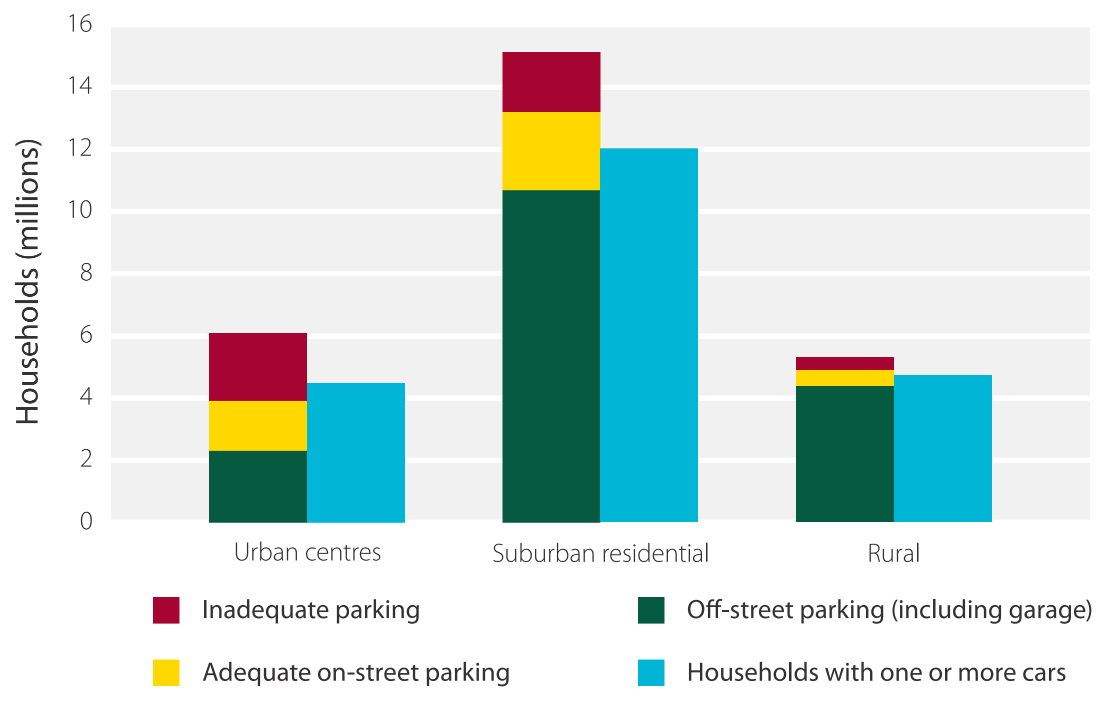
There is therefore a potentially large market for both plug-in hybrids and electric cars. Unlocking this potential will require introduction of charging infrastructure that facilitates required charging consistent with range constraints and trip patterns.

Options for charging infrastructure

We commissioned Element Energy to assess technical and economic aspects of electric car charging infrastructure. Element considered five options for charging infrastructure:

- **Off-street charging.** Over 60% of households in the UK have off-street parking (less than 40% in urban areas and around 75% in suburban and rural areas). The cost of associated charging infrastructure is very low, at around £50 per car, and significantly lower than the other options listed below (Box 6.9). This makes off-street charging a very cost-effective option for a large proportion of potential drivers.
- **On-street charging outside homes.** Targeting those urban households without off-street parking is likely to be important as part of encouraging electric car uptake, especially as urban users tend to make shorter trips well-suited to electric vehicles, and dedicated on-street charging points are therefore likely to be required. One low cost option would be to run cables from houses to the street. Installation of more sophisticated charging points – probably a more enduring solution – would cost several thousand pounds.
- **Charging in public places (e.g. car parks, supermarkets, etc).** This could be necessary in order to allow substitution of longer non-commuting journeys (Figure 6.21) to electric cars (e.g. business journeys, visiting friends, day trips)

Figure 6.19 Parking availability and car ownership by area type

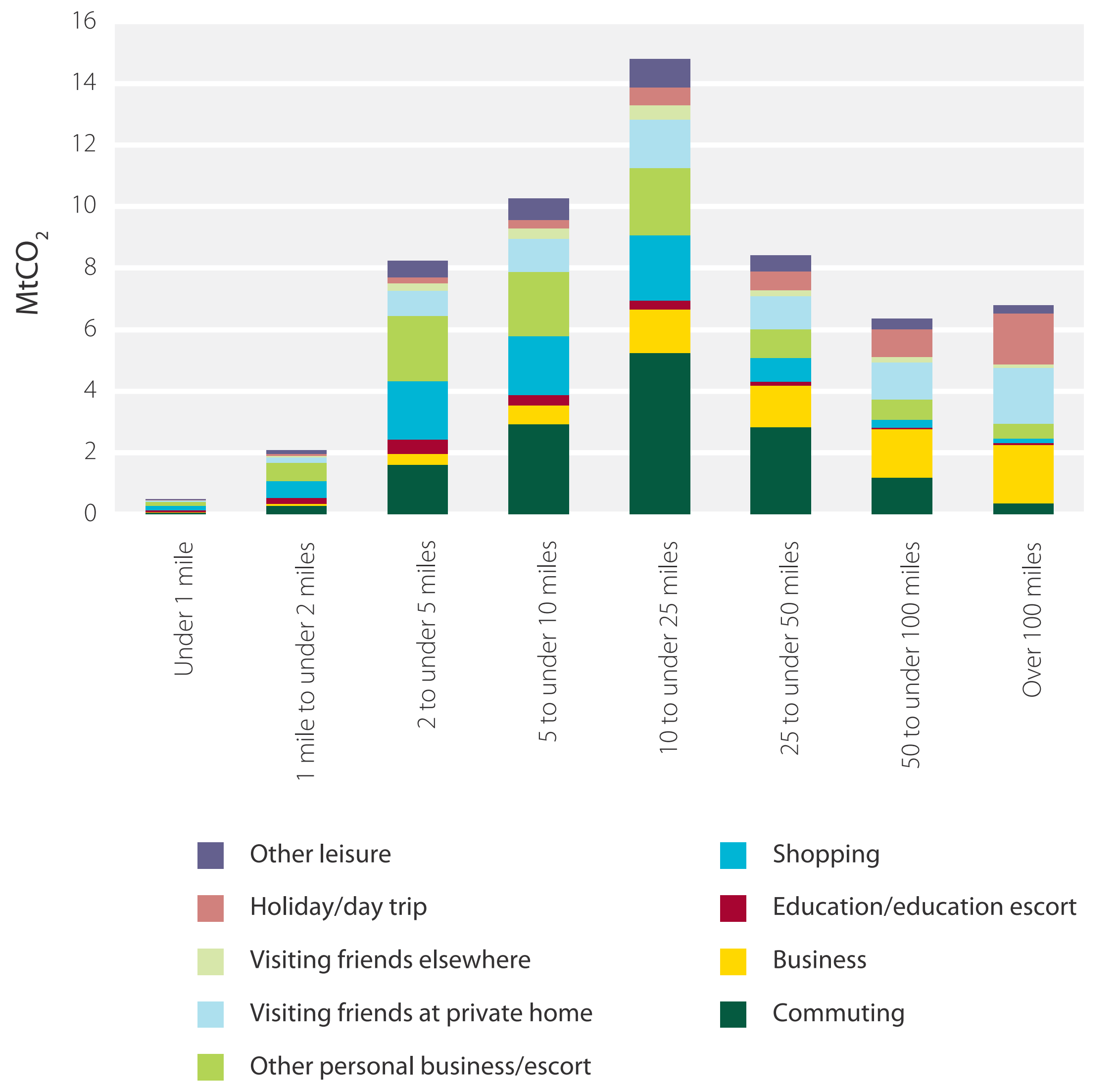


Sources: Parking data from the English Housing Condition Survey; car ownership data from the National Travel Survey.
Note: Despite the apparent correlation, it is not possible to state definitively that households without cars are also those that do not have adequate parking availability, as the data on car ownership and parking availability are from different sources.

which together account for 17 $MtCO_2$ annually (Figure 6.20) and in doing this increase the potential size of the electric car market. Fast-charging technology is likely to be needed given that people tend to stay at such public places for one or two hours rather than the eight hours required for a full slow charge (Figure 6.22). Fast charging points are likely to cost around £40,000 on average, although their installation may in some places also necessitate an upgrade of the distribution grid, costing a further £50,000 on average.

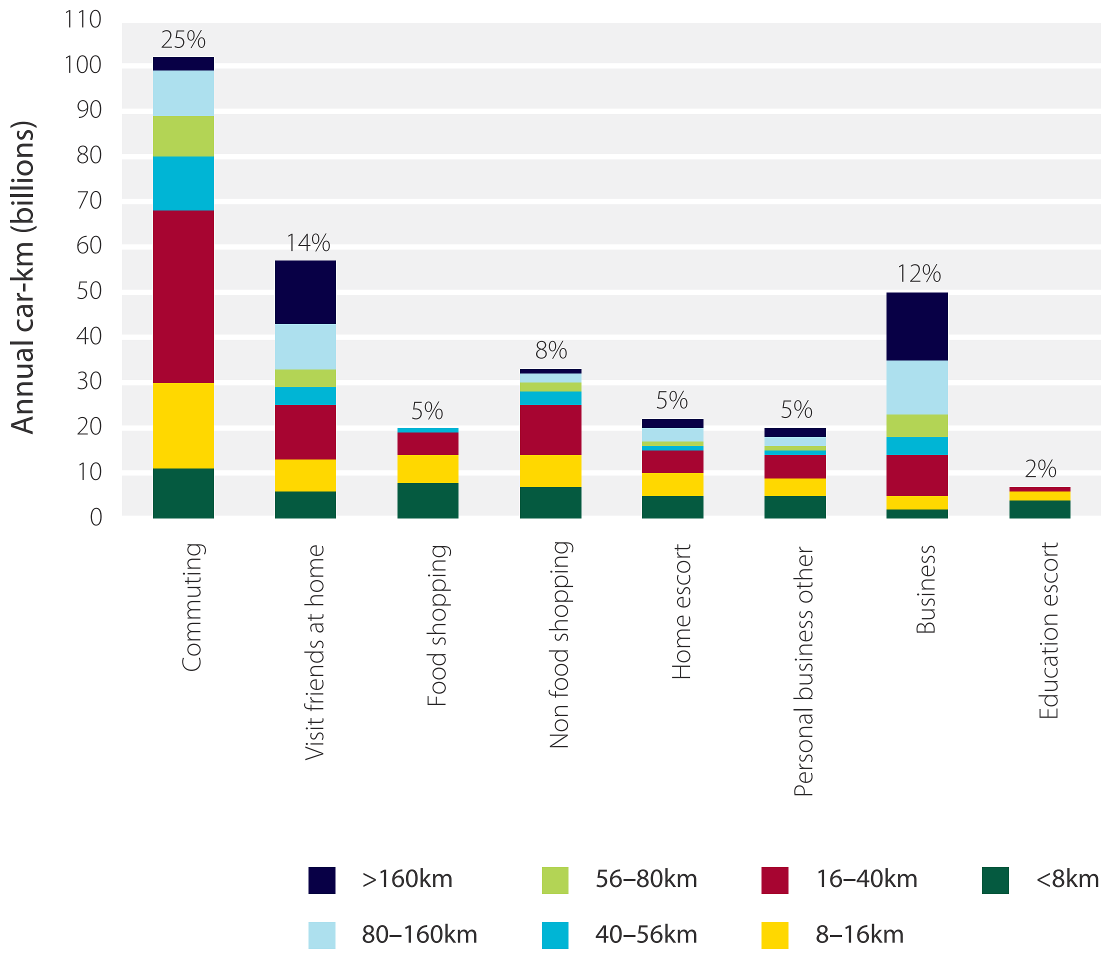
- **Workplace charging.** Commuting journeys between 25-100 miles account for around 4 $MtCO_2$ annually and substitution of these journeys to electric cars therefore offers an important emissions reduction opportunity. Substitution would, however, require access to recharging points before returning home given the range constraint of electric cars. For workplaces with car parks, installing charging infrastructure is relatively straightforward, either through adding points to existing circuits or installing more sophisticated charging points.

Figure 6.20 Car CO_2 emissions by journey length and purpose



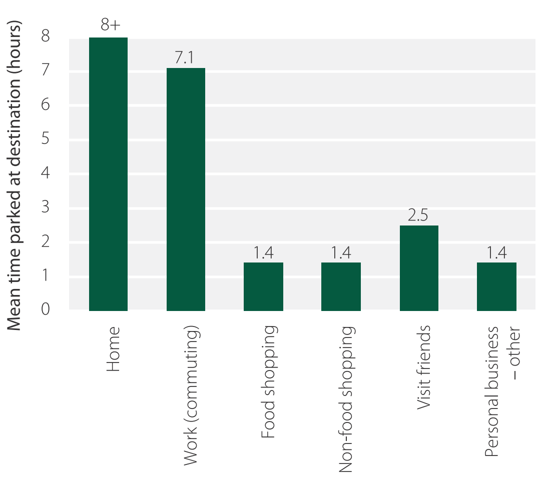
Source: Carbon Pathways Analysis (2008), *Informing Development of Carbon Reduction Strategy for the transport sector.*

Figure 6.21 Estimated contribution of trip types to total car driving distance



Source: Element Energy analysis, based on the National Travel Survey (2009).

Figure 6.22 Mean time spent parked at destination for various journey purposes



Source: DfT (2009).

- **Battery exchanges.** These could operate in a similar way to today's filling stations, restoring the vehicle to a full state of charge in a matter of seconds by swapping the discharged battery for a pre-charged module. With sufficient coverage, a battery exchange infrastructure would potentially enable EVs to be used for all car journeys. A major challenge would be the requirement for standardisation of both battery design and car battery mounting system.

A national charging infrastructure would probably need to include most of the above in order to maximise the potential size of the electric car market and emissions reduction ensuing from substitution to electric cars. There would be scope over time for electric car drivers to contribute to infrastructure costs as battery costs fall and electric cars become profitable to drive.

A charging infrastructure consistent with our Extended Ambition scenario for electric car deployment in 2020 may not, however, require a widespread public charging infrastructure, and could be supported by primarily off-street, on-street home and workplace slow-charging. We estimate that the cost of introducing such charging infrastructure would be in the range £150m to £1.5bn, depending on the options chosen for on-street home and workplace charging (Box 6.9).

Box 6.9 Cost estimates for electric vehicle charging infrastructure

The costs of electric charging facilities can vary from around £50 for off-street home-charging, to several thousand pounds for a public slow-charging point, to £40,000 – or more if electricity grid upgrades are required – for a fast-charging point.

The cost of the battery, electricity and charging infrastructure have the potential to become lower than the cost of driving a petrol or diesel car, which are current around 7p per km.

Depending on the type of infrastructure used, the total infrastructure costs to support the roll out of 1.7m EVs and PHEVs to 2020 could be very low, at around £150m. This cost estimate would require all charging to be undertaken via off-street home charging, or simple solutions in workplaces that use the existing power supply and don't require major works to be undertaken.

A more extensive infrastructure for the same number of users might cost around £1.4bn, comprising:

- dedicated slow-charging posts for the 25% of drivers who do not have off-street parking, at a cost of around £1bn.
- charging posts in work-places for 5% of drivers, at £210m.
- a total of 3,200 fast-charging points (i.e. two for every 1,000 electric cars) in public places, e.g. supermarkets, at a cost of £130m.
- provision of four fast-charging points every 35 km in each direction on motorways and every 50 km on trunk roads, at £70m.

Table B6.9 Estimates for electric cars costs including infrastructure

Costs of EV operation		£ per vehicle	pence per km
Battery ($200-800 per kWh)		2,900 – 11,500	4 – 15
Electricity (12p/kWh)			1.7
Home-charging infrastructure			
– off-street charging		50	0.05
– on-street charging		100 – 2,600	0.1 – 2.8
plus	**Workplace charging**	50 – 2,600	0.05 – 2.8
and/or	**Fast-charging** (2-10 per 1,000 cars)	130 – 650	0.15 – 0.75

Source: CCC analysis, based on data from Element Energy on infrastructure costs.
Notes: This analysis makes numerous assumptions, including 7% real discount rate; Ford Focus with 160 km range; battery lifetime 8 years; charging infrastructure lifetime 10 years; 13,000 vehicle-km/year.

It will be important to understand how the presence of public charging infrastructure might affect uptake and use of electric vehicles to give a better idea of how a charging infrastructure to support wider roll-out might best be designed.

Next steps in rolling out charging infrastructure

There are likely to be economies of scale in concentrating roll-out of electric cars in certain areas. The Committee therefore recommends that the appropriate next step is to develop a number of pilot projects that should:

- cover different types of areas (e.g. a city, a town, a pair of neighbouring towns with significant traffic between them, etc.).
- cover the range of charging options (off-street charging; on-street charging outside homes on-demand; public place charging built to anticipate demand based on an assessment of likely car uptake, trip patterns of people driving cars, battery range constraints and cost; workplace charging on-demand; and possibly battery exchanges) (Box 6.10).
- be designed to produce clear evidence on the effect of public charging points on vehicle purchase and utilisation, by having pilot areas with similar demographics but differing levels of publicly available infrastructure.
- include participation of national and local government, energy companies, providers of charging infrastructure and the electric car industry and local businesses.
- be supported by any necessary planning and regulatory changes (e.g. to facilitate installation of on street charging points).
- be funded to cover costs of on-street charging, public place charging, work place charging and possibly battery exchanges, either by central or local government; this would provide a bridge to alternative funding mechanisms upon wider roll-out (e.g. full commercial financing).

Box 6.10 An alternative approach to pilot project design: the Better Place proposal for London

Better Place has proposed a London pilot project that would aim to install to service 50,000 electric cars by 2015 at a cost of £200 million:

- Better Place envisage an infrastructure with battery exchanges and 90,000 charging points.
- The bulk of the cost relates to public charging infrastructure.
- The focus on battery exchanges and public charging infrastructure fits with the Better Place business model which is targeted at the high mileage driver market (i.e. drivers who cannot just recharge at home).

The Better Place proposal raises questions over the target market for pilot projects and implied requirements for charging infrastructure. Appropriate pilot design will depend on the proportion of high mileage drivers, and the cost of public charging infrastructure.

Source: Discussion with Better Place.

- use a range of levers to promote electric cars, from price support to network measures (e.g. allowing use of bus lanes, prioritising parking, exempting from road pricing, etc.) and innovative marketing campaigns (e.g. aimed at making electric cars fashionable).

Implementation of pilot projects forms part of our scenarios for electric car deployment and our indicators. We envisage pilot projects covering up to 240,000 electric cars in the period to 2015. In addition to the cost of purchasing the vehicles, we estimate that this would cost:

- Up to £230 million to pay for installation of on-street charging points outside homes and public fast-charging (depending on the balance of off-versus on-street charging in the pilots, and the choice of technology for on-street charging – costs could be negligible for pilots focused on households with off-street parking or on running cables from houses to the street).

- Additional funding for public charging infrastructure, workplace charging and battery exchanges.

Implications for the power system

In our December report we set out scenarios to 2050 where there is increasing demand for electricity from the 2020s partly due to electric cars and partly due to electric heating. Our working assumption, at least for electric cars, was that the bulk of this demand would be overnight. Electric cars would therefore support power sector decarbonisation by creating demand for low-carbon baseload capacity.

We did not consider possible investments in power generation or networks that could be needed as a result of demand from electric cars. In order to fill in this gap in our analysis, we commissioned Element Energy to assess implications of increasing electric car penetration for power sector investment (Box 6.11).

The Element Energy analysis suggests that near term implications should be very limited, both because demand for electricity from electric cars is expected to be relatively small, and the bulk of this is expected to be overnight. These factors together suggest that increased electricity demand could be accommodated within existing system capacity constraints. To the extent that distribution grid upgrades may be required, accommodating increased demand is a standard part of ongoing investment programmes.

Going further out in time, the analysis suggests that investments in power generation, transmission and distribution could be required to meet increasing demand, particularly if there is significant charging in peak periods.

Box 6.11 Power system implications of electric vehicle introduction

Peak electricity demand occurs in the early evening, when people arrive home from work. Charging an electric vehicle at this time would add to system peak demand, implying significant investment in generating plant and distribution networks to provide the necessary peak capacity.

These investments can largely be avoided using a simple solution such as a delay timer, which would facilitate charging in the off-peak overnight periods, (i.e. 11pm-7am). In addition to this simple technical solution – which could incorporate an 'override' button to ensure that users can charge immediately if necessary – electricity tariffs with a lower overnight rate will be required to incentivise charging during this period. The resultant increase in off-peak demand is also conducive to an increase in the proportion of baseload generating plant on the system, i.e. favouring nuclear, wind and CCS rather than gas.

The electrical loads for a fast-charging point are much greater than those of a slow-charging point or home charging, and fast-charging will also tend to occur during the daytime period rather than off-peak. As a result, the installation of fast-charging points could increase the peak load on distribution networks, potentially requiring an upgrade to transformers and/or lines and cables. This can be minimised with placement of fast-charging points where the local network is strong, e.g. near to the substation.

Existing processes for the upgrade of distribution networks to accommodate growing electricity household demands are also appropriate for any reinforcements required to support electric vehicle charging.

Power system implications should therefore not be a barrier to moving forward with electric car roll-out to 2020. It will, however, be important to better understand implications of larger scale roll-out in the 2020s and how impacts in terms of power sector investment can be minimised. The Committee will undertake further work on this and, in particular, will look in more detail at how smarter operation of the grid and new electricity pricing schemes could encourage the timing of electricity consumption to reflect system capacity constraints at different times of the day; we will publish this in our report on the fourth carbon budget which we will present to Government in 2010.

Based on a high level assessment of electricity sector investment costs, when these are spread over asset lifetimes and compared against very significant emissions cuts, then electric cars should remain the least cost option for transport decarbonisation in the 2020s.

(iv) Electric car scenarios and indicators

In our December report we set out scenarios for carbon intensity improvement of cars over the first three budget periods in which electric car and plug-in hybrid penetration reached around 20% of new cars and 7% of the fleet in 2020. We developed these scenarios based on analysis that we commissioned from a consortium of transport consultancies.

We now update these scenarios to incorporate evidence from three new pieces of analysis:

- In May 2009 the RAC Foundation published survey data that suggested around 20% of people would consider purchasing an electric car; this is higher than the Committee would expect given uncertainty over performance characteristics of electric cars, and is consistent with the level of deployment required to 2020.
- We commissioned AEA technology to review our scenarios given their analysis of electric car costs. AEA's revised analysis suggests a central case electric and plug-in hybrid car penetration of 7% to 10% of new car sales in 2020.
- The consultancy Arup, in partnership with Cenex (the Government's delivery agency for low-carbon and fuel technology) developed scenarios for DfT showing uptake in the range of 8% to 16% of new cars in 2020 by building on information of planned vehicle releases by manufacturers under a medium and high scenario respectively, with 20% of new car sales being reached shortly after 2020[10] (Figure 6.23).

In addition, there is evidence that manufacturers are now moving faster towards developing and introducing electric car models than anticipated a year ago, with a major manufacturer (Nissan) having announced the launch in late 2010 of an electric car with potential to reach mass production.

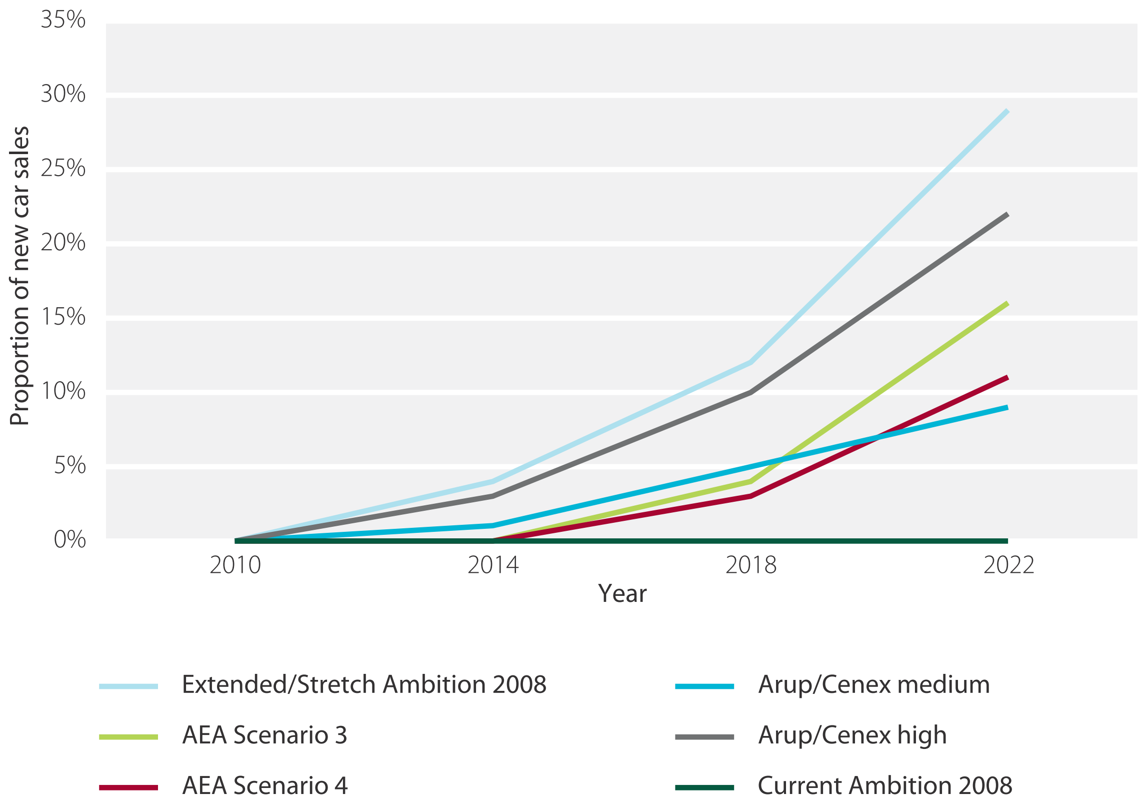
Based on this evidence, it is the view of the Committee that an Extended Ambition scenario under which electric and plug-in hybrid cars achieve significant penetration (tens of thousands of combined vehicles sold annually) from 2013 and account for 5% of all new cars in 2015, 16% in 2020 and 20% shortly thereafter (i.e. a scenario consistent with Arup/Cenex above) is ambitious but feasible; this would result in cumulative penetration of 240,000 cars by 2015, and 1.7 million cars by 2020.

This level of penetration would provide critical mass for more widespread roll-out through the 2020s, if evidence continues to show that electric cars are the most economically attractive option for sector decarbonisation. The scenario also embodies an assumption (consistent with the aspirations set out by the Government) that the UK will be a leader in the adoption of ultra-low-carbon vehicles.

We will therefore use our Extended Ambition scenario as a benchmark for assessing progress in rolling out electric cars. To the extent that electric car roll-out were not to be consistent with this scenario, this would raise a question whether sufficient progress were being made developing the electric car option, whether remedial action were required, or whether there is an alternative strategy for reducing transport emissions through the 2020s.

10 Arup (2008), *Investigation into the Scope for the Transport sector to Switch to Electric and Plug-in Hybrid Vehicles.*

Figure 6.23 Combined annual sales of electric and plug-in hybrid cars as a proportion of new car sales under different scenarios



Source: CCC 2008; Arup/Cenex (2008), *Investigation into the scope for transport sector to switch to electric and plug-in hybrid vehicles.* AEA (2009), *Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric vehicles.*

Our general approach to indicators is to look at high level indicators and drivers of these indicators. This approach is relevant in the case of electric car penetration. Our analysis has suggested that electric car roll-out will be driven both by pilot projects and cost reductions.

- **Pilot projects**: the focus of our monitoring in the near term will be on development of the pilot projects which will be key to unlocking the Extended Ambition scenario.
- **Cost reductions:** further out in time as electric car penetration increases, we will consider whether costs have fallen in line with the AEA learning scenarios upon which the roll-out scenario is predicated. To the extent that cost reductions diverge from the AEA learning scenarios, this would require a reconsideration of the appropriate path for roll-out.

4. Emissions reduction from changing transport consumer behaviour

In our December report we considered high level evidence on scope for emissions reductions through a range of options for changing transport consumer behaviour including using price levers, providing better information on transport choices, encouraging eco-driving and limiting speed. We now return to these options. We discuss the use of price levers in the specific context of road pricing. We revisit our estimates of what may be achievable through implementation of Smarter Choices based on the Sustainable Travel Town data. We recap our recommendations on eco-driving and assess the role of technology in supporting enforcement of the speed limit.

We consider in turn:

(i) Using prices to manage transport demand

(ii) Smarter Choices and Sustainable Travel Towns

(iii) Eco-driving indicators

(iv) Enforcing the speed limit.

(i) Using prices to manage transport demand

The December report reviewed the evidence on transport demand responsiveness to changes in price and concluded that this provides scope for emissions reductions in two ways:

- The demand for car travel is responsive to fuel prices, with lower demand at higher prices as consumers adjust trips made, trip distances and mode of travel.
- Demand for more fuel efficient cars is also responsive to the fuel price, with consumers purchasing more efficient cars as the fuel price is higher.

Given that fuel duty is a key component of fuel prices, we concluded that fuel duty is a potentially important lever in reducing emissions. This is borne out in the recent fuel duty increase announced in Budget 2009, which Government projections suggest should result in an annual emissions reduction of 2 $MtCO_2$ (Box 6.12).

Box 6.12 Budget 2009 fuel duty increase and expected impact

Fuel duty in the UK at Budget 2009 was £0.54 per litre of petrol and diesel and accounted for around 50% of petrol and diesel prices. On 22 April the Chancellor of the Exchequer announced that fuel duty would increase by 2 pence per litre on 1 September 2009, and by 1 penny per litre in real terms each year from 2010 to 2013. This represents a 6p increase by 2013, bringing total fuel duty to £0.60 per litre. The Treasury estimated that this would save 2 $MtCO_2$ per year by 2013-14.

Whilst debates about possibly increasing fuel duty further remain very controversial, this should not be ruled out as an option for triggering a short term response to meet carbon budgets should emissions reductions fall short in other sectors or should there be a significant drop in the oil price. From a purely economic perspective, however, there is a stronger case now for introducing road pricing rather than increasing fuel duty given the large market failures associated with current and projected levels of road congestion.

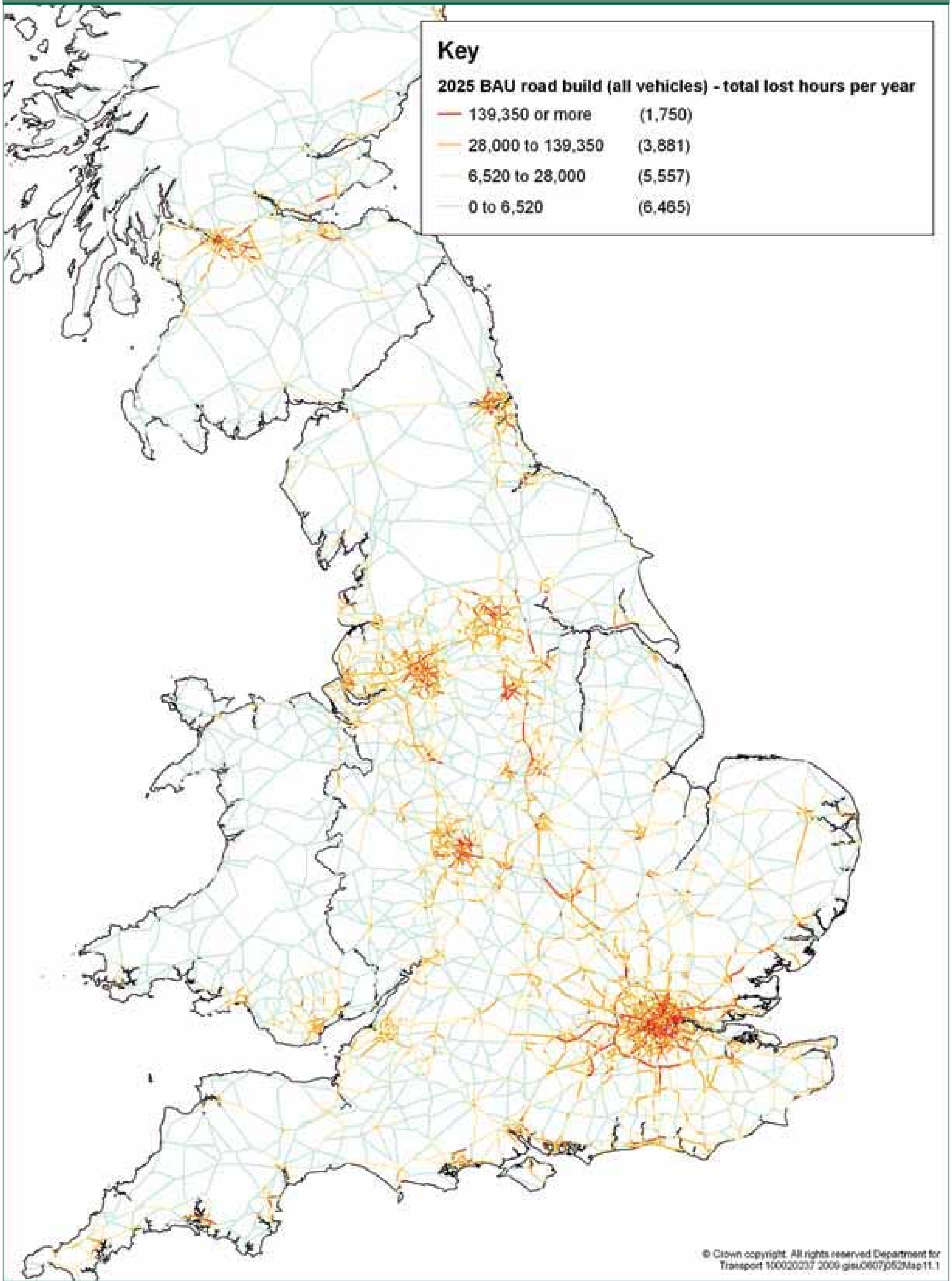
Road pricing impacts on emissions

In the absence of road pricing across almost all the UK road network, high levels of transport demand have resulted in congestion, which is forecast to worsen significantly in future (Figure 6.24). Road users consider only the private cost of travel, and not the impact that they will have on other road users in terms of exacerbating congestion. In not accounting for the costs that they impose on others, road users therefore overuse roads. This is a market failure which standard microeconomic theory would suggest should be addressed through introduction of prices that reflect congestion costs.

The economic benefit of road pricing would mainly ensue through lower levels of congestion resulting in travel time savings. In addition, however, road pricing could result in emissions reductions both through reducing demand for car travel and through increasing car speed to levels where fuel consumption is more efficient.

In political debates, it is sometimes argued that if road pricing were to be introduced this would have to be offset by a reduction in fuel duty. From a carbon perspective, however, this would result in increased emissions (i.e. fuel consumption and emissions are potentially more responsive to fuel duty than to road pricing). From an emissions perspective, therefore, road pricing should be introduced as a complement to fuel duty rather than a substitute. This conclusion is buttressed by the fact that fuel duty plays a crucial role in providing incentives for purchase of electric cars, increasing electric car cost savings relative to conventional cars and offsetting upfront cost premiums.

Figure 6.24 Map of projected congestion on roads in Great Britain in 2025



Source: DfT (2006), *The Eddington Transport Study.*
Note: Business As Usual (BAU) road build refers to road-building equivalent to an additional 3,500 Highways Agency lane kilometres by 2025, representing a continuation of current spending levels.

Where road pricing is additional to fuel duty, evidence suggests that this could result in significant emissions reductions:

- Modelling by the Department for Transport for the Committee on Climate Change suggests that a national road pricing system could reduce annual CO_2 emissions by around 5% in 2020.
- Analysis by the RAC Foundation on the effects of road pricing on carbon emissions in 2040 suggests that an efficient national road pricing system would reduce annual CO_2 emissions by around 15% in that year.

It is beyond the scope of the Committee to recommend that road pricing should be introduced given the political judgements involved. The analysis suggests, however, that road pricing could be a useful component of a strategy for transport emissions reduction, and the Committee recommends that this should be seriously considered by the Government. Recognising this, we include an additional 5.6 $MtCO_2$ reduction in 2020 corresponding to roll-out of a national road pricing scheme in our Stretch Ambition scenario.

(ii) Smarter Choices and Sustainable Travel Town data

Smarter Choices refers to a range of measures promoting voluntary reductions in levels of car use, achieved either through the elimination of unnecessary trips, or through modal shift to public transport, walking and cycling.

Such measures were first implemented in the UK in the 1990s, and include:

- Travel plans (workplace and school travel plans)
- Travel awareness promotion (personalised travel planning, public transport information and marketing and travel awareness campaigns)
- Information Technology (teleworking, teleconferencing and home shopping)
- Car clubs and car sharing schemes.

In our December report we accepted estimates of emissions reductions through Smarter Choices from work commissioned by DfT, including an emissions reduction around 2.9 $MtCO_2$ in 2020 in our Extended Ambition scenario (Box 6.13).

Box 6.13 Alternative estimates of emissions reduction potential of Smarter Choices

Estimates of the emissions reduction potential of Smarter Choices vary considerably. In addition to the 2.9 $MtCO_2$ estimate presented in the December report, the Commission for Integrated Transport (CfIT) estimate a reduction of around 3.7Mt while the Department for Transport have significantly revised their estimate downward to 0.94Mt.

CfIT define a scenario in which implementation of Smarter Choices measures results in a total nationwide reduction in car traffic (vehicle km) of 11% in urban areas and 5% in rural areas and on motorways. Using forecast emissions disaggregated by road type (urban, rural and motorway) from the DfT's National Transport Model (NTM), CfIT calculate the reduction in emissions that corresponds to the reduction in car traffic.

DfT define a scenario with a total nationwide reduction in car trips of 7%, and model the implications of this reduction using the NTM. This is accomplished by raising the modelled cost of car travel to produce a 7% decrease in modelled car trips. This results in an overall reduction in car traffic that is lower than the overall reduction in car trips, as the NTM estimates that most of the reduction in car trips is accounted for by trips of shorter than average distance, for each road type (urban, rural and motorway). DfT assume that Smarter Choices policy is likely to be targeted towards urban areas and that the reduction in car traffic occurs only in urban areas. Using the forecast emissions from urban roads only, DfT calculate the reduction in emissions that corresponds to the 3.7% reduction in car traffic that the NTM estimates for urban roads.

We highlighted uncertainty over both what is achievable through Smarter Choices and the extent to which changed travel behaviour and emissions reductions will persist over time.

New evidence on Smarter Choices

We have subsequently undertaken a deeper review of the evidence on Smarter Choices. Data from the Sustainable Travel Towns and from a literature review carried out by the UK Energy Research Centre (UKERC) suggests that Smarter Choices may offer significant emissions reduction potential (Box 6.14):

The consistency of the conclusions in this evidence suggests that we can be more confident that there is a significant potential emissions reduction from Smarter Choices, if not necessarily in its exact magnitude.

Box 6.14 Evidence on Smarter Choices

Evidence from the Sustainable Travel Towns

The DfT has funded three Sustainable Travel Towns in Peterborough, Darlington and Worcester to assess the results of the intensive implementation of packages of Smarter Choices measures in one locality. The three towns are sharing £10 million of DfT funding over the five years of the project 2004/05 – 2008/09.

The implementation packages comprised the following measures:

- Travel plans (workplace and school travel plans)
- Travel awareness promotion (personalised travel planning, public transport information and marketing and travel awareness campaigns)
- Car clubs.

Car sharing outside the context of workplace travel plans and Information Technology measures were not included. Uptake of complementary traffic restraint measures to 'lock in' the reduction in traffic was relatively limited.

The project was conducted in the context of a national increase in traffic of 1.1% on all urban roads between 2004 and 2007 (a 1.8% decrease in traffic on major urban roads more than offset by a 3.2% increase in traffic on minor urban roads).

Emerging evidence on the effects of implementation comes from two sources:

- The results of household travel surveys conducted between 2004 and 2008
- National Road Traffic Estimates manual and automatic counts.

The results of the household travel surveys suggest that over the study period the number of car driver trips per person declined by 9% in Darlington and Peterborough, and by 7% in Worcester. Data on car mileage was not collected so it is not clear to what extent the reduction in car driver trips translates into a reduction in car mileage.

Other evidence on Smarter Choices measures

A UKERC literature review outlines further evidence of the effectiveness of Smarter Choices measures:

- An evaluation of UK case studies on the effectiveness of personalised travel planning suggests that this can reduce car driver trips by 11% and distance travelled by car by 12%.
- A trial of individualised marketing in South Perth, Western Australia in 1997 suggests that car driver trips were reduced by 10% and mileage by 14%.

Data from case studies in the UK (including from British Telecom), the US and the Netherlands on individual workplace travel plans suggest that this can reduce car driver trips for commuting purposes by between 10% and 30%.

Source: Sloman, Cairns, Newson, Anable, Pridmore and Goodwin (2009 forthcoming), *Draft results from Smarter Choices Follow-On Study*. May be revised before publication.
UK Energy Research Centre (2009), *What Policies are Effective at Reducing Carbon Emissions from Surface Passenger Transport?*

Network management and locking in benefits

We noted in our December report that there is a question as to whether changed travel behaviour through Smarter Choices will persist over time. This question remains as the Sustainable Travel Town data do not cover a long enough period to make inferences about locking in of benefits.

We argued in our December report that network management measures (e.g. bus lanes, parking controls) could be important in 'locking in' emission reductions, through encouraging persistence of changed behaviour and preventing additional traffic in response to improved travel conditions for cars as more people use public transport.

New evidence considered by the Committee relating to the effects of road space reallocation and road infrastructure provision suggests that network management measures are potentially very strong levers which could both lock in and leverage benefits from implementation of Smarter Choices (Box 6.15):

Box 6.15 Evidence on effects of network management

There is considerable evidence that network management measures that reallocate road space away from private car use can result in lower traffic levels without exacerbating congestion or loss of economic vitality.

For example, the Cambridge Core Traffic Scheme was implemented between 1997 and 1999 to reduce the negative impacts of traffic. The Scheme involved the removal of through traffic via closure of the main through routes to the City centre. A reduction in overall traffic levels of 8.4% has been observed over the period 1996-2000.

Similarly, the Oxford Integrated Transport Strategy was implemented to reduce problems of traffic congestion and pollution and improve conditions for pedestrians and cyclists. This involved the full pedestrianisation in 1999 of the most important shopping streets, and exclusion of traffic from other important streets during the day. In addition, bus priority routes and central area parking restrictions were introduced. A reduction in traffic levels of 17% was observed in the city centre over the period 1998-2000.

It should be noted that these results refer to traffic within the city centre and not to total traffic within the city as a whole.

The notion that road capacity influences traffic volumes is widely accepted, and has been recognised by the UK Government since publication in 1994 of the report Trunk Roads and the Generation of Traffic (SACTRA, 1994), which discussed the phenomenon of 'induced traffic' (i.e. additional traffic generated by an increase in road capacity). Evidence on the size and significance of this effect is limited at present but a recent study highlights some features. The effects on traffic of completion of the M60 Manchester Motorway Box, a major highway scheme that generated significant induced traffic, were studied through traffic observations and before and after surveys (roadside interviews, public transport intercept surveys and a household interview survey).

The research evidence collected allowed the effects of the scheme on choices of travel frequency, travel time, mode and destination to be estimated. The results suggested that the greatest proportion of the induced traffic (70% for commuter traffic and 76% for other traffic) was generated through selection of new journey destinations facilitated by the scheme, with the remaining proportion generated through modal shift. Given that such effects arise when highway capacity is increased, it seems plausible that similar effects lie behind the reduction in car traffic observed following implementation of network management measures such as those described above.

Source: Cairns, Atkins and Goodwin (2002), *Disappearing Traffic*; RAND Europe (2009).

Areas for increased focus in Smarter Choices

Data from the Sustainable Travel Towns includes some emissions reductions through changing behaviour around commuting journeys. New evidence from DfT, however, suggests that longer commuting journeys (journeys over 8km) account for around 22% of total car emissions (see Figure 6.20 in Section 3 above). In light of this evidence, there may be more emissions reduction potential from more specific targeting of long commuting journeys than was envisaged at the time that the Sustainable Travel Town pilots were designed. Increased focus on work journey planning, for example through local authorities working with employers and commuters to encourage car pooling, could therefore offer emissions reductions over and above what has been achieved in the Sustainable Travel Towns.

The estimates also exclude potential emissions impacts through teleworking, teleconferencing and home shopping which could in principle be incorporated into a Smarter Choices programme:

- These measures can reduce travel demand and therefore reduce emissions.
- Emissions reductions may be offset, however, as telecommuting employees choose to live further from work, or where time saved through home shopping or reduced commuting is used for other travel.

The available evidence on these measures suggests that there may be considerable opportunities to replace car travel with teleworking, teleconferencing and home shopping. The evidence is, however, incomplete, and scope for emissions reductions is currently highly uncertain. These measures might therefore usefully be trialled in further roll-out of Smarter Choices, with a working assumption that these may reduce emissions, but without banking this as a firm contribution towards meeting carbon budgets in advance.

Recommendations, revised scenarios and indicators

In summary, new evidence supports our earlier assumption that there is a significant potential emissions reduction available from Smarter Choices. Given this evidence, it is the view of the Committee that Smarter Choices should now be scaled up.

The UK and Scottish Governments have recently announced positive steps in rolling out Smarter Choices:

- In May 2009 the UK Government announced funding of £29 million over a three year period to support a Sustainable Travel City project.
- In March 2008, the Scottish Government announced the Smarter Choices, Smarter Places initiative. This provides funding for a number of Local Authorities to implement Smarter Choices measures over a two year period, with funding agreed for seven projects to date.

The Committee welcomes these initiatives, but believes that these should be complemented through scaling up implementation of Smarter Choices through:

- Phased roll-out of Smarter Choices to other towns that are comparable to the Sustainable Travel Towns, and a plan to roll out to other cities following the city pilot.
- A demonstration project in rural areas.
- Incorporation of measures to encourage emissions reduction from longer commuting journeys.
- Introduction of complementary network measures alongside Smarter Choices measures.
- Ongoing evaluation of Smarter Choices implementation to inform design for roll-out.

Given the significant potential but also significant uncertainties, we continue to include a 2.9 $MtCO_2$ emissions reduction for Smarter Choices in our Extended ambition scenario (Box 6.16).

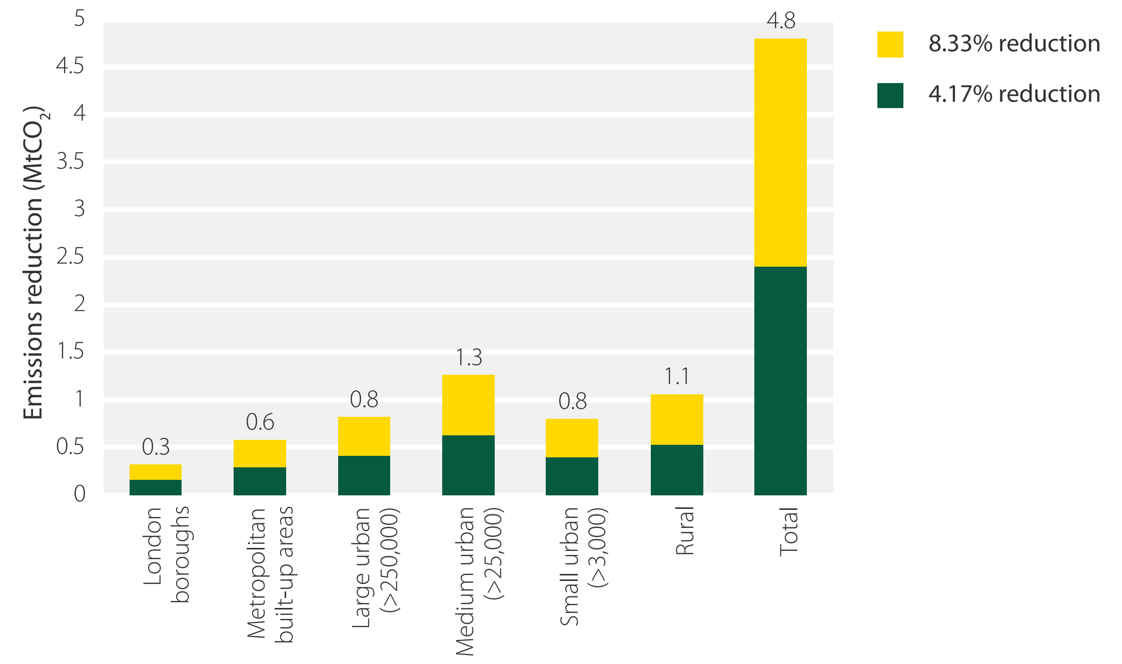
Box 6.16 Emissions reduction potential from Smarter Choices

The Sustainable Travel Towns evidence suggests that implementation of Smarter Choices reduced the number of car driver trips per person by 9% in Darlington and Peterborough, and by 7% in Worcester, or an average of 8.33% overall (Box 6.14). Evidence on the reduction in car mileage is not yet available, and in any case the Sustainable Travel Towns project does not include measures to target a reduction in longer distance trips.

In the absence of conclusive evidence on these effects we have examined the implications of both a reduction in car mileage that is equal to the reduction in car trips (i.e. 8.33%) and a reduction in mileage that is half as great as the reduction in car trips (i.e. 4.17%); the latter assumption is consistent with the DfT approach outlined in Box 6.13.

The figure below shows possible CO_2 emissions reductions for roll out of Smarter Choices in different types of settlements, totalling up to 2.4-4.8 $MtCO_2$.

Figure B6.16 Implications of reduction in total mileage from trips originating in different sizes of settlement



Source: CCC analysis.

In monitoring implementation of Smarter Choices, we note that emissions reductions ensue through reduced car emissions which in turn require reduced car miles. We will therefore track car miles to assess the extent to which these fall from trend as a result of demand-side measures (Figure 6.25).

(iii) Eco-driving indicators

In our December report we set out analysis showing that fuel efficiency can be significantly improved by adopting a smoother style of driving, with less aggressive use of accelerator and brake, even without reducing average or maximum speeds. We reviewed the evidence which suggests that adoption of these eco-driving techniques can improve average fuel efficiency by 5-10%.

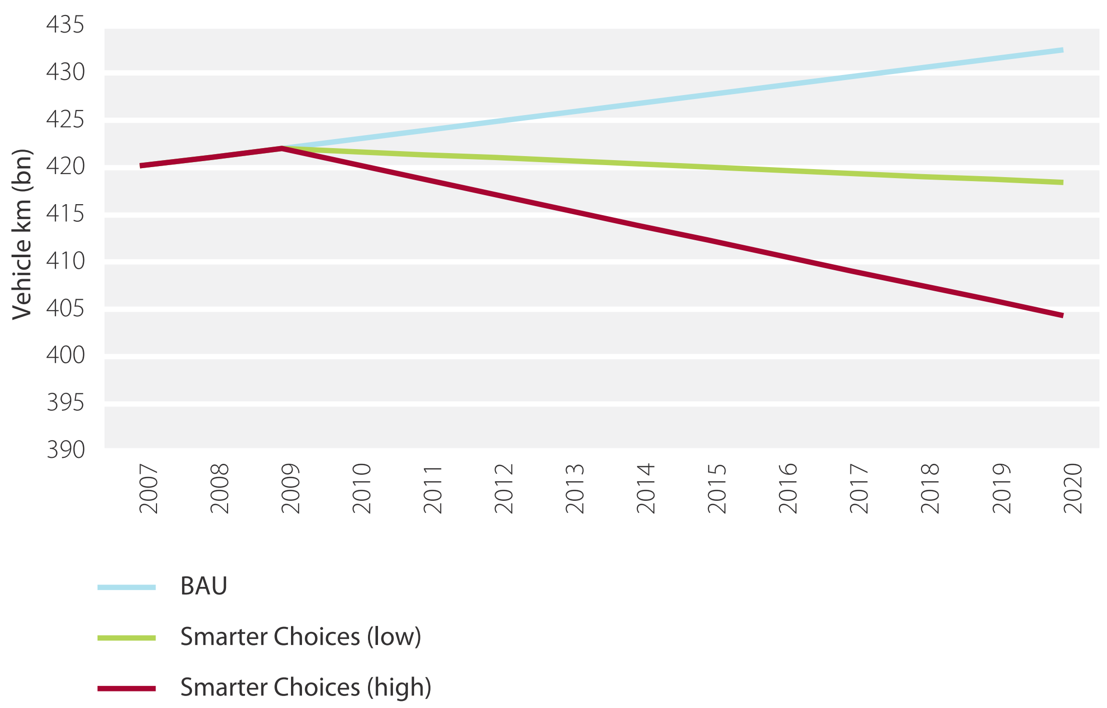
We reviewed survey evidence suggesting that a significant proportion of the population are willing to adopt eco-driving techniques in order to reduce fuel bills, and that there are various means in place for eco-driver training (e.g. through driving tests, measures aimed at the freight sector, etc.).

Under an assumption that up to 1% of all drivers are trained to eco-drive annually (which would require the roll-out of an ambitious, government-funded training programme), and that this results in a 3% reduction in fuel consumption, we estimated that emissions reduction of 0.3 $MtCO_2$ would be achievable in 2020. We also estimated that 1.0 $MtCO_2$ would be achievable given wider uptake (with 40% of car drivers adopting eco-driving behaviour by 2020).

DfT is currently funding the Smarter Driving programme, in which eco-driving training is delivered by the Energy Saving Trust (EST). The EST forecasts, however, that only 21,000 drivers will be trained in 2009-10. This is significantly less than the 350,000 drivers implied by our assumption that 1% of all drivers are trained annually, and it is not clear how the EST delivery mechanism could be sufficiently scaled up.

An alternative would be to target new drivers. From 10 September 2008, the UK driving test has included questions about eco-driving in the

Figure 6.25 Trend car mileage and potential reductions through demand-side measures



Source: DfT Projections; CCC.

theory part of the driving test. Whilst useful, the Committee believes that better training could be achieved through including eco-driving in the practical test, and proposes that this should be seriously considered. Effective testing of eco-driving as part of the driving test could have a significant impact given that 900,000 new driving licenses are awarded annually.

Given that driver training will be key in supporting uptake of eco-driving, however, we include this as the relevant variable in our wider set of transport indicators. In particular, we will monitor the number of drivers trained through (i) specific programmes (ii) driving tests.

At a higher level, we will also track emissions to assess whether there is any evidence of eco-driving (e.g. through emissions reductions over and above what would be expected due to reductions in the carbon intensity of cars – see Figure 6.26).

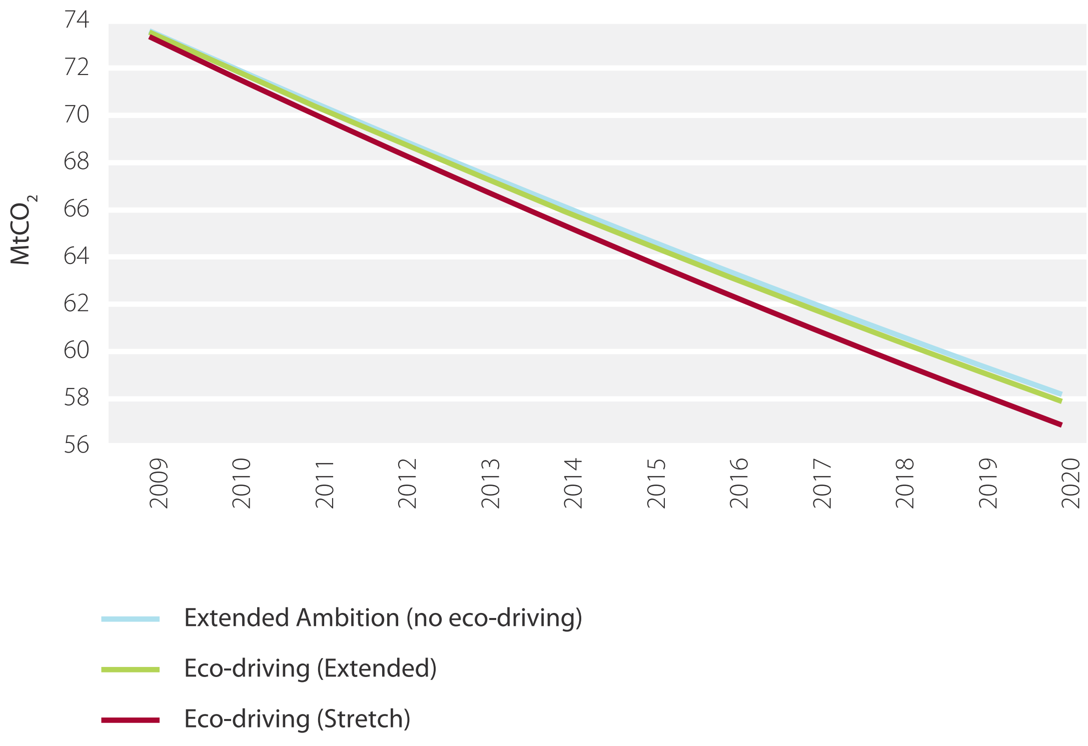
(iv) Enforcing the speed limit

We previously set out analysis showing that fuel efficiency falls significantly as vehicle speeds are pushed above optimal levels. A petrol car driven at 70 mph, for example, emits around 20% more CO_2 per km than when driven at 50 mph. A significant proportion of drivers currently exceed the speed limit on motorways and dual carriageways (Figure 6.27). This provides an opportunity for reducing emissions through limiting speed.

We estimate that there is a potential emissions reduction of 1.4 $MtCO_2$ through enforcing the existing 70 mph limit on motorways and dual carriageways, with an additional 1.5 $MtCO_2$ saving through reduction of the speed limit to 60mph (a total saving of 2.9 $MtCO_2$).

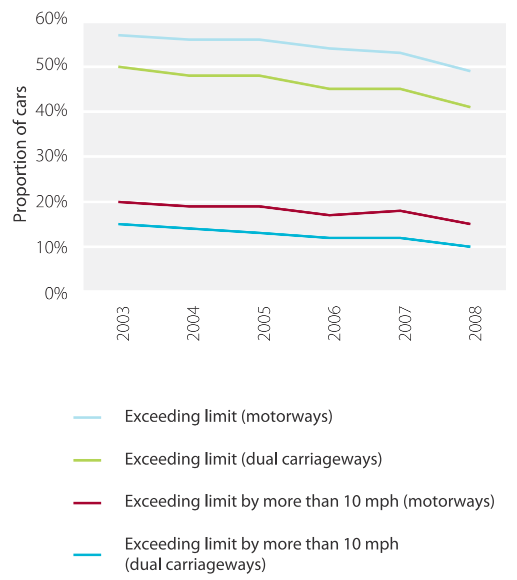
There are at least two means for enforcing the existing speed limit:

Figure 6.26 Emissions from cars in the Extended Ambition scenario with and without eco-driving



Source: DfT Projections; CCC.

Figure 6.27 Proportion of cars exceeding the speed limit on motorways and dual carriageways



Source: DfT (2009), *Road Statistics 2008: Traffic, Speeds and Congestion*; Table 4.2.

- Greater use of speed cameras or average speed controls
- Use of intelligent Speed Adaptation (ISA) technology.

Intelligent Speed Adaptation (ISA) is a system that provides a vehicle driver with information on the speed limit for the road on which the vehicle is being driven. The technology involved is similar to that for satellite navigation systems and is available in three forms:

- Advisory ISA, which displays the speed limit and warns the driver if the vehicle is being driven above the speed limit.
- Voluntary (overridable) ISA, which is as advisory ISA but is linked to the vehicle's engine management system to limit vehicle speed to the speed limit; can be overridden by the driver.
- Mandatory (non-overridable) ISA, which is as voluntary ISA but cannot be overridden by the driver.

Given that the 70 mph speed limit is an existing policy, the Committee believes that the Government should seriously consider enforcing this, either through the current enforcement mechanism, or through rolling out ISA technology to both new and existing cars.

We reflect enforcement of the 70 mph limit by including emissions reductions of 1.4 $MtCO_2$ in 2020 in our Extended Ambition scenario. We continue to include an additional emissions reduction from reducing the 70 mph speed limit to 60 mph in our Stretch Ambition scenario. We estimate an additional saving of 1.5 $MtCO_2$, which could be considered as an option if there were a shortfall in meeting budgets.

The Committee will therefore assess the extent of enforcement using DfT data to understand whether and how much current levels of speeding are reduced.

5. Integrated land use and transport planning

Evidence on land use and transport demand

In our December report we referred to the literature on the relationship between land use and emissions, and committed to consider this area in more detail. We noted that energy consumption for passenger transport varies according to the proportion of journeys made by different transport modes. We argued that new construction presents an opportunity to build from the start a pattern of transport activity associated with shorter journeys and less emitting modes.

We have now reviewed the evidence on land use and transport demand in more detail. There are various complexities and uncertainties which make it extremely difficult to quantify the potential scale of impacts, but the evidence bears out our hypothesis that land use planning will have potentially significant implications for transport emissions (Box 6.17):

Box 6.17: Effects of land use factors on the demand for car travel

A study using multiple regression to determine effects on car ownership and mode choice on land use characteristics based on data from the UK National Travel Survey collected in 1989/91 and 1999/2001 identified the following factors:

- Density: municipalities of population density greater than 40 persons/ha are associated with a 10% decrease in the share of distance travelled by car compared with municipalities of population density of 1-15 persons/ha.
- Size: London is associated with an 11% decrease in the share of distance travelled by car compared with municipalities with a population of 3,000-100,000. While this study does not identify a similar effect of settlement size for other municipalities of population greater than 100,000, it is likely that where towns are well connected to each other, larger towns are associated with lower levels of car travel.
- Bus frequency: areas with buses serving every quarter of an hour are associated with a 4% decrease in the share of distance travelled by car compared with areas with buses serving half hourly, and a 13% decrease compared with areas with less than one bus per hour.
- Walking distance to bus stop: areas over 13 minutes' walking distance to the nearest bus stop area are associated with a 9% increase in the share of distance travelled by car compared with areas 7-13 minutes to nearest bus stop.
- Walking distance to amenities: areas a 'short walk' to amenities are associated with a 6% decrease in the share of distance travelled by car compared with areas a 'medium walk' to amenities, and an 11% decrease compared with areas a 'long walk' to amenities.

Source: Dargay (2009). *Land Use and Mobility in Britain*.

Application to new residential development

This evidence has potentially important implications in the UK context given the ambitious programme of new housing development in the period to 2030:

- CLG projects that the number of UK households will increase from the current level of 21.5 million to around 27.8 million in 2030 (i.e. there will be an increase of 6.3 million households).
- The accommodate this growth, the Government has set a target to add two million new dwellings by 2016 and three million new dwellings by 2020.

It is difficult to provide precise estimates of the impact of new development on transport emissions, but we can be clear that – depending on how new developments are planned – these could be significant.

- In the absence of land use designations and other planning policy restrictions, a 'market' approach to the provision of new housing could result in patterns of development associated with very high levels of car travel and associated emissions.
- Planning and transport policy focusing new development within existing cities and large towns could therefore result in significant emissions reductions.
- We estimate that such a land use framework could deliver an emissions reduction of at least 2 $MtCO_2$ in 2020 and 3.6$MtCO_2$ in 2030 (Box 6.18).

This can be compared to the additional 0.7 $MtCO_2$[11] saving Government estimates the Zero Carbon Homes initiative would deliver on top of other policy measures in the residential sector in 2020. This suggests that transport emissions should be given at least as much consideration as residential emissions in the design of new development.

11 10.4Mt non-traded and 0.3Mt traded.

Box 6.18 Estimate of emissions reduction potential from land use policy

If three million new homes were to be located far from workplaces, this could result in significantly increased transport emissions. We have constructed an example to illustrate the possible order of magnitude of this impact. The table below shows emissions from commuting trips where different proportions of the population living in new houses commute between 10 and 25 miles to work. If one person from each of three million households were to commute this distance on a daily basis, the table shows that this could increase transport emissions by around 4.7 $MtCO_2$.

More detailed analysis of possible impacts from new housing development on transport emissions has been undertaken as part of the Sustainability Of Land Use and Transport In Outer Neighbourhoods (SOLUTIONS) project funded by the Engineering and Physical Research Council (EPSRC) (www.suburbansolutions.ac.uk), formed to examine factors relating to economic, social and environmental performance in planning towns and cities.

The SOLUTIONS project involved modelling the effects of concentrating future development in both the Wider South East (WSE), 50 miles around London, and the Tyne and Wear City Region (TWCR) in each of three spatial configurations:

- Compaction (concentrating development within existing settlements; public transport investment)
- Planned expansion (concentrating development at edge of settlements, within transport corridors, or in new settlements; highway and public transport investment)
- Market dispersal (allowing development with no land use zoning restrictions; highway investment).

The modelling suggests that the three spatial configurations would have the following effects on total car km in 2031, compared to 'trend' (development according to existing land use policy).

- Compaction: 3% reduction in the Wider South East and a 2% reduction in the Tyne and Wear City Region
- Planned expansion: neutral
- Market dispersal: 4% increase in the Wider South East and a 1.5% increase in the Tyne and Wear City Region.

These results reflect the change in car travel demand arising from all development (i.e. both existing and new development). The table below sets out the implications of these results for the effects of spatial configuration on car travel demand in new development only.

Table B6.18a the potential effect of longer car commuter trips from new dwellings by 2020

Proportion commuting 10-25 miles	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Total car commuter CO_2 (Mt)	1.3	1.7	2.1	2.4	2.8	3.2	3.6	3.9	4.3	4.7

Table B6.18b Effects of spatial configuration on car travel demand

	Increase in dwellings	Total car km change over trend		Effect of compaction over	
		Compaction	Market	Trend	Market
WSE	25%	-3%	4%	-12%	28%
TWCR	15%	-2%	2%	-15%	26%

Source: EPSRC (2009).

Box 6.18 continued

The total increase in dwellings over the period 2000-2031 is 25.4% in the Wider South East and 15% in the Tyne and Wear City Region. The modelled effects of the compaction and market configurations on total car travel (arising from both existing and new development) imply that in new development, compaction is associated with a 12-15% reduction in car travel compared with 'trend' and a 26-28% reduction compared with market dispersal.

The Government target of 3 million new dwellings in England by 2020 represents a 13.5% increase in the housing stock, implying that planning policy for new development has the potential to address an equal proportion of car km. Under the assumption that compaction could reduce total car travel by 26-28% of this 13.5% (around 3.6%), our projected car emissions of around 60MtCO_2 could be reduced by around 2MtCO_2.

Redesigning existing cities

Whilst significant, emissions reduction potential from location of new homes in cities and towns is limited by the fact that these only account for a small proportion of the population; 99% of existing homes will still exist in 2020 and these will form around 90% of the housing stock. Even by 2030, existing homes are likely to account for around 80% of the total.

The evidence reported above about settlement size, population density, proximity of homes to shops and work places and public transport suggests that there may be an opportunity to reduce transport emissions by changing land use and public transport infrastructure in existing cities. This is borne out by both national and international city specific evidence, which shows a wide range of car use for cities with different characteristics (Box 6.19).

This raises questions over whether there is scope for changing design of existing urban areas to reduce car use and emissions. Clearly it is not feasible to knock down existing cities and rebuild these to encourage shorter journeys and increased public transport use. There are, however, a number of land use and transport planning levers available in principle that would result in reduced car emissions:

- Planning measures to encourage significant urban regeneration over the next two decades in a manner to support less carbon intense transport choices.
- Planning measures to support shopping developments in towns or cities rather than in out of town locations (Box 6.20).
- Network and pricing measures to improve the cost and convenience of public transport relative to private transport.
- Smarter Choices measures to leverage planning and network measures, providing better information and encouraging travel by public transport.
- Public transport infrastructure investment (e.g. in modern tram systems) to change the relative costs of public versus private transport.
- Transport investment appraisal that fully account for carbon impacts of investment in new transport infrastructure (e.g. roads, high speed rail lines).
- Planning measures addressing any barriers to delivery of infrastructure to support roll-out of electric cars.

As far as the Committee is aware, there is not comprehensive evidence on the emissions impacts and economics of these measures in the UK context. Changing the building stock and enhancing public transport infrastructure, for example, would require significant investment which may or may not be justified given increasing penetration of low-carbon vehicles.

Greater clarity would be desirable given the potentially significant emissions reduction that may be available, and could be provided as part of developing the integrated approach to land use planning and transport.

Box 6.19 International and national city specific evidence

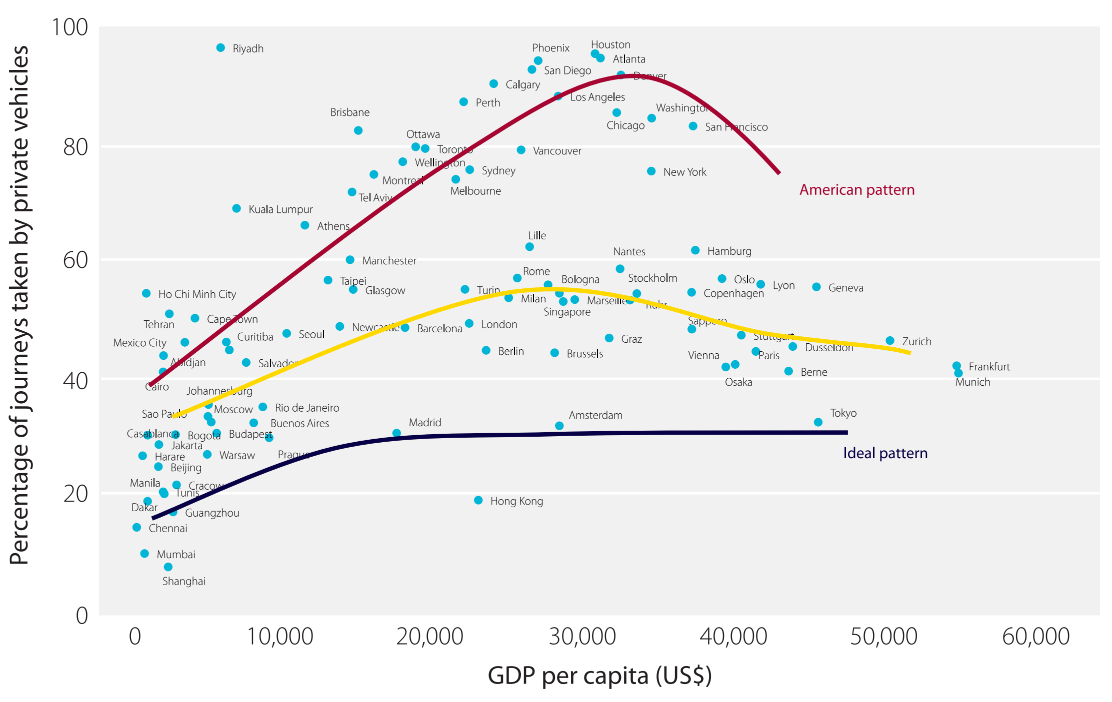
The figure below demonstrates the great variation in levels of private car use in cities across the world. For any given level of prosperity several patterns of car use can be identified.

For example, while the New York tri-state and Tokyo areas possess many similar characteristics, they have significantly different levels of car use, as shown in the table below.

Outside Manhattan, the majority of the urbanised New York tri-state area consists of relatively low-density neighbourhoods in the other New York City boroughs and the surrounding states of New York, Connecticut and New Jersey, and overall levels of car use are far higher than in major European and Asian cities (Figure).

In contrast, Tokyo has one of the lowest levels of car use of the major world cities. While levels of road infrastructure and public transport provision are similar to those in the New York tri-state area, there are also some major differences. First, Tokyo has much higher population density. Second, it has lower levels of parking provision. Third, traffic speeds are lower in Tokyo, so that the average speed of public (rail and metro) transport exceeds that of general road traffic.

Figure B6.19 Use of private and public transport in cities of varying prosperity levels



Source: IEA (2008); International Association of Public Transport (2006).

Box 6.19 continued

Table B6.19 Spatial and transport characteristics of New York tri-state and Tokyo areas

	New York tri-state area	Tokyo
GDP per capita (2008$)	34,000	45,000
Population of urbanised area	19 million	33 million
Proportion of jobs in the Central Business District	21%	14%
Average trip length	12km	11km
Total urbanised area	11,000	4,000
Population density of urbanised area	1,804	8,768
Length of road network per 1,000 residents	4,900	4,000
Average traffic speed	39kph	26kph
Formal parking spaces per 1,000 CBD jobs	66	40
Length of metro system per million residents	93km	92km
Percentage of journeys taken by private vehicles	75%	32%

Source: IEA (2008); IAPT (2006); CfIT (2005); CLG.

While UK cities do not generally demonstrate the same variability in levels of car use as can be observed in the international evidence, there is nevertheless a significant difference between cities with the lowest and highest levels of car use:

- Cambridge (population 109,000) has the lowest level of car use of any UK city outside London, with 41.2% of residents travelling to work by car. It is likely that the Cambridge Core Traffic Scheme (Box 6.13) has contributed to this.
- Other cities with similar populations to Cambridge – Brighton (population 307,000), York (181,000), Hull (244,000), Newcastle (795,000) and Ipswich (117,000) – have higher car use, with 50-60% of residents travelling to work by car.
- At the other extreme, Milton Keynes (population 207,000) has among the highest at 71%. Milton Keynes was developed as a New Town in the 1960s, and designed specifically to accommodate high levels of car use. Population density is very low at around 5.3 people per hectare, and the city road system is laid out in a grid pattern, with roads at the national speed limit.

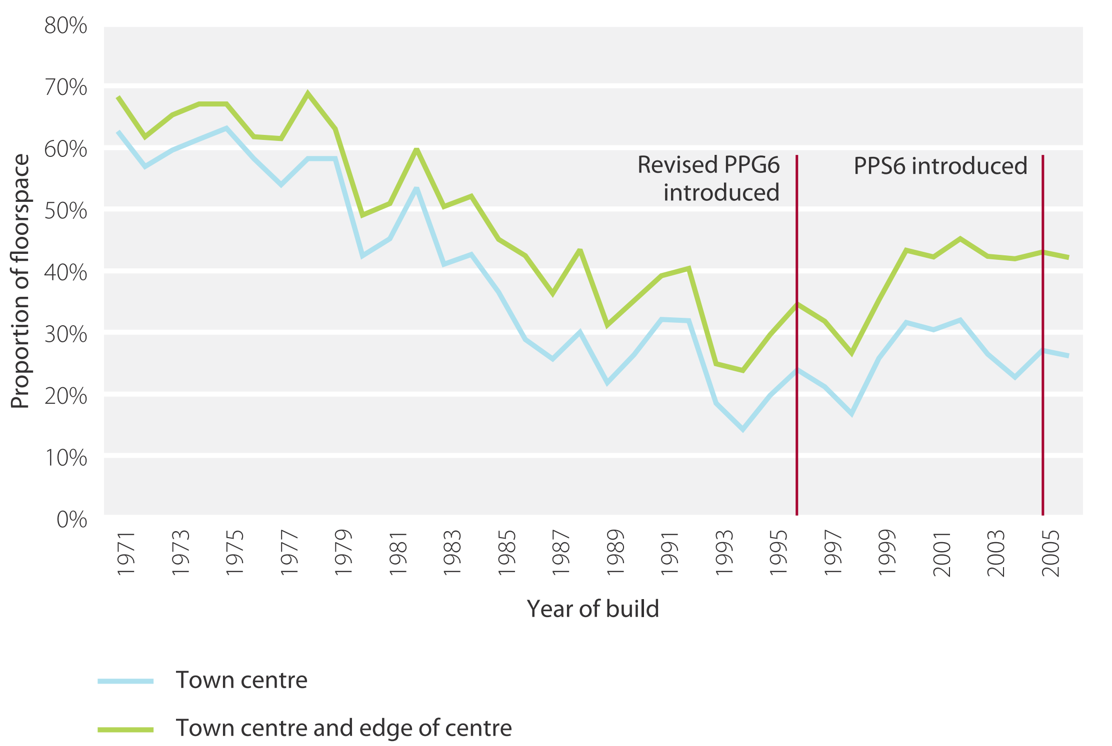
Box 6.20 Government planning policy on out of town retail development

Planning policy since the mid 1980s resulted in the rapid growth of out of town retail development, such that by 1994 only 14% of new retail floorspace was located in town centre locations, and a total of less than 25 per cent in both town centre and edge of centre locations (figure).

This trend has been partially reversed since the introduction of new planning guidance setting out a policy objective of promoting vital and viable town centres through a 'town centre-first' policy (Planning Policy Guidance Note 6: Town Centres and Retail Developments introduced in 1996, replaced by Planning Policy Statement 6 in March 2005). By 2006 the proportion of new retail development located in town centre and edge of centre locations had risen to 42%, with 78% of new of shopping centres located within the town centre, and 85% at edge of centre.

However, significant new retail development continues to be located out of town and in edge-of-centre locations, in particular supermarkets (23% within the town centre, 50% at edge of centre), and retail warehouses (7% within the town centre, 50% at edge of centre).

Figure B6.20 Proportion of new build retail floorspace in town centres 1971-2006



Source: CLG; Valuation Office Agency.

An integrated approach to land use planning and transport

It is not clear that incentives under current land use and transport planning systems attach sufficient weight to transport emissions. At a high level, much planning guidance acknowledges that it may be desirable to constrain transport emissions. In practice, however, there is sufficient flexibility such that other factors may take priority over transport emissions. There is a risk, therefore, that development of both existing and new areas does not unlock emissions reductions, and that the design of new transport schemes pays insufficient attention to their implications for emissions and land use (Box 6.21).

The Committee's view is that a new approach to planning that fully accounts for transport emissions should be developed:

- Barriers to urban development should be addressed.
- Planning decisions should incorporate consideration of all transport emissions (e.g. commuting, leisure and shopping trips within developments and between developments and other areas).
- Transport policies should be designed to reinforce this planning approach (e.g. through network measures, Smarter Choices to address commuting journeys, etc.).
- Possible investment in public transport infrastructure should be further considered.

The first step in developing this approach is to develop an integrated planning and transport strategy. The Committee believes that such a strategy should be developed as a priority in order to inform planning decisions around the ambitious home building programme over the coming years and to allow unlocking of emissions reduction potential in a timely manner.

Box 6.21 Campaign for Better Transport assessment of regional priorities under Regional Funding Advice

It is widely accepted that the influence of pure land use policy on decreasing the demand for car travel depends strongly on the degree to which broader transport measures are aligned with this objective. Investment in public transport services and walking and cycling provision, which increase the relative attractiveness of these modes, would strengthen the effectiveness of land use policy in reducing car travel. Equally, highway investment to increase capacity for private vehicles, which increases the relative attractiveness of car travel, would weaken the effectiveness of land use policy in reducing car travel.

A review of transport scheme funding priorities of the English regions undertaken by the Campaign for Better Transport suggests that highway schemes tend to be prioritised over public transport schemes, even when the latter are shown to be both more compatible with national and regional policy objectives, and more cost-effective.

The Campaign for Better Transport's review of the Regional Funding Advice (a process through which regions advise the Government on their long-term investment priorities in transport, housing and other areas) highlights the following concerns:

- Schemes are prioritised which conflict with national and regional environmental and transport policy objectives.
- Schemes are prioritised despite having no assessment, or inadequate assessment, of their carbon impacts despite the instruction to do so in the Regional Funding Advice guidance. While most regions failed to compare the greenhouse gas emissions of individual options, some incorrectly treated schemes where carbon impacts were not assessed as carbon neutral, thus penalising those schemes where such information was provided.
- Schemes which are considered to carry risks to deliverability on time and to budget are prioritised over alternative public transport options which are considered to be more readily deliverable.
- In many cases there did not appear to be a systematic consideration of the full range of possible alternatives that could be taken forward as the solution to the transport problem, such that public transport options that might have delivered better solutions were not considered. Independent analysis frequently confirmed that alternative options performed better and were more cost effective than the proposed scheme.

The dominance of highway schemes in transport investment suggests that planning policy and practice for transport and land use may not be sufficiently integrated to deliver real reductions in the demand for car travel.

Source: Campaign for Better Transport (2009).

6. Summary of transport indicators

Our indicators of progress in reducing transport emissions (Table 6.3) include the following categories:

- Transport sector emissions and emissions intensities;
- Indicators relating to the measures that have to be implemented (e.g. penetration of biofuels, penetration of electric cars, etc.);
- Policy milestones required to be met for appropriate enabling frameworks to be in place (e.g. development of large scale EV pilots, roll-out of Smarter Choices, etc.).

Table 3.4 Transport indicators

Road Transport		Budget 1	Budget 2	Budget 3
Headline indicators				
Direct emissions (% change on 2007)	Total	-11%	-19%	-29%
	Car	-17%	-24%	-37%
	Van	11%	16%	14%
	HGV	-13%	-16%	-19%
gCO_2/km (carbon intensity of a vehicle kilometre)	Car	152	132	104
	Van	247	226	196
	HGV	743	687	639
Vehicle-km billions	Car	421	419	420
Supporting indicators				
Vehicle technology				
New vehicle gCO_2/km	Car	142	110	95 (by 2020)
New electric cars registered each year (value at end of Budget period)		11,000	230,000	550,000
Stock of electric cars in vehicle fleet		22,000	640,000 (240,000 delivered through pilot projects in 2015)	2.6 million (1.7 million by 2020)
Biofuels				
Penetration of biofuels (by volume)		4.5%	7.9%	10.0%
Decision on whether future biofuels target can be met sustainably		2011/12		

Table 3.4 continued

Road Transport	Budget 1	Budget 2	Budget 3
Demand side measures			
Proportion of drivers exceeding 70mph		0%*	0%
Car drivers who have undergone eco driving training	1,050,000	2,800,000	4,550,000
Smarter Choices – demonstration in a city and development plan for roll out if successful, demonstration in rural areas and demonstration targeting longer journeys	2010		
Smarter Choices – phased roll out to towns	2010		Complete
Development of integrated planning and transport strategy	2011		
Other drivers			
*Fuel pump prices, Fuel duty, Proportion of new car sales that are 'best in class', Proportion of small/medium/ large cars, Van and HGV km (vehicle/tonne)**, Petrol/diesel consumption, Surface transport modal split, Average speed of drivers exceeding 70mph*			
*Agreement of modalities for reaching an EU target of 95 gCO_2/km target and strong enough penalties to deliver the target, New Car CO_2 in EU, New Van and HGV gCO_2/km***, Number of EV car models on market, Developments in battery and hydrogen fuel cell technology, Battery costs*			
Successful conclusion of EU work on Indirect Land Use Change/development of accounting system for ILUC and sustainability			
Number of households and Car ownership by household, Cost of car travel vs. cost of public transport, Funding allocated to and percentage of population covered by Smarter Choices initiatives†, Proportion of new retail floorspace in town centre/edge of centre locations, Ratio of parking spaces to new dwellings on annual basis			

Note: Numbers indicate amount in last year of budget period i.e. 2012, 2017, 2022.
* These are the values implied by the estimated savings from speed limiting. CCC recognise that in practice it is impossible to achieve zero speeding. However, as close to zero as practicable is required to achieve the greatest carbon savings.
** We will include van and HGV km travelled in our headline indicators following new work on freight for our 2010 report.
*** We aim to include new van and HGV gCO_2/km in our indicator set as the available monitoring data improves
† Our initial recommendation is for phased roll-out of Smarter Choices to further establish emissions reduction potential. If initial roll-out proves successful, our subsequent recommendation would be for national roll-out. We would then need to monitor population covered and also total expenditure to verify sufficient coverage and intensity. Once national roll-out is underway and suitable data sources are identified, population covered and total expenditure will be included in our set of supporting indicators.

Key: Headline indicators | Implementation Indicators | Milestones | Other drivers

Future work of the Committee

The Committee is required either under the Climate Change Act 2008 or at the request of Government to produce a number of reports over the next year including:

UK aviation emissions review: the Committee was requested by the UK Government to review UK aviation emissions and recommend how these can be reduced to meet the target that emissions in 2050 will be no more than 2005 levels. The Committee will report back in December 2009.

Advice to the Scottish Government on emissions reduction targets. The Committee has agreed to a request by the Scottish Government to advise on appropriate Scottish emissions reduction targets, and will report back in February 2010.

Annual report to Parliament: the Committee's second annual report to Parliament is required in June 2010. This will include an assessment of progress reducing emissions to meet budgets. It will also report any new analysis, particularly as regards scope for reducing agriculture emissions.

Advice on the second phase Carbon Reduction Commitment (CRC) cap: The Low Carbon Transition Plan noted the Government's request that the Committee advise on the CRC cap in 2010. The Committee will report back on this at a date to be determined in 2010, possibly in conjunction with the annual progress report.

A review of UK low carbon R&D: this has been requested by the Government's Chief Scientist. It will cover technologies to be supported, support mechanisms and the institutional framework. The Committee will report back in summer 2010.

Advice on the fourth budget (2023-27): the Committee is required under the Climate Change Act to advise on the appropriate level of the fourth carbon budget by the end of 2010. In undertaking this work, the Committee will consider any new scientific evidence, appropriate global trajectories, UK contributions, and emissions reduction opportunities. This work will include consideration of outcomes from Copenhagen including implications for moving from the Interim to Intended budgets.

Glossary

Achievable Emissions Intensity
The minimum average annual emissions intensity 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, particularly waste, material in the absence of oxygen. Produces a methane-rich biogas that can substitute for fossil fuels.

Best Available Technology
The latest stage of development of a particular technology (or e.g. a process or operating method) that is practically suitable for deployment.

Biofuel
A fuel derived from recently dead biological material and used to power vehicles (can be liquid or gas). Biofuels are commonly derived from cereal crops but can also be derived from dead animals, trees and even algae. Blended with petrol and diesel biofuels it can be used in conventional vehicles.

Biogas
A fuel derived from recently dead biological material which can be burned in a generator or a CHP plant, or upgraded to biomethane for injection into the gas grid.

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.

Carbon Capture and Storage (CCS)
Technology which involves capturing the carbon dioxide emitted from burning fossil fuels, transporting it and storing it in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

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 amount of carbon dioxide emission that would give rise to the same level of radiative forcing, integrated over a given time period, as a given amount of well-mixed greenhouse gas emission. For an individual greenhouse gas species, carbon dioxide equivalent emission is calculated by multiplying the mass emitted by the Global Warming Potential over the given time period for that species. Standard international reporting processes use a time period of 100 years.

Carbon Emissions Reduction Target (CERT)
CERT is an obligation on energy supply companies to implement measures in homes that will reduce emissions (such as insulation, efficient lightbulbs or appliances).

Carbon Reduction Commitment (CRC)
A mandatory carbon reduction and energy efficiency scheme for large non-energy intensive public and private sector organisations. CRC will capture CO_2 emissions not already covered by Climate Change Agreements and the EU Emissions Trading System and will start in April 2010.

Clean Development Mechanism (CDM)
UN-regulated scheme which allows credits to be issued from projects reducing GHG gases in Kyoto non-Annex 1 countries (developing countries).

Climate Change Levy (CCL)
A levy charged on the industrial and commercial supply of electricity, natural gas, coal and coke for lighting, heating and power.

Combined Cycle Gas Turbine (CCGT)
A gas turbine generator that generates electricity. Waste heat is used to make steam to generate

additional electricity via a steam turbine, thereby increasing the efficiency of the plant.

Combined Heat and Power (CHP)
The simultaneous generation of heat and power, putting to use heat that would normally be wasted. This results in a highly efficient way to use both fossil and renewable fuels. Technologies range from small units similar to domestic gas boilers to large scale CCGT or biomass plants which supply heat for major industrial processes.

Company car tax
A tax applied where because of their employment, a car is made available to and is available for private use by a director or an employee earning £8,500 a year or more, or to a member of their family or household. This tax is based on the CO_2 performance of the car.

Contracts for Difference
A contract between a buyer and a seller, stipulating that the seller will pay to the buyer the difference between the current value of an asset and its value at contract time

Derated capacity
Electricity plant capacities expressed in terms of their average plant availability during peak demand (rather than in terms of their maximum potential output).

Discount rate
The rate at which the valuation of future costs and benefits decline. It reflects a number of factors including a person's preference for consumption now over having to wait, the value of an extra £1 at different income levels (given future incomes are likely to be higher) and the risk of catastrophe which means that future benefits are never enjoyed. For example the Social Discount Rate (3.5%) suggests future consumption of £1.035 next year is equivalent in value to £1 today. Discount rates in the private sector generally reflect the real cost of raising capital, or the real interest rate at which consumers can borrow.

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 (i.e. without an internal combustion engine) fuelled by battery power.

Emissions Performance Standard
A CO_2 emissions performance standard would entail regulation to set a limit on emissions per unit of energy output. This limit could be applied at plant level, or to the average emissions intensity of a power company's output.

Energy Efficiency Commitment (EEC)
The predecessor of the CERT, and a type of Supplier Obligation.

Energy intensity
A measure of total primary energy use per unit of gross domestic product.

Energy Performance Certificate (EPC) The certificate provides a rating for residential and commercial buildings, showing their energy efficiency based on the performance of the building itself and its services (such as heating and lighting). EPCs are required whenever a building is built, sold or rented out.

Energy Unserved
The amount of demand within each year that cannot be met due to insufficient supply

European Union Allowance (EUA)
Units corresponding to one tonne of CO_2 which can be traded in the EU ETS.

European Union Emissions Trading Scheme (EU ETS)
Cap and trade system covering the power sector and energy intensive industry in the EU.

Fast-charging
A process of charging a battery quickly by delivering high voltages to the battery

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.

Fuel Duty
A tax on petrol and diesel. In May 2008, the UK tax was £0.55 per litre for diesel and £0.52 for unleaded petrol.

Fuel Poverty
A fuel poor household is one that needs to spend in excess of 10% of household income on all fuel use in order to maintain a satisfactory heating regime.

Full hybrid
A vehicle powered by an internal combustion engine and electric motor that can provide drive train power individually or together.

Funded Decommissioning Programme (FDP)
A plan developed by operators to tackle back-end waste and decommissioning costs of nuclear power stations.

Generic Design Assessment (GDA)
Generic Design Assessment (GDA), also known as pre-licensing, is intended to ensure that the technical aspects of designs for nuclear power plants are considered ahead of site-specific license applications.

Global Warming Potential (GWP)
A metric for comparing the climate effect of different greenhouse gases, all of which have differing lifetimes in the atmosphere and differing abilities to absorb radiation. The GWP is calculated as the integrated radiative forcing of a given gas over a given time period, relative to that of carbon dioxide. Standard international reporting processes use a time period of 100 years.

GLOCAF
The Global Carbon Finance model was developed by the Office of Climate Change to looks at the costs to different countries of moving to a low carbon global economy, and the kind of international financial flows this might generate.

Greenhouse Gas (GHG)
Any atmospheric gas (either natural or anthropogenic in origin) 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, hence it is commonly called the Greenhouse Effect.

Gross Domestic Product (GDP)
A measure of the total economic activity occurring in the UK.

Gross Value Added (GVA)
The difference between output and intermediate consumption for any given sector/industry.

Gt
A gigatonne or 1000 million tonnes.

GWh (Gigawatt hour)
A measure of energy equal to 1000 MWh.

Heat pumps
Can be an air source or ground source heat pump to provide heating for buildings. 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.

Heavy Good Vehicle (HGV)
A truck over 3.5 tonnes (articulated or rigid).

Infrastructure Planning Commission
A new body established by the Planning Act (2008) to take decisions on planning applications for major infrastructure projects

Integrated gasification combined-cycle (IGCC)
A technology in which a solid or liquid fuel (coal, heavy oil or biomass) is gasified, followed by use for electricity generation in a combined-cycle power plant. It is widely considered a promising electricity generation technology, due to its potential to achieve high efficiencies and low emissions.

Intergovernmental Panel on Climate Change (IPCC)
The IPCC was formed in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).

It is designed to assess the latest scientific, technical and socio-economic literature on climate change in an open and transparent way which is neutral with respect to policy. This is done through publishing a range of special reports and assessment reports, the most recent of which (the Fourth Assessment Report, or AR4) was produced in 2007.

Justification
The concept of Regulatory Justification is based on the internationally accepted principle of radiological protection that no practice involving exposure to ionising radiation should be adopted unless it produces sufficient net benefits to the exposed individuals, or society, to offset any radiation detriment it may cause. This principle is derived from the recommendations of the International Commission on Radiological Protection (ICRP) and included in the European Council Directive 96/29/Euratom 13 May 1996 which sets the basic safety standards for protecting the health of workers and the general public against dangers arising from ionising radiation

kWh (Kilowatt hour)
A measure of energy equal to 1000 Watt hours. A convenient unit for consumption at the household level.

Kyoto gas
A greenhouse gas covered by the Kyoto Protocol.

Kyoto Protocol/Agreement
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. Gases covered by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Levelised cost
Lifetime costs and output of electricity generation technologies are discounted back to their present values to produce estimates of cost per unit of output (e.g. p/kWh).

Life-cycle
Life-cycle assessment tracks emissions generated and materials consumed for a product system over its entire life-cycle, from cradle to grave, including material production, product manufacture, product use, product maintenance and disposal at end of life. This includes biomass, where the CO_2 released on combustion was absorbed by the plant matter during its growing lifetime.

Light Goods Vehicle (LGV)
A van (weight up to 3.5 tonnes; classification N1 vehicle).

Lithium-ion batteries
Modern batteries with relatively high energy storage density. Presently used widely in mobile phones and laptops and likely to be the dominant battery technology in the new generation of plug-in hybrid and battery electric vehicles.

Marginal Abatement Cost Curve
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.

MARKAL
Optimisation model that can provide insights into the least-cost path to meeting national emissions targets over the long-term.

Micro hybrid
Vehicle engine with stop start and capable of regenerative braking.

Mild Hybrid
An internal combustion engine which can be assisted by an electric motor when extra power is needed, but where the electric motor cannot power the vehicle independently.

Mitigation
Action to reduce the sources (or enhance the sinks) of factors causing climate change, such as greenhouse gases.

$MtCO_2$
Million tonnes of Carbon Dioxide (CO_2).

MWh (Megawatt hour)
A measure of energy equal to 1000 KWh.

National Atmospheric Emissions Inventory (NAEI)
Data source compiling estimates of the UK's emissions to the atmosphere of various (particularly greenhouse) gases.

National Balancing Point (NBP)
A measure of the wholesale price of gas in the UK (measured in p/therm or p/kWh).

National Policy Statement (NPS)
The Government would produce National Policy Statements (NPS) that would establish the national case for infrastructure development and set the policy framework for the Infrastructure Planning Commission (IPC) to take decisions.

Non-powertrain
Relating to parts of a vehicle that are not components of the engine or transmission

Offset credits
Credits corresponding to units of abatement from projects, such as those generated under the Kyoto treaty's project based flexibility mechanisms, Joint Implementation (JI) and Clean Development Mechanism (CDM).

Ofgem (Office of Gas and Electricity Markets)
The regulator for electricity and downstream gas markets.

Plug-in Hybrid
A full hybrid vehicle with additional electrical storage capacity which can be charged from an external electrical source such as mains supply.

Powertrain
Relating to the engine and transmission of a vehicle

Pre-Industrial
The period before rapid industrial growth led to increasing use of fossil fuels around the world. For the purposes of measuring radiative forcing and global mean temperature increases, 'pre-industrial' is often defined as before 1750.

Pumped storage
A technology which stores energy in the form of water, pumped from a lower elevation reservoir to a higher elevation. Lower cost off-peak electric power is generally used to run the pumps. During periods of high electrical demand, the stored water is released through turbines.

Renewable Energy Strategy (RES)
Strategy to promote renewable energy to meet its 2020 target. Published in 2009 by DECC.

Renewable Heat Incentive (RHI)
Will provide financial assistance to producers (householders and businesses) of renewable heat when implemented in April 2011.

Renewables
Energy resources, where energy is 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. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated.

Reserved powers
Policy areas governed by the UK Government. Also refers to 'excepted' matters in the case of Northern Ireland.

Rising Block Tariff (RBT)
Energy is priced at a low initial rate up to a specified volume of consumption, and then the unit price increases as consumption increases.

Security of supply
The certainty with which energy supplies (typically electricity, but also gas and oil) are available when demanded.

Standard Assessment Procedure (SAP)
UK Government's recommended method for measuring the energy rating of residential dwellings. The rating is on a scale of 1 to 120.

Strategic Siting Assessment (SSA)
The Government is undertaking a process called Strategic Siting Assessment (SSA), to identify sites that are suitable or potentially suitable for the deployment of new nuclear power stations by the end of 2025, which includes assessing the sites against set criteria. These sites will be included in a National Policy Statement. **Smart meters**
Advanced metering technology that allows suppliers to remotely record customers' gas and electricity use. Customers can be provided with real-time information that could encourage them use less energy, (e.g. through display units).

Smarter Choices
Smarter Choices are techniques to influence people's travel behaviour towards less carbon intensive alternatives to the car such as public transport, cycling and walking by providing targeted information and opportunities to consider alternative modes.

Social Tariff
An energy tariff where vulnerable or poorer customers pay a lower rate.

Solar photovoltaics (PV)
Solar technology which uses the sun's energy to produce electricity.

Solar thermal
Solar technology which uses the warmth of the sun to heat water to supply hot water in buildings.

Stop start
Vehicle engine with automated starter motor.

Technical potential
The theoretical maximum amount of emissions reduction that is possible from a particular technology (e.g. What would be achieved if every cavity wall were filled). This measure ignores constraints on delivery and barriers to firms and consumers that may prevent up take.

Tidal range
A form of renewable electricity generation which uses the difference in water height between low and high tide by impounding water at high tide in barrages or lagoons, and then releasing it through turbines at lower tide levels.

Tidal stream
A form of renewable electricity generation which harnesses the energy contained in fast-flowing tidal currents.

TWh (Terawatt hour)
A measure of energy equal to 1000 GWh or 1 billion kWh. Suitable for measuring very large quantities of energy - e.g. annual UK electricity generation.

United Nations Framework Convention on Climate Change (UNFCCC)
Signed at the Earth Summit in Rio de Janeiro in 1992 by over 150 countries and the European Community, the UNFCCC has an ultimate aim of 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.'

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).

Abbreviations

AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
BETTA	British Electricity Trading and Transmission Arrangements
BIS	Department for Business, Innovation and Skills
BWEA	British Wind Energy Association
CCA	Climate Change Agreement
CCC	Committee on Climate Change
CCGT	Combined-Cycle Gas Turbine
CCL	Climate Change Levy
CCP	Climate Change Programme
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CERT	Carbon Emissions Reduction Target
CHP	Combined Heat and Power
CLG	Department for Communities and Local Government
CRC	Carbon Reduction Commitment
DEC	Display Energy Certificate
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DUKES	Digest of UK Energy Statistics
EC	European Commission
EEC	Energy Efficiency Commitment
ENSG	Electricity Network Strategy Group
EPC	Energy Performance Certificate
EST	Energy Saving Trust
EU ETS	European Union Emissions T rading Scheme
EUA	European Union Allowance
EV	Electric Vehicle
EWP	Energy White Paper
FDP	Funded Decommissioning Programme
FEED	Front-End Engineering Design
FIT	Feed-in Tariff
G8	Group of 8 main industrialised countries
GDA	Generic Design Assessment
GHG	Greenhouse Gas
GLOCAF	Global Carbon Finance Model
GSHP	Ground Source Heat Pump
GVA	Gross value added
GWP	Global Warming Potential
HESS	Heat and Energy Saving Strategy
HGV	Heavy duty vehicle
ICAO	International Civil Aviation Organisation
ICT	Information and Communication Technologies
IEA	International Energy Agency
IMO	International Maritime Organisation
IPC	Infrastructure Planning Commission
IPCC	Intergovernmental Panel on Climate Change
ISA	Intelligent Speed Adaptation

LDV	Light duty vehicle
LULUCF	Land Use, Land Use Change and Forestry
MACC	Marginal Abatement Cost Curve
MPP	Major Power Producer
MS	Member State
MTOE	Million Tonnes of Oil Equivalent
NAEI	National Atmospheric Emissions Inventory
NAIGT	New Automotive Innovation and Growth Team
NETA	New Electricity Trading Arrangements
NG	National Grid
NPS	National Policy Statement
NTM	National Transport Model (DfT)
NTS	Non-Traded Sector
OFTO	Offshore Transmission Owner
OLEV	Office for Low Emission Vehicles
PHEV	Plug-In Hybrid Electric Vehicle
PV	Photovoltaic
RBT	Rising Block Tariff
RHI	Renewable Heat Incentive
RO	Renewable Obligation
ROC	Renewable Obligations Certificate
RP	Redpoint
RTFO	Renewable Transport Fuel Obligation
SAP	Standard Assessment Procedure
SMEs	Small & Medium Enterprises
SMMT	Society of Motor Manufacturers and Traders
	Supplier Obligation
SSA	Strategic Siting Assessment
UEP	Updated Energy Projections
UKERC	UK Energy Research Centre
UNFCCC	United Nations Framework Convention on Climate Change
VED	Vehicle Excise Duty

Designed by Bell Design www.belldesign.co.uk