Building a low-carbon economy –
The UK's contribution to tackling climate change

The First Report of the Committee on Climate Change
December 2008

Executive Summary

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FOREWORD

The Committee on Climate Change was appointed in 'shadow' form in March 2008, becoming a statutory committee on 1st December 2008 when the Climate Change Bill became law. Its core function is to recommend what the level of the UK's 'carbon budgets' should be. These budgets are established by the Climate Change Act and will define the maximum level of CO_2 and (potentially) of other greenhouse gases (GHG) which the UK will emit in each 5 year budget period, beginning with 2008-12.

The Climate Change Act requires the Government to gain Parliament's approval to a proposed level for the next three budgets, setting a trajectory of UK CO_2/GHG emissions over the next 15 years. The Committee is required to make recommendations on this basis.

This first report of the Committee on Climate Change therefore recommends UK carbon budgets for the three periods 2008-12, 2013-17 and 2018-22. In addition, it covers issues on which we are required to report by the Climate Change Act, or on which we have been asked by the Secretary of State to provide our opinion. These include:

- What should be the target for UK emissions reduction by 2050?
- Whether budgets should cover CO_2 emissions, or all greenhouse gas (GHG) emissions, including the relevant non- CO_2 gases
- How far CO_2/GHG emissions reduction should be achieved by domestic UK action, and what reliance on emissions reduction credits bought from other countries is acceptable?
- Whether and how international aviation and shipping should be included in the UK's targets and budgets
- And the implications of our recommended budgets for economic growth, energy security, the competitiveness of particular industrial sectors, fuel poverty, and for specific regions and devolved administrations.

The Committee's recommendations on the first of these issues – the target for 2050 – have already been presented in a letter to the Secretary to State delivered on 7th October 2008. We recommended that the UK should commit to reducing its GHG emissions by at least 80% below 1990 levels by 2050.

Part I of this Report sets out the detailed analysis which underpins that recommendation. Part II sets out our recommendations on the level of the first three budgets and the extent to which these should be addressed via domestic action versus through the purchase of bought-in credits from other countries. Part III explains our proposed approach to international aviation and shipping and to non-CO_2 gases, and Part IV covers wider economic and social considerations.

The essential task of the Committee can be summed up as providing advice on how fast the UK can and should progress towards a low-carbon economy and how it achieves that progress. In developing that advice, we have had to asses the technologies that are or might be available to deliver low-carbon energy and increased energy efficiency, the potential for consumer behaviour changes that reduce energy consumption and carbon emissions, and the likely effectiveness of the policies presently in place or potentially applicable in future. Around each of these there is significant uncertainty.

It is not therefore possible, nor is it the role of the Committee, to attempt to predict what the precise path to a low-carbon economy should entail either in terms of technologies or policies. Instead, our role is to recommend a path of emissions which is appropriate as a UK contribution to global climate change mitigation, and to identify whether that path is feasible at manageable economic cost, given the range of different technologies and policy levers which could be deployed.

This Report therefore sets out alternative ways in which emission reductions could be achieved, and assesses whether there are reasonable scenarios in which different combinations of actions would deliver the required emission reductions path. The analysis clearly shows that the required reduction path is feasible.

Once the recommendations of this Report have been considered by government and deliberated by Parliament, statutory budgets for the UK emissions of CO_2/GHG emissions will be set. One role of the Committee will then be to monitor actual progress in reducing emissions versus the budgets set. We will provide our first progress report to Parliament in September 2009. In addition we will need to provide advice to government on how to fine tune the level of the budgets in the light of the results of the Copenhagen negotiations on a global climate deal. We will also begin work soon on the analysis which will inform our recommendations for the fourth budget period (2023-27) which we will deliver by 2011. And there are a range of specific issues, identified at various points in the Report, where the tight timescales to which we have had to work have allowed only preliminary analysis and where we intend to do more detailed analysis over the coming year.

The progress we have made so far would not have been possible without the hard work and dedication of the members of the Secretariat and the whole Committee would like to express our thanks to them.

THE COMMITTEE ON CLIMATE CHANGE

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 Confederation of British Industry (CBI).

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 EBRD. He has a PhD in economics from the London School of Economics.

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 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. Previously he was Head of the Energy and Environmental Programme at Royal Institute of International Affairs, before joining Imperial College as Professor of Climate Change and Energy Policy.

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 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' examining vehicle and fuel technologies that, over the next 25 years, could help to reduce carbon emissions from road transport.

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 is Research Director at UK Energy Research Centre (UKERC) having previously been the Director of 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.

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The team that prepared the analysis for the report. This was led by David Kennedy and included: Mark Bainbridge, Alice Barrs, Jenny Byars, Liz Cassidy, Ben Combes, James Davey, Kristofer Davies, Jamila Fattah, Sharon Gaisie, Ajay Gambhir, Neil Golborne, Sarah Guy, Rachel Hall, Julia Heard, Debbie Hemming, Edward Hogg, Richard Houston, David Joffe, Swati Khare-Zodgekar, David Lewis, Rachel Lund, Nina Meddings, Sarah Naghi, Stephanie Ockenden, Akshay Paonaskar, Nicholas Petersen, Michele Pittini, Niall Riddell, Stephen Smith, Caroline Spencer, Jonathan Stern, Kiran Sura, Mike Thompson, Claire Thornhill, Emily Towers, Mark Weiner, Katherine White.

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A wide range of around 1000 stakeholders who responded to our Call for Evidence and Commented on our Work Programme, and who attended our kick off events (London, Belfast, Cardiff and Glasgow), expert workshops, or met with the CCC bilaterally.

EXECUTIVE SUMMARY

Climate change resulting from CO_2 and other greenhouse gas emissions poses a huge threat to human welfare. To contain that threat, the world needs to cut emissions by about 50% by 2050, and to start cutting emissions now. A global agreement to take action is vital. But a global agreement will not be possible unless the countries of the rich, developed world provide leadership.

A fair global deal will require the UK to cut emissions by at least 80% below 1990 levels by 2050. The good news is that reductions of that size are possible without sacrificing the benefits of economic growth and rising prosperity. Technologies are available or with appropriate support could be developed which deliver low-carbon energy; opportunities to increase the efficiency with which we use energy are huge; lifestyle changes which will not undermine welfare can produce significant cuts in energy consumption. And many of the actions required to tackle climate change we should want to do anyway because these have economic, wider environmental and security of supply benefits.

But the potential will not be achieved without appropriate policies: financial incentives through carbon prices, taxes and subsidies; support for technology innovation; information and encouragement; and regulation when needed. The challenge is not the technical feasibility of a low-carbon economy but making it happen. Ensuring action will require strong leadership from government and a concerted response from individuals and businesses. It will require policy commitment to cutting emissions steadily over time, sticking on the path to an 80% reduction, and reacting to any diversion with new policies to get back on track. The UK's Climate Change Act makes that commitment, establishing a system of five year "carbon budgets". The Committee on Climate Change is charged with recommending the level of those budgets.

In this our first report, we begin by explaining why the UK should aim for an 80% reduction by 2050 and how that is attainable, and we then recommend the first three budgets that will define the path to 2022. Achieving this path requires strong policies; some of these are already in place, some need to be reinforced, and some new ones will be required.

But the path is attainable at manageable cost, and following it is essential if the UK is to play its fair part in avoiding the far higher costs of harmful climate change.

* * *

The key findings and recommendations of the report are set out below in three sections:

1. The 2050 target

2. The first three budgets

3. Wider social and economic impacts of budgets

1. THE 2050 TARGET

Box 1 sets out our summary findings and recommendations relating to the 2050 target. These are based on:

(i) Consideration of appropriate global and UK targets to reduce the risk of dangerous climate change.

(ii) Analysis of the technological feasibility of radical emissions cuts and the possible costs of achieving them.

Box 1 Summary findings and recommendations on the UK's 2050 emissions reduction target

- The UK should aim to reduce Kyoto greenhouse gas emissions by at least 80% below 1990 levels by 2050 (77% below 2005 levels). This would be an appropriate UK contribution to a global deal aiming to reduce Kyoto greenhouse gas emissions to between 20-24 billion tonnes by 2050 (about 50-60% below current global levels).
- The 80% target should apply to the sum of all sectors of the UK economy, including international aviation and shipping. To the extent that international aviation and shipping emissions are not reduced by 80%, more effort would have to be made in other sectors.
- The costs to the UK from this level of emissions reduction can be made affordable – we estimate between 1-2% of GDP in 2050 – with appropriate policies and given early action to put the UK on an appropriate path. Our estimates are the same order of magnitude as those provided by the Stern Review and other global and UK studies.

(i) Setting a 2050 target to avoid dangerous climate change

There is a very strong case for the UK to adopt a significantly more ambitious target than the 60% objective set in the 2003 Energy White Paper. There have been two key changes since this objective was set:

- Recent developments in climate science and in the analysis of potential impacts mean that the whole world should now be aiming for deeper reductions in GHG emissions than previously seemed appropriate.
- Latest evidence on emissions and atmospheric concentrations suggests that these are higher than was projected at the time that the 60% target was set. More radical and earlier action is therefore needed to achieve climate objectives.

The UK should strongly support a global commitment to cutting GHG emissions by at least 50% below current levels by 2050, with total global Kyoto GHG emissions between 20-24 billion tonnes CO_2e in 2050, and with further reductions to between 8-10 billion tonnes CO_2e required by 2100. Cuts of this scale would limit our central expectation of temperature rise by 2100 to as close to 2°C as possible, and reduce the risk of extremely dangerous climate change to very low levels (e.g. less than a 1% chance of 4°C temperature rise). CO_2e concentrations would peak at around 500ppm by the end of the century before falling towards 450ppm.

By 2050 the UK should reduce its Kyoto GHG emissions by at least 80% below 1990 levels (i.e. about 77% below 2005 levels). The appropriate UK share of a global emissions target involves ethical judgements and will be the subject of international negotiations. But we believe that it is difficult to imagine a global deal which allows developed countries to have emissions per capita in 2050 which are significantly above a sustainable global average. In 2050 the global

average could be between 2.1 and 2.6 tonnes per capita, implying an 80% cut in UK Kyoto GHG emissions from 1990 levels.

The target should cover all Kyoto GHGs and all sectors including international aviation and shipping. To the extent that international aviation and shipping emissions are not reduced by 80% more effort would have to be made in other sectors.

The majority of the 80% cut will in the long term need to be achieved via domestic action. Free trade in emissions reductions certificates is desirable within a global deal since it reduces the total cost of reducing emissions and can provide a flow of finance to support emissions cuts in developing countries. But in the long term low cost opportunities to cut emissions in developing countries will diminish and radical reductions in emissions of developed countries will be unavoidable.

Over time, more information and analysis will become available which may suggest that the target should be adjusted. Our recommended targets reflect the best judgement on imperfect information and analysis available today. Over time better information will become available, and it may become appropriate to adopt a new target.

(ii) Achieving the 2050 target: technologies and costs

A range of technologies are available or can be developed which would:

- make the required emissions reductions possible
- cost the UK 1-2% of GDP in 2050.

Key points supporting each of these conclusions are set out below.

Low-carbon technologies

There exists a range of technologies in power, buildings and industry, and transport that could deliver the required emissions reduction.

Decarbonisation of the power sector is key to achieving emissions reduction targets. A number of technologies exist that could in combination deliver required emissions reductions:

- **Renewable generation could make a significant contribution to power sector decarbonisation, both globally and in the UK:**
  - Wind generation is a proven form of low-carbon power generation, the costs of which have fallen fourfold since the 1980s and are likely to continue to fall given further scope for technology innovation. Despite the inherent intermittency of wind power supply, wind generation could make a significant contribution to total global electricity generation, and be a major source of electricity in the UK (e.g. 30% by 2020 and more beyond), particularly in combination with new energy storage and load balancing technologies such as smart metering.
  - Solar power is expected to become increasingly cost competitive, particularly in sub-tropical sunny regions, although low yields are likely to keep costs in the UK high.
  - The economics of tidal range (i.e. Severn Barrage type) power generation depend crucially on the discount rate assumed; this technology also has potential wider environmental impacts (e.g. for biodiversity) which should be considered. Other forms of tidal and wave power are at an earlier stage of development and not currently cost competitive, but may become so with technological development. Across the world marine power is likely to count for only a small share of electricity generation, but the opportunity in the UK is likely to be higher.

  - Biomass power generation – in particular co-firing with fossil fuels in CCS plants – may become economic in future. But if concerns about bioenergy production cannot be overcome via new technology developments, the role of appropriate biomass use in power generation may be limited given other opportunities to use bioenergy where either transformation losses are lower (e.g. heat) or where alternative low-carbon energy sources are less likely to be available (e.g. aviation).

- **Nuclear power is cost competitive with conventional fossil fuel generation:** This is true even when decommissioning costs and possible fuel price increases due to increased uranium demand are allowed for. The main constraints on nuclear deployment are likely to be the feasible build rate, which is limited by the supply of technically competent nuclear specialist engineers and demanding regulatory frameworks. The Committee recognises that there are also concerns about the long-term sustainability of nuclear waste storage and about the possible implications of an extensive global nuclear power industry for nuclear military proliferation. But if these risks are in principle acceptable – a judgment which is beyond our remit – the Committee believes that the economic case for nuclear power deployment is strong.

- **CCS generation is an essential technology for reducing global emissions, but needs to be developed rapidly.** CCS will always be more expensive than conventional fossil fuel generation because of the additional process steps involved. But it is a technically feasible solution and best estimates suggest that it is likely to play a major role in a cost-efficient global abatement strategy. It is now essential to invest in projects which demonstrate the effectiveness of various CCS technologies in large-scale installations, and which identify the feasible timescales and likely costs of extensive deployment.

Investment in a combination of these technologies in the UK would help to reduce power generation emissions from current levels of around 550 gCO_2/kWh to well below 50 gCO_2/kWh in 2050. It would also support decarbonisation of other sectors, namely heat and transport, where there is scope for introduction of low-carbon electricity based technologies and notwithstanding technical challenges that this would pose for design of the power system.

Emissions reductions in buildings and industry can be achieved through energy efficiency improvement and the introduction of new technologies. In the near term, there is major scope for significant emissions reductions (electricity and heat related) through energy efficiency improvement and through relatively minor changes in behaviour that have minimal consequences for welfare. Further emissions cuts will require the introduction of new technologies based on electricity (e.g. heat pumps, storage heating) and the use of sustainable biomass. In industry, application of new technologies to reduce emissions (e.g. CCS in cement and steel) is likely to be feasible and economically viable.

Transport emissions cuts through introduction of new technologies will be required:

- The carbon efficiency of vehicles using fossil fuels can be increased by 30-40%. But there are absolute physical limits to what can be achieved through these improvements and, given underlying demand growth, efficiency improvements will not themselves be sufficient to reduce carbon emissions to the extent needed.

- Electric vehicles combined with the decarbonisation of electricity generation could lead to a dramatic reduction in emissions from cars and light vans. Investments in recharging infrastructure, and improvements in battery technologies are however required to unlock this potential. And further innovation would be necessary before this technology could be applied to more challenging transport segments such as HGVs.

- Hydrogen could become a feasible source of energy for some transport modes and could play a major role if improvements in battery technology are slow. But hydrogen vehicles are not as close to commercial deployment as electric, with significant challenges remaining in

relation to hydrogen infrastructure, storage, and safety, and the durability and cost of fuel cells.

- Biofuels have a potentially important role in reducing transport emissions. The extent to which this will be the case in practice is currently unclear, given uncertainties over quantities of sustainable biofuels that will be available. A clearer picture will emerge however as sustainability safeguards and new generations of biofuels are developed.

Economic cost of meeting an 80% target in the UK

The costs of meeting the 80% target are affordable and should be accepted given the consequences and higher costs of not acting. Our modelling suggests that the least-cost path is likely to entail a major contribution from energy efficiency improvements in both buildings and surface transport between now and the mid 2020s, the radical decarbonisation of power generation by 2030, and the increasing application of electricity to surface transport from 2015 onwards and to heat production from the 2020s onwards. It indicates that meeting the UK target of an 80% cut can be achieved at a cost in the order 1-2% of GDP in 2050. This order of magnitude is consistent with cost estimates from the Stern Review and the IPCC and with various UK studies. The Committee recommends that it is accepted given the consequences and much higher costs of not acting.

2. THE FIRST THREE BUDGETS

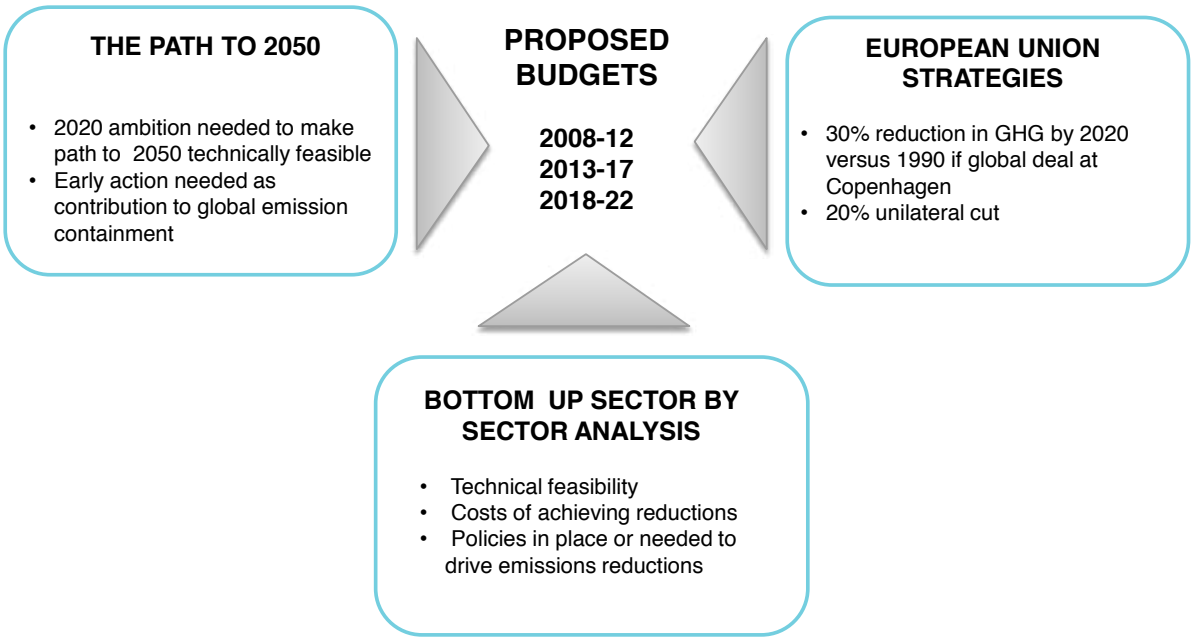
In determining the appropriate level for the first three carbon budgets covering the period 2008-22 we have considered three factors (Figure 1):

1. The implications of the 2050 target for the appropriate trajectory over the next fifteen years, and appropriate contributions by the UK to required global emissions reductions in 2020.

2. The implications of EU targets for emissions reductions to which the UK is already committed.

3. A bottom up sector by sector analysis of feasible emissions reductions, likely costs, and the policies required to ensure that they are achieved.

Figure 1: Factors considered in setting the first three carbon budgets



Source: CCC

Box 2 presents our summary findings and recommendations, which we explain below in two subsections:

(i) The proposed level of the first three budgets.

(ii) Our sector by sector assessment of feasible emissions reduction.

Box 2: Summary findings and recommendations on budgets for the period 2008-2022

- We follow the EU framework and propose two sets of budgets, one to apply following a global deal on emissions reductions ('Intended' budgets), and the other to apply for the period before a global deal is reached ('Interim' budgets).
- The budget should apply to all Kyoto greenhouse gases.
- The Intended budgets require an emissions reduction of 42% in 2020 relative to 1990 (31% relative to 2005). The Interim budget requires a 34% emissions reduction in 2020 relative to 1990 (21% relative to 2005). Intended and Interim budgets are summarised in table 1.

Table 1 GHG budgets for the UK for 2008-2022

		Budget 1 (2008-2012)	Budget 2 (2013-2017)	Budget 3 (2018-2022)
Interim budget ($MtCO_2e$)	Traded sector	1233	1114	1011
	Non-traded sector	1785	1704	1559
	Non-traded sector CO_2	1304	1235	1103
	Non-traded sector non-CO_2	481	469	456
	Total	3018	2819	2570
Intended budget ($MtCO_2e$)	Traded sector	1233	1009	800
	Non-traded sector	1785	1671	1445
	Non-traded sector CO_2	1304	1201	989
	Non-traded sector non-CO_2	481	469	456
	Total	3018	2679	2245

Source: CCC
Note: The traded sector comprises energy-intensive firms in the European Union Emissions Trading Scheme (EU ETS). The non-traded sector comprises residential, commercial, small industrial and transport sectors. Non-CO2 gases are Kyoto greenhouse gases apart from carbon.

- International aviation and shipping should be part of the UK's climate strategy but should not be explicitly included in the budget given unresolved issues related to allocating emissions at the national level. The Committee proposes, however, to report annually on progress reducing emissions in these sectors.
- Our proposed budgets can be feasibly reached through energy efficiency improvement in buildings and industry and fuel efficiency improvement in road vehicles, combined with a significant shift towards renewable and nuclear power generation and renewable heat.
- To deliver feasible emissions reductions, strengthening of existing policies and development of new policies – at the EU, UK and national [within UK] levels – will be required.
- The Government should not plan to purchase offset credits (e.g. CDM) to meet the Interim budget. More generous use of offset credits, however, would be appropriate in transitioning from the Interim to the Intended budgets.
- The cost of meeting proposed budgets is less than 1% of GDP in 2020, and potential competitiveness issues for energy-intensive industries can be addressed through appropriate design of the policy framework.
- There will be potential costs for the fuel poor which can and should be addressed through design of the policy framework.

(i) The proposed level of the first three carbon budgets

Budgets should include all Kyoto GHGs, for three reasons**:** it is all GHGs rather than just CO_2 that cause climate change; the UK's international commitments are in terms of GHGs; and including non-CO_2 GHGs provides additional options for meeting budgets. There is some measurement uncertainty regarding the level of non-CO_2 emissions, but the Committee concludes that this is manageable.

International aviation and shipping should not be included in budgets, but there need to be clear strategies to achieve emissions reductions, and the Committee's annual reports of progress against budgets should be accompanied by reports on international aviation and shipping. These sectors are important from a climate change perspective and should be covered by the UK's climate strategy and ideally by global agreements. There are, however, complexities that currently make it difficult sensibly to allocate international emissions to the national level. We therefore recommend that budgets should not include international aviation and shipping. But the level of ambition in budgets for other sectors should ideally reflect likely progress in reducing emissions in these sectors, and other mechanisms to drive emissions reduction in aviation and shipping should be in place. The Committee's annual reports on progress in these sectors should keep under review whether at any time it does become appropriate to include either sector within the budget process.

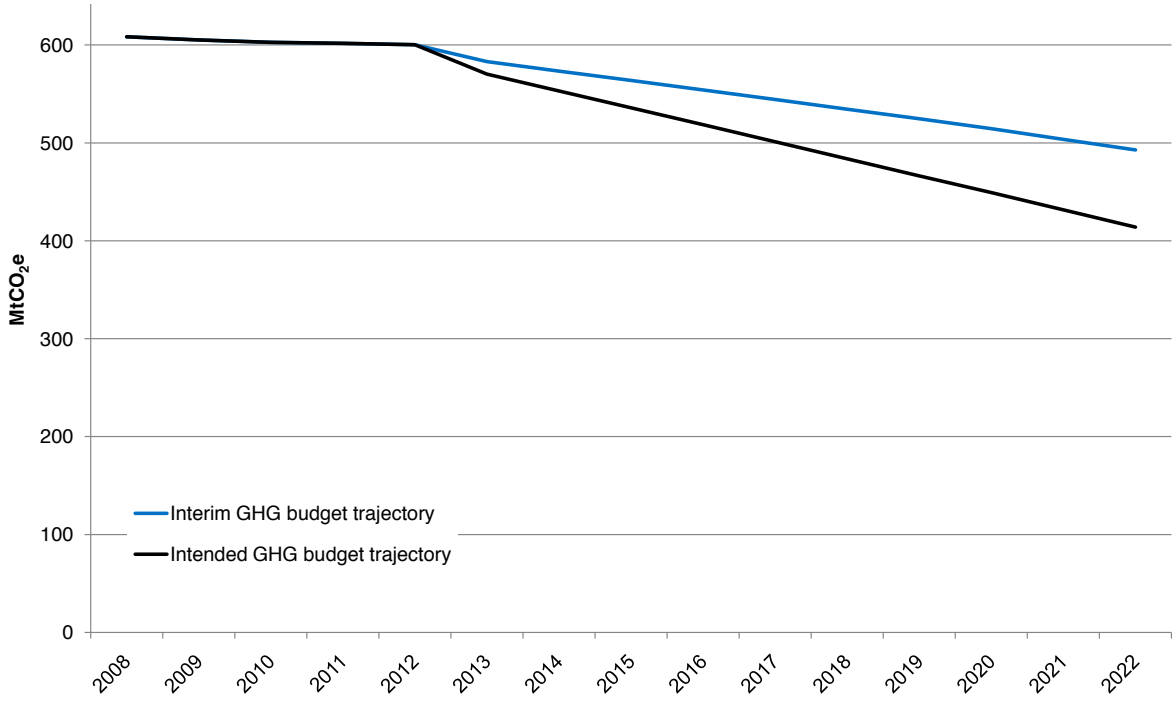
The appropriate budgets for the UK should reflect the outcome of the Copenhagen and any subsequent negotiations on a global treaty, and should be in line with the EU approach:

- The Intended budget, which should apply once a global deal has been reached, would require a reduction in 2020 of 42% in GHG emissions below 1990 levels, which is equivalent to 31% below 2005 levels; this translates to required emissions reductions of 175 $MtCO_2e$ in 2020

- The Interim budget, which the UK would be committed to even in the absence of a global deal, would require a reduction of 34% in 2020 from 1990 levels, which is equivalent to 21% below 2005 levels; this translates to required emissions reductions of 110 $MtCO_2e$ in 2020.

The allowed emissions under these budgets are shown in Figure 2.

Figure 2 Annual allowed emissions for the UK 2008-2022, consistent with the proposed GHG budgets



Source: CCC

Meeting budgets is feasible given power sector decarbonisation, energy efficiency improvement in homes, buildings and industry, and emissions reductions in transport. Some of the required emissions reduction can be achieved at negative cost and would therefore save money for households and businesses. A significant part of the required emissions reduction can be achieved at a cost below the likely carbon price within EU ETS, which we project to be around £40/tCO_2 in 2020 in a central scenario. But some significant abatement options cost more than the carbon price, and would not be pursued if the objective were simply to minimise the cost of meeting a 2020 emissions reduction target. We believe, however, that it is important to pursue these options to foster technology innovation and to ensure that the UK is on the path to meeting the 80% target in 2050.

Strengthening of the policy framework will be required. The current policy framework will deliver some of the required emission reductions. But strengthening of existing policies will be needed if they are to deliver the full abatement potential we have identified. New policies will also be needed to support deployment of renewable heat and to reduce emissions from road vehicles. In addition, there is a range of other areas where new policies will have to be considered (e.g. to support widespread solid wall insulation, and the application of plug-in hybrid technologies to vans).

There should be no limit on the use of credits bought from the rest of Europe (i.e. EUAs) to meet the budgets, but the use of offset credits (e.g. CDM) should be tightly controlled, particularly to meet the Interim budget:

- The Committee recognises the benefits of carbon markets, which can help achieve emissions reductions at least cost and drive emissions reductions in developing countries. But we believe that it is essential for rich developed countries to achieve significant domestic reductions to drive the development of required low-carbon technologies and to be on the path to meeting the deep domestic emissions cuts that will be required in the longer term.

- Limits on the use of credits from other European countries (European Union Allowances [EUAs] in EU ETS) are neither feasible nor necessary: as long as emissions reductions happen somewhere within Europe, the technologies of a low-carbon economy will be developed. The overall policy imperative is simply to ensure that overall emissions caps within EU ETS are sufficiently tight.

- But the use of offset (e.g. CDM) credits bought from outside Europe should be limited.

  – In respect to the EU ETS, the purchase would be by private companies under rules set at the European level. These envisage limited purchase in the "no global deal" scenario, but with a significant proportion of the additional effort following a global deal being purchased as offset credits. The Committee supports this approach.

  – In the non-traded (i.e. non EU ETS) sectors, however, purchase of offset credits would be by Government. The Committee recommends that there should be no planned purchase of offset credits to meet the Interim budget, but that if the Intended budget is adopted after a global deal, the incremental non-traded sector effort required could be achieved by purchasing offsets up to the limit proposed within the EU's framework.

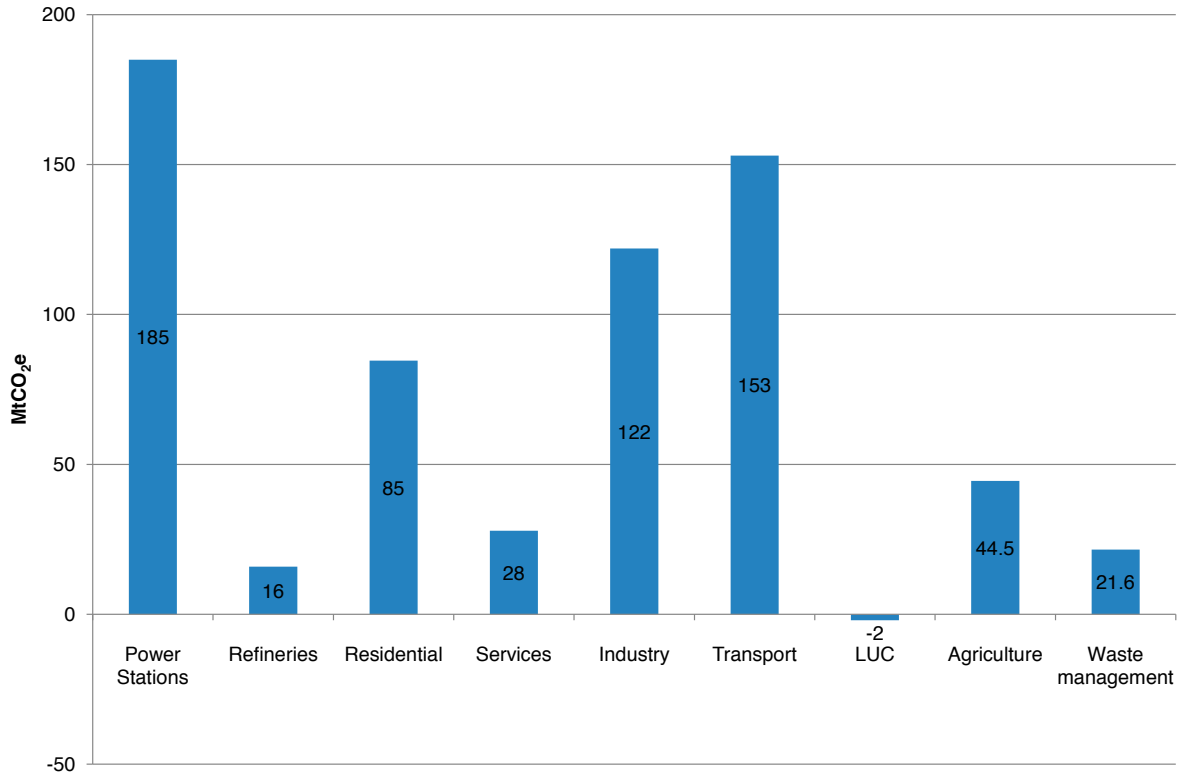
The overall result of these recommendations would be that in the Interim budget case, less than 10% of required emissions reductions would come from purchase of offset credits, with the remaining 90% coming domestically or from elsewhere in the EU. In the Intended budget case, domestic effort would be higher, but up to 20% of the required emissions reduction could be achieved through offset credit purchase.

The cost of meeting budgets is less than 1% of GDP in 2020. This cost is due to the impact of higher energy prices, net of any increases in income due to energy efficiency improvements. The 1% figure can be compared to annual growth forecast to be above 2% on average across the three budget periods, which will result in an economy that is about 30% larger than now in 2020; the cost of meeting budgets would be equivalent to losing half of one year's growth. The Committee's view is that this cost should be accepted given the consequences and costs of not acting.

(ii) Feasible emissions reductions

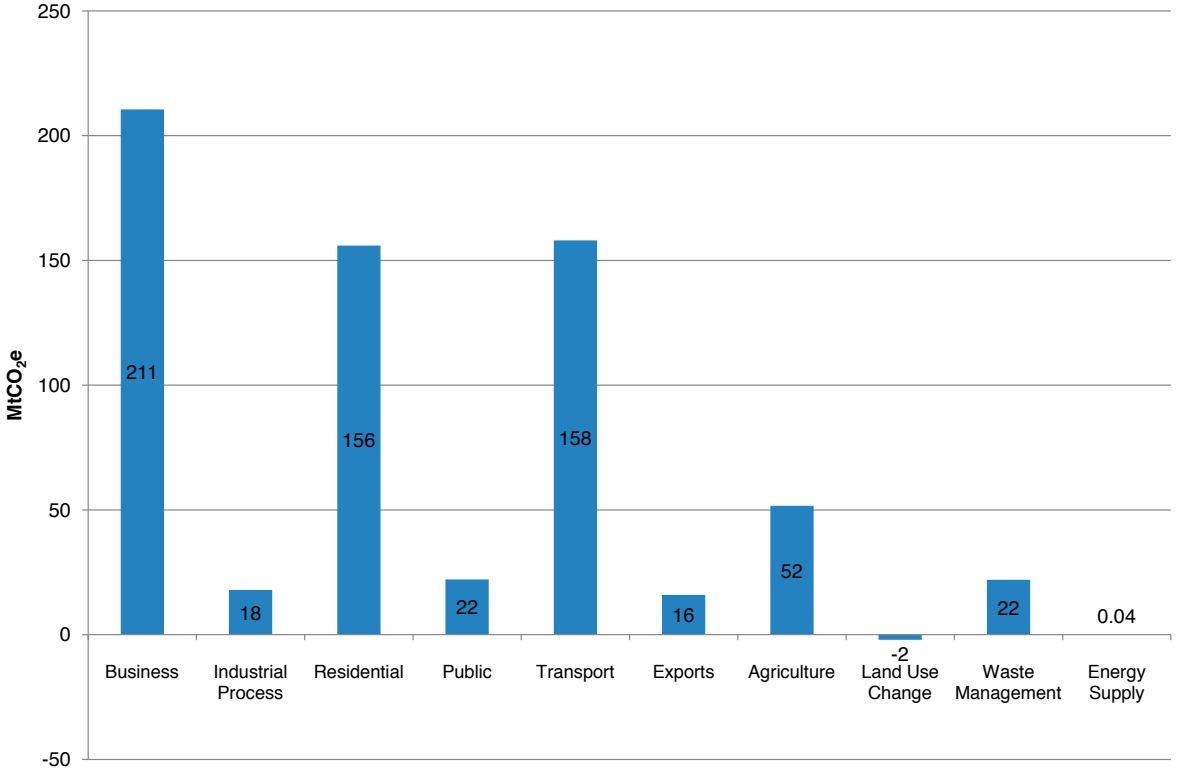
Current UK emissions are shown in Figures 3 and 4. We have assessed the potential to reduce these emissions sector by sector, looking at technical feasibility, at the costs of achieving reductions, and at the policies either in place or required to achieve emissions reductions. In particular, we have considered scope for decarbonising power generation, reducing emissions from energy use in buildings and industry, and reducing emissions from domestic transport.

Figure 3 UK 2006 GHG emissions presented by DECC source sector category



Source: DECC

Figure 4 UK 2006 GHG emissions presented by DECC end use sector category



Source: DECC

Decarbonising the power sector

The UK has a major opportunity to achieve significant progress towards the decarbonisation of electricity generation in the first three budget period. This comes because around a third of UK electricity generation capacity – in particular, coal generation capacity – is scheduled to be retired in the next 15 years. It is important that this opportunity is grasped given the almost full decarbonisation of the power sector required by 2030, and the likely need to apply electricity to an increasing set of activities (e.g. in heat production and transport) to meet the 2050 target.

A range of economically viable low-carbon generation technologies will be available in the first three budget periods:

- The costs of onshore and offshore wind should be accepted given the significant emissions reduction potential that these technologies offer in the first three budget periods, and scope for driving down costs through wider deployment.

- Analysis suggests that nuclear new build is justified on economic grounds in the first three budget periods. If the feasible pace of deployment of wind power is less than currently envisaged in the Government's draft Renewable Energy Strategy, and if concerns about waste storage can be addressed, nuclear power deployment should be accelerated to fill this gap.

- CCS may be demonstrated to be economic towards the end of the first three budget periods. The contribution of CCS during the first three budget periods, however, is likely to be limited given that this technology has not yet been demonstrated at the appropriate scale.

Various policies will be required to support deployment of these technologies. The creation of a clear carbon price signal within the EU ETS over the first three budget periods is a priority for driving electricity sector emission reductions, but additional policy levers will be required:

- The financial support and non-financial (i.e. relating to planning and transmission) policy measures of the draft Renewable Energy Strategy are vital;

- the extension of the EU ETS beyond 2020 is essential to support investment across the range of low-carbon generation technologies;

- and CCS projects to demonstrate this technology at scale are of key importance.

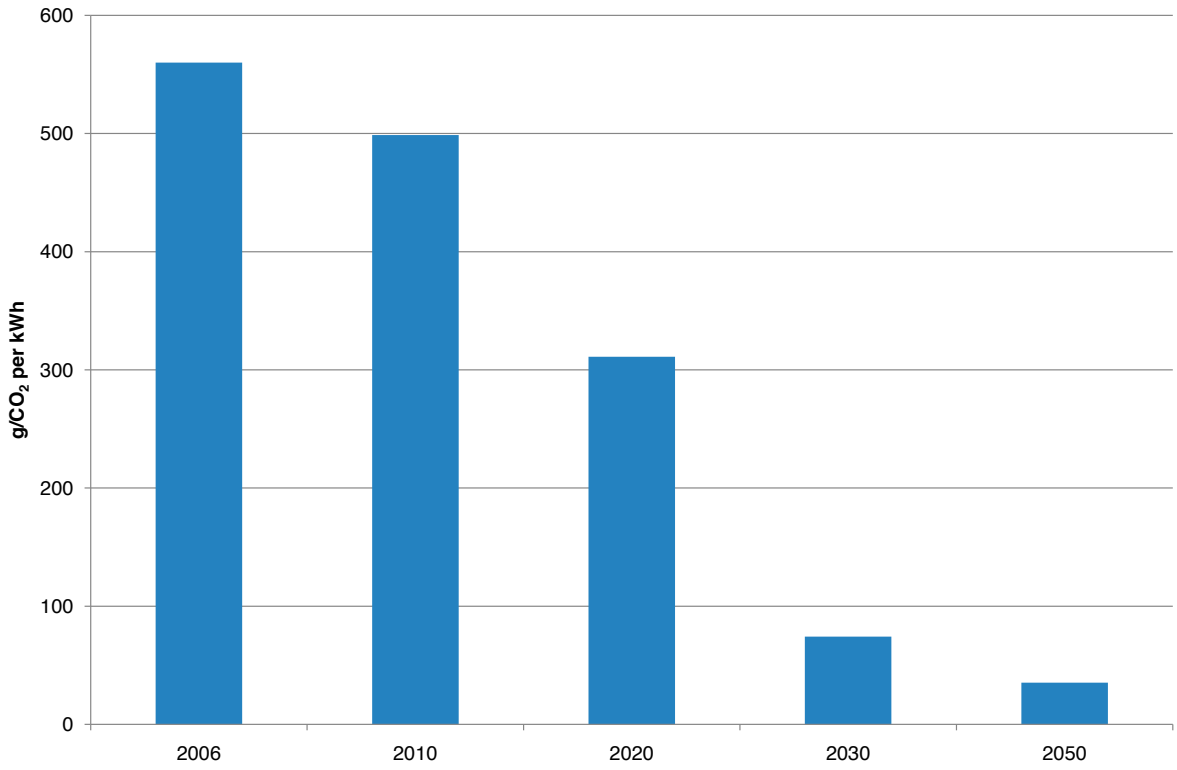
Conventional coal-fired power generation should only be built on the expectation that it will be retrofitted with CCS equipment by the early 2020s. Given reasonable estimates of likely carbon prices in the 2020s, it is unlikely that conventional coal-fired generation will be economic even if no other policy levers are in place. But there is a danger that uncertainties about future carbon prices could result in investments that lock the UK in to carbon intense generating plant. There is therefore a strong case for buttressing the carbon price lever by establishing a clear and publicly stated expectation that coal-fired power stations will not be able to generate unabated beyond the early 2020s.

One way to achieve this would be to establish a requirement that coal-fired power stations cannot be built beyond a certain date without CCS (say 2020), that those built before that date will be given a deadline for retrofitting CCS (say in the period 2020-2025), or that plants which choose not to retrofit should be allowed to generate for a very limited number of hours. Alternatives could be (i) to set emissions standards (i.e. company specific ceilings on the g/kWh emissions from power generation) implying the need for CCS retrofit in the 2020s to any conventional plant added over the next ten years, and ensuring that overall progress towards decarbonisation of electricity was in line with the required path to 2030 and beyond, and (ii) to establish a floor price within the EU ETS. These and other possible options warrant further consideration.

Power sector emissions reductions of 40% below 1990 levels are realistically achievable by 2020. These emissions reductions would result if renewable generation can be increased to 30%

of the total, which would require a similar pace of deployment over the next 12 years to what has been achieved on average in Germany over the last ten years, and a slower pace to that which has been achieved in Spain. Alternatively, a slightly lower level of renewables with some nuclear new build would deliver the same emissions reduction of around 50 $MtCO_2$ in 2020. In either scenario, average carbon intensity would fall by 2020 in line with what is required on the longer term path to full decarbonisation by 2050, shown in Figure 5.

Figure 5 CO_2 intensity per kWh of electricity generated, 2006-2050



Source: CCC

Energy use in buildings and industry

The use of energy is often not subject to the professional management of costs. As a result, there appears to be scope for significant energy efficiency improvement at a cost to the economy and to individuals which is low, nil, or indeed negative (i.e. where upfront investment would be quickly repaid and give a good return). This is particularly true in the residential sector, but also in commercial sectors of the economy where energy costs are a small proportion of total costs. In practice however, there are numerous barriers which prevent theoretically attractive opportunities from being implemented (e.g. due to lack of information, hidden costs, hassle factors, etc.). Conversely there is a wide range of possible options for the micro-generation of electricity which are technically possible but high cost. We make a crucial distinction therefore between theoretical technical potential, cost-effective potential, and realistic potential[1].

Significant emissions cuts through relatively low cost energy efficiency measures in homes are realistically achievable. By 2020:

- In the residential sector there is technical potential to reduce emissions by almost 40$MtCO_2$ through energy efficiency improvement and lifestyle changes. Over half of these reductions would result from measures whose cost is negative or nil, with the remainder achievable at a cost less than our forecast carbon price of £40/tCO_2.

1 Theoretical potential is defined as abatement potential that could be achieved absent any barriers to uptake of measures. Cost-effective potential is abatement potential that costs less per tonne of carbon saved than the projected carbon price. Realistic potential is technical potential adjusted to reflect any barriers to uptake of measures and ways that these might be addressed by the policy framework.

- Our assessment of realistic potential suggests that a reduction of 9-18 $MtCO_2$ could be achieved from existing buildings, with an additional 4 $MtCO_2$ from new buildings.

- Delivering this would, however, require some development of the policy framework to provide stronger incentives under the Supplier Obligation (which requires energy companies to implement energy efficiency measures in the residential sector) and the tightening of appliance standards.

Significant emissions cuts through more expensive renewable heat measures in the residential sector are realistically achievable and should be pursued. The development of renewable heat sources (mainly biomass but also heat pumps) and of micro-generation (solar photovoltaic) could save up to 65 $MtCO_2$ in 2020 but at a much higher cost per tonne saved than for energy efficiency improvements. Our assessment of realistic potential suggests a much lower reduction of up to 10 $MtCO_2$ in 20202. Delivering this potential is desirable in the context of meeting our proposed budgets and 2050 target. It will require development of new policies, in particular to support wider deployment of renewable heat through a range of price and non-price measures.

There is significant scope for cutting emissions in non-residential buildings and industry. By 2020:

- In non-domestic buildings there is technical potential to reduce emissions by 11 $MtCO_2$ through zero or negative cost energy efficiency improvements, of which we believe 5-9 $MtCO_2$ can realistically be saved. In addition, we estimate a realistic potential to save up to 2 $MtCO_2$ via higher cost abatement actions involving renewable heat and micro-generation.

- In industry, there is only limited technical potential (7 $MtCO_2$) to save CO_2 at zero or negative cost, but the majority of this (4-6 $MtCO_2$) should be realistically achievable.

- Over 50% of emissions from commercial buildings and 95% of emissions from industry are covered by strong binding policy levers which will support delivery of emissions reductions. The Committee recommends, however, that new policies should be considered to unlock emissions reductions in those firms currently not covered by these binding levers.

Reducing domestic transport emissions

Deep emissions cuts in road transport can be achieved through improved fuel efficiency of new cars and vans in the first three budget periods. This opportunity arises from the potential intensification of energy efficiency improvement in internal combustion engines and application of a range of non-powertrain measures (e.g. improved aerodynamics), the potential to deploy new technologies (e.g. plug in hybrid and pure electric cars and vans), and from potential changes in purchase behaviour (e.g. encouraging consumers to buy slightly smaller more fuel efficient cars). A robust framework will, however, be required to deliver emissions reduction potential:

- Unlocking the full potential for emissions reductions from cars of up to 12 $MtCO_2$ will require a legally binding EU target that carbon emissions of new cars should be no more than 100 gCO_2/km in 2020, together with ambitious interim targets. Given an EU framework, delivering this in the UK will require a range of domestic policy measures (e.g. awareness raising, fiscal levers).

- Unlocking the full potential of at least 3$MtCO_2$ in vans will require a legally binding framework at the EU level supported by domestic measures.

Significant potential for emissions reductions exists through changed driver behaviour, modal shift and better journey planning. The Committee has not carried out detailed analysis of the opportunity to reduce surface transport emissions via demand side measures (i.e. measures which reduce kilometres travelled or modal shift to less carbon intensive transport [e.g.

rail rather than car]). But indicative estimates suggest a potential to deliver cuts of up to 10 $MtCO_2$ in 2020, if a range of levers (e.g. better information, driver training) are deployed. The Committee will assess the potential for more significant reductions as part of our future work programme.

Reducing emissions of non-CO_2 greenhouse gases

We have identified scope for significant emissions cuts in agriculture and waste:

- **In agriculture,** a preliminary analysis has indentified realistically achievable abatement potential of up to 15 $MtCO_2e$ in 2020 through a range of measures around livestock and soils. These exclude both controversial hi-tech options (e.g. the use of Ionophores) and scope for changed consumer behaviour (e.g. eating less carbon intensive types of meat). Analysis of opportunities in agriculture is at an early stage and the policy framework for delivering abatement is undeveloped. The Committee intends to do further work on this sector and urges the Government to consider the policies available to drive emissions reduction.

- **In waste,** our assessment is that there is around 5 $MtCO_2e$ realistically achievable emissions reduction in 2020 (e.g. through increased levels of Anaerobic Digestion which converts gases from waste to biogas that can be substituted for fossil fuels). There is already a policy framework in place at national and international levels that should unlock at least some of this potential. This could be strengthened through introduction of new policies to support renewable heat, including through the use of biogas from waste.

Economy wide emissions reductions to meet budgets

We have aggregated our sectoral assessments of emissions reduction potential to three economy wide scenarios which we label Current Ambition, Extended Ambition and Stretch Ambition.

- **The Current Ambition scenario** includes identified measures which would cost less per tonne than the forecast carbon price, and/or which are covered by policies already in place; the scenario includes cautious estimates of emissions reductions from these measures. It includes significant progress towards low-carbon electricity generation, and some progress on improving fuel efficiency in new cars.

- **The Extended Ambition scenario** incorporates more ambitious but still reasonable assumptions on the penetration of energy efficiency improvements and a number of measures which would cost appreciably more per tonne of carbon abated than the predicted carbon price, but which are important stepping stones on the path to 2050. It is broadly in line with policies to which the government and/or EU is committed in principle, but where precise definition and implementation of policy is still required. It includes, for instance, a significant penetration of renewable heat, more radical energy efficiency improvement in cars and vans, and some lifestyle changes in homes and transport.

- **The Stretch Ambition scenario** adds further feasible abatement opportunities for which at the moment no policy commitment is in place, including more radical new technology deployment and more significant lifestyle adjustments.

Achieving the emissions reductions in our Extended Ambition scenario would ensure that the UK meets the domestic reductions required in the Interim and Intended budgets. This would be complemented by purchase of offset credits by firms in the EU ETS, and by possible Government purchase of offset credits to achieve the higher emissions reduction needed under the Intended budget. The Stretch Ambition scenario therefore includes measures which could compensate for a shortfall in delivery of measures in the Extended Ambition scenario or which could be pursued as an alternative to the purchase of offset credits.

3. WIDER SOCIAL AND ECONOMIC IMPACTS OF BUDGETS

The Committee is required under the Climate Change Bill to consider a range of wider economic and social impacts from budgets including competitiveness, fuel poverty, security of supply, and differences in circumstances between the regions of the UK; we now briefly consider each of these in turn.

Competitiveness impacts can be mitigated through appropriate design of the policy framework. These impacts are potentially important for a small number of globally competitive energy-intensive industries. Imposing a carbon price on these industries could in principle result in carbon leakage, with relocation of production to other countries. This risk could, however, be mitigated through one of three policies: the introduction of border carbon price adjustments, the free allocation of permits to selected sectors, or the possible future negotiation of global sectoral agreements. The Committee notes that the EC will make a proposal to mitigate the risk of emissions leakage in the context of the revised EU ETS.

Carbon budgets would not undermine sustainability of public finances. There are a number of specific significant fiscal impacts of carbon budgets, some positive and some negative. Revenue from auctioned permits in EU ETS could reach £8 billion by 2020, but losses of fuel duty could amount to £4 billion. Overall the impact may be positive in 2020 but mildly negative in earlier years. This reinforces the importance of progressing as rapidly as possible to auctioning rather than free allocation of EU ETS permits.

Fuel poverty impacts should be addressed through energy efficiency improvement and income transfers or social tariffs. Higher energy prices required to meet carbon budgets will increase the number of fuel poor households (i.e. households who have to spend more than 10% of income to reach a defined minimum level of energy consumption). This impact could be partially offset, however, through energy efficiency improvement amongst fuel poor households, and more fully offset through income transfer or social tariffs. The Committee's view is that fuel poverty impacts should be mitigated, and our analysis suggests that this could be achieved at manageable cost. Further work is required to understand the most appropriate delivery mechanism.

Security of supply impacts from intermittent generation can be managed, and the achievement of a lower carbon economy will provide a hedge against price volatility:

- In principle, the intermittent nature of wind generation could pose issues for security of supply. In practice, this can be managed through having adequate back-up capacity available to increase generation at short notice. Intermittency is therefore an issue of cost rather than security of supply. Issues of market design and incentives may however need to be addressed to ensure that adequate investment in back-up capacity takes place.

- More generally, increasing levels of low-carbon power generation and energy efficiency improvement will reduce exposure to volatile oil and gas prices, and mitigate the risk of sustained high price periods and possible supply interruptions, thus providing economic benefits in addition to climate change benefits.

There is an opportunity to cut emissions in all the nations of the UK, and an important role for national authorities in delivering emissions reductions:

- Significant opportunities exist across all the sectors – power, buildings, industry transport and agriculture – in each of Northern Ireland, Scotland and Wales, but with some variation. National authorities have an important role to play in unlocking this potential given the balance of reserved and devolved powers.

- Wider social and economic effects, notably competitiveness and fuel poverty, are more important in some regions than at the national average level, but as we noted above these potential impacts can be mitigated through appropriate design of the policy framework.

* * *

Deep emissions cuts in the UK are required both over the next fifteen years and in the period out to 2050 as part of a wider global emissions reduction effort. Realistically achievable emissions reductions are sufficient to meet the required objective. And the cost of these emissions cuts is manageable. The challenge now is for the Government to strengthen the policy framework and for individuals and businesses to respond. Meeting this challenge is vital if we are to avoid dangerous climate change and the significant consequences and costs that this would involve.