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Making the Right Choices for our Future

An economic framework for designing policies to reduce carbon emissions

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Table of Contents

Executive Summary

- This paper is in response to Recommendation 1 of the Better Regulation Commission report "Regulating to Mitigate Climate Change – A Response to the Stern Review", that recommends

  "the Government should publish their understanding of the pros and cons of the alternative ways of ensuring carbon emissions are priced to reflect the damage they cause identified in the Review, including the level in the supply chain at which these should be placed, and taking into account that it may be necessary for several instruments to be imposed on the same sector. In doing so they should take into account the effect on final prices and demand, the likely administrative burden, the potential for avoidance and for double-counting, any cost of living or distributional effects, the potential for unintended consequences and any international consequences."

- In recent years there has been a growing consensus within the scientific community and within government on the need for more and urgent action to tackle climate change. Reflecting this consensus, the Committee on Climate Change was asked to review the Government's long-term target, to reduce *carbon dioxide emissions* to 60% below 1990 levels by 2050. The Government has accepted the Committee's recommendation that the target should be to reduce *greenhouse gas emissions* to 80% below base year levels by 2050[1]. Designing climate change interventions to be as cost effective and efficient as possible has become increasingly important in the current economic climate. And realising the mitigation potential at the least cost to the economy requires a credible, effective, and well considered policy framework to deliver the required emissions reductions.

- The Climate Change Act has put in place a legal framework to reduce greenhouse gas emissions through the introduction of successive five-year carbon budgets, starting in 2008. The budgets must be set with a view to meeting the new long-term target to reduce greenhouse gas emissions by

[1] In this paper, 'greenhouse gas' refers to the Kyoto 'basket' of six gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The base year is 1990 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6.

80% by 2050.[2] The Government will announce the first three five-year carbon budgets in spring 2009. This will be followed in the summer by a more comprehensive report, required by the Act, setting out its proposals and policies for meeting the carbon budgets. Ahead of that, this paper sets out some principles for climate change policy design, and outlines an economic framework to guide the development of policy to help meet carbon budgets.

- The primary reason for government intervention is to correct for market failures in tackling climate change – the carbon externality, under-investment in R&D of low carbon technologies, and barriers to behaviour change. A number of other considerations are also likely to influence climate change policy design and the suite of instruments best suited to meet the UK's climate change goals, such as balancing competing objectives, the need to be effective across various time scales and investment cycles (to avoid locking the UK into high carbon infrastructure), the call for strategic deployment of cost effective low carbon technologies in certain sectors, and realising low cost mitigation potential from sectors which do not respond very well to price signals.

- Interventions to meet climate change goals must tackle multiple market failures and take account of wider economic, environmental, and social objectives, such as macroeconomic stability, business competitiveness, social inclusion, and reducing fuel poverty. Consequently, climate change policy will be judged against a range of diverse criteria, from efficiency and cost effectiveness of the policy, to its effect on distributional equity and on the competitiveness of UK industry, and its ancillary impacts on other environmental objectives such as air quality.

[2] The interim target is to reduce carbon dioxide emissions by at least 26% for the 2018-2022 budgetary period, although this target will be reviewed in light of the Climate Change Committee's advice and any amendments to the target will be proposed at the same time as the levels of the first three carbon budgets in spring 2009.

- The Government has a range of instruments available for tackling climate change – market-based instruments (taxes, trading), direct regulation, technology/spending programmes, information provision and public engagement programmes, and negotiated agreements. No one instrument is capable of effectively addressing the market failures and policy considerations that need to be taken into account when designing climate change policy.

- Using a mix of instruments to tackle climate change has several advantages, including the potential to deliver emissions reductions more efficiently and cost effectively than any single instrument alone, allowing climate change policy to target sector-specific market failures, and providing policy-makers with flexibility to deal with and adapt to changing circumstances. However, care needs to be taken when choosing a mix of instruments to make sure that they are consistent with each other, maintain a reasonable degree of policy certainty (in terms of outcome), and are consistent with policies in related areas.

- A comprehensive policy framework should seek to establish a carbon price – usually best achieved through an intervention upstream in the supply chain. It should also carefully consider the differences between sectors when choosing a combination of instruments (upstream or downstream) to encourage innovation and remove barriers to behaviour change and the diffusion of new technologies.

- Given the global nature of the problem and the UK's membership of the European Union, any discussion of instruments to tackle climate change needs to consider domestic interventions in the context of EU and international action to tackle climate change. There are clear advantages to establishing a carbon price and coordinating R&D policy at the EU and/or international level. The value of domestic instruments needs to be considered in the context of any significant global action to reduce greenhouse gas emissions. Domestic interventions can be justified alongside

international actions to tackle climate change, but they need to be carefully designed and targeted to ensure they add value.

- In order to meet carbon budgets set under the Climate Change Act, the UK will need to keep its policies under review, including options for additional measures to help meet our climate change goals. Establishing a carbon price is key to identifying mitigation potential across the economy that is both efficient and cost effective to achieve – especially in sectors not covered by EU ETS.[3] Recent analysis by the Committee on Climate Change sheds some light on the abatement potential in the UK and the carbon price required to achieve that potential, and will be used to update guidance on a target-consistent shadow price of carbon and inform policy development more generally.

- The ideal policy framework is one that allows policy to adapt to changing circumstances while maintaining sufficient certainty for those affected to allow them to make long-term investment decisions. Care needs to be taken that changes to the package of measures does not unnecessarily create policy uncertainty. Dynamic instrument choice within the context of a broader climate change target (such as set out in the Climate Change Act) is likely to reduce policy uncertainty by providing clarity on the desired outcome.

[3] For sectors covered by EU ETS, the relevant carbon price is the EU ETS allowance price. For non-EU ETS sectors, the shadow price of carbon establishes the relevant carbon price.

Need for multiple instruments

Carbon price externality	Under-investment in low carbon R&D	Barriers to behaviour change	Other policy design considerations

Policy performance criteria and the available range of instruments

Performance criteria: economic efficiency, cost effectiveness, administrative burden, secondary effects (including wider environmental and other co-benefits), price vs. quantity uncertainty, distributional equity, flexibility vs. policy certainty, impact on public finances, security of supply, competitiveness effects, simplicity and transparency

Instruments: market-based (economic), direct regulation, technology/spending programmes, information provision/public engagement, negotiated agreements

Sectors and behaviours to target

Energy supply	Business			Transport	Residential	Agriculture	Public
- Fuel switching (including shift to nuclear/renewables) - R&D: energy efficient technologies - Investment: low carbon technologies /	*Energy-intensive*: - Fuel switching - R&D & investment: energy efficient technologies / processes / products	*Non-energy intensive*: - Energy efficiency: building / equipment / products / practices - On-site CHP / renewables	*Waste*: - Emissions from waste disposal - Uptake of new technologies	- Switching to more energy efficient transportation and fuels - Technology/R&D: low carbon options	- Energy efficiency: building / appliances / practices - Reduce marginal / discretionary use	- Direct methane / nitrous oxides emissions - Indirect (fuel / fertiliser production) emissions - Soil carbon capture	- Energy efficiency: building / equipment / practices - Non-essential use - CHP

Choice of instruments

Upstream interventions (power sector, fuel producers/suppliers): Pricing carbon externality, encouraging development/diffusion of low carbon technologies

Sector-level interventions: Dealing with sector-specific barriers to diffusion and behaviour change, technology/spending programmes targeted at strategically important sectors

- Carbon pricing -Support for low carbon technologies (CHP, renewables) - Support for uptake of new technologies	- Carbon pricing - Incentives and support for energy efficiency (products/processes)	- Carbon pricing - Incentives and support for energy efficiency (products) - Info provision	- Carbon pricing - Support improved efficiency of waste disposal) - Info provision	- Carbon pricing - New car CO_2 standards - Support for fuel efficiency measures - Info provision (car running costs, public trans.)	- Carbon pricing -Info provision / public engagement - Support for home energy efficiency	- Carbon pricing - Info provision on best practice - Support for R&D (agri methods, genetics)	- Carbon pricing (direct regulation) - Govt targets - Support for energy efficiency / sustainable procurement

Introduction

In 2007, the Better Regulation Commission published their report "Regulating to Mitigate Climate Change – A Response to the Stern Review" that looked at the regulatory implications of the Stern review, particularly in terms of developing the appropriate economic framework for designing policies that would help the UK move towards a low carbon economy. The report made a number of recommendations that reflected the Commission's concern about the effectiveness of and the burden imposed by the UK regulatory system.

The Better Regulation Commission's first recommendation stated:

"the Government should publish their understanding of the pros and cons of the alternative ways of ensuring carbon emissions are priced to reflect the damage they cause identified in the Review, including the level in the supply chain at which these should be placed, and taking into account that it may be necessary for several instruments to be imposed on the same sector. In doing so they should take into account the effect on final prices and demand, the likely administrative burden, the potential for avoidance and for double-counting, any cost of living or distributional effects, the potential for unintended consequences and any international consequences."

In response, the Government agreed to

- identify overlaps, inconsistencies, and conflicts between existing regulatory regimes and suggest how best to resolve them
- set out its strategic approach to selecting appropriate instruments to tackle emissions from different sectors and points in the supply chain

The Government published the Climate Change Simplification paper[4] in December 2007, identifying areas of overlap between the EU Emissions Trading Scheme (EU ETS), Climate Change Agreements, and Carbon Reduction Commitment and suggesting options for simplification.[5] This paper sets out

[4] Climate Change Instruments: Areas of Overlap and Options for Simplification, Defra, December 2007.

[5] Specific recommendations are being taken forward by (i) CCAs in the consultation in 2008 on the future form of CCAs, (ii) CRC as the policy is developed for implementation up to 2010, and (iii) EU ETS and IPPC in the on-going reviews of the Directives and UK implementation.

some economic principles for instrument selection and climate change policy design. The focus is on mitigation policies adopted at a UK and EU level, although similar principles would apply to the design of international policies operating outside the EU.

The 2006 Stern review concluded that, "[Climate change] is the greatest and widest-ranging market failure ever seen." The scale of the market failure is reflected in

- its geographical scope and the fact that it affects the entire world, developed and developing;
- the wide range of day-to-day activities it covers in the industrial, business, agriculture, and domestic sectors;
- its potential impact on all aspects of human life and activity, for example, the environment, food production, water resource use, and health; and
- the time scale over which the problem is likely to manifest itself, and hence needs to be dealt with.

The review set out a framework for thinking about national, European, and international climate change mitigation policy around three core guiding principles: establishing a carbon price (through tax, trading, or direct regulation), supporting the development of a range of low-carbon and high-efficiency technologies, and removing barriers to behavioural change and the take-up of cost effective energy efficiency measures.

In recent years, there has been a growing consensus within the scientific community and within government on the need for more and urgent action to tackle climate change. Reflecting this consensus, the Government has recently tightened its 2050 target from a reduction of at least 60% below 1990 levels in carbon dioxide emissions to a reduction of at least 80% in greenhouse gas emissions, following the advice of the Committee on Climate Change. Designing climate change interventions to be as cost effective and efficient as possible has

become increasingly important in order to demonstrate that action on climate change can be achieved at an affordable impact on economic growth.

The Climate Change Act puts in place a legal framework to reduce greenhouse gas emissions through the introduction of successive five-year carbon budgets, starting in 2008. The budgets must be set with a view to meeting the new long-term target to reduce greenhouse gas emissions by 80% by 2050.[6] The Government will set the first three five-year carbon budgets in law in spring 2009. This will be followed in the summer by a more comprehensive report, required by the Act, setting out its proposals and policies for meeting the carbon budgets. Ahead of that, this paper provides an opportunity for the Government to set out the principles of its approach to climate change policy design, and outline an economic framework to guide the development of policy to help meet carbon budgets.

The Government has published a number of papers and reports setting out its strategy for delivering emissions reductions required to meet its domestic and international climate change commitments. For example:

→ The 2006 UK Climate Change Programme set out a programme of new measures to deliver additional carbon savings of some 26-44 $MtCO_2e$ in 2010.

→ The 2006 Energy Review[7] describes future measures and proposals intended to put the UK on a path to cut carbon dioxide emissions by around 60% by 2050, while ensuring reliable energy supplies, raising the rate of sustainable economic growth, and improving the UK industry productivity.

→ The 2007 Energy White Paper set out an integrated international energy strategy describing the action necessary to reduce carbon dioxide emissions (by 60% by 2050, with real progress towards that target by 2020) and deliver secure energy supplies. It also set out how measures proposed in the

[6] Interim target is to reduce carbon dioxide emissions by at least 26% for the 2018-2022 budgetary period, although this target will be reviewed in light of the Climate Change Committee's advice and any amendments to the target will be proposed at the same time as the levels of the first three carbon budgets in spring 2009.

[7] Now the Department of Energy and Climate Change

2006 Energy Review and other measures announced since (in the 2006 Pre-Budget Report and the 2007 Budget) are being implemented.

Climate change policy should be the outcome of balanced decision-making. Interventions to meet environmental aims must also take account of wider economic and social objectives, including macroeconomic stability, security of supply, business competitiveness, social inclusion and reducing fuel poverty. The Climate Change Act sets out matters to be taken into account in connection with carbon budgets:

- scientific knowledge about climate change;
- technology relevant to climate change;
- economic circumstances, and in particular the likely impact of the decision on the economy and the competitiveness of particular sectors of the economy;
- fiscal circumstances, and in particular the likely impact of the decision on taxation, public spending and public borrowing;
- social circumstances, and in particular the likely impact of the decision on fuel poverty;
- energy policy, and in particular the likely impact of the decision on energy supplies and the carbon and energy intensity of the economy;
- differences in circumstances between England, Wales, Scotland and Northern Ireland;
- circumstances at European and international level; and
- the estimated amount of reportable emissions from international aviation and international shipping for the budgetary period or periods in question.

Within this policy context, the economic framework for government intervention to tackle climate change is developed based on the rationale for government

intervention, the nature and extent of the market failure, and instruments available to bring about emissions reductions.

The Government set out its principles for environmental policy in its 2002 publication "Tax and the Environment: Using Economic Instruments", and the 2005 Pre-Budget Report restated these principles.

Box 1: Principles of Environmental Policy Making[8]

The decision to take action must be evidence-based: In order to determine the case for intervention, it is necessary to understand the nature of the environmental challenge and its causes, including market failures. If a market failure has been identified and understood, the Government can then consider what form of intervention is required to achieve a change in the relevant behaviour.

Any intervention to tackle environmental challenges must take place at the appropriate level: Some environmental issues have localised causes and consequences and can be tackled on a domestic level unilaterally. Some environmental issues cross national borders and need to be tackled collectively and internationally if policy is to be effective.

Action to protect the environment must take account of wider economic and social objectives: Failure to consider the full outcomes and consequences of any action before making the decision to go ahead could result in benefits to the environment but undermine efforts to pursue other important goals. In particular, environmental objectives need to be balanced against other objectives including sound public finances, increasing productivity, expanding economic and employment opportunities, and promoting a fair and efficient tax system.

Action on the environment must be as part of a long-term strategy: Short-term action should support and not hinder our ability to deliver long-term objectives. Indeed, intervention needs to take account of the long-term nature of many environmental challenges, and of the potential for innovative solutions to be developed in the future.

The right instrument must be chosen to meet each particular objective: The most efficient approach will be the one that provides the greatest overall economic benefit. Tax is one option but must be considered alongside an analysis of other approaches such as regulation, information, public spending, tradable permit schemes and voluntary agreements.

Where tax is used, it will aim to shift the burden of tax from 'goods' to 'bads': Taxes represent a means to signal economic activities that should be encouraged or discouraged, and are a way to ensure that the polluter pays. The revenue from an environmental tax can be used to reinforce the effectiveness of the tax when it provides value for money and benefits to business.

The aim of this paper is to set out the economic principles underpinning the Government's climate change policies to-date, and to consolidate it into an

[8] as set out in "Tax and the Environment: Using Economic Instruments"

economic framework for choosing instruments to achieve our emissions reduction targets in an efficient and cost effective manner.

The paper sets out economic criteria for selecting instrument(s) to reduce emissions from various parts of the economy, including the possibility that a combination of upstream and downstream instruments may be the most cost effective way of delivering the required emissions reductions. It draws on a 2007 audit of climate change policies conducted by the Office of Climate Change[9] that tested the effectiveness of current measures against Stern's three-leg framework – carbon pricing, technology policy, and barriers to behaviour change.

Chapter 1 reiterates the importance of a credible and effective policy framework in delivering the required emissions reductions at least cost to the economy. Chapter 2 examines the rationale for government intervention to reduce emissions and factors affecting policy design. Chapter 3 discusses the main criteria by which climate change policy will be judged and the range of instruments available to the government to tackle the problem. Chapter 4 discusses the pros and cons of selecting upstream versus downstream instruments, including the possibility of using a combination of the two, and considers the role of domestic policy in the context of EU and international action to tackle climate change. Chapter 5 applies the analysis to the current UK climate change policy landscape and discusses behaviours to target in different sectors.

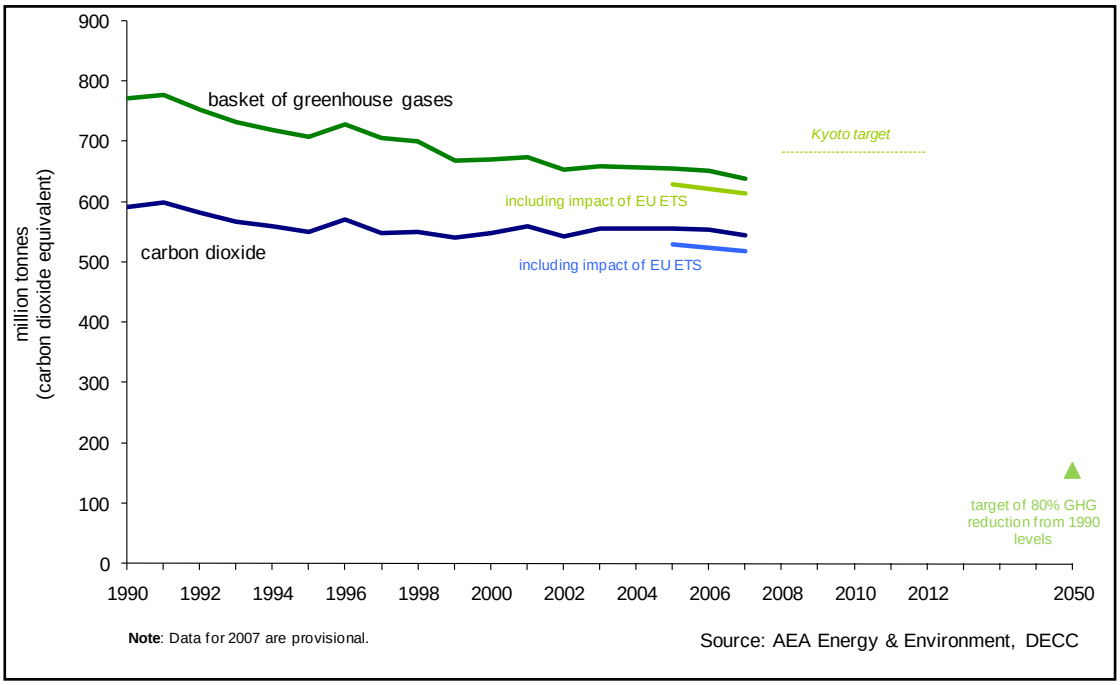
[9] Analytical Audit, Office of Climate Change, 2007 (http://www.occ.gov.uk/activities/aa.htm).

CHAPTER 1: Our objective – avoiding dangerous climate change and securing sustainable development

The Government is committed to leading global efforts to avoid dangerous climate change, as set out in its Public Service Agreement. Economic activities that lead to greenhouse gas emissions today are likely to have consequences far into the future. Balancing current economic growth and prosperity against the potential for catastrophic climate change and environmental degradation (and hence economic prosperity) in the future is the challenge for climate policy.

Current state of play

Chart 1: UK greenhouse gas and CO_2 emissions



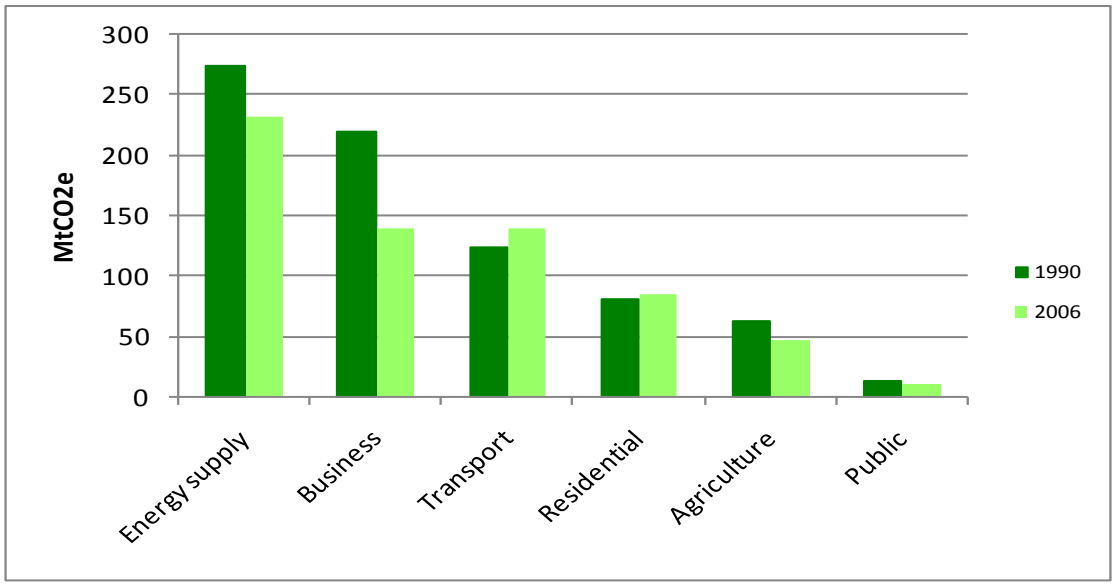
Source: Department of Energy and Climate Change (UEP32 projections)

UK emissions of greenhouse gases declined by over 20% (17% excluding EU ETS) between 1990 and 2007[10], with carbon dioxide emissions falling by a little over 13% (8% excluding EU ETS) over the same period (see chart 1).[11] Based on this data, the UK is on course to more than meet its 2008-12 Kyoto protocol

[10] Figures for 2007 are provisional
[11] CO_2 accounted for approximately 85% of total UK greenhouse gas emissions in 2004

commitment[12], but not to meet its goal for 2010 CO_2 emissions[13]. The Climate Change Act sets in statute the UK's 2050 target of reducing greenhouse gases by at least 80% over base year levels, with an interim target of reducing carbon dioxide emissions by at least 26% for the 2018-2022 budgetary period.[14] To ensure the UK is on course to meet its carbon budgets, the Government must develop proposals and policies to meet them and will publish a report setting these out in mid-2009.

Chart 2: Change in GHG emissions, by source[15]



Source: Department of Energy and Climate Change

The decrease in aggregate emissions has been driven by a fall in emissions from the energy supply and business sectors. A shift away from coal and oil towards gas has reduced emissions from the energy supply sector and a shift from manufacturing towards service industries has done the same for the business sector. Some of the declines in emissions from the energy supply and business sectors have been mitigated by an increase in emissions from the transport and domestic sectors. Structural changes apart, factors like improved energy

[12] 12.5% reduction in greenhouse gas emissions over 1990 levels
[13] Reducing CO_2 emissions to 20% below 1990 levels
[14] The Government recognises the need to review the 2018-22 target in light of the Climate Change Committee's recent advice (the committee's interim budget would require a 34% reduction in GHG emissions relative to base year levels), and any amendments to the target will be proposed at the same time as the levels of the first three carbon budgets in spring 2009.
[15] Data does not include emissions purchased from abroad through the EU ETS.

efficiency, use of lower carbon fuels, pollution control measures in the industrial sector, and significant reductions in non-CO_2 greenhouse gases have also contributed to the fall in emissions since 1990. Chapter 5 provides a detailed analysis of greenhouse gas emissions by source sector.

The economic growth context

Greenhouse gas emissions arise as a result of most of our current production and consumption activities. The path to industrialisation has been characterised by high and increasing greenhouse gas emissions. Tackling climate change will require fundamental changes to the global and the UK economy, for example, changing the energy production and use mix away from fossil fuels and towards low carbon and renewable energy sources, increasing energy efficiency in production and consumption, and finding ways to reduce non-CO_2 emissions further from agriculture, waste and other sources.

The Stern review estimates that a stabilisation goal of 450-550ppm of CO_2 equivalent (CO_2e) is reasonable in terms of the costs and benefits of taking action – above 550ppm the expected benefits of making additional reductions are likely to be greater than the expected costs, with the opposite being true for emissions reductions below 450ppm.[16]

- The cost of continuing with business-as-usual (or the benefits of tackling climate change) is estimated to reduce welfare by an amount equivalent to a 5% to 20% reduction in per capita consumption (or the equivalent of a 5-20% loss in global GDP) now and forever, with the measure likely to be in the upper part of this range.
- On the other hand, the cost of taking steps to stabilise the atmosphere at 550ppm of CO_2e[17] is estimated to be around 1% of global GDP by 2050, with a range of +/- 3%.

[16] For a stabilisation goal above this range the risk of harmful climate change is greatly increased, with the expected costs of mitigation falling relatively little. For a stabilisation goal below this range, the near-term adjustments costs of meeting the stabilisation goal are relatively high compared to the gains.

[17] Requires global emissions to peak in the next 10-20 years and then decline by at least 1-3% after that.

According to a literature review by the Inter-governmental Panel on Climate Change's (IPCC) Fourth Assessment Report[18], stabilisation between 445-710ppm CO_2e has been estimated to impose costs ranging from a 1% increase to a 5.5% decrease in global GDP in 2050.

Following on from the Stern review, a key challenge for the government is designing policy that delivers the required emissions reductions while minimising the negative growth impacts of such interventions. While well-designed policies could deliver emissions reductions at around the Stern estimate of 1% of global GDP by 2050, badly designed policy could significantly raise costs.

In this context, a high-level economic framework for choosing climate change instruments can provide a structure for policy design. For example,

- using costs and benefits to determine the economically efficient level of emissions reductions in the UK; for example, in decisions on long-term targets such as the 80% reduction target in the Climate Change Act and in decisions on the appropriate level of abatement that should take place within the UK;[19]
- ensuring that domestic climate change policy is cost effective, and emissions reductions are made by adopting the least costly measures; and
- choosing instrument(s) such that compliance and administrative costs are kept to the minimum necessary to deliver a given abatement target.

It also allows consideration of the suite of climate change instruments, rather than individual instruments and measures, best suited to deliver the required reductions (at the aggregate and sectoral level) such that synergies are maximised and perverse interactions are minimised.

[18] Technical Summary of Working Group III Report "Mitigation of Climate Change" (http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf).
[19] Refer to the accompanying paper on the Shadow Price of Carbon for a more detailed discussion of the appropriate level of abatement that should take place within the UK, as opposed to purchasing emissions allowances from outside the UK.

Failure or delay in implementing coherent policies to tackle climate change is likely to raise mitigation costs, with a larger eventual effect on economic growth and output.[20] Stern notes that, based on past experience, maintaining economic growth while reducing emissions by more than a few percent a year is likely to prove challenging. In terms of mitigation potential, the IPCC concludes that the global mitigation potential in 2030 at a carbon price of <$100/$tCO_2e$ (estimated to range from 15-30$GtCO_2e$, including some mitigation opportunities at negative costs) could be large enough to cover the projected increase in emissions between 2000 and 2030 (estimated to be 7-35 $GtCO_2e$).[21]

Realising the mitigation potential at the least cost to the economy requires a credible, effective, and well considered policy framework to deliver the required emissions reductions.

[20] Continuing with business-as-usual will only increase the stock of greenhouse gases in the atmosphere and hence the risk of catastrophic climate change. In addition, delaying any action to reduce emissions into the future could also increase the eventual level of mitigation required to achieve stabilisation, make the required emissions reductions more difficult and costly to achieve, and require mitigation to occur over a more compressed time frame.

[21] The accompanying document on the Shadow Price of Carbon provides further data and discussion on carbon prices.

CHAPTER 2: The rationale for intervention: Why a market response is essential, but not sufficient

Why are markets efficient

It is the Government's view that markets are usually the best available mechanism for allocating resources in order to maximise the productive capacity of the economy. The price mechanism, through which suppliers and consumers are provided with information and incentives, generally leads to the most efficient allocation of scarce resources at the minimum cost for the economy. The informational requirements for a central planner to achieve the same outcome – on individual preferences, firms' costs, market structures, available technologies and substitutes, to name a few – would be significantly higher even if the information were available.

However, some markets, like those involving the use of environmental resources, are subject to imperfections or failures that ultimately distort prices and undermine markets' ability to achieve an efficient allocation of resources. In the context of climate change, producers and consumers do not pay the full cost to society of their greenhouse gas emissions, leading to emissions in excess of what is economically efficient. Ensuring that producers and consumers pay the full cost of using an environmental resource corrects for the market failure and improves efficiency.

What are market failures

Economic efficiency depends on a number of key assumptions: markets being complete[22], markets being perfectly competitive, and all agents in the market making decisions based on full information. If any of these assumptions do not hold true, the market allocation of resources will not be efficient.

[22] Completeness is defined as there being a supply of all goods for which consumers create demand.

In reality, there are a number of reasons why these assumptions don't hold true and why the market does not produce an efficient outcome. The presence of market failures justifies government intervention, as long as the distortive effect of the intervention is outweighed by efficiency improvements of correcting for a market failure and any other benefits that the intervention produces for the economy.

Economy-wide market failures

The first of the market failures discussed by Stern is the failure of production and consumption decisions to take full account of the cost to society of emitting greenhouse gases, or the *carbon price externality*. While production and consumption costs include costs of inputs such as labour and capital, they do not fully reflect the cost of using environmental resources. To the extent that actual costs associated with production and consumption activities are understated and fail to fully reflect resource scarcity, environmental resources will be over-used to beyond what is economically efficient.

Government interventions to price greenhouse gas emissions are intended to adjust production and consumption costs such that they are more reflective of the true cost, or internalise the carbon externality. As Stern sets out, a comprehensive policy framework should seek to establish a carbon price across all sectors of the economy in order to maximise efficiency and ensure that emissions reductions are made where they are cheapest. This can be achieved through market-based instruments such as taxes and trading mechanisms – which put an *explicit* price on emissions – and direct regulations such as technology- and performance-based standards which put an *implicit* price on emissions.

The second market failure discussed by Stern is the *under-investment in R&D* into renewable and other low carbon technologies below the socially desirable level. The private rate of return on such investments does not capture all the long-term benefits to society, for example, due to the relatively short planning horizon of private investment decisions compared to the time horizon over which benefits

are likely to accrue, uncertainty about returns and long period over which returns accrue, and the non-excludable nature of some of the benefits which are not fully captured by the rate of return received by the investing individual or business.

While carbon pricing mechanisms lead to greater efficiency in the allocation of resources, including to R&D, addressing this market failure requires additional government support to incentivise and encourage investment to the socially optimum level. Government interventions to address this market failure can take the form of technology/spending programmes such as investment grants and subsidies that directly raise private returns closer to the social rate of return and measures that improve credit and capital availability for such investments.

While underinvestment in R&D is an economy-wide market failure, the nature and extent of R&D spillovers can vary by sector and market structure. It requires consideration of sector-specific factors – such as the nature of the innovative process and the adequacy of the intellectual property rights regime – when designing government interventions to encourage and support R&D. The Government will be setting out its approach to addressing innovation market failures relevant to climate change its report on proposals and policies for meeting carbon budgets.

Sector-specific barriers to economic efficiency

The third set of market imperfections discussed by Stern relate to *barriers to behaviour change* that prevent the take-up of cost effective technologies/measures to reduce emissions and improve energy efficiency. The nature of these market failures and barriers vary from sector to sector, and consequently the appropriate interventions are likely to be sector-specific. These barriers include:

- *Informational failures*, or lack of sufficient knowledge to make optimal decisions and asymmetric information between parties. Informational failures are particularly significant in the residential sector due to, for

example, uncertainty about future energy prices and search costs relating to information on energy efficiency measures.

- *Split incentives*, or instances when the economic benefits of low carbon or energy efficiency improvements do not accrue to the person making the investment; for example, investment by landlords in loft and cavity wall insulation whose benefits accrue to tenants in the form of lower energy bills or the split incentives between local authorities who pay landfill costs and households making decisions on the amount of waste generated.
- *Credit market failures*, or barriers to accessing capital needed to make the required investment. For example, when lenders behave sub-optimally and provide less-than-efficient levels of capital to firms (especially small and medium enterprises) for R&D investments and to individuals (especially low income households) for long-term investment in new technologies and equipment.
- *Inertia*, or individuals and businesses acting habitually or according to existing norms rather than objectively considering the costs and benefits of their various actions. For example, internal structures, cultures, and strategies can prevent firms from taking advantage of energy cost saving measures – one of the reasons identified for the low uptake of cost effective energy efficiency measures in the large non-energy intensive sector.
- *High search and transaction costs*, while not market failures these refer to search costs associated with identifying opportunities and technologies/measures for improving energy efficiency and/or transaction costs of undertaking a desirable action (for example, the cost of negotiating with potential suppliers, partners and customers[23]).
- *Path dependency*, or factors such as the inertia of long-lived capital (due to large sunk costs) and existing network externalities[24] that could result in the

[23] Transaction costs for energy efficient measures can be high, and vary between 3-8% of total investment costs [Hein and Blok (1995)].

[24] When the benefits of consuming a product (or service) is an increasing function of the number of other users of the same or compatible products or services, the product (or service) is said to display positive network effects (or positive network externalities). For example, network economies between technologies, infrastructures, interdependent industries suppliers, users, institutions (public and private), etc. may lock-in certain behaviours and technologies (even when they are not the best, either economically or technically) and prevent the desired changes from being made.

businesses and households (and hence the economy) getting locked-in to a high emissions path, even though it may be more technologically and economically desirable to shift to other low carbon technologies.

Other policy design considerations

Correcting for market failures in tackling climate change is the primary reason for government intervention to reduce emissions. However, a number of other considerations are likely to influence climate change policy design and the suite of instruments best suited to meet the UK's climate change goals.

For instance, any comprehensive policy to tackle greenhouse gas emissions will need to include a well-balanced set of instruments that are *effective across various time scales and investment cycles*. Emissions trading and product bans have the advantage of providing a degree of certainty about the emissions reductions they can deliver. Other interventions such as spending on R&D, voluntary agreements, and information campaigns do not provide the same degree of emissions reduction certainty, but are crucial to engineering a long-term shift to a low carbon economy. Meeting emissions reduction targets at least cost to the economy – from the carbon budgets to the 2050 target set under the Climate Change Act – will require a combination of instruments that are able to deliver in the short-, medium-, and long-term.

Policy to combat climate change will also need to be informed by and consistent with *other (often competing) economic, social, environmental, political, and institutional concerns*. For example, a policy to reduce emissions has to be balanced against the need to keep the price of heating homes affordable, and to avoid carbon leakage in internationally competitive sectors[25]. Similarly, action to meet environmental goals needs to be developed with an eye to issues of distributional equity, across various sectors and emitters and across time. Interventions to meet environmental aims must take account of these wider

[25] The latter concern is mitigated when global action is coordinated, for example, through international agreements which cap other economies' emissions.

objectives, from macroeconomic stability and business competitiveness to social inclusion and fuel poverty.

Climate change policy will also need to be informed by the government's approach to the development and deployment of low carbon technologies. Due to difficulty identifying "winners" in the early stages of R&D, there are large risks associated with government support for specific technologies. However, the speed and scale of the emissions reductions required to tackle climate change make the case for the *strategic deployment of cutting-edge low-carbon technologies* in areas of the economy with potentially cost effective returns to the UK industry, for example, power generation and transport. As noted by Grubb (2006), regulatory risk and market failures – at the R&D stage, in converting R&D into viable industries, and in the diffusion of new technologies – may justify government intervention in certain sectors.[26]

Climate change policy will also need to be designed to take account of *differing degrees of responsiveness to carbon prices across sectors*. The extent of emitters' responsiveness to changes in energy prices might vary depending on the availability of substitutes, the percentage of total costs attributable to energy use[27], the ability to raise and fund investments, existing levels of regulation, and the ability to deal with compliance and administrative burdens[28]. These elements limit the ability to respond to price incentives, and to realise the potential for low cost emissions reductions in these sectors.

[26] How close a technology is to being viable, and factors such as high domestic learning, high national resources, or high potential for the UK industry to become a major player internationally might help define areas of greater interest for R&D support intervention.

[27] For example, energy costs are estimated to be 1-3% of total operating costs in the large non-energy-intensive sector, limiting their response to even large changes in fuel prices.

[28] For example, compliance and administrative cost burdens may make energy efficiency standards or indirect taxes on emissions a more appropriate instrument than trading when sources are small, dispersed, and mobile due to the large fixed costs associated with participating in an emissions trading scheme.

Table 1 illustrates the significant market failures and policy considerations relevant to six broad sources of emissions in the UK economy – energy supply, business[29], transport, residential, agriculture, forestry and land use, and public.

[29] includes the energy-intensive sector, manufacturing and commercial sectors (including commercial and institutional emissions), industrial processes, and waste management, similar to the Climate Change Programme (2006).

Table 1: Market failures and other considerations, by sector

Sectors	**Major source of emissions**	**Major market failures and other policy considerations**
Energy supply	Direct emissions from electricity generation, oil production and refining, gas production and transmission, production of coal and other solid fuels	✓ Carbon externality ✓ Under-investment in low carbon R&D: development and diffusion of new technologies ✓ Credit market failures ✓ Path dependency due to inertia of long-lived capital and network externalities preventing the take-up of new technologies ✓ Balancing short-medium, and long-term objectives[30] ✓ Strategic sector in terms of technology dynamics/deployment ✓ Increasing security of energy supplies
Business: Energy-intensive industries	Direct emissions arising from the production process Indirect emissions arising from the use of electricity	✓ Carbon externality ✓ Under-investment in low carbon R&D: in production processes and energy efficient products ✓ Credit market failures ✓ Path dependency (same as above) ✓ Balancing emissions reductions with the potential for carbon leakage in internationally competitive sectors
Business: Non-energy intensive industries	Indirect energy (electricity) consumption, especially buildings-related emission	✓ Carbon externality ✓ Organisational inertia ✓ Credit market failures

[30] For example, balancing the need for emissions reductions in the short-term with policies to encourage R&D that have the potential to reduce emissions more cost effectively in the longer-term.

Sectors	Major source of emissions	Major market failures and other policy considerations
	Production of non-energy efficient goods	✓ Split incentives ✓ Informational failures ✓ Hidden and transaction costs ✓ Credit market failures, especially financial constraints on small and medium enterprises ✓ Low response elasticity: energy costs typically form a small part of total operating costs (between 1-3%)
Business: Waste	Emissions from waste disposal (for example, from landfills, waste incineration)	✓ Carbon externality ✓ Under-investment in low carbon R&D (development and diffusion of new technologies) ✓ Informational failures
Transport	Emissions from fuel consumption	✓ Carbon externality[31] ✓ Path dependency, especially in terms of inertia of infrastructure capital and associated network externalities[32] ✓ Informational failures ✓ Inertia due to consumers' unfamiliarity with low CO_2 vehicles ✓ Uncertainty about future oil prices (and its effect on low carbon investments) ✓ Low response elasticity to fuel prices[33] ✓ Trade-off between high short-term costs due to strong correlation between

[31] Several externalities affect the transport sector, for example, carbon, local air pollution, accident costs, noise, and congestion, of which the carbon externality represents a relatively small part.

[32] For example, the need for a high density of outlets to supply new energy sources in order that users will switch to new energy sources – a positive network externality

[33] due to the strong link between transport demand and economic growth and the value the public place on mobility

Sectors	Major source of emissions	Major market failures and other policy considerations
		transport and GDP growth and the potentially significant long term benefits from carbon saving technology in transport ✓ Balancing emissions reduction objectives with equity considerations of higher transportation costs on low income households/individuals ✓ Interaction between climate change policies and policies to reduce congestion ✓ Co-ordination between markets to supply vehicles and the energy vector (fuel, electricity, hydrogen)
Residential	Direct emissions from water heating, space heating/cooling of homes Indirect energy consumption from the use of appliances	✓ Carbon externality ✓ Informational failures ✓ Split incentives, between landlords and tenants ✓ Hidden and transaction costs, especially search costs ✓ Inertia ✓ Low response elasticity: energy cost less than 10% of total household expenditure in 2006, search/transaction costs, limited substitution options ✓ Balancing emissions reduction objectives with equity consideration of higher costs on low income households/individuals
Agriculture, forestry, and land use	Non-carbon emissions (methane, nitrous oxides) from diffuse sources Energy consumption: from petrol/diesel, gas, electricity use and for fertiliser production	✓ Carbon externality ✓ Under-investment in R&D: into new technologies, agricultural practices, crops ✓ Credit market failures, especially financial constraints on small farmers ✓ Informational failures ✓ High transaction/search costs ✓ Measurement difficulties

Sectors	**Major source of emissions**	**Major market failures and other policy considerations**
Public sector	Indirect energy consumption from buildings- and office equipment-related emissions	✓ Carbon externality ✓ Split incentives ✓ Informational failures ✓ Hidden and transaction costs, especially search costs

CHAPTER 3: Designing policy

Climate change policy should be the outcome of balanced decision-making, and the policy-maker needs to consider how the policy performs along several dimensions.

Performance Criteria

→ *Economic (allocative) Efficiency*[34]*/Cost Effectiveness*: Achieving the required emissions reduction at the lowest cost, i.e., reductions are made by adopting the least costly measures and abatement cost of removing an additional tonne of CO_2 is equal across all sources (see Box 2 on the shadow price of carbon).

→ *Administrative Burden*: The cost to regulated sources of demonstrating compliance (i.e., monitoring, reporting, and verification) and the cost to government of administering and enforcing the instrument.

→ *Secondary Effects*: Effects beyond emissions reductions, such as double dividends, wider environmental and other co-benefits[35]/dis-benefits, increased technological innovation and spillovers, and improved perception, awareness, dissemination of technology

→ *Distributional Equity*: The degree to which alternative instruments have a progressive or regressive impact, or have different impacts on different agents/sectors/income groups and across time.

→ *Price vs. Quantity Uncertainty*: Uncertainty of achieving an environmental outcome (i.e., achieving a specific level of emissions reduction) compared to the uncertainty in the price (or cost) of achieving that outcome.

→ *Flexibility vs. Policy Certainty*: Trade-off between the flexibility to adapt to exogenous changes in technology/resource use/consumer tastes and the risk of creating policy uncertainty/regulatory capture/other perverse effects associated with a more flexible instrument.

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[34] the marginal abatement cost (or carbon price) required to bring about emissions reductions that will allow a given stabilisation pathway to be reached and contribute to securing global commitment to reduce greenhouse gas emissions globally

[35] For example, improvements in air quality

→ *Impact on Public Finance*: Impact of the instrument on the exchequer, for example, market-based instruments like taxes and trading schemes could have significant implications for public finances.

→ *Ensuring Energy Security of Supply*: Maximising synergies between climate change and energy security policy such that emissions reductions are made in a way that helps the UK secure, diverse, and sustainable supplies of energy at competitive prices.

→ *Competitiveness Effects*: Choosing economically efficient and cost effective interventions that reduce the potential for carbon leakage in internationally competitive sectors.

→ *Simplicity and Transparency*: An important criteria for gaining business and more generally public acceptance and support for climate change policy as being fair, logical, robust, and consistent.

Box 2: Shadow price of carbon

As the stringency of climate change targets has increased, it is increasingly important for the policy environment to respond to this challenge cost effectively – thus minimising the overall cost on the UK economy of meeting its obligations. Key to achieving cost effectiveness is the use of consistent carbon pricing in the appraisal of policies and projects across Government. *Cost effectiveness* dictates that emissions reductions are made where they are the cheapest, to the point where marginal cost of abatement is equalised across regulated sources.

To that end, the government is currently finalising guidance on the application of carbon pricing across government which will establish a carbon price for policy and investment appraisals that is consistent with achieving our emission reduction goals. These goals, in turn, are consistent with atmospheric stabilisation scenarios in the Stern Review and the recommendations of the Committee on Climate Change. The new guidance will replace the current approach of the Shadow Price of Carbon, which is based on the incremental damages associated with emissions. The new approach moves from a damage-cost based approach towards one that is based explicitly on abatement costs.

The effect of using this guidance in impact assessments is to raise the net present value of policy and investment options with low carbon impacts relative to those with larger carbon impacts (for carbon abatement policies, it will raise the net present value of policies with larger carbon savings relative to those with lower carbon savings), and thereby enable policy-makers to identify the most efficient options for securing abatement, or for avoiding policies which increase emissions at net cost to society. Incorporating the guidance into appraisals should ensure that options and projects are ranked in a way which gives due weight to carbon they emit or abate, allowing emissions reductions to be made where they are cheapest.

Range of instruments

UK climate change mitigation policy (at the domestic and EU level) encompasses a range of different instruments, classified into five broad categories:

- *Market-based (economic) instruments.* Instruments targeting the price of emissions can include taxes, tax credits, and subsidies directly related to emissions and indirect emissions pricing such as fuel charges. Instruments targeting the quantity of emissions (and hence indirectly the price of emissions) include trading regimes such as cap-and-trade systems and credit exchange programmes and deposit refund systems. Market-based instruments are effective tools for internalising the carbon externality, with higher emissions prices also creating a greater incentive for R&D investment and for overcoming barriers to behaviour change and diffusion of low carbon technologies. Such instruments can help achieve emissions reductions in an efficient and cost effective manner, without requiring the policy-maker to have this information beforehand.
- *Direct regulation.* These include the more traditional regulations that set prescriptive technology-based standards specifying the use of particular equipment, processes, or procedures, permitting regimes that set performance standards, and product bans. Direct regulation put an indirect price on emissions, and internalise some or all of the carbon externality. Higher emissions prices caused by regulation can also create a greater incentive for R&D investment and for overcoming barriers to behaviour change. However, to the extent that they create an expectation that future returns will be eroded by even higher standards, direct regulation may reduce to invest in R&D.
- *Technology/spending programmes.* These include investment grants such as infant industry support of renewables and publicly funded R&D, technology diffusion measures, operating subsidies or grants, and infrastructure (industrial or otherwise) policies. These programmes are intended to encourage innovation, overcome market failures leading to under-investment in R&D, support the diffusion/adoption of new technologies, and mitigate the effects of policy uncertainty.

- *Information provision and public engagement.* This includes awareness campaigns, education programmes, citizens and community engagement programmes, and product labelling requirements. They are important for bringing about behaviour change by increasing awareness and overcoming informational market failures. When used in conjunction with other instruments, such programmes have been shown to be effective in bringing about cost effective emissions reductions and in improving the effectiveness of the climate change policy.
- *Negotiated agreements.* These are agreements between the government and one or more private parties to reduce emissions beyond compliance with existing regulations. They can be either incentivised or voluntary: climate change agreements are an example of incentivised negotiated agreements and agreements with car manufacturer associations in Europe, Japan, and Korea to reduce new car CO_2 are examples of voluntary agreements. These instruments tend to work best as part of a policy package, and can be useful in raising awareness, realising cost effective emission reductions not targeted elsewhere, and exemplifying best practice.

Each type of instrument has its pros and cons, and no one instrument is capable of effectively addressing all of the market failures and policy considerations that need to be taken into account when designing climate change policy. Appendices A, B, C, D, and E discuss how different types of instruments are likely to perform against the performance criteria set out above.

CHAPTER 4: Selecting the right mix of instruments

Climate change involves multiple, jointly reinforcing[36] market failures and policy considerations that require the use of multiple instruments.

Using a mix of instruments

Using a mix of policy instruments could mean several instruments being imposed on any one sector or part of the economy. For example, a combination of market-based instruments, technology/spending programmes, and information and public engagement policies could lower emissions in a given sector more efficiently than reliance on one of these instruments alone.[37] The push-pull complementarity between instruments – technology/spending programmes push new technologies into the market and market-based instruments, direct regulation, and information campaigns pull them in – can improve the efficiency of the overall policy package. As long as the instruments target different market failures, their co-existence could improve effectiveness of the policy.[38]

Using a mix of instruments also allows climate change policy to be more targeted. While the carbon externality and under-investment in low carbon R&D are market failures affecting all parts of the economy, there are reasons for adopting a more sector-specific approach. The varied nature and extent of R&D spillovers in different sectors may require a more sector-specific approach. The nature of the barriers to behaviour change, be it information asymmetry, split incentives, or problems accessing credit markets, tend to vary across sectors. Policy considerations such as distributional equity, low response elasticity, strategic deployment of technology, and the balance between competing policy objectives

[36] In some cases, market failures can be jointly ameliorating: (i) jointly ameliorating implies correction of one market failure ameliorates welfare losses from the other, (ii) jointly reinforcing implies correction for one market failure exacerbates welfare losses from the other, and (iii) neutral implies correction of one market failure does not affect the welfare losses from the other). (Bennear and Stavins, 2007).

[37] Market-based instruments to internalise the carbon externality, technology/spending programmes to encourage innovation and lower abatement costs on the long run, and information and public engagement campaigns to raise awareness and overcome information asymmetries and other barriers to behaviour change.

[38] While studies exist on how to design an economically efficient basket of instruments, there is little academic literature on the ex-post effectiveness of alternative regulatory approaches, and even less on the ex-post effectiveness of alternative packages.

also tend to vary between sectors. A coherent climate change policy needs to address all sectors and participants in the economy in an integrated manner, but with recognition of specific market failures and other differences that exist between them. Chapter 5 discusses instrument choice at the sectoral level in more detail.

Finally, a well-chosen mix of instruments is also likely to be effective in dealing with circumstances as they evolve over time. The certainty over overall emissions reductions up to 2050 provided by the Climate Change Act is critical for reducing policy risk and encouraging long-term investment into the development and adoption of low carbon technologies and processes. Within the framework of the Climate Change Act and carbon budgets, delivering the required emissions at least cost requires a flexible approach, and a suite of instruments provides policy makers with flexibility to deal with and adapt to changing circumstances. For example, imperfect information may be a significant market failure currently in the take-up of cost-effective energy efficiency measures by households, but could become less important as UK's public attitudes and behaviours change. Against a backdrop of changing circumstances, a mix of instruments provides the flexibility to design a dynamic climate change policy.

The challenge is determining the conditions under which an instrument, or set of instruments, is the appropriate choice. Multiple instruments can be problematic if

- they are inconsistent with each other, for example, perverse consequences can result if interactions between different policies are not carefully considered;
- policies/instruments are frequently modified or withdrawn as this increases uncertainty and risk and dulls agents' incentive to respond[39]; and
- bad policy design and a lack of policy coherence (for example, between environmental, energy, transport, and other related policies) could raise

[39] The effect of uncertainty and policy risk is especially important in the context of climate change as any investment tends to be large-scale and over a long time horizon.

overall costs and mitigate some or all of the potential gains from using a mix of instruments.

Thus, care needs to be taken when choosing a mix of instruments to tackle climate change. In recognition of the challenge and in response to business concerns about the increasing complexity of the climate change policy landscape, the Government published the Climate Change Simplification paper[40] in December 2007, identifying areas of overlap between three existing instruments – EU ETS, CCAs, and CRC – and suggesting options for simplification. Recommendations are intended to make the current set of climate change instruments more coherent and cost effective[41], as well as inform the development of future measures.

Where in the supply chain to intervene

Designing an effective climate change policy package requires not only selecting the most appropriate instrument(s), but also choosing where in the supply chain to intervene.

There are clear benefits to applying carbon pricing instruments upstream in the supply chain.

- Creating an upstream carbon price by targeting upstream suppliers (power and fuel) has the advantage of establishing a carbon price across a sector or even the whole economy. Upstream carbon prices are shown to be generally passed through to downstream sectors and consumers.[42] This broadens the range of possible behavioural adjustments for reducing emissions. An approach which targeted downstream agents is likely to bring into play mainly downstream adjustments, reducing the scope for cost effective abatement across the supply chain; for example, an upstream instrument might induce energy suppliers to change their fuel mix, and this could

[40] Climate Change Instruments: Areas of Overlap and Options for Simplification, Defra, December 2007.

[41] Recommendations are being taken forward by (i) CCAs in the consultation in 2008 on the future form of CCAs, (ii) CRC as the policy is developed for implementation up to 2010, and (iii) EU ETS and IPPC in the on-going reviews of the Directives and UK implementation.

[42] although this depends on the extent and nature of competition in the markets affected

provide a lower cost means of adjustments than any downstream change alone could achieve.

- Upstream interventions also mean fewer regulated sources – lowering administrative, monitoring, and enforcement costs.
- Finally, such interventions can also reduce the potential for carbon-generating activities being left uncovered, by reducing the potential for carbon leakage.

However, multiple barriers and market failures mean that a basic carbon price alone would not be sufficiently strong to unlock potential for cost effective carbon savings in some sectors of the economy. Tackling these market failures and balancing various policy considerations requires a more sector-specific approach (whether upstream or downstream in the supply chain). For example, an upstream carbon price alone may not be sufficient to unlock mitigation potential in the non-energy intensive sector (energy costs are usually a small fraction of total operating costs), but could be effective in reducing emissions from this sector when combined with other instruments specifically targeting this sector. For example, a downstream mechanism could have the advantage of being more visible to the final customer, and therefore better suited to tackling barriers such as information failures. Similarly, emissions from the transport sector could be reduced more effectively when the upstream price signal is combined with policies that encourage use of low carbon transport.

As set out in Stern, multiple, different carbon prices are not economically efficient, and any comprehensive policy framework should seek to *establish a carbon price* across sectors.[43] While an upstream intervention is in theory the most efficient way of achieving this objective, there could be policy and other considerations that require a more disaggregated approach.[44] In addition, the

[43] While current separate EU targets could produce different carbon prices for the traded and non-traded sectors, convergence in these prices is required for long-term efficiency of climate change policy.

[44] An efficient allocation of resources under a disaggregated approach would require downstream policies to be designed such that the level of abatement secured from each sector/part of the economy is based on cost effective abatement potential across sectors.

policy framework needs to carefully consider the differences between sectors when choosing a combination of upstream and downstream instruments to

→ *encourage innovation*: potentially reducing abatement costs in the future; and

→ *remove barriers to behaviour change and the diffusion of new technologies*: reduce the need for additional interventions to meet tightening emissions reduction targets.

The EU/international context

Given the global nature of the problem and the existence of multi-national policy instruments intended to tackle it, any discussion of instruments to tackle climate change needs to consider domestic interventions in the context of international action to tackle climate change. As the Stern review states, "*Climate change is global in its causes and consequences, and international collective action will be critical in driving an effective, efficient and equitable response on the scale required."*

In terms of *carbon pricing*, using taxes, trading schemes, or direct regulation to establish a global carbon price has clear economic efficiency and cost effectiveness benefits. The economically efficient level of abatement is where the cost of reducing another tonne of greenhouse gas *anywhere in the world* is equal to the long-term damage an extra tonne of greenhouse gas will cause (or the social cost of carbon). Interventions at the trans-national level are more likely to achieve a given level of shared commitment to cost effective abatement than separate domestic interventions.[45] Establishing a carbon price at the international level also has the advantage of minimising negative competitiveness effects and the effect of these interventions on economic growth.

[45] The efficient level of abatement in the domestic context is where cost of reducing another tonne of greenhouse gas *anywhere in the economy* is equal to the long-term damage an extra tonne of greenhouse gas will cause (or the social cost of carbon).

Taxes and trading tend to be more cost effective than direct regulation as they allow for emissions reductions to occur where they are cheapest, unconstrained by national boundaries. A tax puts a price on carbon emissions and lets markets determine the amount of carbon emitted. In contrast, trading specifies a particular level of emissions and lets the market determine where the emissions come from.

Theoretical analysis, as reviewed by Stern, suggests that taxes are preferable when the benefits of abatement rise at a slower rate than abatement costs and quantity controls through trading are preferable where the benefits of further abatement increase at a faster rate than do the costs of delivering these reductions. In the short-term, the benefits of abatement are likely to rise slower than costs.[46] However, this can reverse in the longer term, with marginal benefits of abatement accelerating as cumulative emissions rise and marginal costs of abatement remaining relatively flat as new technologies become available. In this context, the Stern review suggests a two pronged approach: a long-term stabilisation target to establish a quantity ceiling to limit the total stock of carbon over time and short-term policies (taxes or trading) consistent with that target.

There are also advantages of multilateral cooperation on *R&D investment into low carbon technologies*. Knowledge sharing, joint funding of projects, and other cooperation between countries is likely to lower costs – by aligning priorities and avoiding duplication, by sharing costs and spreading the risk, and by accelerating market learning through an increase in the potential for technology transfers and spillovers. However, countries will see national economic benefit in investing in domestic R&D, and combined with the risk of any global fund becoming overly bureaucratic and/or politicised, a model of 'loose coordination' may be most appropriate.[47] This should both reduce the overall global cost of

[46] The benefits of each additional unit of abatement are likely to rise slower than costs as the damage caused by climate change is more a function of the stock of greenhouse gases in the atmosphere than each additional unit of emissions over a short period of time.
[47] Source: OCC Global Technology Project, 2008 (http://www.occ.gov.uk/publications/Global%20technology%20project%20report.pdf)

delivering a given level of shared commitment to abatement, and increase the economically efficient level of overall ambition for abatement.

Ensuring that domestic interventions add value

Even though the UK accounts for a little over 2% of global greenhouse gas emissions[48], the Climate Change Act demonstrates leadership in tackling the issue and increasing certainty for investment. However, domestic UK climate change policies to deliver these targets need to be designed to complement (current and future) EU measures.

EU actions have a large impact on the scope and design of UK climate change policies, whether they are in terms of setting EU-wide targets for emissions reduction, renewable energy, or energy efficiency or in terms of the adoption of specific policies and measures to cut emissions. The value of domestic instruments needs to be considered in the context of any significant EU/global action to reduce greenhouse gas emissions. As discussed earlier, implementing a carbon pricing instrument such as the EU ETS at the trans-national level has clear advantages in terms of economic efficiency, cost effectiveness, and reduction of negative competitiveness impacts on UK industry. Domestic instruments should be designed to supplement interventions like the EU ETS, either by improving the efficiency of the scheme, by targeting emissions not directly covered by the scheme, or by targeting other climate change-related market failures.

- *Correcting for distortions to price signals*. Sector-level market failures such as organisational inertia, split incentives, credit market failures, and path dependency mean that the price signal from carbon pricing mechanisms (for example, higher electricity prices from the EU ETS) is distorted and/or does not produce the economically efficient response downstream. Measures aimed at overcoming these market failures can be justified as they could increase the efficiency of carbon pricing instruments like the EU ETS.

[48] Source: World Resources Institute

- *Supporting and enhancing the carbon price signal*. In sectors such as the residential and large non-energy intensive sector (and small and medium enterprises in most sectors), energy costs account for a small proportion of total costs, making them less sensitive to even large changes in energy prices. For example, the price signal from the EU ETS alone may not be enough to encourage sufficiently high levels of take-up of cost effective technologies and measures that have been shown to be available in these sectors. Measures that support/enhance the EU ETS price signal[49] have the potential to bring about more cost effective achievement of EU ETS targets and additional emissions reductions outside of the EU ETS and can be justified along with the EU ETS.

- *Meeting economy-wide targets by targeting non-EU ETS emissions.* The Climate Change Act commits the UK to mandatory greenhouse gas emissions reductions of at least 80% over base year levels by 2050. Measures targeting emissions not directly covered by EU ETS could provide emissions reductions from the non-traded sector in order to meet these targets. Without a change to the EU ETS cap, domestic policies targeting EU ETS emissions may reduce the costs to the UK of meeting the cap, but will not reduce aggregate emissions at the EU level.

- *Encouraging the development and diffusion of new technologies*. As discussed in Chapter 2, leaving R&D investment to market forces alone is likely to result in underinvestment compared to the socially optimum level. Government support for R&D and for the diffusion of new technologies has the potential for reducing abatement costs in the future, thus improving the cost effectiveness of UK's climate change policy as a whole. Early support for low carbon technologies could also create viable 'green' industries that are global market leaders in low carbon technologies and products. [50] [51]

[49] For example, information and public engagement campaigns and measures such as supplier obligations which aim to pull through energy efficiency improvements in the residential sector.
[50] To that end, the 2008 Manufacturing Strategy Review identifies the challenges and opportunities created for UK manufacturing from moving to a low carbon economy as one of five

→ *Bringing about behaviour change*. Domestic interventions that induce behaviour change have the advantage of reducing long-term energy demand (by shifting the energy demand curve inward). Meeting the UK's climate change targets requires significant adjustments by the UK economy, and instruments that induce behaviour change reduce the need for additional interventions that would otherwise be required to meet these targets. As the EU ETS cap gets progressively tighter (as is being proposed), such measures will put the UK economy in a better position to meet its obligations under the cap at minimum cost to the economy and to economic growth.

Thus, while domestic interventions can be justified in the context of EU/international actions to tackle climate change, they need to be carefully designed and targeted to ensure that they add value.

As part of its consideration of the Committee on Climate Change's recommendations on carbon budgets, Government is reviewing potential overlaps between various policies, to ensure that possible inefficiencies are eliminated. This will enable a comprehensive and consistent package of policies to be set out in the report on policies and proposals in mid-2009.

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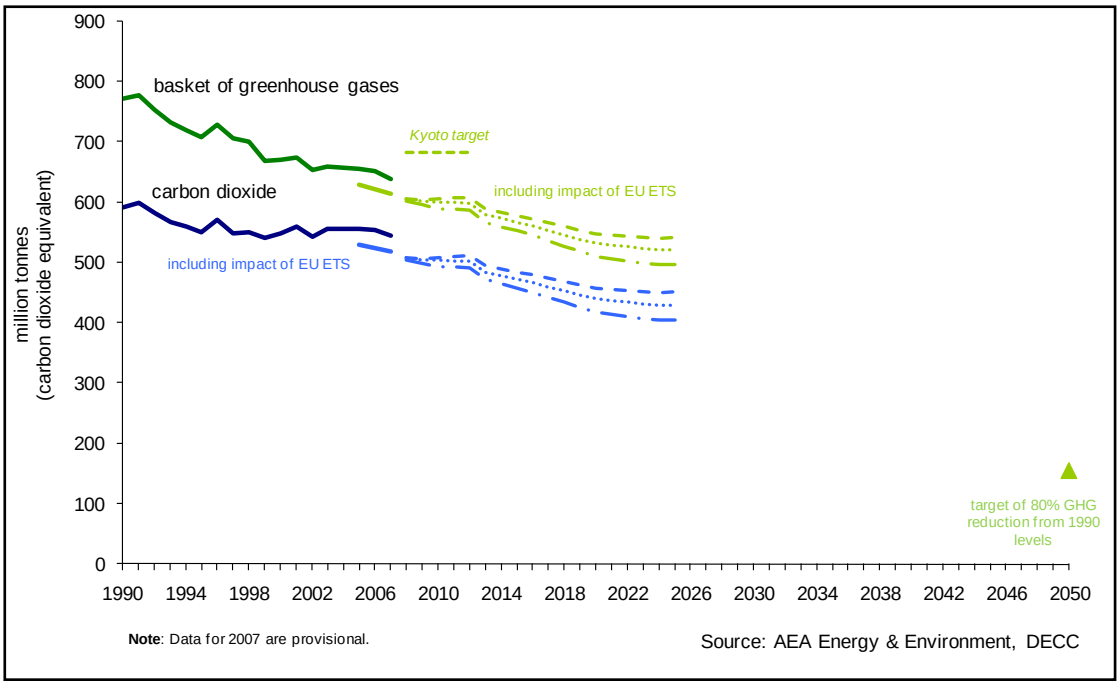
major dynamics reshaping global manufacturing is identified by, and sets out the government's medium-term strategy to support business in taking advantage of these opportunities.

[51] The Stern review estimates that the market for low carbon energy products is likely to be worth £500 billion or more by 2050.

CHAPTER 5: Applying the analysis: selecting the right mix of instruments

In order to meet the carbon budgets set under the Climate Change Act, the UK will need to consider effective ways of delivering the required emissions reductions (see chart 3). The Government will announce the carbon budgets in spring 2009, taking into account advice from the Committee on Climate Change. Carbon budgets will set whole economy emission reduction targets, but emissions falling under the EU ETS will be determined by the UK share of the EU ETS cap.

Chart 3: UK projected GHG and CO_2 emissions



Source: DECC (UEP32)

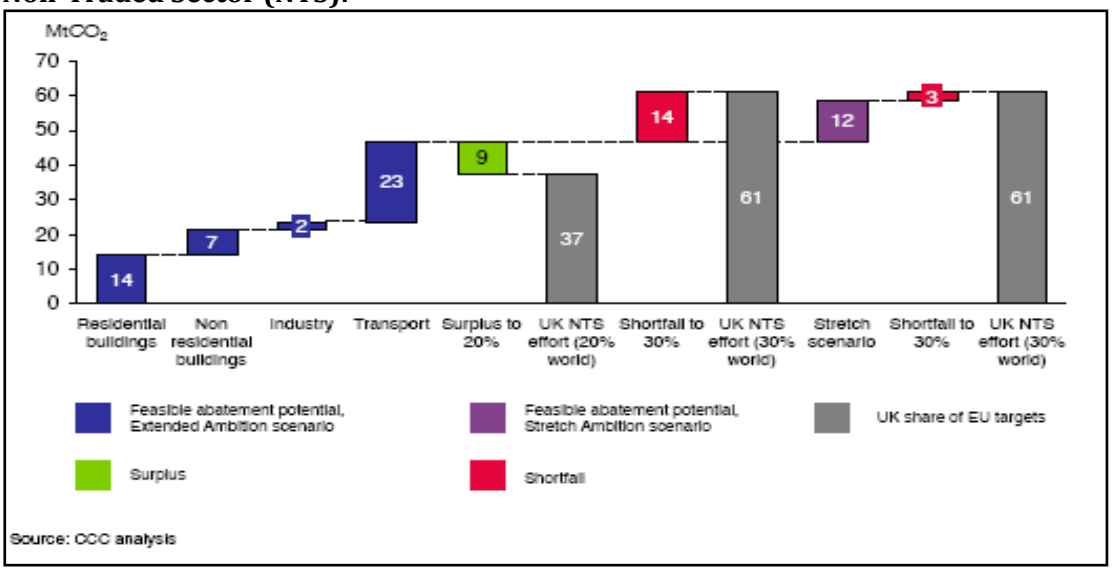
Establishing a carbon price is key to identifying mitigation potential across the economy that is both efficient and cost effective to achieve – especially in sectors not covered by EU ETS. For sectors covered by EU ETS, the relevant carbon price is the EU ETS allowance price. The shadow price of carbon establishes the relevant carbon price for non-EU ETS sectors.

Moving to a target-consistent shadow price of carbon based on abatement costs, as suggested in box 2, would help ensure that the shadow price of carbon was at the correct level to deliver abatement required to meet targets in non EU-ETS sectors of the economy. The accompanying paper on the shadow price of carbon assesses how to reflect the level of emissions reduction ambition in decisions on policies and investment projects. It recommends some significant changes to the way emissions are valued when choosing between public policies and projects, consistent with the introduction of carbon budgets and the new emissions reductions targets set out in the EU climate change and energy package.

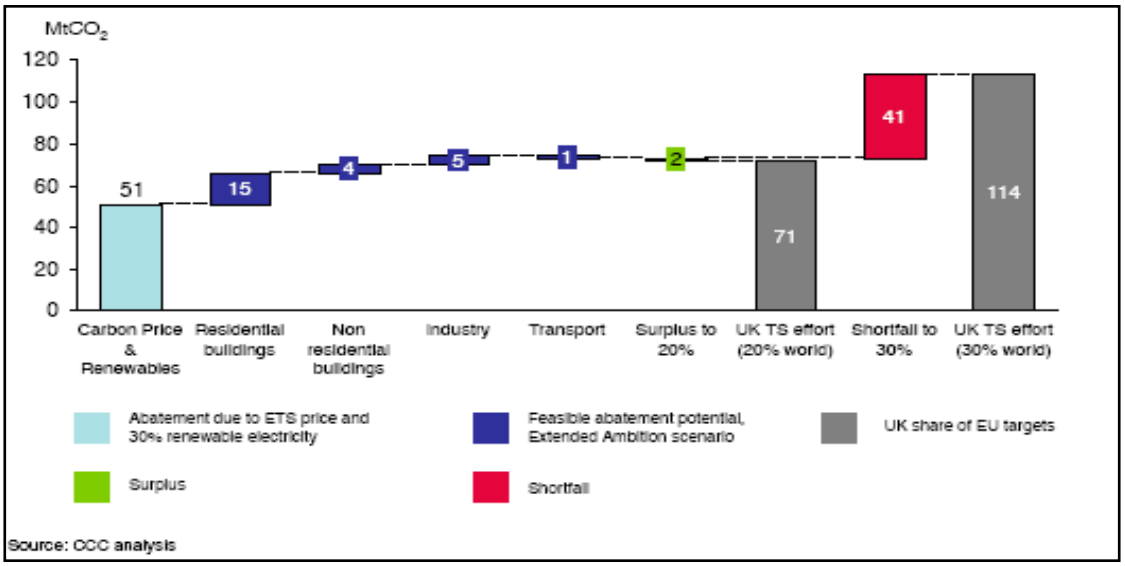
Recent analysis by the Committee on Climate Change sheds some light on the abatement potential in the UK and the carbon price required to achieve that potential. The report estimates the abatement potential in the traded and non-traded sector under three scenarios – current ambition, extended ambition, and stretch ambition – and compares it to the level of UK effort required under 20% and 30% EU 2020 GHG emissions reduction targets (see chart 4).

Chart 4: Abatement potential vs. the level of effort required under 20% and 30% EU 2020 targets

Non-Traded Sector (NTS):



Traded sector (TS):



The Committee's analysis finds:

- The current ambition scenario does not deliver emissions required to meet a 20% target, in the traded and in the non-traded sector. Current ambition includes abatement measures that cost less per tonne than the forecast carbon price (central estimate of £40/tCO2 in 2020) and/or emissions reduction from policies that are already in place – estimated to deliver savings of 79 $MtCO_2e$ in 2020.
- The extended ambition scenario is able to deliver emissions reductions to meet a 20% EU target in the traded and non-traded sectors. Extended ambition includes more ambitious assumptions about penetration of energy efficiency improvements and a number of measures that would cost significantly more per tonne than the forecast carbon price – estimated to deliver savings of 121 $MtCO_2e$ in 2020.[52]
- The stretch ambition scenario is able to deliver emissions reductions to meet a 30% EU target in the non-traded sectors. However, emissions reduction to meet the target in the traded sector cannot be made from domestic emissions alone. Stretch ambition includes further feasible abatement opportunities for which there is no policy commitment at the moment (the move from extended to stretch largely comprises lifestyle changes, for example,

[52] The measures are broadly in line with what the Government has committed to in principle, but where precise definition and implementation still remains to be decided.

increased deployment of renewable heat and improved fuel efficiency in road vehicles – estimated to deliver savings of 121 $MtCO_2e$ in 2020.

Analysis by sector

The rest of this chapter describes sector-specific barriers (by broad categories of sources of emissions) and policy considerations, along with the set of climate change measures currently in place to address them. The analysis is intended to clarify the rationale for current policies and identify key issues to consider in the design of future policies to deliver the required abatement.

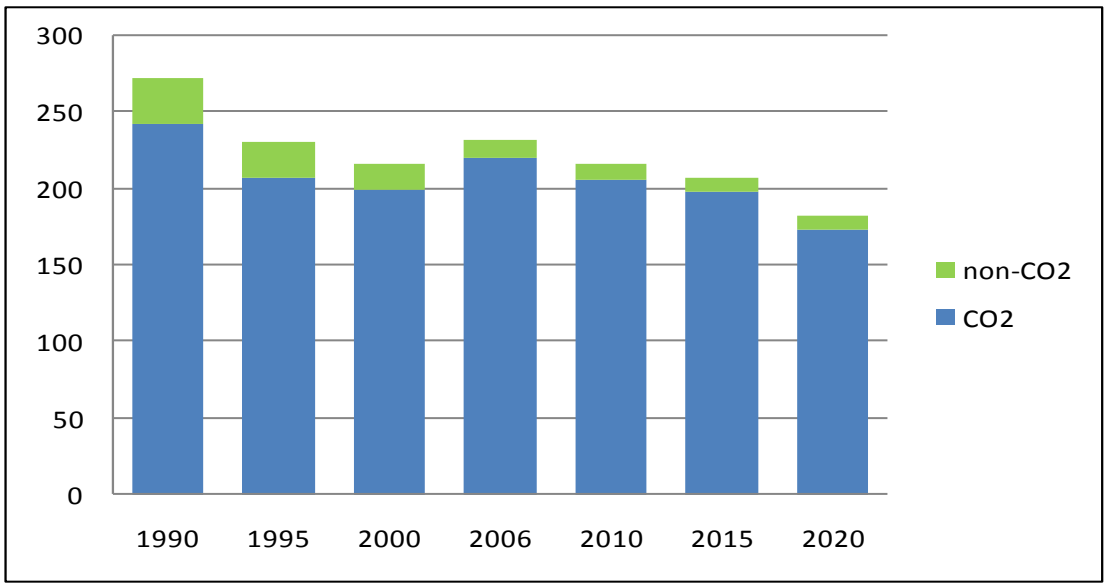
While emissions reported below are direct emissions from each sector based on that sector's fossil fuel consumption, climate change policies target both direct emissions and indirect emissions from electricity consumption from each sector. To the extent that policies target direct and indirect emissions, there will be some overlap; for example, policies that targeting the energy supply sector to reduce emissions from the production of electricity and policies that target the business sector to reduce electricity use. Such an overlap can be justified as long as the policies together deliver additional emissions reductions compared to what each policy might have delivered on its own.

I. *Energy Supply***.** Emissions from this sector are largely direct emissions from the production of energy for final consumption by other sectors, for example, electricity generation; oil production and refining; gas production and transmission; and the production of coal and other solid fuels.

In 2006, this sector accounted for the largest share of greenhouse gas emissions, 232 $MtCO_2e$ or 36% of the UK's total GHG emissions by source.[53] Despite a general rise in the demand for electricity, annual emissions from energy supply have fallen since 1990, and they are projected to be 21% lower than 1990 emissions in 2010 (see chart 5). European Commission proposals on the EU ETS and renewable energy go further, and are likely to lead to additional emissions reductions in the future.

[53] not including emissions reductions purchased from abroad

Chart 5: CO_2 and non- CO_2 emissions from the energy supply sector[54]



Source: AEA Technology, DECC (UEP32)

Table 2 summarises some of the main interventions in this sector[55], along with the market failures and behaviours being targeted.

[54] Charts 5-10 do not include emissions purchased from abroad through the EU ETS.
[55] Based on the 2007 Analytical Audit of climate change policy by the Office of Climate Change.

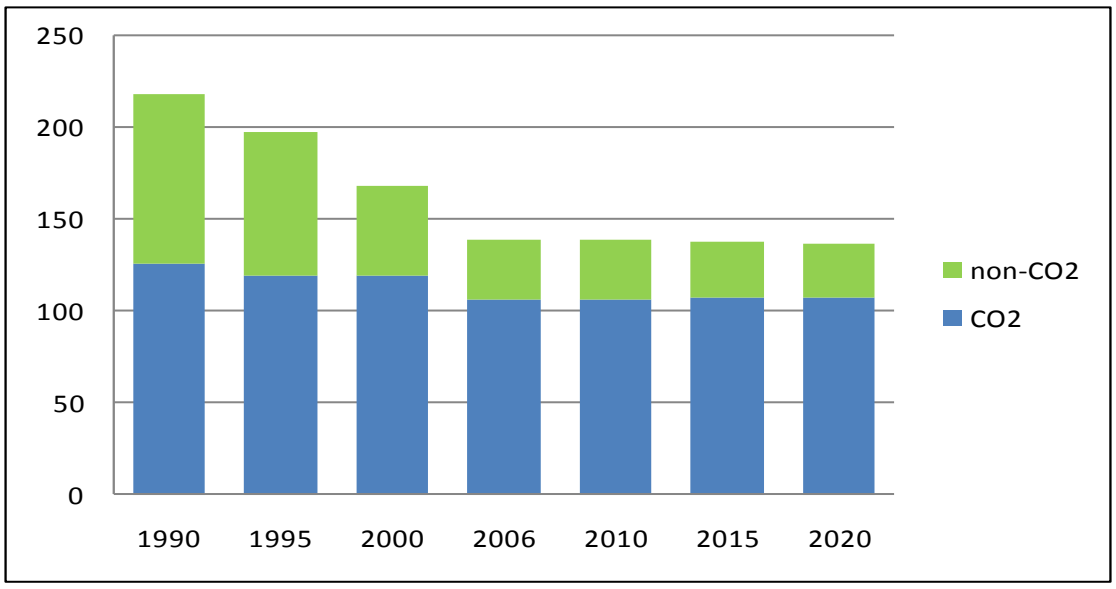
Table 2: Summary of instruments targeting the energy supply sector

Major market failures and other policy design considerations	Behaviours to target	Major policy interventions
✓ Carbon price externality ✓ Under-investment in low carbon R&D: development and diffusion of new technologies ✓ Credit market failures ✓ Path dependency due to inertia of long-lived capital and network externalities preventing the take-up of new technologies ✓ Balancing short-medium, and long-term objectives ✓ Strategic sector in terms of technology dynamics/deployment ✓ Increasing security of energy supplies	✓ Switching to low carbon fuels ✓ Promoting energy efficiency ✓ R&D into low carbon technologies ✓ Investment in low carbon technologies (combined heat and power, carbon capture and storage, renewables) ✓ Investment in infrastructure to support new technologies and aid their take-up	✓ EU Emissions Trading Scheme ✓ Climate Change Levy (and exemptions) for renewables and CHP ✓ Renewables policy (Renewables Obligation, R&D funding for renewable energies, capital grants for renewable energy) ✓ CHP policy (targets for government departments, appropriate treatment of CHP in EU ETS, other measures to support CHP) ✓ Environmental Transformation Fund ✓ Marine Renewables Development Fund ✓ Demonstration projects (hydrogen, carbon abatement, microgeneration, marine biomass, and fuel cell technologies; carbon capture and storage)

II. *Business.* This sector includes the energy-intensive sector, the manufacturing and commercial sectors (including commercial and institutional emissions), industrial processes, and waste management. The diverse nature of organisations in this sector means that selecting instruments requires careful consideration of the characteristics of different organisations being targeted as well as the different barriers they face. Emissions to be targeted include direct emissions from the use of fossil fuels, indirect emissions from the consumption of electricity (especially from commercial buildings), and emissions from landfills (mainly in the form of methane).

This sector was responsible for 140 $MtCO_2e$ or 21% of the UK's total greenhouse gas emissions by source[56] in 2006. Emissions from this sector have been falling since 1990, largely driven by the structural shift in the UK economy, away from manufacturing and towards service industries (see chart 6). In 2010, emissions are projected to be approximately 37% lower than 1990 levels.

Chart 6: CO_2 and non- CO_2 emissions from the business sector



Source: AEA Technology, DECC (UEP30)

Policies targeting this sector focus on (1) pricing the carbon externality and overcoming barriers limiting R&D investments in the energy-intensive sector

[56] includes only direct emissions (and not indirect emissions associated with electricity use)

and (2) addressing barriers to behaviour change and the take-up of cost effective technologies and measures in the non-energy intensive sector.

Table 3 summarises some of the main interventions in this sector, along with the market failures and behaviours being targeted.

Table 3: Summary of instruments targeting the business sector

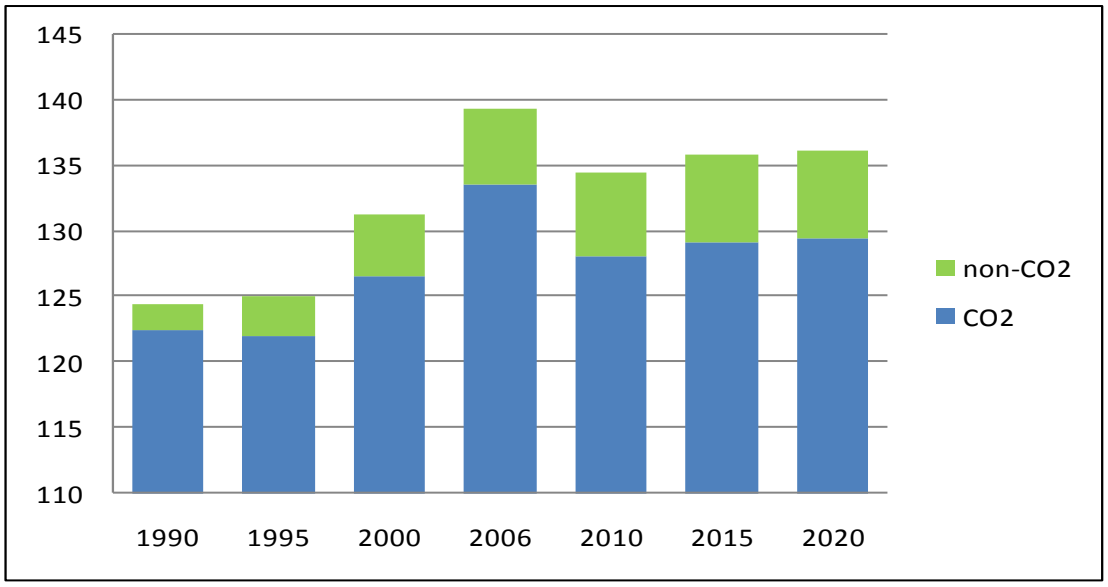
Market failures/Policy considerations	Behaviours to target	Major policy interventions
Energy-intensive industries		
✓ Carbon price externality ✓ Under-investment in low carbon R&D: in production processes and energy efficient products ✓ Credit market failures ✓ Path dependency (same as above) ✓ Balancing emissions reduction with avoiding carbon leakage in internationally competitive sectors	✓ Switch to low carbon fuels ✓ Investment in zero/low carbon technologies (combined heat and power, carbon capture and storage, renewables) ✓ Promoting energy efficient production processes ✓ Investment in R&D into energy efficient products	✓ EU Emissions Trading Scheme (for direct emissions) ✓ Carbon price signal from upstream EU ETS on electricity generation ✓ Climate Change Levy and Climate Change Agreements ✓ Integrated Pollution Prevention and Control regulations (through technology- and performance-based standards) ✓ Enhanced capital allowances ✓ Carbon Trust (support to assess energy efficiency performance and potential investments in low carbon measures)
Non-energy intensive industries (including the commercial sector, and commercial and institutional emissions)		
✓ Carbon price externality	✓ Improving the energy efficiency of buildings	✓ Carbon price signal from upstream EU ETS on electricity generation and other industrial activities

Market failures/Policy considerations	Behaviours to target	Major policy interventions
✓ Organisational inertia ✓ Split incentives ✓ Informational failures ✓ Hidden and transaction costs ✓ Credit market failures, especially financial constraints on small and medium enterprises ✓ Low response elasticity: energy costs typically form a small part of total operating costs (between 1-3%)	✓ Investment in more efficient equipment and practices ✓ Promoting the production and use of energy efficient products (through product mix, marketing, labelling) ✓ Switching to on-site renewables and combined heat and power ✓ Reduce search and other transaction costs through information provision ✓ Improving public and company information on green house gas emissions	✓ EU Emissions Trading Scheme (some large emitters) ✓ Climate Change Levy ✓ Carbon Reduction Commitment ✓ Building Regulations 2002 and 2005 ✓ Low Carbon Buildings Programme ✓ Carbon Trust (support for investment in and take-up of energy efficiency/energy saving opportunities) ✓ Measures for better billing and metering (for example, through smart metering) ✓ Market transformation measures including appliances standards and labelling ✓ Enhanced capital allowances
Waste		
✓ Carbon price externality ✓ Under-investment in low carbon R&D	✓ Reduce emissions from waste disposal (for example, emissions from landfills)	✓ EU Landfill Directive ✓ Landfill Allowances Trading Scheme

Market failures/Policy considerations	Behaviours to target	Major policy interventions
(development and diffusion of new technologies) ✓ Informational failures	✓ Greater uptake of new technologies	✓ Landfill tax and escalator ✓ Packaging Directive ✓ Waste Implementation Programme (education programme, capital grants for demonstration of technologies, advice to local authorities, technologies data centre) ✓ Waste and Resources Action Plan ✓ Business Resource Efficiency and Waste ✓ Sustainable Consumption and Production policy ✓ Technology Research and Innovation Fund

III. *Transport.* Domestic transport accounted for 139 $MtCO_2e$, or approximately 21% of total UK greenhouse gas emissions by source in 2006 (excluding international aviation and shipping); mainly attributable to road transport.[57] The demand for transport fuel tends to be positively correlated with economic growth, and this sector has seen emissions (primarily CO_2) rise from 1990 levels. Despite increases in new car fuel efficiency of 15% since 1997[58] greenhouse gas emissions rose by 8% between 1990 and 2006 (see chart 7).

Chart 7: CO_2 and non- CO_2 emissions from the transport sector



Source: AEA Technology, DECC (UEP30)

International aviation and shipping emissions are estimated from UK fuel sales, for the purposes of reporting to the United Nations Framework Convention on Climate Change (they were estimated to be approximately 35 $MtCO_2e$ in 2006). These emissions are not currently included within the UK's domestic or international emissions targets because there is no agreed way to allocate national responsibility; however, the Climate Change Act places new requirements on Government in relation to these emissions.[59] The agreement to

[57] Road transport accounted for 90% of total transport emissions in 2006.
[58] Society of Motor Manufacturers & Traders, New Car CO_2 report, 2008
[59] The Climate Change Act requires emissions from international aviation and shipping either to be included in UK targets and budgets by the end of 2012, or for Government to report to Parliament to explain why not. In addition, the Act requires that, before the emissions are included in the budgets, they must be taken into account when setting or amending the budgets.

include aviation in the EU Emissions Trading Scheme from 2012 will mean that any growth in aviation emissions above average 2004-06 levels will have to be met by corresponding reductions in emissions in other sectors within the scheme.

Delivering additional emissions reductions from this sector will require addressing both demand and supply. On the supply side, businesses might be hesitant to invest in R&D for new fuels or low emission vehicles due to uncertainty of the carbon price, large sunk costs, knowledge spillovers, and the short-time horizon of investments. On the demand side, consumers might face high transaction costs in acquiring information on low-emission transport options and related benefits, or may simply be reluctant to change their habitual behaviour. Positive network externalities, lack of infrastructure required for new technologies, and the need for greater coordination between markets to supply vehicles and the energy vector further increases the risk associated with any investment decision by both consumers and suppliers.

In addition, although cost is cited as a key consideration in travel choices, public understanding of costs is limited. For example, when comparing the travel costs of alternative behaviours, the tendency is to consider fuel costs in isolation from full car operating costs. This limited understanding of the full costs of travel alternatives is likely to limit the impact of purely cost-based measures.

Table 4 summarises some of the main interventions in this sector, along with the market failures and behaviours being targeted.

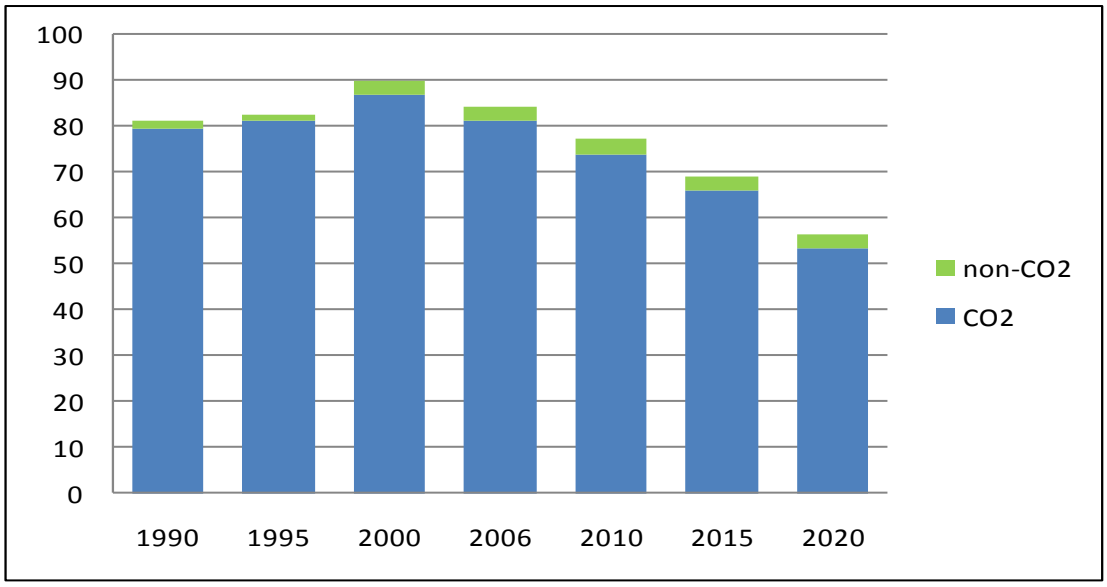
Table 4: Summary of instruments targeting the transport sector

Market failures/Policy considerations	Behaviours to target	Major policy interventions
✓ Carbon externality ✓ Path dependency, especially in terms of inertia of infrastructure capital and associated network externalities ✓ Informational failures ✓ Inertia due to consumers' unfamiliarity with low CO_2 vehicles ✓ Uncertainty about future oil prices ✓ Low response elasticity to fuel prices ✓ Trade-off between high short-term costs and the potentially significant long term benefits from carbon saving technology in transport ✓ Balancing emissions reduction objectives with equity considerations of higher transportation costs on low income households/individuals ✓ Interaction between climate change	✓ R&D into low carbon fuels, technologies, and modes of transportation ✓ Switching to more energy efficient transportation and fuels ✓ Lifestyle choices about location of homes (and second homes)	✓ Regulation and Voluntary Agreements on new car fuel efficiency ✓ Fuel Duty ✓ Company car tax and VED differentiated on a fuel efficiency basis ✓ Renewable Transport Fuel Obligation ✓ Low Carbon Vehicle Partnership ✓ Fuel efficiency labelling ✓ Grants and information to encourage more efficient haulage ✓ Inclusion of aviation in EU ETS ✓ Air passenger duty ✓ ACARE voluntary standards for fuel efficiency of new aircraft ✓ Low Carbon Transport Innovation Strategy ✓ ACT on CO_2, communication and information campaigns

Market failures/Policy considerations	Behaviours to target	Major policy interventions
policies and policies to reduce congestion ✓ Co-ordination between markets to supply vehicles and the energy vector		✓ Requiring all future rail franchises to include environmental targets

IV. *Residential.* The residential sector was responsible for 85 $MtCO_2e$, or 13% of total UK greenhouse gas emissions by source[60] in 2006. Of the energy consumed by the residential sector, approximately 53% is attributable to space heating, 20% to water heating, 5% to cooking, and the remainder to lights and appliances. Despite existing measures, greenhouse gas emissions from this sector have increased since 1990, by around 4%. However, emissions have been falling in recent years, and are projected to be 5% below 1990 levels in 2010 (see chart 8).

Chart 8: CO_2 and non- CO_2 emissions from the residential sector



Source: AEA Technology, DECC (UEP30)

The increased demand for energy over the period has partially offset the impact of existing policies. This, and the existence of substantial potential for carbon emissions reductions with net benefits rather than costs to the economy warranted the introduction of further measures in order to meet UK's 2010 targets for household energy efficiency.[61]

Behaviour change is a critical component of instruments targeting the residential sector. Barriers preventing households from adopting measures and technologies to improve energy efficiency (even when they produce cost

[60] includes only direct emissions (and not indirect emissions associated with electricity use)
[61] Savings of 12.8 MtCO2e from households in England (Energy Efficiency Action Plan, 2004), and improving household energy efficiency in England by 20% by 2010 from a 2000 baseline (Housing Act 2004).

savings) include imperfect information, high transaction costs (especially search costs), relatively long payback periods (high discount rate), low response elasticity, split incentives, and inertia/lack of motivation.

Table 5 summarises some of the main interventions in this sector, along with the market failures and behaviours being targeted.

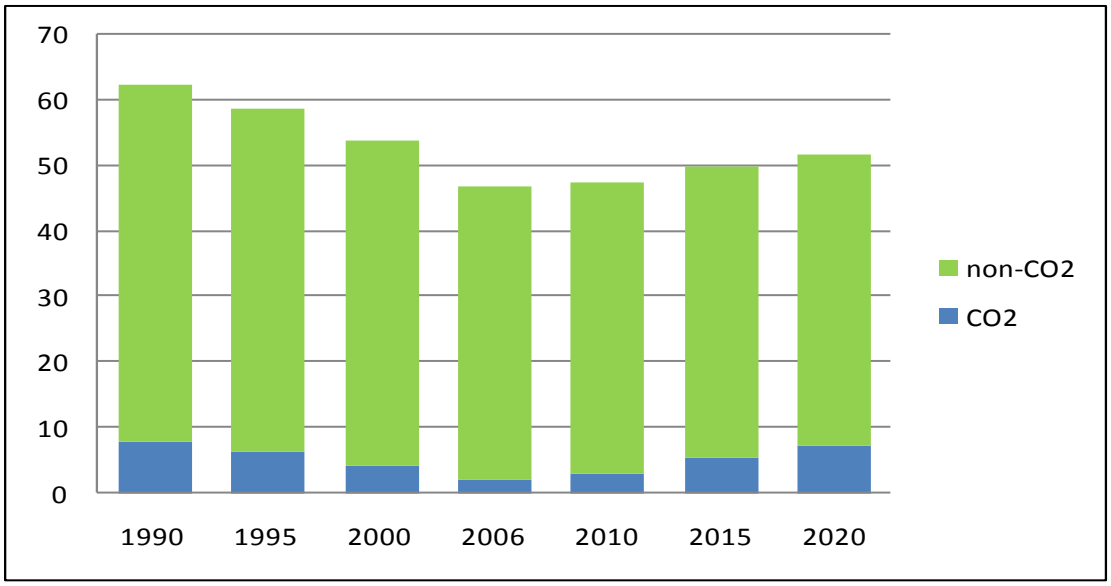
Table 5: Summary of instruments targeting the residential sector

Market failures/Policy considerations	Behaviours to target	Major policy interventions
✓ Carbon price externality ✓ Informational failures ✓ Split incentives, between landlords and tenants ✓ Hidden and transaction costs, especially search costs ✓ Inertia ✓ Low response elasticity: energy costs formed approximately 10% household expenditure in 2006 ✓ Balancing emissions reduction objectives with equity consideration of higher costs on low income households/individuals	✓ Improving energy efficiency of residential buildings ✓ Increasing use of energy efficient appliances ✓ Promoting energy efficient practices ✓ Reducing marginal/discretionary use	✓ Carbon price signal from upstream EU ETS on electricity generation ✓ Building Regulations 2002 and 2006 ✓ Code for Sustainable Homes ✓ EU Energy Performance of Buildings Directive ✓ Energy Efficiency Commitments ✓ Supplier Obligation (for household energy supply) ✓ Carbon Emission Reduction Target 2008-2011 ✓ Stamp duty relief for zero carbon homes ✓ Reduced VAT for installation of energy saving materials ✓ Landlords Energy Saving Allowance ✓ Measures for better billing and metering (for example, through smart metering) ✓ Energy Performance Certificates

Market failures/Policy considerations	Behaviours to target	Major policy interventions
		✓ Changing in planning requirements for microgeneration ✓ Energy Saving Trust information campaign ✓ Act on CO_2 ✓ Warm Front ✓ Low carbon Thames Gateway

V. *Agriculture, forestry, and land use.* The agriculture and forestry sector contributed approximately 47 $MtCO_2e$ or 7% of total UK greenhouse gas emissions by source in 2006 (but for only 0.4% of total CO_2 emissions). Of these emissions, most were in the form of nitrous oxides and methane, making this sector a major contributor to UK's non-CO_2 emissions (45%). Annual GHG emissions from this sector have been falling since 1990, and are projected to fall to 24% below 1990 levels in 2010.

Chart 9: CO_2 and non- CO_2 emissions from the agriculture, forestry, and land use sector



Source: Source: AEA Technology, DECC (UEP30)

Emissions from agriculture are both direct (mainly attributable to digestive processes of animals, animal wastes, and fertiliser use) and indirect (attributable to petrol/diesel, electricity, and fertiliser production). However, pollution from this sector is diffuse, making it difficult to identify sources and target emissions. Along with tackling emissions (mitigation), policies targeting this sector also need to look at the potential role of land in providing a natural carbon sink, and serving as a source of clean energy (e.g. biomass and biogas) and alternatives to fossil fuels.

Table 6 summarises some of the main interventions in this sector, along with the market failures and behaviours being targeted.

Table 6: Summary of instruments targeting the agriculture, forestry, and land use sector

Market failures/Policy considerations	Behaviours to target	Major policy interventions
✓ Carbon price externality ✓ Under-investment in R&D: into new technologies, agricultural practices, crops ✓ Credit market failures, especially financial constraints on small farmers ✓ Informational failures ✓ Transaction costs, especially search costs	✓ Encourage adoption of best practice with regard to climate change ✓ Better management of manure and nitrates ✓ Encourage use of biomass energy ✓ Encourage afforestation/techniques to maximise soil carbon sequestration	✓ Higher energy prices (upstream price signal from EU ETS and Renewable Obligation) ✓ R&D on feedstocks, livestock and plant genetics ✓ Research into fertiliser application, anaerobic digestion, and other technologies ✓ CAP reform towards rewarding environmental stewardship role and other policies[62] ✓ Agriculture (soils) – Codes of Good Agricultural Practice ✓ Improvements of Nitrate Action Plan ✓ Energy Crops Scheme ✓ Bioenergy Infratructure scheme ✓ Non-food Crops Strategy ✓ Information about best practice, for example, on fertiliser application, anaerobic digestion

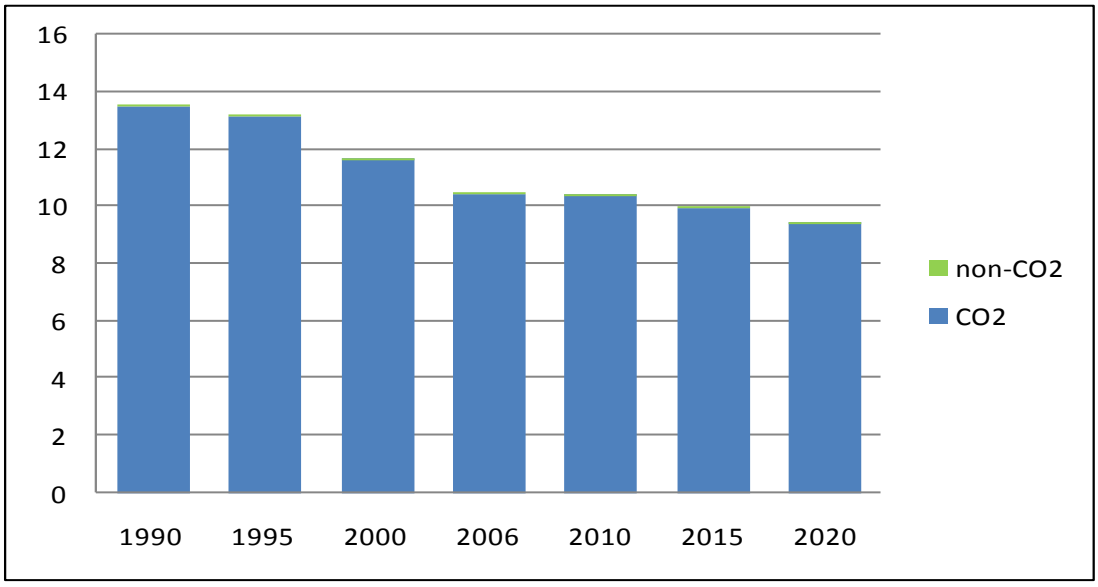
[62] For example, the Woodland Grant Scheme, grants for bio-crops, Environmental Stewardship scheme.

Market failures/Policy considerations	Behaviours to target	Major policy interventions

VI. *Public sector.* Public sector emissions include those from the central government estate, the NHS estate, local authorities and the education sector.[63]

This sector was responsible for over 11 $MtCO_2e$ or a little under 2% of the UK's total greenhouse gas emissions by source in 2006. Emissions from this sector have fallen by 23% since 1990 (see chart 10).

Chart 10: CO_2 and non- CO_2 emissions from the public sector



Source: Source: AEA Technology, DECC (UEP30)

Beyond the direct environmental benefits of reducing emissions from the public sector, reducing emissions from this sector can also play a role in changing behaviour – leading by example, raising awareness, and transforming the market through sustainable procurement. The scale of public sector procurement expenditure means the public sector is a dominating demand-driver for several markets. For example, in 2004 it accounted for 34% of non-domestic construction and 37% of non-domestic refurbishment and maintenance work.

Barriers to behaviour change in this sector include competing claims on limited resources, lack of time, limited knowledge about energy consumption and existing suite of energy efficient technologies, and split incentives.

[63] Local authority housing is covered under the domestic sector.

Table 7 summarises some of the main interventions in this sector, along with the market failures and behaviours being targeted.

Table7: Summary of instruments targeting the public sector

Market failures/Policy considerations	Behaviours to target	Major policy interventions
✓ Carbon price externality ✓ Split incentives ✓ Informational failures ✓ Hidden and transaction costs, especially search costs	✓ Improving the energy efficiency of buildings ✓ Increasing use of energy efficient equipment ✓ Promoting energy efficient practices ✓ Promoting use of combined heat and power	✓ Central Government estate energy efficiency target, NHS estate targets, UK university and English schools targets ✓ Building Regulations 2002 and 2005 ✓ Support for public sector sustainable procurement ✓ Revolving Loan Fund for energy efficiency (Salix) ✓ EU Energy Performance of Buildings Directive

Conclusion

The challenge facing Government is to maintain a credible, effective, clearly-understood and well considered policy framework to deliver the required emissions reductions. The urgency comes from the need to deliver significant additional emissions reductions in order to meet the carbon budgets that the Government will set under the Climate Change Act, and to meet the UK's share of the EU's emissions reduction target for 2020.

The ideal policy framework is one that is flexible enough to adapt to changing circumstances (for example, to changes in scientific knowledge about and technology to deal with climate change, to changes in the EU or international climate change policy landscape, or to improved understanding about the impact of existing policies) while still providing businesses and individuals with policy certainty to make long-term investment decisions. Fundamental to this effort is securing a global agreement to reduce greenhouse gas emissions. This should help move towards establishing an international carbon price by enabling more comprehensive emissions trading, and help secure the necessary financing in low carbon investments at the global level. Designing domestic climate change policy around international interventions and adjusting it dynamically alongside significant actions to tackle the problem at the global level will help achieve the required emissions reductions in a cost effective manner.

Care needs to be taken that changes to the package of domestic measures does not unnecessarily create policy uncertainty. Dynamic instrument choice within the context of a broader climate change target, such as the 2050 emissions reductions target and the five-yearly carbon budgets is likely to reduce policy uncertainty by providing clarity around the desired outcome. However, reaping all the benefits of a flexible policy package depends on the measures being cost effective, internally consistent, and consistent with broader environmental and other policy goals.

References

Baumol, W. J., and W. Oates, 1988. *The Theory of Environmental Policy.* Cambridge University Press, Massachusetts.

Bennear, L. S., and R. N. Stavins, 2007. *Second-Best Theory and the Use of Multiple Policy Instruments*. Environmental and Resource Economics, 37(1): 111-129.

BRC, 2007. *Regulating to Mitigate Climate Change – A Response to the Stern Review.* Better Regulation Commission, February 2007.

Carbon Trust, 2005: *The UK Climate Change Programme: Potential Evolution for Business and the Public Sector*. Carbon Trust, December 2005.

Climate Change Act, 2008. Acts of the UK Parliament and Explanatory Notes, Public Acts 2008, Chapter 27, November 2008.

CCC, 2008. *Building a Low Carbon Economy – the UK's Contribution to Tackling Climate Change.* Committee on Climate Change, December 2008.

Defra, 2007. *The Social Cost of Carbon and the Shadow Price of Carbon: What they are, and How to Use them In Economic Appraisal in the UK*. Richard Price, Simeon Thornton, Stephen Nelson, Economics Group, Department of Environment, Food, and Rural Affairs, December 2007.

Defra 2007. *Climate Change Instruments: Areas of Overlap and Options for Simplification*, Department of Environment, Food, and Rural Affairs, December 2007.

Defra, 2006. *Climate Change: The UK Programme 2006*. Department of Environment, Food, and Rural Affairs, March 2006.

Defra, 2006. *Synthesis of Climate Change Policy Evaluations*. Department of Environment, Food, and Rural Affairs, April 2006.

Defra 2005. *Securing the Future: Delivering UK Sustainable Development Strategy.* Department of Environment, Food, and Rural Affairs, March 2005.

DTI 2007: *Meeting the Energy Challenge: A White Paper on Energy*. Department for Trade and Industry, May 2007.

DTI, 2006: The *Energy Challenge: The Energy Review Report 2006*. Department for Trade and Industry, July 2006.

Grubb, M., 2006. *Economics of Strategic Deployment Incentives for Low Carbon Technology*. Internal note, Department for Environment, Food, and Rural Affairs, May 2006.

Helm, D., 2006. *Regulatory Reform, Capture, and the Regulatory Burden*. Oxford Review of Economic Policy 22(2): 169-85.

Helm, D., 2003. *The Assessment: Climate-Change Policy*. Oxford Review of Economic Policy 19(3): 349-61.

Hepburn, C., 2006. *Regulation by Prices, Quantities, or Both: A Review of Instrument Choice*. Oxford Review of Economic Policy 22(2): 226-46.

HMT, 2002. *Tax and the Environment: Using Economic Instruments*. HM Treasury, November 2002.

IPCC, 2007. *Climate Change 2007 Synthesis Report*. Inter-governmental Panel on Climate Change Fourth Assessment Report, November 2007.

IPCC 2007. *Climate Change 2007 Mitigation of Climate Change*. Inter-governmental Panel on Climate Change Fourth Assessment Report, Working Group III Report, November 2007.

Kolstad, C. D., and M. Toman, 2001. *The Economics of Climate Policy*. Discussion paper 00-40REV, Resources for the Future, Washington, DC.

NAO, 2006. *Climate Change Policy: Options for Scrutiny*. A review by the National Audit Office, April 2006.

NERA and Enviros, 2006. *Policy Options to Encourage Energy Efficiency in the SME and Public Sectors*. A report prepared by NERA Economic Consulting and Enviros for the Department of Environment, Food, and Rural Affairs, 2006.

Newell, R. G., and R. N. Stavins, 2003. *Cost Heterogeneity and the Potential Savings from Market-Based Policies*. Journal of Regulatory Economics 23: 43-59.

OECD, 2006. *Instrument Mixes for Environmental Policy*. A report by the Working Party on National Environmental Policy, Environment Policy Committee, Organisation for Economic Cooperation and Development, May 2007.

OCC, 2007. *Analytic Audit*. Final Report, Office of Climate Change, May 2007

Pizer, W. A., 1999. *The Optimal Choice of Climate Change Policy in the Presence of Uncertainty*. Resource and Energy Economics 21(3-4): 255-87.

Sijm, J., 2005. *The Interaction between the EU Emissions Trading Scheme and National Energy Policies*. Climate Policy 5: 79-96.

Sorrell, S. (ed.), 2003. *Interaction in EU Climate Policy*. Research funded in part by the European Commission in the framework of the Fifth Framework Programme: Energy, Environment, and Sustainable Development, March 2003.

Sorrell, S., and J. Sijm, 2003. *Carbon Trading in the Policy Mix*. Oxford Review of Economic Policy 19(3): 420-37.

Stavins, R. N., 1997. *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem*. Discussion paper 97-11, Resources for the Future, Washington, DC.

Stern, N., 2006. *Stern Review on the Economics of Climate Change*. Report prepared for the Prime Minister and the Chancellor of the Exchequer on the Economics of Climate Change, October 2006.

Weitzman, M. L., 1974. *Prices vs. Quantities*. Review of Economic Studies 41: 477-91.

Bartle, I., and P. Vass, 2007. *Climate Change Policy and the Regulatory State – A Better Regulation Perspective*. Centre for the study of Regulated Industries, University of Bath Management School, Bath.

Atkinson, G., 2003. *Chapter 2: Sustainable Development and Policy*. In D. Helm (ed.) Environmental Policy: Objectives, Instruments, and Implementation, Oxford University Press, pp 29-48.

Helm, D., 2003. *Chapter 1: Objectives, Instruments, and Institutions*. In D. Helm (ed.) Environmental Policy: Objectives, Instruments, and Implementation, Oxford University Press, pp 1-29.

Appendix A: Market-based instruments (following analysis set out in the Stern review)

	Putting a price on carbon – taxes and trading
Effective tool for internalising the carbon externality, with higher emissions prices also creating a greater incentive for R&D investment and for overcoming barriers to behaviour change and diffusion of low carbon technologies.	
Economic efficiency	Efficient
Cost effectiveness	Cost effective, especially so when there is heterogeneity in abatement costs and baseline emissions across sources
Administrative burden	Varies with specific carbon pricing instrument
Secondary effects	Incentive to innovate/overcome barriers to diffusion
Price vs. quantity uncertainty	Quantity instrument (trading) may provide greater certainty in emissions reductions achieved, while price instrument (such as tax) could provide greater certainty in price (or cost) of abatement
Flexibility vs. policy certainty	Can be relatively flexible to adapt to exogenous change
Distributional equity	Tax and spend separate functions of government - no government policy for hypothecation. However, in theory, distributional equity can be addressed

	Putting a price on carbon – taxes and trading
Impact on public finances	Has implications for public finance
Ensuring energy security of supply	Rewards emissions reductions below those required (through innovation/overcoming barriers to diffusion), and by doing so encourages the creation of diverse and sustainable supplies of energy at competitive prices
Competitiveness Effects	Depends on the extent and nature of EU/international action to price carbon emissions
Simplicity and transparency	Multiple, overlapping policies are a risk to simplicity and transparency

Appendix B: Direct regulation

	Technology-/performance-based standards, product bans
Effective tool for internalising the carbon externality and indirectly raising the price of emissions, with higher emissions prices also creating a greater incentive for R&D investment and for overcoming barriers to behaviour change and diffusion of low carbon technologies.	
Economic efficiency	Significant information requirements for regulator to set standards to the efficient level, product bans only efficient under certain circumstances[64]
Cost effectiveness	The prescriptive nature of how emissions reductions are made and who makes them can limit cost effectiveness of direct regulation, but they can be preferred under certain circumstances[65]; performance-based standards usually more cost effective than technology-based standards[66], product bans only cost effective under certain circumstances
Administrative	Tends to be high, but can sometimes be easier to implement for institutional reasons[67]

[64] A product ban will be efficient only if (i) the cost of abating additional tonnes of CO_2 is zero or (ii) the benefit of additional tonnes of CO_2 abated is infinite (or when environmental consequences are extreme).

[65] Making technology/performance standards as cost effective as market-based instruments requires the regulator to have detailed information about baseline emissions and abatement costs for all sources, increasing the complexity of the regulation. However, if the degree of heterogeneity among sources is limited, standards could be as cost effective as market-based instruments, and can be preferred to market-based instruments if market failures/barriers prevent agents from responding to price signals and/or if there are economies of scale to be had from collective action. For example, EU regulation of new car CO_2 provides a way to achieve economies of scale in low car CO_2 technology, as the trajectory set by the regulation will encourage technology sharing and mass production.

[66] because agents have flexibility in how standards are met

[67] For example, if the monitoring, reporting, and verification costs associated with market-based instruments are very high, use of technology- or performance-based standards (such as building and appliance standards, supplier obligations) could prove to be less burdensome overall.

	Technology-/performance-based standards, product bans
burden	
Secondary effects	Limited incentive to innovate below standard[68], can raise costs and act as a barrier to entry
Quantity vs. price uncertainty	Greater certainty in delivering the required emissions reductions, but large uncertainties in price (or cost) of abatement
Flexibility vs. policy certainty	Limited flexibility, risk of regulatory capture[69], generally provides high policy certainty
Distributional equity	Limited ability to deal with distributional equity concerns due to limited ability to take account of all the differences between sources
Impact on public finances	No direct public finance implications[70]
Ensuring energy security of supply	Limited incentive to reduce emissions below standard, but could help harness economies of scale in the development and diffusion of low carbon technologies

[68] In fact, technology standards could inhibit innovation and the development of new low carbon technologies due to fear that this could lead to further tightening of the standards.
[69] as standard setting is information-intensive and susceptible to manipulation by sources
[70] Could have indirect implications for public finances if they improve energy efficiency

	Technology-/performance-based standards, product bans
Competitiveness Effects	Depends on the extent and nature of EU/international action
Simplicity and transparency	Depends on how complex and prescriptive the standards are

Appendix C: Technology/Spending Programmes

	Technology/spending programmes
Effective tool for addressing under-investment in development and diffusion of low carbon technologies, potentially lowering abatement costs in the long run and reducing the cost to the economy of tackling climate change	
Economic efficiency	Can lower the efficient level of emissions reduction in the long run (so stabilisation occurs at a lower concentration of CO_2e) by encouraging innovations that lower abatement costs in the future[71]
Cost effectiveness	Can improve cost effectiveness of climate change policy in the long run (through innovations that lower abatement costs and shift the marginal abatement cost curve downwards), can be used to leverage additional private sector funding/investment[72]
Administrative burden	Not significant, but depends on monitoring and reporting requirements of specific spending programmes
Secondary effects	Technology transfers to reduce emissions across the world (especially in developing countries), potential technological spillovers to other environmental areas

[71] The challenge for government technology and spending programmes is ensuring additionality and avoiding crowding out private investment; for example, identifying and supporting only R&D that would not have happened without government funding.

[72] Strategic support for certain technologies/sectors (due to limited government resources) needs to be balanced against the risks associated with government support for specific technologies. How close a technology is to being viable, and factors such as high domestic learning, high national resources, or high potential for the UK industry to become a major player internationally might help define areas of greater interest for R&D support intervention

	Technology/spending programmes
Quantity vs. price uncertainty	Provides cost certainty, and enables potentially significant (though uncertain) long-term emissions reductions
Flexibility vs. policy certainty	Flexible in adapting to exogenous changes, high risk of regulatory capture, could create significant policy uncertainty in the absence of a clearly stated government technology policy
Distributional equity	Can be designed to address distributional equity concerns
Impact on public finances	Implications for public finances will depend on how the programmes are structured and targeted
Ensuring energy security of supply	Can be an important tool in supporting the development of a secure, diverse, and sustainable supply of energy for the UK in the long-term
Competitiveness Effects	Can provide long-term benefits by creating opportunities for UK industry to become market leaders in the development and deployment of low carbon technologies
Simplicity and transparency	Depends on design of individual programmes

Appendix D: Information and Public Engagement Campaigns

	Information and public engagement campaigns
Effective tool for addressing informational and other barriers to behaviour change, potentially lowering abatement costs and the need for regulations/measures to tackle climate change in the long run	
Economic efficiency	Helps achieve the efficient level of emissions reduction, by overcoming barriers to the take-up of cost effective energy efficiency/emissions reduction measures
Cost effectiveness	Could potentially lower the cost of (and even the need for) emissions reductions in the long run, by bringing about a change in public attitude towards climate change and facilitating the move towards a low carbon economy
Administrative burden	Tends not to be significant (evaluation of the impact of such measures could raise administrative costs)
Secondary effects	Changes attitudes towards the environment more broadly, provides lessons for the future on types of campaigns that work best for different types of consumers
Quantity vs. price uncertainty	Provides cost certainty, and potentially significant (though uncertain) emissions reduction by helping overcome barriers to the take-up of cost effective energy efficiency/emissions reduction measures
Flexibility vs. policy certainty	Flexible in adapting to exogenous changes, but not generally significant in creating policy certainty

	Information and public engagement campaigns
Distributional equity	Can be used to highlight measures being taken to address distributional equity concerns
Impact on public finances	Generally have no significant implications for public finances
Ensuring energy security of supply	Can enhance/speed up the shift to low carbon sources of energy through behaviour change
Competitiveness Effects	Can reduce the need for additional regulation (and their effect on the competitiveness of UK industry) in the long run by changing public behaviours/attitude to climate change
Simplicity and transparency	Can be designed to provide simple, clear messages

Appendix E: Negotiated Agreements

	Negotiated agreements
Effective tool for raising awareness, realising cost effective emission reductions not targeted elsewhere, and exemplifying best practice	
Economic efficiency	Not likely to be efficient, as targets determined on a consensus-basis
Cost effectiveness	Could be cost effective, depending on information revealed by sources about their abatement costs and baseline emissions during negotiations
Administrative burden	Could be high, depending on the complexity of negotiations and the level of monitoring and verification required
Secondary effects	Increases stakeholder involvement/buy-in, raises awareness, and exemplifies change
Quantity vs. price uncertainty	Generally shown to produce an uncertain environmental outcome (depends on available substitutes), but provides certainty in price (or cost) of abatement
Flexibility vs. policy certainty	Not very flexible because of the need for consensus, high risk of regulatory capture, not a significant tool for creating policy certainty

	Negotiated agreements
Distributional equity	Consensus basis for this instrument generally makes is sensitive to and reflective of distributional equity concerns
Impact on public finances	Depends on whether the agreements are voluntary or incentivised
Simplicity and transparency	Tend to be complex due to the need to create and reflect a consensus