Commission for Integrated Transport

Transport and Climate Change

Advice to Government from the Commission for Integrated Transport

2007

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Foreword

Climate change has recently risen to become one of the top political issues of our day. The damage we do to our own environment, the relatively small actions we take that have such a major impact on the world around us and the disturbance to climate caused by our everyday lives – should be a cause for concern amongst us all.

Not surprisingly, therefore, the calls for action to halt this dangerous spiral have been growing, with a particularly strong emphasis on what Government should be doing.

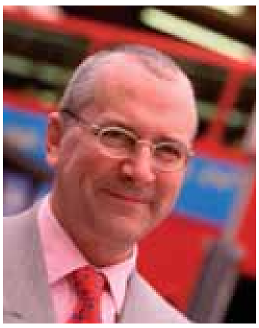
One of the responses by the UK Government has been to set a 60% reduction target by 2050 for the carbon emissions that are widely accepted as one of the key causes of climate change. Much of the responsibility for hitting this target rests on the transport sector, as one of the prime and growing causes of carbon emissions in the UK today.

In our role as a key advisory body to Government on transport, therefore, the Commission for Integrated Transport (CfIT) has put together this substantial report in order to:

- identify areas of transport in which carbon emissions could most cost-effectively be targeted;
- look at practical and deliverable ways of targeting those areas of transport mode and behaviour; and
- evaluate those measures in terms of affordability, acceptability, fairness and deliverability, to recommend a package of readily implementable solutions.

We would like to take this opportunity to thank every member of the Working Group for their dedication, time, and effort in producing this report. It represented a substantial piece of work to research, pull together and draft, and provides an excellent contribution to a very topical debate.

Finally, we would like to stress that it is incumbent on all of us – not just Government and its advisers – to understand the impact that our own behaviours have on the environment around us. We sincerely hope this report sheds useful light on what we might do, practically and cost-effectively, to reduce the impact of our individual choices.



Peter Hendy
CfIT Chair

Michael Roberts
Chair, Climate Change Working Group

Executive summary

Climate change is now one of the biggest issues facing humankind. In identifying what needs to be done in the UK, there is much focus on the role that measures to cut greenhouse gas emissions from transport can play alongside action elsewhere in the economy.

Options to cut transport emissions essentially involve addressing one or more of the following: the demand for movement; the choice of transport mode; the technical efficiency of vehicles; the carbon content of the fuels used to power them; and the efficiency of vehicle use.

Technological improvements have delivered carbon-reduction benefits, but in some cases these have been either offset or out-stripped by rising demand and choices made by transport users – trends that are set to continue in future unless action is taken now.

Transport (including international transport) is now the largest end-use category of emissions in the UK, accounting for between a quarter and one-third of UK carbon emissions (depending on which definitions are used). Within this, road transport is the main component, of which cars are the most significant element.

In the UK, transport has been the only sector whose carbon emissions were higher in 2005 than they were in 1990, a period in which reductions achieved by other sectors of the economy helped deliver a cut in total UK carbon emissions of just over 5%.

Emissions from air travel, and from the movement of vans and lorries, have been among the fastest-growing sources of transport emissions in the UK. Emissions from cars have been stable since 1990, while those from public transport have fallen.

While there is no shortage of ideas about how transport emissions might be reduced in future, the current state of knowledge on which individual options and packages of measures are *cost-effective* relative to other transport and non-transport policies needs to be strengthened. This is vital to identifying the optimum response across the economy to cutting emissions: we have reviewed existing evidence in this area and used it to inform our recommendations.

Some studies suggest that transport has a major role to play as part of an economy-wide set of cost-effective measures to reduce carbon by at least 60% from 1990 levels by 2050, but the significance of that role compared with the contribution of other sectors grows after 2020 or 2030 as technological developments take real effect. These analyses need to be treated with caution and may understate the short and long-term potential for cost-effective carbon reduction in transport emissions, and the potential for packages of measures that target both behaviour and technology to be more cost-effective.

The Government's own approach is informed by modelling which indicates that transport emissions could potentially fall by as much as 45% against 2000 levels by 2050, helping to deliver its goal to cut UK emissions by 60% by this date against 1990 levels. In the shorter term, the impact of the main programme of current policies to tackle transport emissions, if delivered successfully, would be to avoid growth that would otherwise happen and to stabilise transport emissions at broadly 2005 levels by 2020.

While we support the Government's efforts in tackling CO_2 emissions within the transport sector, the transport element of the Climate Change Programme (CCP) appears to depend heavily on relatively expensive, technology-based measures to deliver emissions savings by 2020 – and there is an additional opportunity to capture greater cost-effective carbon savings through measures to encourage behavioural change.

We have identified scope for an integrated set of measures that builds on the measures included in the Government's Climate Change Programme in a cost-effective way. This would significantly increase the carbon savings that would otherwise be expected from the CCP and would mean that, for the first time, emissions from this sector could begin to fall against 1990 levels. The combined effect would increase cost-effectively the carbon savings expected from the CCP by 71%, which would mean that transport emissions would fall by 14% against 1990 levels by 2020, instead of stabilising broadly at 2005 levels.

Key features of our approach are a focus on tackling either the largest or fastest-growing areas of transport emissions, and an emphasis on measures to encourage behaviour change by transport users as a way of 'locking in' the benefits from technological developments.

We have identified five key packages of measures to deliver additional carbon savings from transport by 2020:

- a mandatory EU target for new car sales of 100 g CO_2/km but with a deadline (2020) that allows a more cost-effective response by the industry, combined with measures to stimulate demand for lower-emission vehicles;
- an incentive and reward approach to promoting more efficient use of cars through the price of fuel, greater promotion of eco-driving and better enforcement of speed limits;
- more intensive promotion of smarter choices to encourage take-up of alternatives to car travel supported by improvements to the carbon performance of public transport;
- measures to capture the significant opportunities for carbon reduction in van and lorry fleets; and
- the inclusion of aviation in the EU-ETS and consideration of supplementary measures to crystallise and develop further the emissions reduction potential of this sector.

There are also issues that need to be tackled now with regard to the longer-term contribution of transport to emissions reduction, such as the pathway for future technological change, and the roles that road pricing, land-use policy and emissions trading can play as part of a longer strategy to address transport emissions.

Chapter 1: Introduction

The challenge of climate change

1.1 Climate change is now one of the biggest issues facing humankind. Three reports in 2007 from the Intergovernmental Panel on Climate Change point to a strengthening international scientific consensus about the causes, impacts of and responses to climate change (IPCC 2007 a, b and c) (Exhibit 1.1). The Stern Review has been key in translating a critical global environmental issue into one of the world's most pressing economic challenges (HM Treasury, 2006).

1.2 The key challenge is to cut emissions of greenhouse gases (GHG – of which there are six, the most significant in volume being carbon dioxide) in order to stabilise carbon levels in the atmosphere and contain climate change to limits deemed acceptable. Two-thirds of global GHG arise from the burning of fossil fuels in sectors such as power, transport, buildings, and industry. The essence of the Stern Review is that, while the cost of inaction might be very significant, taking appropriate action at the right time could avert the worst impacts of climate change at affordable cost.

Exhibit 1.1

Scientific consensus on climate change

According to the IPCC, the scientific evidence that the climate is warming is unequivocal, with a high level of confidence that this is due to increases in human-made emissions of greenhouse gases (IPCC, 2007a). Global mean temperatures have risen by 0.74°C over the past century, with 0.4°C of this warming occurring since the 1970s. Forecasts suggest that average global temperature will increase by between 1.8°C and 4.0°C by 2090–99 depending on a range of assumptions (IPCC, 2007a). Average global warming of 2°C could result in dangerous and irreversible effects, which rapidly worsen above C warming. Even if greenhouse gas concentrations were stabilised at 2000 levels (implying reductions in emissions), warming of around 0.1°C per decade would still occur. The effect will be greater intensity and frequency of extreme weather conditions, such as floods, heat waves, droughts, hurricanes and tornadoes.

The latest report says there is substantial economic potential for the mitigation of global greenhouse gas emissions using green taxes and carbon trading (IPCC, 2007c). The Stern Report estimated that the economic consequences of unabated climate change over the long run could cost between 5 and 20% of global GDP – described as the equivalent of the combined effect of the Great Depression and the two world wars of the twentieth century (HM Treasury, 2006).

Targets to reduce greenhouse gas emissions

1.3 The Kyoto Protocol is an international treaty designed to limit global greenhouse gas emissions. As of June 2007, 175 states have ratified the Protocol and, of these, 36 countries have agreed to legally binding targets to reduce greenhouse gas emissions below levels specified for each of them.[1] These add up to a total cut in greenhouse-gas emissions of at least 5% from 1990 levels in the commitment period 2008–12, with the effort shared in the form of targets for individual countries (12.5% in the case of the UK). Governments are now actively considering more ambitious and longer-term commitments: the EU, for example has recently set out a target of at least a 20% reduction in greenhouse gas emissions by 2020 from 1990 levels (CEC, 2007a).

1.4 In the UK, apart from our Kyoto target (which we are on course to achieve with room to spare),[2] the Government has also had a tougher self-imposed target to cut just emissions of carbon dioxide (CO_2) by 20% from 1990 levels by 2010. This is almost certainly not going to be achieved and has now been superseded by new targets in a draft Climate Change Bill (Exhibit 1.2). The Bill will enshrine in law an interim target of 26–32% reduction in CO_2 by 2020 as well as the 2050 target of a 60% reduction. In order to achieve even the lower end of the Climate Change Bill targets for 2020, the Government admits it will have to achieve the upper end of the policies included in its Energy White Paper, including EU Emissions trading (DTI, 2007a).[3]

Exhibit 1.2

The draft Climate Change Bill

In summary, the Bill:

- makes legally binding targets to reduce carbon dioxide emissions through domestic and international action by 60% by 2050 and 26–32% by 2020, against a 1990 baseline;
- introduces a system of 'carbon budgeting', capping emissions over five-year periods – with three budgets set ahead;
- confirms emission reductions purchased overseas may be counted towards the UK's targets, consistent with the UK's international obligations;
- creates a new independent body to advise on the setting of carbon budgets and to report on progress (the Committee on Climate Change);
- contains enabling powers to make future policies to control emissions quicker and easier to introduce; and
- introduces a new system of Government reporting to Parliament, including on climate change adaptation policies.

Source: HM Government, 2007

1 http://unfccc.int/kyoto_protocol/items/2830.php
2 Final estimates for 2005 emissions published in January 2007 show that UK greenhouse gas emissions fell by 15.6% from 1990 levels. However, carbon reductions are currently at around 5% below the base year (Defra, 2007e).
3 DTI 2007a, Annex B, Table B2 and see Anable and Bristow, 2007, for a discussion.

1.5 The Climate Change Bill proposes a system of 'carbon budgeting' which caps emissions over five-year periods. This is important because the science of climate change, with its focus on the atmospheric concentration of carbon, underlines that it is the total amount of emissions released into the atmosphere between now and the target date that is important. Carbon dioxide produced today will still be contributing towards the greenhouse effect beyond 2100, and delaying action now will require greater action later for the same temperature target. Thus the *pace* of emissions reduction is as important as achieving the 2050 end-point (Buchan, 2007; Anderson and Bows, 2007).

1.6 In simple terms, in order to have a reasonable chance of staying below 2ºC warming, global greenhouse emissions, which have been growing steadily, need to peak within ten years and then fall. And while the UK Government's proposed targets are challenging, a scientific consensus is emerging which argues that even these do not go far enough or quickly enough, and that cuts more in the order of 80% by 2050 will be required, at least in developed countries (HM Treasury, 2006; Tyndall, 2007).

The debate about transport and climate change

1.7 Increasingly, therefore, the debate has focused on what needs to be done, including the role that measures to cut transport emissions can play alongside action elsewhere (such as business or domestic energy use). This is unsurprising, as transport globally accounts for 14% of all greenhouse gas emissions. In the UK, it accounts for a higher share of national emissions and has grown in recent years to become the largest 'end user' creator of emissions (see Chapter 2).

1.8 Equally, there is no shortage of ideas in the UK about how transport-related emissions might be reduced. Transport is a major focus for the Government's current programme of measures to cut emissions across the economy and is due to deliver the second largest share of emissions reduction in the programme by 2020.[4] However, to a large degree these reductions are offsetting future growth rather than delivering absolute reductions. There is also an emerging body of other work setting out proposals and scenarios for reducing UK transport emissions (Exhibit 1.3).

1.9 However, while much attention in the debate is often given to quantifying the emission reduction potential of various transport measures, a lower profile is given to the cost-effectiveness of such measures – either in their own right, or compared with other possible transport measures, or relative to potential action in other, non-transport sectors.

1.10 This is a cause for concern, which this report seeks to help address. If one of the central tenets of the Stern Review is to hold true – that action to tackle climate change is possible at affordable cost – then it is essential that any programme of measures, nationally or internationally, should consist of the most cost-effective package of measures across all key sources of GHG emissions that can practically be delivered.

1.11 The implications of this approach are that the contribution over time of some sectors towards overall emissions reduction may be greater than of others, and that some sectors may make a more significant contribution than others. There should not be an automatic

4 Second only to the residential sector if savings from the EU-ETS are not included. Derived from tables D1 and D2 in DTI 2007b, pp31 and 32.

assumption that all sectors should contribute equally towards the total reduction needed (e.g. a 60% cut by 2050 from each sector in the UK) or even that the largest single source of emissions should deliver the largest element of emission reduction.

Exhibit 1.3

Proposals for reducing carbon emissions within transport

VIBAT (Hickman and Banister, 2006)

Visioning and Backcasting for UK Transport Policy (VIBAT) established that a 60% cut in domestic transport emissions could be achieved by 2030 through a combination of strong technological innovation and behavioural change. Whilst the major contribution of technological innovation would not occur until after 2020, travel behaviour change was seen as having a significant effect in the short term. The research also noted that, without behavioural change, a 60% reduction in emissions by 2030 was not possible, as the increase in CO_2 emissions from expected travel growth outweighed the possible savings from changes in technology.

Sustainable Development Commission (2005)

The SDC believes a 50% cut in transport emissions by 2025 can be achieved through a mixture of technological and behavioural change (changes to VED, biofuels, adjusting speed limits, road pricing (congestion and distance) and acceleration of ‘smarter choices’ (e.g. travel planning), a charge on some air travel, progress on trading for aviation and more efficient take-off/landing.

Tyndall Centre for Climate Change Research

Tyndall Centre research notes the significance of international aviation (and also international shipping), which suggests more effort is needed from transport (and sooner), even with significant action in other sectors (Tyndall Centre, 2005). Research examining land passenger transport to 2050 concluded that reductions in CO_2 emissions of 60–80% could only be achieved through a combination of technological and behavioural change (Bristow et al., 2004).

Greater London Authority (2007)

The Mayor’s Climate Change Action Plan sets out initiatives capable of reducing annual transport-related CO_2 emissions in London by 1.2 MtC by 2025 – a saving of 35% from the projected business-as-usual baseline and a 23% cut on today’s level. This will be achieved through a mixture of technology-based and behavioural measures such as travel demand management, road user charging, driver behaviour and improvements in vehicle efficiency. Around a third of the reductions are estimated to come through market measures (take-up of fuel-efficient vehicles etc.) and the biggest contribution from changes in the use of private vehicles, then freight. Low-carbon technologies/fuels offer the greatest potential in the long term, but demand-side policies are also a significant contributor over the next 20 years. Significant savings in excess of those identified would be possible with greater regulatory control.

Exhibit 1.3 *continued*

Buchan (2007)

This report sets out a long-term integrated approach to reduce carbon emissions from passenger cars by a combination of fiscal incentives that reward low carbon behaviour and result in neutral impact on car use. The measures include a sales tax applied on a sliding scale according to carbon emisions above the reference target for new cars; fuel duty applied so that the average fuel cost per kilometre for private cars would stay the same if the more efficient cars are bought, and vehicle excise duty on a sliding scale linked to emissions, but with benefits over today's rates for cars with above-average efficiency. These changes would be accompanied by a recycling of revenue back to UK residents.

UK Energy Research Centre (Cairns and Newson, 2006)

Research on aviation-related climate change notes that technological developments will not be enough to offset the forecast growth in aviation emissions, itself a result of continued growth in leisure trips. The report also concludes that emissions trading, in isolation, will have minimal effect on air travel demand (though it may be help reduce emissions through savings made in other sectors) and argues for more immediate approaches based upon a range of economic policy measures to make flying more expensive.

Focus of this report and working methodology

1.12 This report focuses on establishing transport's role as part of wider efforts across the economy to deliver the most cost-effective carbon reductions consistent with the Government's 2050 aspiration.

1.13 We have particularly focused on what this might mean for public policy in the medium term to 2020, with reference to the longer term, and in so doing have considered other important factors, such as the extent to which cost-effective measures are also publicly acceptable.

1.14 In addition, while there are important issues about how transport users and providers should adapt to the impacts of climate change that are unavoidable, this report concentrates on the role that transport in the UK can play in mitigating climate change by reducing emissions.

1.15 This report represents the views of the Commission for Integrated Transport (CfIT), which in March 2005 established for the task a Working Group composed of some CfIT Commissioners as well as other relevant individuals (see the Annex for a list of Working Group members).

1.16 The Working Group reviewed the existing evidence base, received inputs from a range of departmental stakeholders, held a seminar on public attitudes, consulted on the development of Government policy, commissioned new research into public attitudes on aviation and climate change, and consulted with key stakeholders. The following pieces of commissioned analysis are available from the CfIT website (www.cfit.gov.uk):

- Anable, J. and Bristow, A.L. (2007) *Transport and Climate Change: Supporting Document to the CfIT Report*. London: CfIT.
- McKinnon, A. (2007) *CO_2 Emissions from Freight Transport in the UK*. London: CfIT.
- Watters, H. and Tight, M. (2007) *The Role of Trading in Carbon Emissions for the Transport Sector*. London: CfIT.
- Dargay, J.; Menaz, B. and Cairns, S. (2006) *Public Attitudes towards Aviation and Climate Change: Desktop Research*. London: CfIT.
- Ipsos MORI (2007). *Public Attitudes towards Aviation and Climate Change: Survey*. London: CfIT.

Challenges in compiling this report

1.17 Our task has been a challenging one for several reasons. The level of understanding about the causes, scale and impacts of climate change continues to develop and has accelerated during the period of our work. The language used in the debate on climate change can also be complex: a glossary of some of the terms more frequently used in this report can be found in the Annex.

1.18 A further challenge has arisen because of revisions to official projections of emissions and presentation of the same basic data in often different ways or using different bases. The latter point has been a particular issue when examining the current literature on the cost-effectiveness of adopting different transport measures to reduce carbon emissions. UK Government policies have also gone through change, with completion of the Climate Change Programme review in 2006 and publication of the Energy White Paper in 2007.

Structure of this report

1.19 Notwithstanding the challenges highlighted above, we believe it is possible to identify with confidence some key insights into the role that transport can play in the UK as part of a cost-effective programme of action to reduce carbon emissions. Those insights and what they mean for public policy are set out in this report as follows:

- Chapter 2 summarises current emissions from transport. This helps to clarify the position of transport within the wider context of other sources of emissions, and to establish the key factors behind the profile of transport emissions. This is important to understanding how far measures are focused on material issues, but provides only limited insight into the cost-effectiveness of transport-related measures to reduce emissions.

- Chapter 3 reviews the evidence on the cost-effectiveness of transport measures to reduce carbon emissions and what the contribution of this sector might look like over the long term. It also reviews the current Government programme of measures to reduce UK transport emissions and makes some observations consistent with the goal of pursuing a cost-effective programme of action across the economy as a whole.
- Chapter 4 makes recommendations for policy based on the analysis in previous chapters and for areas requiring further research.
- Chapter 5 closes the report with some overall conclusions.

Chapter 2: Trends in UK transport emissions

Introduction

2.1 In order to establish the role of transport as part of wider efforts across the economy to deliver the most cost-effective carbon reductions consistent with the Government's 2050 aspiration, it is important first to understand the contribution that transport currently makes to UK emissions.

2.2 In this chapter, we set transport within the context of other UK sources of emissions, highlight the main elements of transport emissions by mode and summarise the trends that have defined transport emissions in recent decades.

2.3 The chapter ends with an overview of some of the factors that lie behind trends to date and might be material in future, before going on in Chapter 3 to consider opportunities for reducing transport's carbon emissions over the long and shorter terms.

Transport accounts for between one-quarter and one-third of UK emissions

2.4 The exact share of UK transport-related emissions of carbon dioxide depends on how emissions are apportioned across sectors in the economy, and whether international aviation and shipping are included in the figures.

2.5 The first distinction is between '*end-user*' or '*source*' figures. *End-user* figures include an estimated share of upstream emissions from power stations and refineries allocated back to the sectors using the electricity or fuel (sometimes referred to as 'well to wheel'). *Source* figures allocate emissions according to where the fuel (e.g. coal, gas, oil, petrol etc.) is consumed and so do not attribute emissions arising from fuel refining or electricity generation to the transport sector but to the energy sector.

2.6 Total UK emissions in both cases are the same (151.7 MtC in 2005, not including international aviation and shipping), but the difference for individual sectors can be substantial. Transport sector figures increase from 35.2 to 41.6 MtC, with the sectoral share of the total rising from 23% to 27%, once upstream emissions are reallocated (Defra, 2007b).

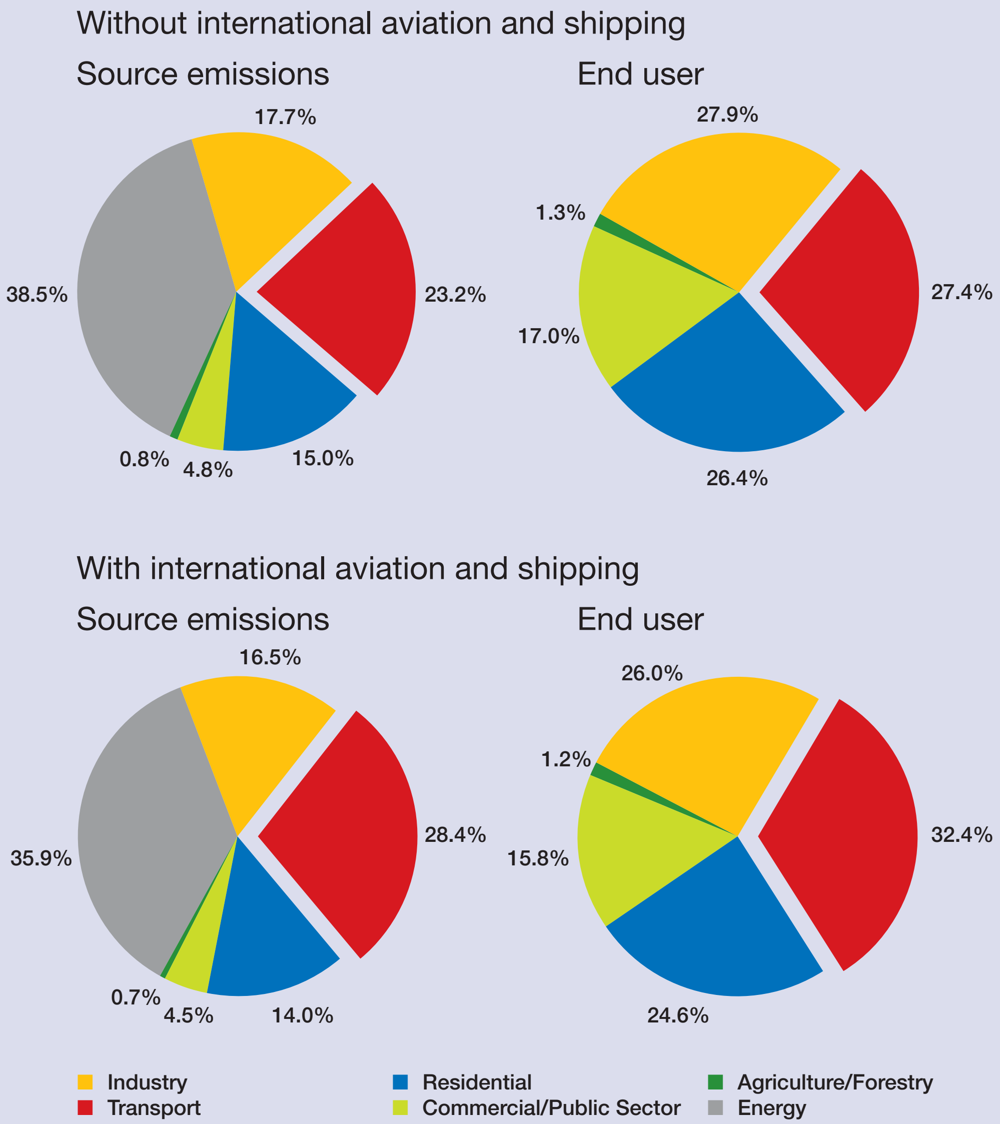
2.7 The second distinction is between domestic and international emissions. Government targets, projections and modelling usually exclude emissions from international aviation and shipping, as there is no agreed convention on how to allocate these emissions to individual countries. For instance, the UK's Kyoto target does not include emissions from these sectors, with responsibility for regulating emission levels within international shipping and aviation passing to the International Maritime Organisation and the International Civil Aviation Organisation.

2.8 A truer picture of the UK's emissions would include at least some emissions from these international movements. Using a method of calculating aviation and shipping emissions based on fuel used in 'international bunkers', this would add 11 MtC to the normally-reported figures, increasing transport's share to 28% (46.3 MtC, as source) or 32% (52.7 MtC, as end user) of an expanded UK total for carbon emissions. It would mean that air traffic would account for approximately 6% (9.5 MtC) of total emissions by source.

2.9 These figures exclude the additional effect of other greenhouse gases and atmospheric effects including those caused by air travel at high altitudes. Scientific studies have identified other climate effects in the upper atmosphere, linked to the emissions of nitrogen oxides, particles and water vapour – and similar effects may also arise from ground-based emissions sources. Research continues to assess how much warming is caused by aviation emissions at high altitudes, as the science is still much more uncertain in this area than for CO_2 and the other greenhouse gasses identified in the Kyoto protocol. In addition, these upper-atmosphere effects are much more short-term than the warming impact of CO_2 that continues for hundreds of years.

2.10 Some studies have attempted to express these upper-atmosphere impacts of aviation as a multiple of its CO_2 emissions, using an index of radiative forcing (RFI). On this basis, IPCC (1999) estimated that the total climate change impact of aviation emissions to 2050 would be 2.7 times the carbon dioxide impact, though more recent research has reduced this figure to a central estimate of 1.9 (Sausen et al., 2005). Scientific uncertainty places a wide band around both estimates. But, just as important, the short-term nature of the non-CO_2 global warming impacts means that these multipliers are very sensitive to the time period considered. Forster, Shine and Stuber (2005) show that the IPCC central estimate of a multiplier of 2.7 could increase to 3.7 if a 20-year time horizon was considered, but would fall to 1.2 using a 500-year time horizon. For this reason, great care needs to be taken when applying these RFI multipliers in a policy context, as the European Commission recognised in its recent proposals to include aviation in the EU Emissions Trading Scheme.

Figure 2.1
UK carbon emissions by sector as a share of total emissions (2005)



Source:
Defra, 2007b[1,2]

2.11 Depending on whether 'end-user' or 'source' figures are used, transport thus accounts for between approximately a quarter and one-third of UK carbon emissions. At the higher figure (end-user and including international transport), transport is the largest single sector for UK emissions.

2.12 A further way of presenting the figures is to consider emissions at the level of households: Exhibit 2.1 uses official data to show that transport accounts for a large share of household GHG emissions, though energy use in the home and indirect emissions associated with household purchase of other goods and services account for larger shares.

1 Energy industry includes: energy industry and fugitive emissions from fuels; commercial/public sector includes: commercial and institutional, military aircraft and shipping, waste (and exports in the case of 'end user'); industrial includes: manufacturing industry and construction and industrial processes.

2 Figures for international aviation and shipping emissions are only available 'by source' and have been added to total end user emissions as an estimate.

Exhibit 2.1

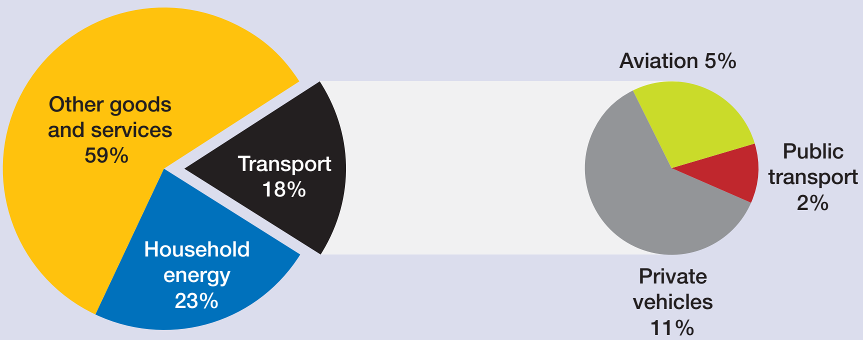
Household total greenhouse gas emissions (2001)

The energy used directly by households through cooking, heating and using their own vehicles, and indirectly by the generation of electricity, through the use of public transport, taxis and aircraft and from households' final demand for goods and services (which include emissions embedded in imports of goods and services), amounts to around 85% of all UK GHG emissions (ONS, 2004).

Personal transport is an important part of this. The Office of National Statistics (2004) estimated total GHG emissions from UK households' personal use of transport at 29.3 MtCO_2 eq. approximately 15% of all UK emissions. This comprised emissions from private vehicles (17.7 MtCO_2 eq.), aviation (here including international aviation, counting only the outbound trip – 8.9 MtCO_2 eq.) and public transport (2.8 MtCO_2 eq.).

Figure 2.2

Household total GHG emissions (2001)



Source: ONS, 2004

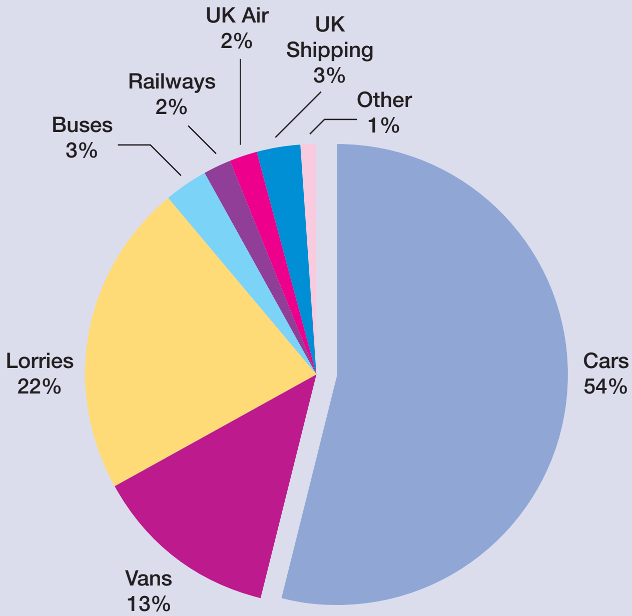
2.13 We believe it more appropriate to refer to end-user figures, as they provide the most complete account of the relationship between emissions and transport, but this classification is subject to more uncertainty than source figures, for which data are more accurate and readily available. Carbon savings attributed to policy instruments discussed later in this report are available as source figures, and so, hereafter, we refer to source emissions and do not include international movements unless otherwise indicated.

Road transport is the main source of transport emissions

2.14 Road transport is the most significant producer of greenhouse gases in the transport sector, accounting for 93% (about 33 MtC) of domestic transport emissions by source. Cars make up over half of these emissions, with large goods vehicles (lorries) and vans together responsible for just over a third.[3] Flights within the UK are currently responsible for 2% of domestic transport emissions, equating to 0.4% of UK total carbon emissions. Including international air travel would increase aviation's share of transport emissions to over one-fifth (see also Figure 2.4).

3 However, figures for carbon emissions from freight traffic can vary according to their method of collection. See research undertaken for this study by McKinnon for alternative figures on freight CO_2 emissions (McKinnon, 2006).

Figure 2.3
UK transport sector carbon emissions by mode 2005 by source (excluding international aviation and shipping



Source:
Defra, 2007b[4,5]

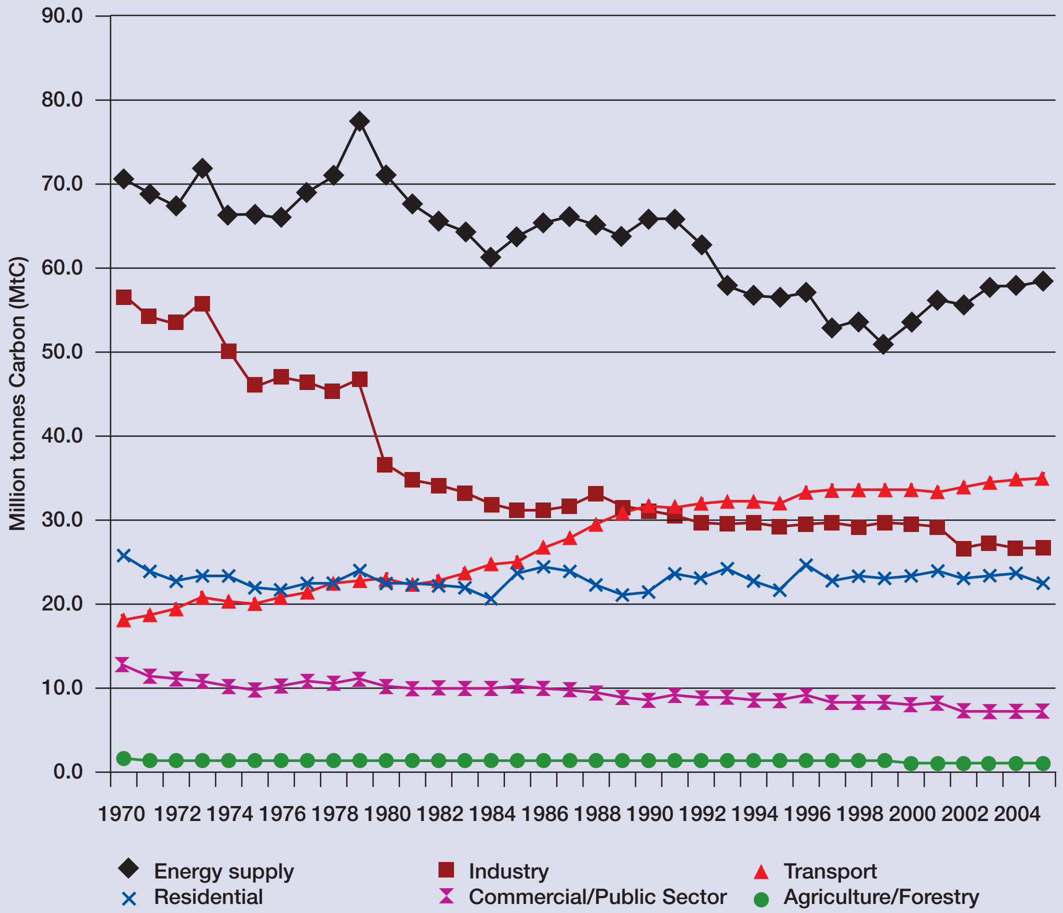
Transport emissions have risen since 1990, while total UK emissions have fallen

2.15 Although other sectors (e.g. residential) have experienced increases in emissions in recent years, transport is the only sector in which carbon emissions were significantly higher in 2005 than in the Kyoto baseline year of 1990 – partially offsetting reductions made elsewhere in the economy (Figure 2.3). Total UK emissions of CO_2 fell by 6%,[6] while transport emissions grew by almost 11% (not including international movements).

4 As this is by source, it excludes the emissions from electricity generation in rail.

5 Note the difference between CO_2 emissions and total greenhouse gas emissions here. The total basket of 'Kyoto' greenhouse gas emissions fell by 15.6% between 1990 and 2005 (Defra, 2007d). However, most recent estimates show carbon emissions rose again during 2006, mainly due to fuel switching from natural gas to coal, so that the level is currently only around 5% below the base year (Defra, 2007e).

Figure 2.4
Carbon emissions by sector: 1970 to 2005 (by source)



Source: Defra, 2007b

Aircraft and goods vehicles are among the fastest-growing sources of transport emissions

2.16 Within transport as a whole, emission trends since 1990 have differed for individual modes (Figure 2.5, which unlike Figure 2.4 includes international transport). While cars are the most significant mode, their emissions have stabilised at roughly 1990 levels, despite an 18% increase in car traffic over this period (DfT, 2006a). Public transport emissions have fallen by 9%[6] since 1990, though this has had marginal impact overall, given public transport's small share of the market (notwithstanding recent growth in rail patronage).[7]

6 This is made up of carbon emissions from buses reducing by 23% (despite +13% increase in bus and coach kilometres since 1990 (TSGB)) and railway emissions increasing by 50%.

7 In 2005, 85% of passenger kilometres were undertaken by car, van or taxi, 6% by bus and coach, 6% by rail and the remainder by motorcycle, bicycle and domestic air travel (DfT, 2006a).

2.17 Aviation emissions have grown fastest of all. Since 1990, domestic aviation has seen emissions growth of nearly 100%; international air travel emissions have grown by 123% (based on figures for fuel used in ‘international bunkers’ and calculating the emissions related to the burning of this fuel). It is worth noting that dedicated freight aircraft only represent around 3% of total aircraft movements at all UK airports: approximately two-thirds of airfreight tonnage is carried in the cargo space of passenger aircraft.

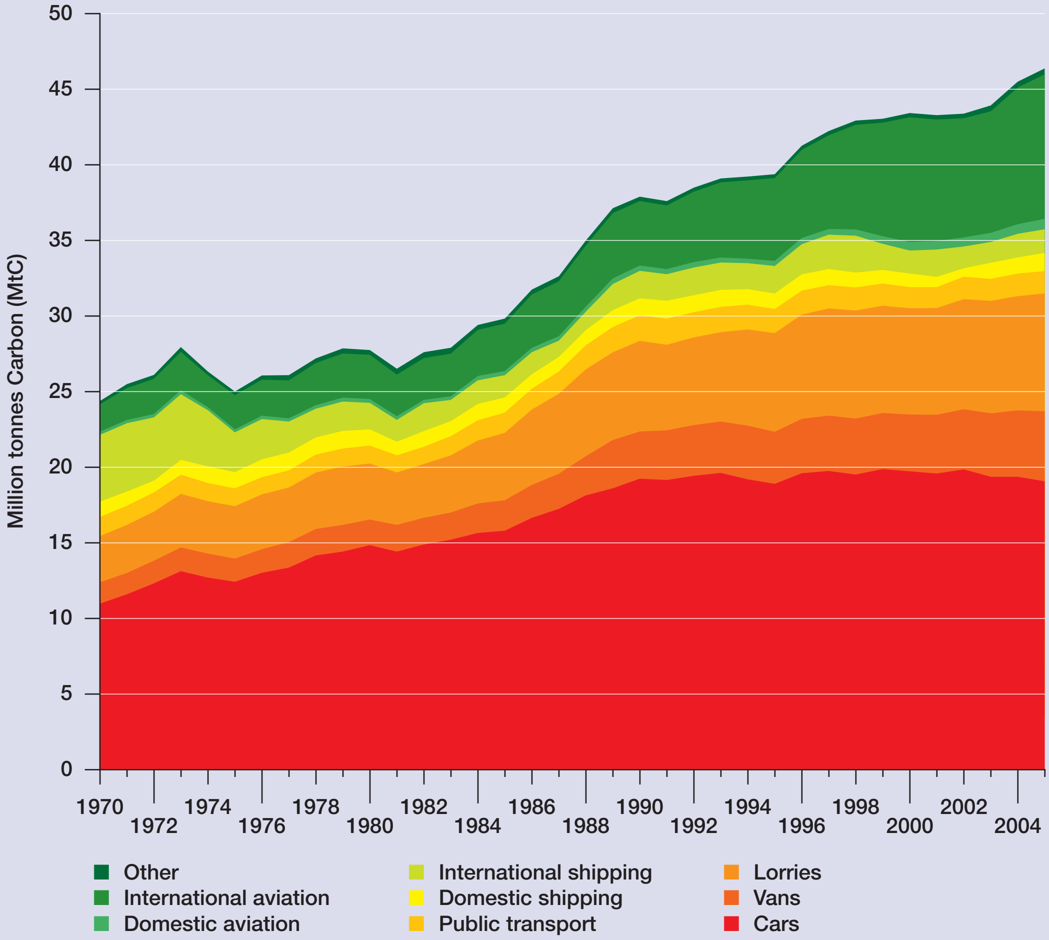
2.18 According to Defra statistics, use of vans has resulted in steep growth in emissions, up nearly half since 1990 so that they now account for 13% of domestic transport emissions. Lorries currently account for 22% of transport emissions and have grown by almost a third over the same period. However, research carried out for CfIT (McKinnon, 2007) has shown that trend emissions figures for lorries and vans can vary by a factor of 3,[8] depending mainly on whether bottom-up surveys of road freight activity and fuel efficiency or top-down sectoral estimates of fuel purchases are used. The above figures seem to be based on the latter, which may overestimate emissions growth from these modes. Crucially, the Defra figures appear to be reporting increases from the road haulage sector alone, which will have been offset by reductions in transport in other sectors particularly as many vehicle fleets were contracted out over the period in question. It is also worth noting the lack of clarity about the proportion of distance travelled by vans that can be considered as ‘freight’. McKinnon estimates[9] that freight – the collection and/or delivery of goods and associated empty running – may be as low as 35% of van kilometres, the remainder being accounted for by commuting and by small businesses such as builders.

8 A recently published Defra document claims that CO_2 emissions from lorries rose by 29% between 1990 and 2004. This figure is more than three times higher than the estimate based on the Continuing Survey of Road Goods Transport and National Road Traffic Survey (see McKinnon (2007) for further discussion).

9 Using results of the 2004 Survey of Van Activity (DfT, 2004c).

Figure 2.5

UK transport CO_2 emissions 1970–2005 (by source)[10]



Source: Defra, 2007

2.19 Emissions from shipping present an interesting picture, albeit once again confused by the different ways of accounting for fuel use and apportioning emissions across countries. Globally, shipping has been estimated to account for between 1.8% and 3.5% of global CO_2 emissions (CE Delft, 2006 cited in DfT, 2007c). Recent reports highlight that CO_2 emissions from shipping are double those of aviation and increasing rapidly (*Guardian*, 3 March, 2007). Others, based on fuel sales in the EU-27, show that carbon emissions from marine and aviation are about the same (Concawe, 2006). However, unlike aviation, emissions from sales of UK shipping fuels (bunker fuel) appear to have fallen by about 12% between 1990 and 2005. This is against a background of significant growth in the amount of freight passing through UK ports since 1970 and the fact that some 95% of the UK's international trade in goods travels by sea (DfT, 2006a and 2007c).

2.20 While the fall in emissions from sales of UK shipping fuel may be partly due to improved efficiency (such as from the general trend towards larger vessels and improvements to engine efficiency), another factor may be the practice of most UK shipping operators of purchasing much of their fuel outside the UK, even when they carry a considerable amount of freight to and from the UK. In addition, much of the world's bunker consumption

10 'Other' includes motorcycles and mopeds; LPG emissions; other road vehicles and mobile sources and machinery. International shipping and aviation have been calculated using fuel in international bunkers.

is accounted for by the large tankers and bulk carriers, and the distances involved allow the long-range ship owner flexibility when choosing a refuelling location. As fuel price varies throughout the world, ships will thus often fill up at locations supplying cheaper fuel, creating inconsistent national variations in the marine bunker fuel purchased each year.

2.21 By contrast, the UK is a major hub for aviation. The competitive nature of fuel supply at UK airports may mean a disproportionate amount of fuel (kerosene) may be being sold here, particularly for short-haul flights to Europe that do not need refuelling on every trip. Although there is no evidence to support this, it does highlight the risks in assuming the bunker fuel purchased within a particular nation approximates to its share of shipping or aviation emissions.

Many factors help explain transport emissions trends

2.22 Transport emissions arise from the use of motorised transport powered by fossil fuels (e.g. petrol, diesel, gas or electricity generated from fossil fuels such as coal or gas) and are essentially a function of four things:

- the demand for movement, itself derived from the need to access facilities, services and goods;
- the mode of transport used to meet that demand;
- the combined technical efficiency of vehicles and the carbon content of the fuels used to power the vehicles; and
- the operational efficiency with which vehicles are used (e.g. how they are driven and how much of their carrying capacity is used).

2.23 Each of these areas in turn is influenced by a wide range of factors that help explain transport emissions trends to date and will shape such trends in future. Some factors will serve to contain or reduce emissions; others will have the opposite effect. A number of the more important factors are set out below.

Economic growth

2.24 Traditionally, transport activity, economic activity and carbon emissions have been strongly correlated (Banister and Stead, 2002). As incomes grow, the demand for travel increases, as does the demand for goods and services. These trends can be influenced by individual preferences as well as social and cultural norms that have an impact on journey purposes (e.g. more travel for leisure), journey lengths and modes used – we travel further and faster, choosing to purchase vehicles with greater power and additional features, thus increasing weight and off-setting efficiency gains.

2.25 Changes in the nature of economic activity (themselves sometimes facilitated by changes in transport) can also affect the demand for transport. Specialisation of production, globalisation and the growth of trade – trends set to continue in future – have also seen increased movement of goods and services.

2.26 The type of land use that accompanies economic growth is also important. The trend towards centralisation of services, distribution and retail provision often at edge of town developments, together with less dense housing provision, have all contributed towards increasing demand for transport.[11]

2.27 Nevertheless, there are signs that the historic correlation between economic growth and road traffic growth may be changing. Between 2000 and 2005, traffic was recorded to have grown by 7% overall (5% for cars only) (DfT, 2006a) which is significantly less than was expected in the Transport White Paper (DfT, 2004b). Going forward, the overall demand for road transport is predicted to slow, with a 31% increase expected between 2003 and 2025, implying an annual growth rate of 1.2% per year (Eddington, 2006). However, within this van traffic is expected to increase most rapidly with expected growth of 70% over the period, in line with recent trends.

Demographic change

2.28 The last fifty years have seen some dramatic changes to the socio-demographic structure of Great Britain. In 2004 there were 7.0 million people living alone in Great Britain, nearly four times as many as in 1961. Over the same period, the average household size has declined from 3.1 to 2.4, while the number of households has increased by 7.8 million. There has also been a marked increase in the number of women in the workplace, and 63% of women now hold a full driving licence, up from 29% in 1975/6 (DfT, 2006a). And while only three out of ten households in Great Britain in 1961 had a car, by 2004, one in four households did *not* have a car, whilst almost one in three had two or more (DfT, 2006a).

2.29 The UK's demographic structure is expected to change significantly in future, in particular through an increasingly ageing population. Although much modelling assumes this will lead to a slow-down in traffic growth, it could lead to an increase as, unlike past generations, these older cohorts may have higher incomes, will have grown up being dependent on the car and may have a higher propensity to travel by air. For example, of those aged over 70, over half hold a driving licence (51%) compared to only 15% in 1975/6 (DfT, 2006a).

11 CfIT (2006). *Sustainable Transport Choices and the Retail Sector*. London: CfIT.

Costs of transport

2.30 The overall costs of motoring have fallen in real terms in last 20 years. In addition, over this period increases in public transport fares above the rate of inflation have also made travel by car relatively cheaper – hence strong growth in private road transport over the long term.

2.31 The demand for petrol-based transport can be dampened, as occurred with the introduction of the Fuel Duty Escalator in 1993 (later removed in 1999), which reduced emissions below what otherwise would have been: the Government estimates it will continue to save 1.9 MtC annually to 2010, making it one of transport's key contributors to the UK Climate Change Programme (see Chapter 3). Fuel tax can encourage some motorists to lower the fuel duty they pay without necessarily reducing mileage, by switching to more-efficient cars. In recent years this has meant primarily diesel cars which, taking a medium sized car, on average produce around 13% less CO_2 per kilometre than a petrol equivalent (Defra, 2007d).

2.32 Since deregulation of the airline industry in 1996, the development of the low-cost aviation sector has significantly altered the way the short-haul airline market operates. In particular, this development has introduced low and unrestricted fares and has opened up the range of destinations and airports available. The DfT suggests 'this increasing desire and propensity to fly can be explained by the growing affordability of air travel' (DfT, 2006b, p25). Research commissioned by CfIT found that recent reductions in the price of flying has stimulated the growth in flying (being given as the single biggest factor why people are flying more for leisure than they did five years ago) (Ipsos MORI, 2007 – Exhibit 2.2).

Exhibit 2.2

Ipsos MORI survey on attitudes to aviation and climate change – results on flying behaviour

Ipsos MORI conducted 1122 face-to-face interviews and a one-and-a-half-day deliberative event involving members of the public with stakeholders from the aviation industry, environmental lobby and academia in order to discuss flying behaviour. The research showed:

- consistent with previous research studies, over 40% of people in England have flown for leisure in the past 12 months;
- while the majority have flown just once, nearly a quarter of those who have flown (23%) have done so three or more times;
- frequent flyers (3+/year) are more likely to have increased their air travel since five years ago, with over 60% flying more often;
- in line with forecasts, the majority of people expect to fly as often or more frequently in the future (82%), with half of those who have not flown in the past year expecting to fly at some point in the future;
- only a small proportion (11%) expect to fly less frequently in the future, and this is predominantly due to changes in personal circumstances rather than a concern about the environmental impact of aviation.

Source: Ipsos MORI, 2007

2.33 There is, however, some debate as to whether the low-cost sector has led to an increase in the overall passenger growth rate or whether the growth in that sector has been at the expense of established full-service scheduled carriers and charter flights – i.e. it may well have happened anyway, particularly because of income growth (CAA, 2006). The evidence is uncertain, since it is difficult to know what would have happened in the absence of the restructuring of the industry. Since 1996, annual growth rates have averaged around 5–6%, which represent strong growth but are similar to the rates experienced prior to deregulation.[12]

2.34 What is clear is that most of the current air-passenger demand is for leisure purposes and the availability of low cost flights has not in fact significantly altered the type of people who are flying (Dargay et al., 2006; CAA, 2006). The growth is made up of existing passengers flying more than in the past, particularly those from middle and higher income bands travelling short-haul. CfIT-commissioned survey work also found the frequent flyers (3+/year) are more likely to have increased their air travel compared to five years ago, with over 60% flying more often (Ipsos MORI, 2007).

Network developments

2.35 Improved transport networks, such as completion of the railway and motorway systems, or development of international and domestic air links, can also encourage growth in transport. There have been points in time when different travel modes have become faster, cheaper, safer and more comfortable, allowing people to travel further within a constant 'travel time budget', even if the benefits of improvements have not always been sustained over time.

2.36 This demand for more speed, power and comfort has eroded some of the efficiency gains that would on their own have led to a reduction in emissions per kilometre travelled. On the other hand, some of the benefits of network improvements are being countered by growing congestion on different modes – something which may or may not be addressed in future by measures aimed at managing demand.

Vehicle/fuel technology and operational efficiency

2.37 Previous decades have seen significant improvements in the efficiency of various vehicle/fuel technologies. Average new (two-wheel drive) petrol car efficiency, for example, has improved by around a quarter since the late 1970s (DfT, 2006a). The share of diesel reached 36% of the new car market in 2005. Diesel cars now account for 21% of the overall car fleet, up from under 9% in 1995. Aircraft fuel efficiency per passenger kilometre has improved by over 40% in recent decades (SITA, 2006).

2.38 Such improvements are positive ones in terms of addressing transport emissions, but their *ultimate* impact may reduce over time. Improved fuel efficiency in cars has worked to stabilise emissions from cars at roughly 1990 levels, despite an 18% increase in road traffic over this period. However, one effect of vehicles becoming more efficient is to reduce the unit cost of travel, partly stimulating increased mileage and the purchase of larger and heavier vehicles, thus partly offsetting the original beneficial effects. This phenomenon of increased travel resulting from efficiency savings is often referred to as the 'rebound effect'.

12 See Dargay and Cairns (2006) for a discussion of growth rates over this period. Certain years since 1996 saw increased growth rates and others, particularly after the September 11 attacks, saw slower growth rates.

2.39 Looking forward, further improvements in road vehicle fuel technology are anticipated, which are due to continue to stabilise emissions from this sector. More significant developments in vehicle and fuel technologies are also expected to deliver further gains in tackling carbon emissions – see Exhibit 2.3.

Exhibit 2.3

Future road vehicle and fuel technologies

Road transport is widely expected to be dependent on oil for several decades to come, but significant changes are anticipated.

The market for diesels in the UK is expected to continue to grow over the next few years, perhaps eventually achieving a market penetration of around 60% (PWC, 2006). Cleaner fuels that provide tangible emissions benefits are being developed, and these can be used in conventional internal combustion engine (ICE) vehicles, such as the use of biofuels.

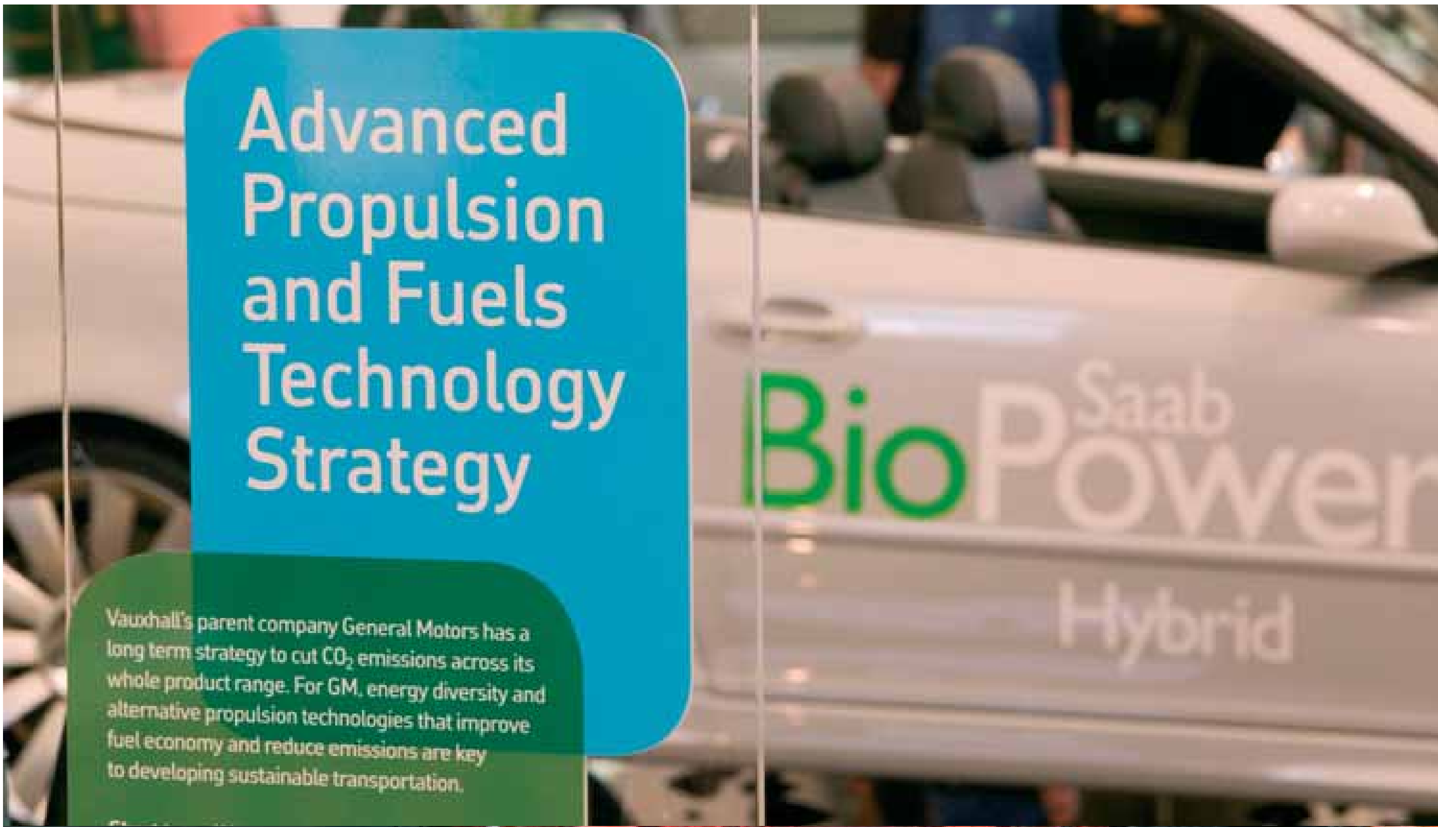
A second strand is the development of alternative vehicle technologies that partially or completely replace conventional engines. This process has already begun with the introduction of the hybrid vehicle, which combines the advantages of the ICE with an electric drive train. Hybrid technology (micro, mild and full) will increasingly be used by automotive manufacturers to reduce CO_2 emissions. Enhanced power systems, combined with regenerative braking, will make better use of engine power, allowing improved environmental performance and/or engine downsizing. Hybrid technology can be combined with renewable fuel technology to reduce real world emissions further.

Hybrids are developing rapidly with a dominant system of design yet to emerge. Figures from SMMT show that 8957 petrol/electric cars were newly registered in 2005, and 298 all electric vehicles, up from zero in 2005 (SMMT, 2007c). Hybridisation of vans and medium-duty trucks is also expected to see rapid development over the next decade.

Pure electric vehicles using batteries have been available for many decades but have suffered major drawbacks in terms of performance, range, recharging times and availability of recharging infrastructure. Improved battery technology is allowing greater mileage between charges and higher speeds in vans as well as cars (PWC, 2006). However, this technology is only zero-emission at the tailpipe and its real climate change benefit is very much linked to the way in which the electricity is produced in the first place (SMMT, 2006).

Hydrogen is seen by many as a potentially dominant fuel, either burnt in a conventional engine or by producing electricity to run a car through a fuel cell. However, hydrogen is a carrier, rather than source of energy, and although the only emission is water at the tailpipe, lifecycle emissions depend on how the hydrogen is produced. There are also big challenges to changing our transport structure over to hydrogen, as it is difficult to store and transport in bulk and needs a lot of energy to produce. Consequently, although hydrogen and fuel-cell cars are available now in prototype, this technology is still several decades away from being commercially available in the UK.

Sources: PWC, 2006; SMMT, 2006 and 2007c

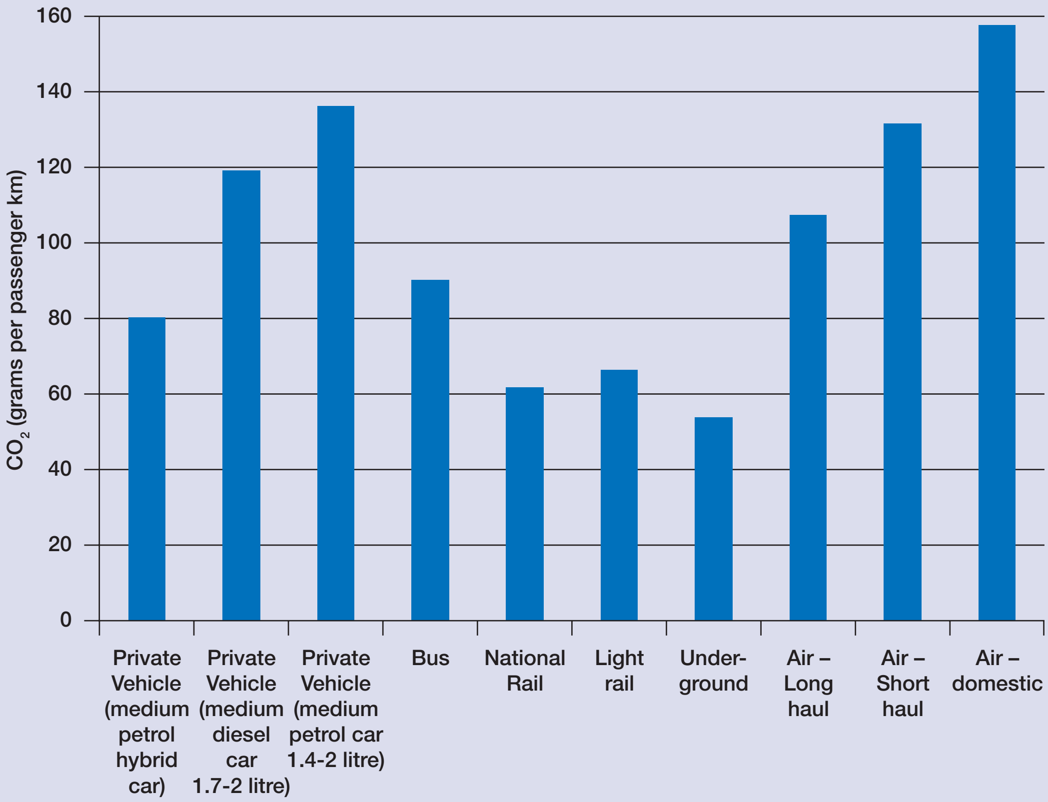


2.40 In the case of aviation, the central-case forecast produced by DfT to support its 2003 Air Transport White Paper assumed aviation fuel efficiency would improve by 50% between 2000 and 2050, resulting from both better engine and airframe design, and operational improvements (DfT, 2004a). The UK aviation industry has made a commitment to improve fuel efficiency by 50% per seat kilometre, including up to 10% from air traffic management efficiencies (AOA, BATA, SBAC and NATS, 2005). However, most scenarios of aviation and emissions growth show that the growth in air travel is likely to outstrip the rate of improvement (see Chapter 3 for emissions growth projections).

2.41 It is also important to note that different carbon efficiencies exist between modes of transport. These differences can be explained by the different technology deployed, vehicle size and capacity, technical standards, or indeed topography or weather conditions. Each mode is also restricted to a specific network, and each network (road, rail, sea and air) has its own unique characteristics that can affect vehicle operation and efficiency. Comparative figures are difficult to produce, given the variety of assumptions involved regarding average vehicle type, driving styles and occupancy rates. Figure 2.5 displays Government reporting guidelines using a set of assumptions found in Defra figures (2007c).

Figure 2.6

CO_2 emissions by private and public transport modes (grams per passenger kilometre travelled)[13]



Source: Defra (2007c) Guidelines to Defra's GHG conversion factors for company reporting: annex updated June 2007.

13 Figures for private vehicles based on average values for UK car fleet in 2005 and use a 15% uplift factor for 'real word' conditions (UK average car occupancy of 1.6). Bus data based upon all bus class and journey data from the UK GHG inventory and an average load factor of 9.2. Air emissions include a 9% uplift factor but **do not** include the additional impacts of radiative forcing (e.g. non-CO_2 impacts). Note the Defra document does not include figures for shipping. It has been reported that shipping can be up to 4–5 times more carbon-efficient than road transport per tonne kilometre (Wahlström et al., 2006)

Conclusions

2.42 Using the most appropriate basis of measurement, transport is now the largest single source of emissions in the UK, within which road transport is the main component and of which in turn cars are the most significant element.

2.43 In the UK, transport has been the only sector whose emissions grew significantly between 1990 and 2005, a period in which reductions in other sectors of the economy saw total UK carbon emissions fall by 5% (Defra, 2007e).

2.44 Emissions from air travel and from the movement of vans and lorries in turn have been among the fastest-growing sources of transport emissions in the UK. Emissions from cars have been stable since 1990, while those from public transport have fallen.

2.45 There is a need for improved data and understanding related to emissions from shipping, and from the use of lorries and vans.

2.46 There are many factors behind transport emission trends to date, including the demand for transport, mode choice, vehicle/fuel technology and the efficiency with which different forms of transport are used.

2.47 Technological improvements have delivered benefits in terms of carbon reduction, but these have either been offset (in the case of car use) or out-stripped (in the case of air travel) by rising demand and choices made by transport users – these trends are set to continue in future.

2.48 These insights underline the importance of looking at how to cut transport's carbon emissions if the UK is to meet its goals for overall carbon reduction – and action to stimulate further technological improvement, as well as behavioural change, will be vital.

2.49 However, these insights in themselves indicate neither the *scale* of reduction in transport emissions, nor the *type* of appropriate measures, that would be consistent with a cost-effective UK-wide programme to deliver major carbon abatement. The following chapter seeks to review the relevant state of knowledge on these issues.

Chapter 3: Cost-effectiveness and the current UK Government approach to cutting transport carbon emissions

3.1 In this chapter, we begin by considering briefly some of the issues relevant to understanding the cost-effectiveness of transport measures in reducing carbon emissions and summarising the existing literature on this topic. We then review the Government's current approach to reducing transport carbon emissions, before identifying four observations that suggest there is scope for improving on the current approach.

Measuring the cost-effectiveness of action to reduce emissions

3.2 The Stern Review described climate change as the greatest and widest-ranging market failure ever seen (HM Treasury, 2006). In identifying what needed to be done to correct this failure, the Review highlighted how:

- mitigation should be seen as an investment, where the costs can be kept manageable by taking the right action at the right time to avoid far greater negative impacts over the longer term; and
- action is needed to deliver progress in three key areas – technological development, carbon pricing and behavioural change. The clear implication is that failure to move on all three fronts could significantly increase the cost of mitigation.

3.3 These insights place particular significance on identifying cost-effective measures, which give the best return in terms of tonnes of carbon saved for the cost incurred. Policy makers have a key role in ensuring that the costs and benefits of potential abatement opportunities are assessed thoroughly and that any carbon reduction strategy seeks as far as possible to prioritise implementation of measures according to their cost-effectiveness. The process of measuring the cost-effectiveness of measures to cut transport-related carbon emissions throws up a number of basic issues:

- Apart from its impact on carbon emissions, a measure may have a range of costs and benefits that can be expressed in monetary terms, some direct and others ancillary (NAO, 2006). Direct costs can include the up-front costs of purchasing a car or ongoing maintenance of the vehicle; ancillary impacts may include the effect that using the vehicle might have on air quality or traffic congestion. There may also be other non-quantifiable impacts, such as those on security of supply; social inclusion and equity; competition and innovation; or on biodiversity and regeneration;

- The calculations also require assumptions to be made about a range of factors, such as the cost of different technologies and how they might vary over time, the future price of oil, or how the demand for transport responds to changes in income and prices. Different base assumptions can generate significantly different results in terms of the cost-effectiveness of potential measures to cut emissions;
- When considering cost-effectiveness, we also need to know what we are willing to pay to save a tonne of carbon, in order to decide whether it is worthwhile. Estimates of the ‘social cost’ of carbon quantify the impacts on health, environment and the economy caused over time by each tonne of carbon emitted. Such calculations are subject to considerable uncertainty, but, where measures cost more than the social costs they would normally be ruled out, unless there are other, strong reasons for pursuing them. The central estimate used by Government and in transport appraisal by the Department for Transport (2006d) was £70/tonne carbon in year 2000 prices, and increases in real terms by £1 per year according to the year the emissions are released, with a sensitivity range of £35–140. The Government committed to producing by the end of summer 2007 revised guidance on the appropriate figure to use in line with the Stern Review;[1] and
- There should be a robust methodology not just to compare the cost-effectiveness of different options to reduce transport-related carbon emissions, but also to compare transport measures with non-transport ones, in order to identify the lowest-cost package of measures across the economy as a whole. In reality, of course, policy makers will also, among other things, have an eye on the practicality and public acceptability of possible measures, individually and as a whole. While this is understandable, it is also important that the decision-making process that weighs these different factors should be well informed and transparent.

Existing literature on cost-effectiveness of transport measures

3.4 CfIT commissioned a review of the technical literature on the cost-effectiveness of different measures to reduce transport-related carbon emissions (Anable and Bristow, 2007). A clear finding of the review, which looked at UK and overseas studies, was the wide variation in estimates of measures’ carbon savings and cost-effectiveness (see Exhibit 3.1). One Dutch study (Kampman et al., 2006) concluded that different studies ‘cannot generally be combined and compared because the assumptions and methodologies differ so much. Choosing the most cost-effective pathway for society to combat global warming is therefore difficult with present knowledge’.

1 Stern reviewed a number of valuations of the social costs and recommended a methodology to calculate it. The revised guidance from the Government will reflect this.

3.5 Notwithstanding the difficulties in comparing the results of different studies, the review of the existing technical literature did suggest some significant common themes:

- Adoption of technology-focused options for reducing transport carbon emissions (e.g. through changes in vehicle or fuel specifications), while potentially capable of delivering cuts in emissions at scale, can often be relatively expensive when pursued in isolation over a short period and can face challenges in implementation;
- Promotion of measures focused on encouraging behaviour change (e.g. in choices about how or even whether to travel) can in some cases and in principle appear relatively cost-effective, but can also depend in practice on millions of separate decisions by individual transport users with little guarantee of consistent and sustained behavioural adaptation to deliver carbon reductions;
- The expectation is that packages of measures, involving combinations of policies addressing technological change, pricing (e.g. through the use of taxes) and other measures to encourage behaviour change (e.g. improved information), could deliver savings greater than the sum of their parts. However, there is as yet no evidence in the literature on the cost-effectiveness of carbon saving measures to this effect. Government estimates of the cost of the Voluntary Agreement (VA) included supportive fiscal measures – without which presumably the costs would have been higher. Otherwise studies by Hickman and Banister (2006) and Bristow et al. (2004) explore the potential of broader policy packages to deliver carbon savings, but do not examine cost effectiveness; and
- There appears to be a significant gap in quantitative analysis of the cost-effectiveness of potential carbon abatement options in some areas of transport, for example in relation to aviation and shipping.

Exhibit 3.1

Difficulties in comparing measures of cost-effectiveness

The variation in estimates of potential carbon savings and the cost-effectiveness of measures to be found in the technical literature can partly be explained by uncertainty, but also significantly by differences in methodology. These include differences in:

- starting points, baselines and start/end dates – more recent studies naturally tend to contain more up-to-date data that may reflect, for example, slower than anticipated progress in policy implementation, or they vary with respect to assumptions on the success or failure of existing policies;
- scope – by geography, or in terms of the range of costs and benefits included, or in terms of purpose and focus. Some studies examine the effects of specific policies prior to or after implementation, others examine routes to achieving target reductions in CO_2, while others are focused on different impacts such as air pollutants or oil consumption;
- the degree of implementation – for example, whether road speed limits are set at 70 mph, 55 mph or 50 mph and how extensively they are applied across different parts of the road network;

Exhibit 3.1 *continued*

- key assumptions about the way people respond to measures – for example, the assumed response to price signals, or whether demand is fixed or changes over time;
- assumptions with respect to the costs of technological developments over time;
- definitions of cost-effectiveness and cost–benefit analysis; the use of different discount rates, currencies and indicators for tonnes of carbon or CO_2 or energy; and in costs per tonne of oil equivalent, per gigajoule etc.

The key differences among studies are probably the range of costs and benefits included, the extent to which demand is assumed to respond to changes, and assumptions made on the future prices of new technologies.

Sources: Anable and Bristow, 2007

3.6 In addition to the existing body of work on the cost-effectiveness of specifically transport-related measures to reduce carbon emissions, there are also several reports that have looked at what might constitute cost-effective responses to climate change from an economy-wide and/or global perspective over time.

3.7 Common among these analyses is a view that there are significant opportunities for carbon abatement across the economy, many at potentially manageable cost. They also highlight that transport-related measures have an important role to play, but that in the medium term there is more scope to deliver cost-effective carbon reductions in other sectors of the economy. Three analyses in particular are worth highlighting:

- The Stern Review (HM Treasury, 2006) concluded that the potential for significant short-term cost-effective abatement in the transport sector was limited, but in the long-term it is much higher. Cost-effective reductions in the short term will come from improvements to oil-based transport vehicles, biofuels and behaviour change. Road transport and certainly air transport will still be largely oil-based by 2050. Despite any improvements, growth in the sector will mean it will be one of the last sectors to bring its emissions down to below current levels;
- McKinsey developed a cost curve of global abatement opportunities over the period to 2030. This analysis compared 'business as usual' projections for emission growth against the cost of possible approaches to reduce emissions. The study focused upon measures that would cost €40 (£27) per tonne CO_2 equivalent (€147 or £99 per tonne carbon) or less in 2030. It found almost three-quarters of the potential to reduce emissions come from measures that are not reliant upon new technologies (e.g. nuclear power, hydropower, better insulation in buildings). Cost-effective reductions in transport to 2030 are seen to come from improvements to oil-based transport vehicles and biofuels (Enkvist, 2007); and
- The report of the third working group of the IPCC (2007c) on mitigation of climate change establishes that, compared to a global baseline for the transport sector and assuming a price for carbon of $100t/$CO_2$ eq. ($367 per tonne carbon or £184), the transport sector can contribute around 9% of the global potential to mitigate GHG emissions by 2030. Whilst the report acknowledges a role for transport demand

management, savings are attributed only to vehicle efficiency and biofuels – and both in roughly equal proportion. Because of a lack of evidence, the IPCC analysis excludes heavy-duty vehicles, shipping, 'high-occupancy passenger transport', and the non-CO_2 emissions from transport. Hence the policies assessed relate almost exclusively to car passenger transport. Overall, the IPCC concludes that mitigation in this sector faces constraints such as consumer preference and the lack of policy frameworks, and that market forces alone (including rising fuel costs) are unlikely to lead to emissions reductions.

3.8 A further, particularly relevant piece of analysis is the economy-wide 'MARKAL-Macro' modelling carried out for the UK Government (updated to support the 2007 Energy White Paper (EWP) (DTI, 2007a) to identify how the UK could meet future energy demands at least cost to society. By looking at carbon reduction opportunities in transport and non-transport sectors, comparing a 'business as usual' scenario to 2050 with scenarios assuming constraints on carbon emissions in the future, the model provides a framework for evaluating alternative technology pathways and futures (see Exhibit 3.2).

Exhibit 3.2

MARKAL scenario modelling of future transport emissions

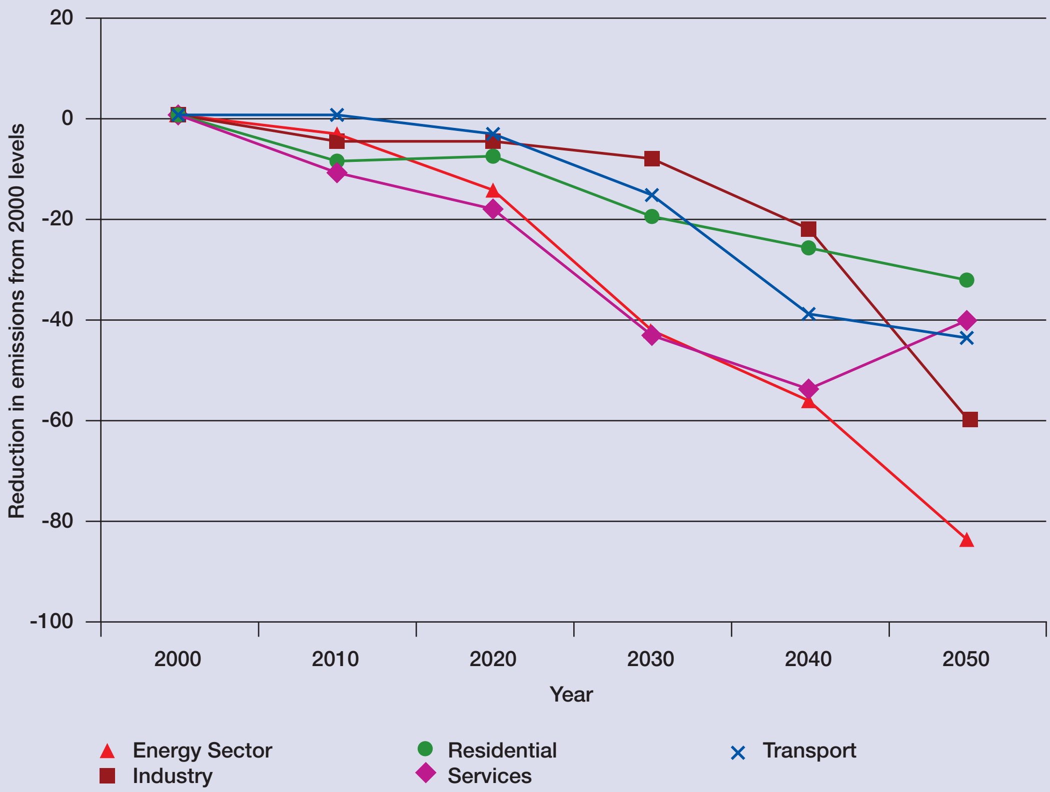
The MARKAL-Macro model uses different assumptions about (among other things) future oil prices, energy demand, and costs of technological options in areas such as power generation, business and domestic energy use, and domestic transport (international aviation and shipping are excluded from the model):

- Projections entered into the model show the transport sector would experience the greatest increases in service demand of all sectors. Overall vehicle kilometres rise 50% between 2000 and 2050, with vans by 100% and domestic aviation by 550%;
- In the base case (where the economy is not constrained to cut carbon by 60%), the transport sector is transformed by petrol and diesel hybrid vehicles introduced in a range of modes from 2020, and buses, lorries and vans move to hydrogen after 2030. Take-up of biofuels in the base case is limited to that mandated under the RTFO. The domestic aviation sector sees the least technological change owing to the limited technology substitution options;
- In the 60% carbon-constrained case, there is very little technological change in aviation, but the introduction of hybrid vehicles is accelerated in the medium term. Biofuels play a more important role (20% by 2050) but are constrained by resource availability. Perhaps unexpectedly, hydrogen is less prevalent in this scenario as, unlike in the base case where it is produced from fossil fuels, it is carbon-neutral in the constrained case and therefore more costly and produced at a lower level; and
- The findings show a continuing role for diesel, petrol and aviation fuels in 2050.

Sources: Strachan et al., 2007

3.9 A major outcome from the modelling is that transport measures could make a significant contribution towards a cost-effective, economy-wide move to cut carbon emissions by 60% by 2050, falling possibly by as much as 45% against 2000 levels by the end of the period.[2] In the short to medium term (up to about 2020), the model indicates that technological developments in transport would do little more than offset the rise in carbon emissions that would otherwise have occurred due to growing demand for transport. More cost-effective opportunities for net carbon abatement would be realised in other sectors such as energy, industry, residential and services, as the economy moves towards its long-term target (see Figure 3.1).

Figure 3.1
Cost-effective carbon reductions by sector to 2050 from the MARKAL-Macro model



Source: DTI, 2007a (Chapter 7, p237), Central scenario, 2030+ trajectory. Energy includes electricity generation and upstream oil and gas production. Data provided by Strachan et al., 2007.

3.10 However, as with all economy-wide analyses, the results of the MARKAL-Macro need to be treated with caution, as modelling such as this is beset with difficulties and uncertainties, and is dependent on the range of base assumptions used. Much rests on assumptions about technology availability, efficiency and cost, all subject to considerable uncertainty, particularly for technologies, such as hydrogen and fuel cells, which are still in their infancy.

2 This appears to be a greater reduction than that achieved by the residential or service sectors. However, this would not be the case if 1990 had been used as the base year as these other sectors had already begun making significant reductions in emissions between 1990 and 2000 whereas transport had not.

3.11 Among its limitations are that the model is focused on technological possibilities for the abatement of emissions and is limited in its consideration of demand-side policy and behaviour change. The only role behavioural change plays in the model is in response to costs (including the implicit carbon price) whereby the model can choose either to reduce demand or to improve the efficiency of a given mode such as by switching fuels. For instance, the model cannot accommodate mode shift, nor can it accommodate a change in the size distribution of cars in the market through, for example, 'downsizing' caused by a change in purchasing patterns towards smaller vehicles. In addition, the base year is 2000, not 1990 – a significant issue for transport, as its emissions were some 6% greater in 2000 than 1990.[3] Assessment appears to focus exclusively on carbon reduction and monetary costs, with little or no consideration of other influences or impacts including lifestyle preferences, equity effects, and impacts on innovation and competitiveness. It is also not obvious how far measures are considered as mutually-supporting packages (with the potential for improved cost-effectiveness) rather than as individual actions. But the insights provided by these economy-wide analyses together and the technical literature focused on the cost-effectiveness of transport interventions specifically provide an extremely useful context for considering the current Government approach to reducing carbon emissions from transport in the next section.

Current Government policies for reducing transport-related carbon emissions

3.12 The package of policy measures favoured by the Government to cut transport emissions was set out in 2000 as part of a Climate Change Programme (CCP) (DETR, 2000). The 2004–06 Climate Change Programme Review (CCPR, Defra, 2004) culminated in the revised CCP (Defra, 2006a) and policy evaluations have been updated in the recent Energy White Paper (EWP) (DTI, 2007a). The CCP includes the following key elements:

- **Voluntary Agreements (VAs) since 1997–98 to reduce average sales-weighted new car fuel emissions,** among the EC and the European, Japanese and Korean automobile producers. The original target for emissions from the tailpipe for European manufacturers was 140 g CO_2/km by 2008–09. Progress has been made, but there is now widespread acknowledgement that the target will not be met;
- **Package of measures (in the UK) to support the VA,** comprising reforms to vehicle excise duty (VED), company car tax, and labelling on car CO_2 emissions:
  - For cars registered on or after 1 March 2001, a system of VED bands exists based on the CO_2 emissions rating of the vehicle. Duty ranges from £0 in band A (less than 100 g CO_2/km) to £300 in band G (over 226 g CO_2/km). The 2007 Budget reduced the band B rate to £35, removed the diesel differential, increased band G to £300, with a further increase to £400 in 2008, with minor adjustments to other bands; and

3 According to Defra (2007b) total domestic transport emissions were 31.8 MtC in 1990 and 33.6 MtC in 2000.

– Company car tax has been based on CO_2 emissions since 2002. These reforms have made significant changes to the company car market. In 2001, new company cars emitted over 2 g CO_2/km more than new private cars (179 g CO_2/km compared to 176.5 g CO_2/km); but by 2005, this had reversed, with new company cars emitting some 5 g CO_2/km less than private cars (167 g CO_2/km compared to 172 g CO_2/km).[4]

- EU successor to the Voluntary Agreements. The CCP envisaged a successor to the current agreement that would deliver similar levels of progress as seen under the current VAs. In the UK, this would equate to reaching a level of 135 g CO_2/km by 2020. Analysis for the Energy White Paper looked at a wider range of scenarios more commensurate with the 130 g CO_2/km by 2012 recently put forward by the European Commission. The UK Government has expressed its wish to see a long term target set of 100 g CO_2/km, although no date for this target has yet been defined;
- UK Renewable Transport Fuels Obligation, requiring suppliers to ensure a share of their sales is from biofuels, rising in stages to 5% by 2010–11. Companies who miss this target can buy surplus certificates from those who exceed it, or pay a penalty. Both a duty discount and the RTFO are implemented at the pump, with biofuels receiving a rebate of 20 pence per litre to encourage their take-up and development. The Government wants the level of the obligation to rise above 5% after 2010, conditional on the development of robust carbon and sustainability standards, new fuel quality standards at EU level, and costs to consumers being acceptable (DfT, 2007c); [5]
- 10 Year Plan (10YP)/Wider transport measures/Smarter Choices – including a sustainable distribution strategy in England, improvements to local public transport and a range of soft or ‘smart’ choices such as school travel plans; and
- Sustainable distribution (in Scotland) – freight is a minor part of the programme with specific carbon savings allocated to this policy in Scotland and an unspecified element of the savings from wider transport measures.

3.13 The Climate Change Programme also refers to the fuel duty escalator, introduced in 1993 at a rate of 3% above inflation, then increased to 5% in 1995, and again to 6% in 1997. Although scrapped in 2000, as fuel duty remained higher than it would have been had the policy never been implemented, it is still considered to be contributing to carbon reduction targets worth 1.9 MtC per annum in 2010. The 2007 Budget included an announcement of with-inflation increases in duty to 2009 (HM Treasury, 2007).

3.14 The potential carbon savings from each policy instrument in the programme are regularly re-estimated by Government as underlying modelling assumptions change in the light of experience and new evidence. Table 3.1 shows the savings attributed to each measure, totalling 10 MtC by 2020, using the most up-to-date published figures.

4 SMMT, 2006.
5 Until September 2007, the DfT are consulting on carbon and sustainability reporting within the renewable transport fuel obligation. See: http://www.dft.gov.uk/consultations/open/rtforeporting/

Table 3.1
Expected carbon savings from transport measures in the CCP

	2010	2015	2020
Voluntary Agreements package (includes supporting fiscal measures e.g. VED, CCT)	2.3[6]	3.1	3.6
Successor to Voluntary Agreements (based on a target of 135 g CO_2/km by 2020)	0.3	1.1	1.8
Fuel duty escalator (1993–2000)	1.9	1.9	1.9
Renewable Transport Fuels Obligation (gross savings based on 5% of fuel sales by 2010 target)[7]	1.6	1.6	1.6
Sustainable distribution in Scotland	0.1	0.1	0.1
10 Year Plan/Wider transport measures[8]	0.8	0.8	0.8
Smarter Choices (low intensity)[9]	0.2	0.2	0.2
Total CCP	**7.3**	**8.9**	**10.0**

Source: Note these figures are the most up-to-date published estimates of potential carbon savings for each instrument compiled from Defra, 2006b and 2007a and DTI, 2007b. Totals do not sum due to rounding.

3.16 In addition to the emissions savings identified above, further developments have been outlined both within and separate to the Energy White Paper (DTI, 2007). However, these policy areas either do not have carbon savings attached to them or cannot be regarded as currently 'firm and funded', and so the savings attributed to them are not included in the graph:[10]

- If aviation were included in the EU Emissions Trading Scheme (EU-ETS), assuming a cap at 2005 emissions on projected 2020 levels in line with the current Commission proposal, this is projected to save 0.3 MtC by 2020 relating to domestic UK flights only, with a further 4.4 MtC accounted for by international departures (Defra and DfT, 2007). It is anticipated that only a small proportions of these emissions savings will come from reduction measures within the aviation sector itself, as opposed to reductions purchased through credits generated elsewhere.
- If the RTFO were extended to 10%, this would save an additional 1 MtC by 2020 (DTI);
- The Energy White Paper also repeated the Government's commitment to pursue the inclusion of shipping and surface transport in the EU-ETS (DTI 2007a);

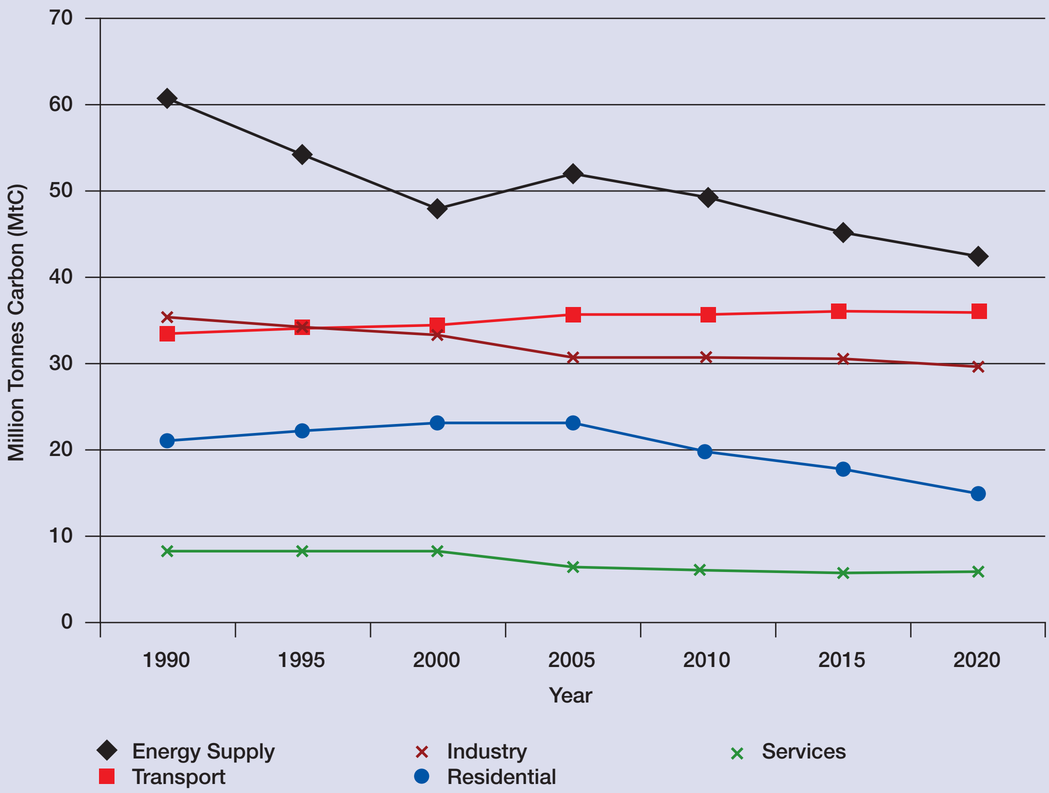
6 Of which vehicle excise duty is 0.15 MtC and company car tax is 0.50 MtC.
7 This figure follows the internationally agreed methodology for allocating emissions to individual states, which prevents global double counting of emissions. As such it does not take into account the carbon emitted during the production of biofuels that are produced abroad and used in the UK. When this is taken into consideration, the net global reduction in CO_2 emissions is around 1 MtC per annum.
8 Estimates available for 2010 only, assumed constant to 2015 and 2020.
9 In the supporting analysis to the EWP (DTI, 2007b), 0.2 MtC was reallocated to the transport sector from 'local authority policies'. We have clarified these as pertaining to smart measures implemented beyond that included in the 10YP. See Chapter 4 for further explanation of policies regarded as smarter choices.
10 It could also be argued that the successor to the Voluntary Agreement is also not 'firm and funded'. However, the Government attaches carbon savings to this measure in the CCP baseline.

- In 2006 a new communications campaign (Act On CO_2[11]) was launched, covering eco-driving and purchasing. This highlights to consumers that they can contribute to tackling climate change without compromising on the type of car they drive – both by driving in a more fuel-efficient way and by purchasing a lower-carbon vehicle within a given class;
- A new Low Carbon Vehicle Innovation Platform will provide up to £30 million for UK industry-led demonstration and collaborative R&D projects from 2008–09 onwards; and
- Air passenger duty (APD) was doubled with effect from 1 February 2007 estimated to save around 0.75 MtC per year by 2010–11 (HM Treasury, 2007).

Emissions projections

3.17 Altogether, the impact of these policies (if delivered successfully) means that emissions from domestic transport will be around 22% lower in 2010 than they would otherwise have been.[12] The overall effect of the programme of measures will be to stabilise transport emissions at broadly 2005 levels by 2020, as savings in the transport sector are expected to offset the growth that would otherwise occur (see Figure 3.2).

Figure 3.2
Historic and projected carbon emissions by sector 1990–2020 (by source)



Source: Figures pre-2005 from DTI, 2006; forecasts from DTI, 2007a, Table 4.2, p12. Figures for transport exclude "off road" and savings from inclusion of aviation in EU ETS.

11 http://www.dft.gov.uk/ActOnCO2/
12 On the basis that emissions in 2020 are projected to be 35.9 MtC after savings from the CCP and EWP of 10 MtC (DTI, 2006b).

Observations on cost-effectiveness and the Government's approach to reducing transport carbon emissions

3.18 We note that the National Audit Office has reviewed the cost-effectiveness analysis in the CCP as a whole, concluding that it was both appropriate, sufficiently reliable for the purpose and an improvement on the analysis in 2000 – though we also note the NAO's view that fiscal measures were not subject to the same quality assurance processes as technical measures (NAO, 2006).

3.19 But our review of the priorities for reducing transport-related emissions, informed by the relevant existing literature highlighted earlier in this chapter, throws up four significant observations about the cost-effectiveness of the Government's current approach:

- The transport element of the Climate Change Programme appears to rely significantly on relatively expensive measures to deliver reductions;
- There are question marks over the ability of major elements of the programme to deliver reductions;
- The lack of emphasis on measures to encourage behavioural change represents a significant missed opportunity; and
- The role that measures related to international transport can play as part of a wider cost-effective response to tackling emissions remains unclear.

The transport element of CCP appears to rely significantly on relatively expensive measures to deliver reductions.

3.20 Figure 3.3 uses cost data from various Government studies to compare the cost-effectiveness of current or potential policies in the CCP, plotted against the size of emissions reduction expected from each measure.[13] The only measures included in current policies are the RTFO at 5%, the extension of new car efficiency to 135 g CO_2/km, as well as the lingering effects of the now-abandoned fuel duty escalator. The assessments of policies related to sustainable distribution, smart choices, extension to the RTFO to 10% and successor to the VA to 104 g/km each relate to intensification of current activity.

3.21 This diagram must be treated as purely indicative and should be read in conjunction with the supporting documentation by Anable and Bristow 2007 (available from www.cfit.gov.uk). By reporting the average cost per unit of carbon reduction over the lifetime of the policy, the single cost-effectiveness figure conceals the fact that costs may change over time (e.g. as technological know-how increases) and does not reflect the total amount of carbon saved or how soon carbon reductions are made (NAO, 2006). It is also important to note that the different cost estimates include different ancillary impacts and are taken from different studies with different base years.

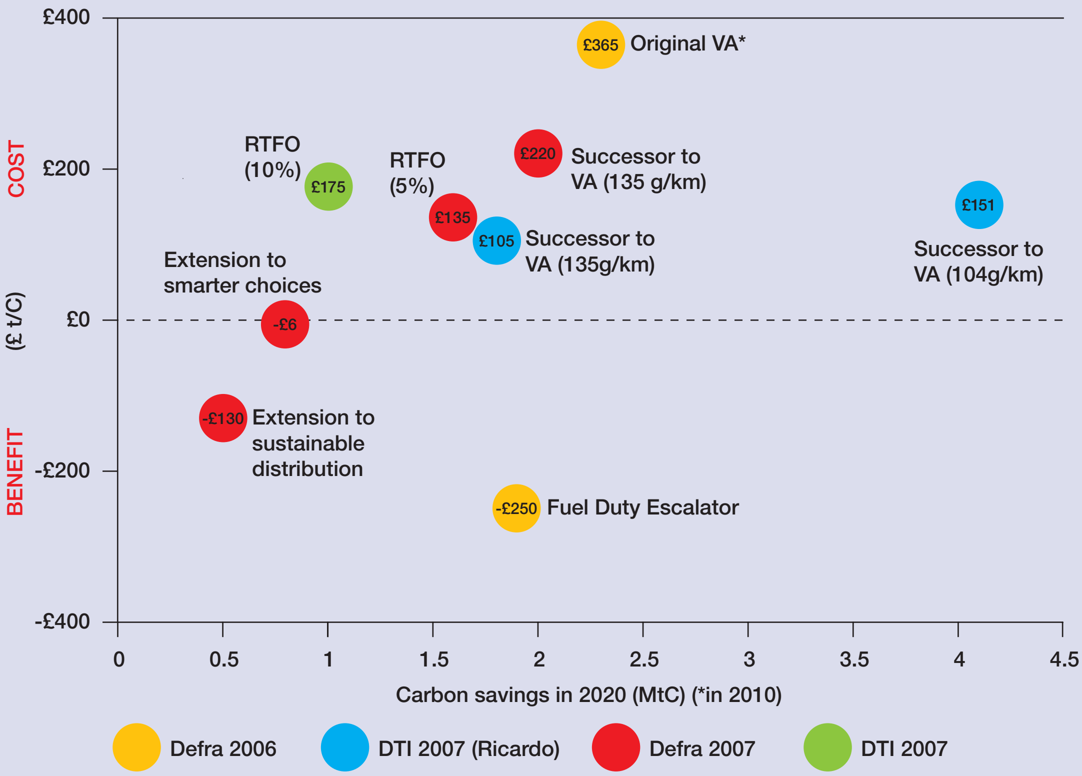
3.22 However, the diagram does suggest that, with the exception of the Fuel Duty Escalator, the measures in the programme are expected to deliver significant savings in emissions (i.e. different versions of the Voluntary Agreement and RTFO) appear relatively expensive. They are more expensive than the mid-range social cost of carbon (c £90/tonne in 2007

13 All costs and benefits are brought to present day values using standard discounting techniques.

prices) used in appraisal by DfT (though not as much as the cost referenced in the Stern Review) and certainly more expensive than the smaller-scale measures in the programme. While movement towards the higher RTFO target would seem to mean adopting a less cost-effective commitment than the present one, there do appear opportunities to lower the cost of the original Voluntary Agreement on cars by aiming for a tighter carbon target but over a longer period of time.[14]

Figure 3.3

Comparative cost data from various studies assessing current or potential policies in the CCP

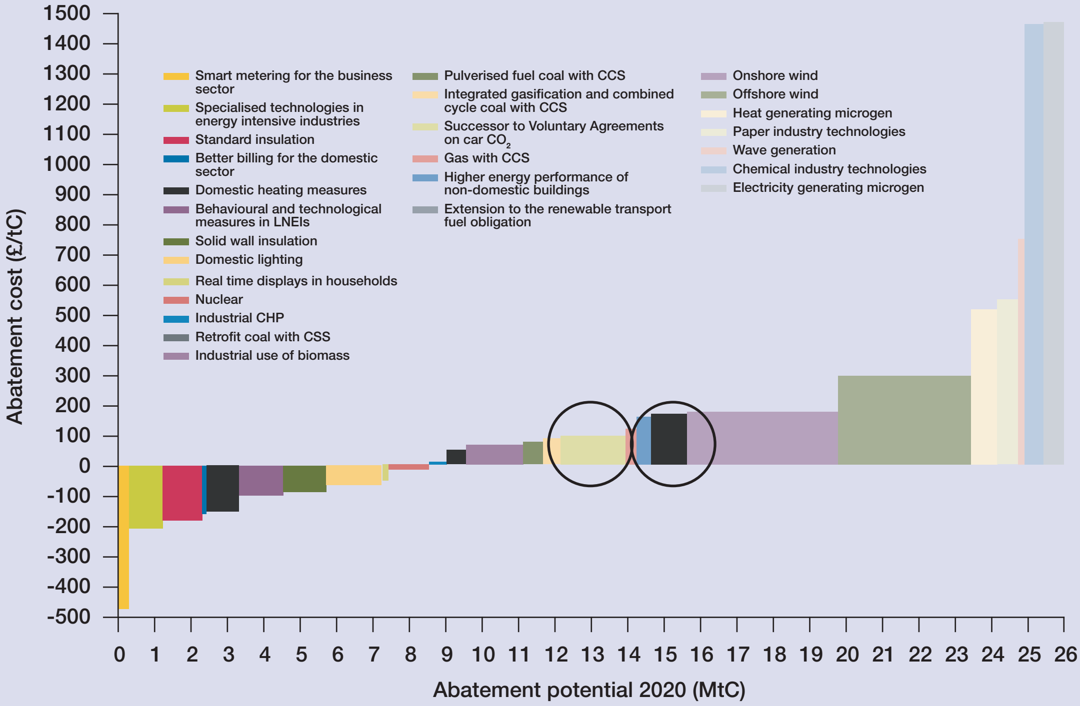


3.23 The heavy reliance on seemingly relatively expensive carbon abatement opportunities in transport, however, begins to make more sense when these options are set in the context of the Government's wider analysis of economy-wide options for cutting emissions. Figure 3.4 reproduces a chart from the Energy White Paper that compares the cost-effectiveness of a range of current and possible measures to reduce carbon emissions across the economy as a whole to 2020. It shows the successor to the Voluntary Agreements and RTFO extension as broadly mid-range of the options evaluated in terms of cost per tonne of carbon saved. However, as indicated above, these cost-effectiveness valuations need to treated with some caution.

14 The analysis for the Energy White Paper (DTI, 2007a) used two different estimates to illustrate the uncertainty in technology cost estimates. The alternative analysis by TNO suggests costs may be lower (implying a benefit of £85/tC saved with historical rates of progress, or £36/tC for more rapid fuel efficiency improvements (reaching 104 g CO_2/km in the UK 2020) – compared to £105/tC and £151/tC for Ricardo. We have used the Ricardo estimates in our own calculations, as these were based on the UK context. See Anable and Bristow (2007) for a discussion.

Figure 3.4

Incremental cost of carbon reduction measures evaluated for the Energy White Paper[15]



Source: DTI, 2007a, Chapter 10, p286

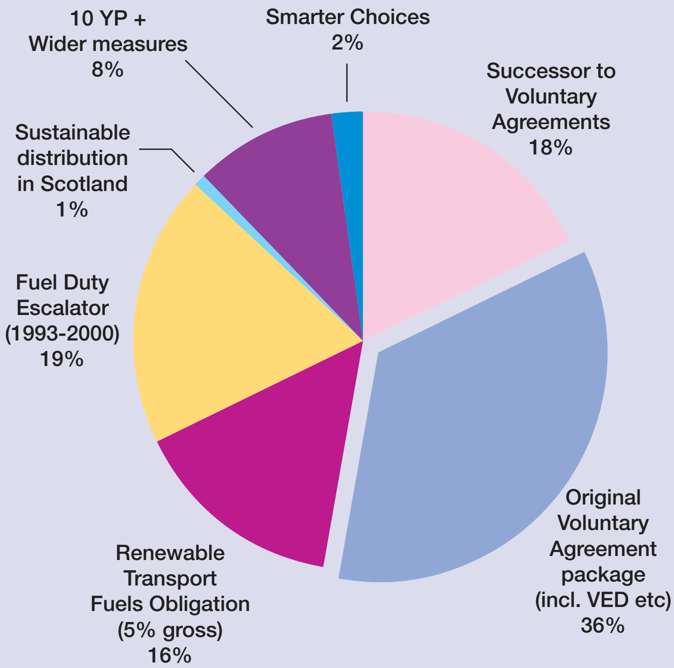
There are question marks over the ability of major elements of the programme to deliver reductions.

3.24 The figures in Table 3.1 earlier indicate that, by 2020, 70% of reductions would come from technology policies, 19% from measures associated with carbon pricing[16] and 11% due to policies to promote behaviour change (including sustainable distribution) – see Figure 3.5.

15 Not all bars in the chart correspond to policies being taken forward. The chart illustrates the potential for carbon savings and their cost-effectiveness.

16 Although the impact of VED and Company car tax is not separately analysed after 2010 and the savings are included in 'technology' instead.

Figure 3.5
Carbon savings in 2020 from policies in the CCP



Source: Note these figures are the most up-to-date published estimates of potential carbon savings for each instrument compiled from Defra, 2006b and 2007a and DTI, 2007b.

3.25 Aside from the issue of whether placing such emphasis in the short to medium term on one of the three key Stern areas for action is likely to be consistent with the most cost-effective approach to reducing emissions, there are two reasons to question how far some key policies can actually deliver the emissions anticipated:

- The current debate about the successor to the Voluntary Agreements has been prompted by the extremely likely failure of the current voluntary approach to deliver on the 2008 targets. In the face of slower than anticipated progress, successive versions of the UK CCP have downgraded projections of savings from the VA to be secured by 2010 – from 4 MtC (DETR, 2000) to 2.3 MtC in the latest figures (Defra, 2006b); and
- The figure used to indicate emissions savings from the RTFO (see Table 3.1) is a gross number, which follows the methodology for allocating emissions to individual member states. By failing to account for carbon emitted during the production of biofuels imported from abroad for use in the UK, it potentially overstates the net global reduction in emissions. From previous Government estimates, it would seem the net figure for carbon savings from this measure is only around two-thirds that of the gross figure.

The lack of emphasis on measures to encourage behavioural change represents a significant missed opportunity.

3.26 Figure 3.3 highlights simultaneously the relative cost-effectiveness in their own right of programmes primarily focused on promoting behaviour change (e.g. smarter choices and promoting sustainable distribution) and the minor contribution which they are expected to make in terms of carbon saved compared with other interventions.

3.27 The positive economic benefits to society arising from implementing these programmes should in themselves prompt more active consideration about extending and intensifying their adoption. As Chapter 4 will highlight, we believe there is significant additional scope for cost-effective carbon reduction through this route. To take one example, work commissioned by CfIT suggests that nearly a fifth of the fuel used in UK distribution could be saved by the sharing of best practice (McKinnon, 2007).

3.28 Equally, as indicated in Chapter 2, experience suggests there is a risk that the benefits of carbon saved through technological advances will be offset without complementary measures to change purchasing and user behaviour, or counteracted by other disbenefits. By way of example, estimates of the cost of the VA take into account the effect that higher fuel efficiency has in lowering the cost of driving and so increasing car usage – yet they do not include the increased congestion or air pollution this might cause (DTI, 2007a), though doing so could increase the costs by a factor of 2 to 4.

3.29 The use of price to reinforce behaviour change can be a contentious option, as experience with the fuel duty escalator would suggest. In some cases, such as road pricing, the particular design of a price measure can work against the objective of reducing carbon emissions: studies have indicated how revenue-neutral implementation of road pricing could actually serve to increase emissions (Grayling et al, 2004; Glaister and Graham, 2005; SMF, 2007). But, equally, the strong cost effectiveness associated with the fuel duty escalator, and the positive impacts which company car tax reform have had in delivering carbon reductions, suggest that use of well-designed fiscal measures in this field should be actively considered (see Chapter 4).

The role that measures related to international transport can play as part of a wider cost-effective response to tackling emissions remains unclear.

3.30 The CCP (2006) and transport chapter of the Energy White Paper (2007) both refer to policies regarding emissions from aviation and shipping, but how such measures fit within a wider cost-effective programme to reduce emissions is unclear. This is underlined by the relative paucity of published figures on expected carbon abatement from these two sources, and the relative lack of figures relating to these sectors in our review of existing analyses of the cost-effectiveness of transport measures.

3.31 We recognise the limitations in this field posed, in particular, by the international dimension to these modes, such as the absence of an agreed convention on attributing emissions from international air movements by country, and acknowledge the current small contribution made by air travel to total UK emissions, even including some element of international movements (see Chapter 2).

3.32 The prevailing wisdom is that in the short-to-medium term a significant net reduction in aviation-related emissions is relatively expensive compared with other possible measures, because of a combination of little likely fundamental change in aircraft design and the use of kerosene for propulsion, slow churn in the aircraft fleet and growth rates in the demand for air transport. However, a continuation of the current high level of oil prices, which have tripled since the 1990s, will provide a significant additional incentive for airlines to economise on fuel and invest in new fuel-efficient aircraft.

3.33 But, given anticipated growth in future emissions from air travel, we feel that more focus should be given to clarifying the cost-effectiveness and scale of contribution that measures in this area could make to the total UK programme of carbon reductions. The Government's 2003 aviation White Paper (AWP, DfT, 2003a) and associated emissions forecasts for aviation emissions (DfT, 2004a) forecast that passenger growth, unconstrained and catered for in full, would double by 2020 and almost quadruple by 2050 compared to levels in 2000 (Table 3.2).[17] This would result in a substantial increase in carbon emissions from approximately 9 MtC at present to central estimates of 14.9 MtC in 2020, and 17.4 MtC in 2050, taking into account:

- all international departures from UK airports as well as domestic air transport movements (passenger and freight);
- a significant fall in the passenger growth rate – 6% p.a. in the years preceding the White Paper (DfT, 2006b) – to about 3.8% p.a. between 2000 and 2020 and around 2% thereafter, reflecting increased market maturity;
- 'best guess' technological and operational improvements over this period.[18].

17 Figures for the rate of growth of air freight are not provided by the DfT. In 2004, air freight rose in the UK by 7.9% (Eurostat, 2006). Industry forecasts that cargo traffic growth will increase 6.2% per year for the next 20 years (Cairns and Newson, 2006).

18 These comprise 15% fuel efficiency improvement between 2000 and 2030, with a further 25% savings occurring between 2030 and 2050, and 10% savings arising from the optimization of air traffic management from 2010 onwards.

Table 3.2

Aviation and total UK emissions

Source: [a]DfT, 2006a (Table 2.1); [b]Defra, 2007b; all remaining forecasts published in EAC, 2004 (p19) based on DTI, 2003 and DfT, 2004a. [c] note: international shipping emissions not included.

	Passenger numbers (mppa)	Average growth rate p.a. (%)	Emissions from UK aviation (domestic + intl.) (MtC)	Total UK CO_2 (domestic but not intl.) (MtC)	Combined total CO_2 (incl. intl. aviation[c]) (MtC)	Aviation as % of combined total (%)
2000	180[a]		8.8[b]	149.8[b]	158.0	5.6%
		3.8%				
2020	379		14.9	n/a	n/a	n/a
		2.2%				
2030	480		17.7	100.4	116.8	15.2%
		1.7%				
2050	670		17.4	65.8	81.6	21.3%

3.34 If the total budget is expanded to include departing flights and the 60% target is applied to this new total, aviation on its own is set to account for around 15% of total CO_2 emissions in 2030 and 21% in 2050 (see Table 3.2). Sensitivity testing on key parameters, such as the cost of flying and economic growth, shows that even with substantially higher costs (some scenarios, for example, assume passengers will face an additional carbon charge based on the Government's own central value for the cost of carbon and phased in from 2010 to 2020) or slower economic growth, the trajectory for air travel is still strongly positive. It should also be noted that these forecasts do not include possible additional non-CO_2 impacts on climate from aircraft or from other sources (see 2.9 above), and that other papers published since the White Paper (Owen and Lee for Defra in 2006, and The Tyndall Centre for Climate Change Research in 2005) have concluded that aviation will have a much more significant impact on UK emissions than suggested by the DfT (largely because of their use of higher future growth rates and lower rates of fuel efficiency improvements).

3.35 Table 3.2 needs to be treated with caution, as it risks giving a distorted pictured by reflecting a broadly 'business as usual' rise in aviation emissions when emission trends from all other sectors of the economy instead are assumed to have changed significantly to deliver a 60% reduction. However, the scale of emissions under official forecasts represents a significant additional element to the UK's future carbon footprint, which is absent from the future scenarios generated by the MARKAL modelling. Taken together with the lack of figures relating to international shipping, these omissions highlight the difficulty for the Government of establishing what represents a cost-effective, economy-wide package of measures to achieve a "true" reduction of UK emissions of 60% by 2050.

Conclusions

3.36 Establishing the cost-effectiveness of transport measures to reduce carbon emissions can be a complex affair, as witnessed in the wide variation in estimates of the impacts of measures that emerges from much of the technical work in this field. An initiative to bring greater consistency, clarity and coverage to the way in which cost-effectiveness is assessed would help policy makers reach effective decisions about priority options.

3.37 Some common themes arise from the body of work in the UK and abroad on the cost-effectiveness of transport measures to cut carbon-based emissions. Measures focused on technology can deliver scale reductions in emissions but can also be relatively expensive; measures focused on behavioural changes can appear relatively more cost-effective but depend on multiple decisions by individuals, with no guarantee of delivery.

3.38 A number of global and/or economy-wide analyses suggest that transport has a major role to play as part of an economy-wide set of cost-effective measures to reduce carbon to 2050, but that the significance of that role compared with the contribution of other sectors grows after about 2020.

3.39 However, the methodology behind such analyses has its limitations, and so the insights generated need to be treated with caution. Apart from the uncertainties arising from any exercise that needs to make base assumptions and looks over the long term, a key issue is the focus of such analyses on the merits of different technological options, with little attention given to the potential of measures framed specifically to encourage behavioural change.

3.40 The impact of the main programme of Government policies to tackle transport emissions means that carbon from transport will be 22% lower in 2010 than it would otherwise have been. The overall effect of the programme, if successful, will be to stabilise transport emissions at broadly 2005 levels by 2020.

3.41 We are concerned that the transport element of the Climate Change Programme (CCP) appears to depend heavily on relatively expensive measures to deliver emissions savings. Estimates of the cost-effectiveness of policies to deliver emissions at scale suggest that many of these measures are significantly more expensive than the mid-range social cost of carbon adopted by Government.

3.42 There are question marks over how far major components of the programme can deliver reductions in practice. Experience on the Voluntary Agreement, for example, has seen steady but insufficient progress to improve the carbon efficiency of new cars sold in the UK.

3.43 With 70% of the carbon emissions in the CCP due to be delivered by technology, we believe there is a missed opportunity to capture greater cost-effective carbon savings from transport and ‘lock in’ the positive impacts of technological advances using measures to encourage behavioural change through fiscal and non-fiscal means.

3.44 The role that measures related to international transport can play as part of a wider cost-effective response to tackling emissions remains unclear. The modelling used by UK Government to review cost-effective options for carbon abatement across the economy does not cover international aviation and shipping.

3.45 In view of these issues, we believe there are significant risks to the Government's ability to deliver transport emission savings as part of a coherent, cost-effective and economy-wide response to mitigation.

3.46 There is therefore a case for identifying measures that can deliver greater and more cost-effective ways of reducing transport carbon emissions. We believe that the case is even stronger, given that there are challenges facing the delivery of carbon abatement opportunities in other sectors and the strengthening scientific evidence pointing to the need for larger carbon reductions to be delivered more quickly than currently anticipated in the Government's approach.

3.47 The following chapter sets out recommendations for improving on the current set of policies to reduce transport carbon emissions in the UK.

Chapter 4: Recommendations to deliver greater cost-effective carbon savings from transport by 2020

Introduction

4.1 In earlier chapters, we identified transport as a major element of carbon emissions in the UK and as a source of significant cost-effective reduction opportunities. Equally, we have identified a number of shortcomings in the current package of policies aimed at realising carbon savings from transport. In this chapter, we set out ways to improve the cost-effectiveness and scale of carbon reductions anticipated under the current approach.

Overall approach

4.2 We have identified scope for an integrated set of measures that builds on the measures included in the Government's Climate Change Programme and proposes some new measures. The combined effect would increase cost-effectively the carbon savings expected from the CCP by 71%, which would mean that transport emissions would fall by 14% against 1990 levels by 2020,[1] instead of stabilising broadly at 2005 levels.

4.3 We felt it appropriate to focus on the period to 2020, given the urgency of securing early cost-effective emissions reduction. We have also focused on measures that have a chance of being delivered, for example in terms of their affordability or public acceptability. Our approach:

- focuses on improving over the medium term the carbon performance of road transport, given its significance within overall transport emissions, with particular focus on cars (responsible for the majority of road transport emissions);
- identifies measures aimed at van and lorry emissions – two important and growing sources of road transport emissions;
- considers action that needs to be taken with regard to air transport. This area accounts for a small part of total UK emissions, but it is a rapidly-growing area and notwithstanding anticipated operational and efficiency improvements is set to become a significant element of the UK's future carbon footprint; and

1 Reducing from 33.3 MtC in 1990, to 28.8 MtC in 2020.

- puts strong emphasis on measures to encourage behavioural change (for example, as it relates to vehicle purchasing, the way in which vehicles are driven and the amount of movement by motorised travel) as a way of 'locking in' the benefits from technological developments already under way or those that might be further promoted by some of our recommendations.

4.4 While our judgement is that there are hard choices to be made whichever set of measures is adopted across the economy to achieve the scale of carbon reduction needed to address climate change, we have not argued for the most aggressive application of some of the individual measures. We believe our proposals for transport are certainly challenging, but reasonable in view of what needs to be done. In the following sections, we set out:

- five key packages of measures to deliver cost-effective emissions reductions to 2020, addressing the purchase and use of cars, alternatives to car use, tackling emissions from the fleets of vans and lorries, and addressing emissions from aviation;
- gaps to fill in the existing knowledge base, specifically on the carbon impacts and abatement opportunities relating to the exploration of policy packages, international transport, vans and freight; and
- areas where work needs to be done now in order to prepare efficient longer-term responses to the transport challenges posed by climate change, namely on the transition to future transport technologies, the contribution of road pricing to emissions reduction, issues related to land use and adaptation, and the scope for greater use of trading in relation to tackling transport emissions.

4.5 The detail of the evidence behind the calculations and the calculations themselves can be found in Anable and Bristow (2007). A table summarising the main assumptions for each package can also be found in Annex Three.

Five key packages of measures to 2020

Recommendation 1

Adopt a mandatory target for new car sales in the EU to achieve an average 100 g CO_2/km by 2020 complemented by a package of supporting measures.

4.6 Carbon savings from improving efficiency in currently-available engine technologies are likely to be among the lowest-cost options that can be delivered from technology in the transport sector over the next 10–20 years (DfT, 2007b). Improving average new passenger car efficiency to 100 g CO_2/km is both feasible and can be relatively cost-effective if the deadline for achieving the target is set at 2020 *and* an integrated approach including supporting measures is adopted.

4.7 We welcome the recent Government commitment to pursue 100 g CO_2/km as a long-term goal and encourage Ministers to secure early agreement within the EU on this as a mandatory target to be achieved by 2020, and which would succeed the current Voluntary Agreements.[2] An interim target should also be set as part of this arrangement, to ensure progress is being made. Achieving the target should include contributions from both vehicle and fuel technologies, and the scope for some form of emissions trading between industry players as a further way of reducing the cost of delivering the target should also be explored. However, the difficulties experienced in achieving the VA target to date demonstrate the need not only for a more realistic timescale for achieving the target, but also for a stronger policy framework of supporting measures which, when combined seek to transform the market for new cars in at least three ways through:

- incentivising low carbon vehicle purchase;
- supplementary vehicle technology;
- changing the official vehicle emissions test procedure.

Measures aimed at incentivising low-carbon vehicle purchase

4.8 A set of measures is needed which aims to incentivise the take-up of lower-carbon vehicles. This could include further development of the existing UK system of CO_2-related vehicle excise duty bands; strengthening the incentive to buy low-carbon cars in company car tax; and helping motorists to change purchasing behaviour through the use of car labelling and awareness campaigns (see Exhibit 4.1).

Exhibit 4.1

Incentivising demand for more carbon-efficient cars

A new approach is needed to replace the existing Voluntary Agreements between the European Commission and vehicle manufacturers as part of a wider market transformation approach for cars. The approach should use a mixture of information, incentives, and regulation to encourage private and public sector car users, as well as players in the car and fuel industries, to play their part.

Vehicle excise duty (VED)

Developing the current graduated VED system further would generate marginal additional benefits but could be part of a package of measures to support delivery of the target. Options include having a more graduated system (i.e. more bands of smaller width in order to incentivise the choice of 'best vehicle in class') or increasing the differential on certain bands to shift the distribution of new car sales towards more environmentally friendly models. Both should be explored, but our judgement is that the latter would be preferable (in the interests of simplicity) and is likely to require differentials significantly greater than the largest currently envisaged by Government – possibly £300 or more between at least some of the bands. A reinforcing measure could be the introduction of tax discs, colour-coded in line with the CO_2 bands to help drivers recognise the link between car type, emissions and the cost of motoring. This would also influence the second hand vehicle market, which currently does not display the eco label when being sold (refer Anable and Bristow 2007 for further information).

2 Note this more ambitious target has not yet been adopted as Government policy and therefore the CCP baseline only includes savings attributed to the lower target of 135 g CO_2/km. We demonstrate here what could be achieved if an integrated approach was put in place to deliver the more ambitious target.

Exhibit 4.1 *continued*

Company car tax (CCT)

A good example of a successful fiscal measure is the reform of CCT so that the lower the emissions of the vehicle, the lower percentage of the list price is taken in tax. This has led to the purchase of more-efficient company cars and, in the absence of a similar incentive in the private car market, new private cars now have higher emissions than new company cars (HMRC, 2006). However, there are signs that the effect is slowing down, not least as the regime was not strengthened in the recent Budget. Further carbon benefits could result from removing the current penalty on diesel existing within the current CCT tax structure. In order to mitigate possible disbenefits to air quality, we recommend this be considered following introduction of Euro V emission standards. CfIT is also aware of a current consultation by HM Treasury on mileage allowance payments. We would encourage reform of the personal mileage allowance system into bands related to CO_2.

Car labelling

Colour-coded fuel efficiency labels matching the graduated VED structure were introduced into UK car showrooms in 2005. However, evidence would suggest that salesroom staff and consumer knowledge is variable. The label needs to be more visible, with significant investment in retailer education. In addition, the scope of the labelling scheme should be widened to cover not only passenger cars but also vans and even second-hand vehicles. Of the 10 million cars sold annually, 76% of these are used vehicles for which there is no labelling scheme (SMMT, 2007a).

Technology procurement

Public procurement policies could help to move the market in the right direction by creating economies of scale for manufacturers, thereby reducing the costs of production. Central Government procures approximately 9,000 vehicles each year, with more vehicles purchased via its many agencies. The target that all new cars bought by central Government for administrative use should achieve an average 130 g CO_2/km emissions by 2010–11 (DfT, 2007b) should be extended to its agencies and local government. We also believe the Government should underline its leadership role as purchaser and user of transport services by encouraging or adopting the wider range of cost-effective initiatives outlined within this report.

Supplementary vehicle technology

4.9 We propose ensuring the 100 g target relates not only to the emissions from the 'tailpipe', but also covers in-car technology, with the potential to deliver carbon savings by encouraging efficient operation of the vehicle. This generally includes instruments that provide information to the driver, such as gearshift indicator lights (GSI), tyre pressure monitoring systems (TPMS) and in-car fuel economy meters.

However, these gadgets are not included in the official test cycle (since their impact on emissions depends on drivers adapting their driving styles), and so manufacturers currently have little incentive to install them. Other options, which can be used on existing as well as new cars, such as low rolling resistance tyres (LRRT) and low viscosity lubricants (LVL) can be reflected under the test cycle, but there is no guarantee that the these tyres will be fitted on the cars sold. The widespread use of these various additional technologies should be encouraged by EU regulation to accompany the new mandatory target for motor manufacturers, including new measurement methodologies and labelling of components.

Changing the official test cycle procedure

4.10 We propose reforming the official test cycle procedure used to support delivery of the new mandatory target. Aside from the limitations of the current procedure in accounting for the emissions-saving potential of the in-car technology highlighted above, a number of other shortcomings need to be addressed as part of a package of measures to support delivery of a new mandatory target (see Exhibit 4.2).

Exhibit 4.2

Improving the official vehicle test cycle

The range of opportunities emerging for vehicle manufacturers and fuel suppliers jointly to deliver improved carbon performance in the use of vehicles in turn requires a more sophisticated approach to testing vehicles.

By 2020, flex fuel vehicles, plug-in hybrids and electric vehicles will be more widely available, and the current test procedure based purely on the tailpipe emissions will not be able to account for these developments and incentivise their introduction.

The current test cycle does not differentiate between carbon emitted from fossil fuels and carbon emitted from biofuels. For 5% blends, this does not lead to large errors. However, for higher biofuel blends, say 85% ethanol (E85) or 30% biodiesel (B30) containing biofuels, which give large greenhouse gas savings, the results from the test cycle will not be representative of the carbon dioxide emissions per kilometre on a ‘well or field to wheels’ basis.

In order to provide a better representation of the tailpipe gCO_2/km of new cars, a correction factor(s) needs to be developed for these vehicles. The factor would likely have to use conservative values of the carbon saving potential of the biofuel, and for flexi-fuel vehicles an estimate of the percentage of operations with E85/B30 rather than petrol/diesel.

A revised test cycle should also take into account air-conditioning systems in cars, which have a negative effect on fuel efficiency, not reflected in the official test cycle figures for new cars.

Additionally, some form of verifiable test cycle will need to be established for vans, large goods vehicles, buses, taxis and trains that reflects the varying contexts within which such vehicles are used.

4.11 We also recognise that low-carbon fuels have a crucial role to play alongside, and must be joined up with, developments in vehicle technology to deliver a mandatory target for the performance of new cars. This is currently a major area of debate and we have not reached a view on what the relative contributions towards the target/s of vehicle- and fuel-based technologies should be.

4.12 On the specific issue of biofuels, we note the Government's approach set out under the current RTFO, its ambitious attempts to develop sustainability reporting and the active interest being taken in trialling the use of biofuels in different transport applications (e.g. in road haulage, public transport and even aviation), but we believe it is premature to move towards greater biofuels penetration of the transport fuels market.[3] There is a significant debate about the true life-cycle carbon benefits of biofuels, the extent to which greater demand might accelerate deforestation (with negative climate change and biodiversity impacts) and crowd out food crops, and about the relative merits of using biofuels for transport as opposed to meeting other energy needs. We believe further work is needed to resolve these questions before committing to more ambitious policy goals for the use of biofuels.

Carbon savings: 2.4 MtC in 2020

4.13 We have calculated that the 100 g CO_2/km target will achieve carbon reductions from passenger cars of 2.4 MtC in 2020 (including potential savings attributable to in-car driver information technologies). The efficiency savings are calculated by extrapolating from the recent analysis undertaken for the Energy White Paper (DTI, 2007c). The trajectory for the period is not linear – starting at a 2% per annum improvement in efficiency from 2009 (the current rate of progress is 1.5% p.a.) and working up to 5.0% later in the period (by 2017).

Cost-effectiveness

4.14 There is uncertainty regarding the technology costs of fuel efficiency improvements. The Energy White Paper presented analysis using two sources of technology cost estimates. Using Ricardo cost estimates, the analysis suggests a continuation of historical rates of progress would cost £105/tC saved, while the same scenario modelled using TNO cost estimates implies a benefit of £85/tC saved. The analysis estimates that more rapid fuel efficiency improvements (reaching 104 g CO_2/km in the UK 2020) would cost £151/tC (Ricardo estimates) or £36/tC (TNO estimates).[4]

4.15 Measures to influence and support the purchasing of lower-carbon vehicles can increase the savings and lower the costs significantly. In addition, cost-effectiveness studies of the VA have shown that if traffic generation and congestion effects due to the 'rebound effect' are included, cost-effectiveness is reduced significantly. We have recommended a framework to support the delivery of the target, one that relies on incentivising low-carbon car purchase and 'locking-in' the efficiency gains.

3 Note, whilst the EU Environment Council recently agreed to a 10% binding biofuels target by 2020, this is sufficiently caveated so as to subject this to competitiveness and sustainability criteria.

4 We have taken the one we considered to be more appropriate for the UK context (by Ricardo). See Chapter 3 and Anable and Bristow (2007) for a discussion.

4.16 The in-car driver information technologies by themselves are estimated to have a net benefit per tonne of carbon saved of £192 for GSI and £123[5] for TPMS, at an oil price of around £34 a barrel.[6] Low rolling resistance tyres are estimated to have a net cost of £180 per tonne of carbon saved and fuel-efficient air conditioning systems £59 to £91 per tonne carbon saved.[7] At lower oil prices, such as those used by Government in the analysis of their policies, the measures become more costly as the fuel savings have a lower value, but they are still estimated to yield a net benefit at oil prices as low as £24 a barrel.

Recommendation 2

Reinforce positive driver behaviour through a combination of measures to sustain fuel prices, encourage eco-driving techniques and promote greater adherence to road speed limits.

4.17 Earlier sections of this report highlighted how one consequence of improved vehicle fuel efficiency can be to reduce the cost of road travel and so has the potential to counter the carbon savings otherwise achieved. We believe the carbon reductions possible under Recommendation 1 need to be ‘locked-in’ through a carrot and stick approach aimed primarily at influencing driver behaviour, implemented as three integrated measures as follows.

Ensure stable, sustained fuel prices

4.18 The price of fuel can be a significant and visible element of overall costs of road transport – up to 40% per mile for car users and accounting for 30% of hauliers’ operating costs, depending on the type of operation and vehicle mileage (AA, 2007; FTA, 2007). Fuel prices for unleaded petrol and diesel have increased substantially since 1990, during which time total road fuel sales have grown but at a significantly slower rate than before – and where falling sales of petrol have been offset by rising sales of diesel (with its superior performance in terms of efficiency).

4.19 Even though abandoned in 2000, the fuel duty escalator is still one of the most significant policies in the CCP in terms of the degree to which carbon emissions are lower than they would otherwise have been. Although the demand response to price changes is limited in the short run, in the longer run behavioural shifts do occur to secure fuel savings by changing car purchasing and/or travel habits.

4.20 Price rises in recent years have been due more to fluctuations in the world price of oil than higher taxation. If world prices were to drop substantially, this would serve to encourage greater vehicle use and so higher CO_2 emissions. In fact, while fuel prices are forecast to increase by 3% between 2003 and 2025, fuel *costs* are forecast to fall by 26% between 2003 and 2025, due to a 28% improvement in fuel efficiency over the same period (Eddington, 2006). We believe that a steady increase in fuel price is essential to help control CO_2 emissions and ‘lock in’ the benefits of the efficiency improvements we are looking for in the vehicle fleet.

5 Converted from –€78 and –€50 per tonne CO_2 eq. at an oil price of €50 per barrel, as reported in Smokers et al., 2006. It should be noted that long-term fuel price forecasts in the EWP (DTI, 2007b) in 2006 real prices are 2010 = $57 (€42/£28)/bbl, 2015= $50 (€37/£25)/ bbl, 2020 = $53 (€39/£26)/ bbl.

6 See footnote above.

7 Converted from €73 and €24 to 37 respectively again from Smokers et al., 2006.

4.21 We therefore advocate that the new Climate Change Committee (CCC) proposed by Government in its draft Climate Change Bill should fulfil an important function by advising Government on whether and by how much fuel duty may need to increase as a part of its anticipated annual review of progress towards carbon targets. The CCC should be explicitly remitted to advise Government on the appropriate fuel duty level to ensure that carbon reductions gained through improvements in vehicle technology, purchasing and driving are supported by proportionate increases in fuel costs. We anticipate that in periods of high oil prices, fuel duty may not need to rise in order to ensure carbon reductions.

4.22 In carrying out this role, the CCC would need to consider a range of factors, such as the impact on UK hauliers[8] and potentially vulnerable categories of road user (e.g. in some rural communities), as well as the effect of any intervention on public finances. The CCC could also fulfil an important function in building motorist acceptance for such a measure by ensuring that fuel duty is used as part of a wider package of measures designed to help road users respond to the effects of higher prices (e.g. through promotion of eco-driving). We acknowledge that the ultimate decision on fuel duty will remain with HM Treasury.

4.23 A further area which the CCC should consider is how fuel duty and National Road User Charging (RUC) might work in a complementary way. CfIT believes that RUC will be integral to our management of vehicle emissions in the future. Although, as highlighted earlier in this report, the design of RUC needs careful consideration if it is to support rather than detract from wider efforts to reduce CO_2 emissions, it can ensure more efficient management of the network, improvements in travel time, and more considered travel planning (e.g. car sharing, public transport). This is why we believe there is a role for co-managing CO_2 emissions through both the price we pay for fuel and how we pay for use of the road network.

4.24 We note the Government's Transport Innovation Fund encourages local authorities to consider strategies to tackle congestion. We also recognise there are proposals (for example, in London) to link congestion charges or residential parking fees to vehicle carbon efficiency. Where local congestion charging schemes are being designed, we believe environmental goals should be considered alongside congestion benefits. However, it is important that a coordinated and consistent signal is provided to motorists across different local authorities and that schemes should also be assessed for cost-effectiveness.

4.25 There is an additional option to introduce a fuel duty differential to stimulate the uptake of diesel-based vehicles which are more fuel efficient. There are a number of issues, such as air quality and security of supply, which may mitigate the carbon benefits from introducing a differential. We therefore have not pursued this option further but would recommend considered analysis.

Encourage eco-driving

4.26 There are a number of measures that private and commercial drivers can employ to keep the costs of driving to a minimum. The principle of 'smart' or eco-driving encapsulates a number of principles and practices aimed at optimising the performance

8 Diesel is taxed at a lower rate in mainland Europe than in the UK. Consideration of fuel price changes would need to take into account the impact on the competitive position of the UK-based freight industry.

of modern engine technology which, when adopted together, can lead to average fuel savings of 5–10% (Exhibit 4.4). This would translate into a saving of around £100 per year to a motorist driving 10,000 miles in a medium-sized family car.[9]

Exhibit 4.3

What is eco-driving?

Aspects of eco-driving include:

- accelerating gently, keeping speed constant and changing gear at the optimal time (between 2,000 and 2,555 rpm);
- adhering to speed limits;
- limiting the use of air conditioning (estimated to add 10–14% to fuel consumption);
- reducing drag by driving with the windows closed and empty roof racks removed;
- avoiding idling the engine;
- not warming the engine up before starting off;
- ensuring the tyres are filled to the optimum pressure;
- shedding excess weight from the car;
- keeping a safe distance from the car in front, as sharp braking wastes fuel.

These principles can be applied to passenger cars, vans, buses and large goods vehicles – as well as to rail, in some cases.

4.27 Savings from eco-driving may be secured across a range of modes at the cost of a few hours' training and can be augmented by technical measures used to influence behaviour, such as in-car information systems and tyre pressure monitoring systems. For instance, Department for Transport (2006b) figures from the introduction of safe and fuel-efficient driver training (SAFED) in the freight industry point to fuel savings of between 2% and 12% across 15 case studies.

Exhibit 4.4

Examples of carbon savings from eco-driving

UK – cars

The Driving Standards Agency found that eco-driving training for car drivers yields immediate results, with an average 8.5% improvement in fuel efficiency for drivers on a set course after two hours of training (DSA, undated).

9 Calculated on the basis of a car achieving on average 33 mpg, travelling 10,000 miles, achieving an average 8.5% fuel efficiency improvement due to smarter driving and paying 90 pence per litre for fuel.

Exhibit 4.4 *continued*

Examples of carbon savings from eco-driving

Finland – cars and vans

The Finland eco-driving program was introduced in 1995 and is expected to cut average fuel consumption by 10–16 %. Training courses were planned for 1,000 bus and truck drivers and 15,000 car drivers in 2005–06. New drivers are an important target: 200,000 driving school students, as well as over 3,500 drivers who already have a driving licence, received training during 2003–05 (Harmsen et al., 2007).

Netherlands – cars

In 2002 a study was undertaken with the car panel of the Dutch Consumer Organisation, which consists of approximately 6,000 drivers, mostly private consumers. Based upon their own self-reported driving behaviour, the participants were divided into those who displayed eco-driving behaviours and those who did not. Over the year-long duration of the study, the eco-drivers consumed 7% less fuel per km (EST, 2005).

Germany – vans

Towards the end of 2003, 91 delivery van drivers employed by Hamburger Wasserwerke (HW) received eco-driving training. Monitoring over the following six months demonstrated that fuel consumption fell by an average of 5.8%, saving HW approximately 10,000 litres of fuel per year, and accident rates fell by 40% (EST, 2005).

Germany – rail

Deutsche Bahn (DB) has trained 14,000 engine drivers in energy-saving techniques and claims that 100,000 tons CO_2 were saved during 2002–04. DB suggest that simply switching off the power early and rolling into stations can save around 8% of the energy consumed between stations for ICE routes (Deutsche Bahn, 2005).

Europe – rail

The GENESIS project (Milton and Greensmith, 2001) modelled and tested changes to driver behaviour on metro and rail networks, focusing on the use of coasting. It found that, for a marginal (3%) increase in journey times, around 10% savings could be gained; if journey time increases of 9% were acceptable, then the potential saving is between 32% and 38% (compared with flat-out running).

Europe – buses

Various bus operators have found savings in fuel consumption, as well as other benefits, such as less wear and tear on brakes and hence less maintenance, reductions in driver stress and improved on-board comfort. (See Anable and Bristow, 2007.)

4.28 The Government should pursue an intensification of eco-driver training programmes, as a way not only of augmenting emissions savings from technical improvements, but also to secure additional safety and air quality benefits, as well as saving money for motorists and public transport operators.

4.29 So far, eco-driving for car users has been promoted in the UK through some awareness campaigning ('Act on CO_2') and a compulsory element into the theory aspect of the driving test (from September 2007). We suggest a combination of some or all of the following additional actions, ideally as a joint initiative between Government and key bodies such as the motoring organisations, the Low Carbon Vehicle Partnership and the Motorists Forum:

- A comprehensive subsidised driver-training programme to target existing drivers. In the Netherlands, the eco-driving programme has a target of 100% of all licence holders by 2010 to have been trained in eco-driving, five years after the start of the programme (Harmsen et al., 2007);
- The principles of eco-driving could be incorporated into the practical examination procedure of the standard driving test as well as into other driver training initiatives such as: 'Pass Plus';[10] safety training,[11] the Advanced Driving Test[12] and periodic training requirements for professional drivers.[13] Some of these initiatives could enable participants to benefit from cheaper car insurance;
- The Energy Efficiency Commitment imposes a statutory obligation upon electricity and gas suppliers to meet a target for the promotion of improvements in energy efficiency among household consumers through the promotion of measures such as cavity wall and loft insulation, energy efficiency light bulbs, boilers and appliances. We propose a similar obligation be placed on fuel companies to promote eco-driving using opportunities at the point of sale of fuel and other promotional means;
- In-car devices to assist eco-driving (econometers, gear-shift indicators, cruise-control) could be exempt from VAT, as they were in the Netherlands until early 2005. Research by the automotive industry estimated 45–60% of in car devices would not have been purchased without the tax exemption over a four-year period when penetration in the whole car fleet increased from 13–33% (Harmsen et al., 2007).

10 This is for new drivers who are looking to improve their driving skills, while also gaining the benefit of cheaper car insurance. One in six drivers pass the test each year. (www.passplus.org.uk/about_pp.asp)

11 The National Speed Awareness Scheme allows individual police forces the option of putting 'low-end' speeding motorists through a course rather than handing out a fixed penalty (www.driver-improvement.org.uk/NSAC/NSAC_f_a_q.htm)

12 Run by the Institute of Advanced Motorists to improve the standard/ability of UK motorists.

13 For all professional light goods (van) and passenger carrying vehicle drivers as per EU Directive 2003/59/EC requiring all drivers to undertake 35 hours of training in any five-year period (http://www.dsa.gov.uk/Documents/policy/Explanatory_Note.doc)

Exhibit 4.5

Insurance company initiatives

Norwich Union

Norwich Union is looking at ways to making its products more environmentally friendly. Their 'Pay-As-You-Drive' package allows customers to fit a black box in their car that will track mileage and type of journeys, and the amount of insurance they pay will be based on how much they use their car.

Royal & SunAlliance

R&SA announced in April 2007 two new green products as part of their campaign aimed at encouraging individual action on climate change:

- A telematics car insurance policy that uses GPS technology to help people drive in a greener way to save money and fuel;
- An eco car discount of up to 15% and free carbon offsetting for the first 3,000 miles.

Promote greater adherence to the 70 mph speed limit

4.30 The importance in terms of environmental impacts of adhering to the 70 mph speed limit on motorways and dual carriageways should form part of any driving training. Currently, 56% of drivers exceed the motorway speed limit, 19% at speeds over 80 mph (DfT, 2006c). The case for enforcing speed limits is based on increasing fuel efficiency, by helping to keep average speeds closer to the optimum. For instance, a medium-sized diesel car will emit up to 14% more CO_2 per kilometre at 80 mph compared to 70 mph (NAEI, 2003).

4.31 Anable et al. (2006) estimate that effective enforcement of the 70 mph speed limit in the UK could save around 1 MtC a year; reducing the limit to 60 mph would almost double this to 1.88 MtC. The figures assume no impact on travel demand due to possible slower journey times, but significant safety benefits would also be observed. A full discussion of the options and calculation of carbon savings can be found in the supporting technical documentation (Anable and Bristow, 2007).

4.32 Enforcing speed limits, while doing no more than ensuring road users obey the law, is in practice a contentious political issue. We do not underestimate this, but believe a sophisticated approach to enforcement that is more effective at demonstrating the benefits of compliance, including safety, network capacity and environmental benefits, could win wide public acceptance. This could involve demonstrating speed-limit enforcement as part of a wider package of measures (including awareness campaigns, real-time information, controlled motorway speed programmes, better infrastructure management and research and regulation for in-car instrumentation) that smooth traffic flow (thus improving journey time reliability) and enhance safety. The recycling of part of the revenue from speeding fines in some way to the benefit of compliant drivers is a further option to consider.

Exhibit 4.6

Controlled motorway speed limit trials

Active Traffic Management systems using variable speed limits as low as 40 mph have been introduced on the M25 and more recently on the M42 near Birmingham, where speed is controlled to smooth traffic flow, reduce congestion, improve journey times and prevent crashes and associated disruption. Speed limits are strictly enforced, in part using automated camera technology with adherence reaching up to 95%.

Reported benefits included smoother and more reliable journey times, improved driver behaviour, reduction in stress for drivers, reduction in the number and severity of crashes, noise and emissions. A survey of users on the M25 system showed that the majority (68%) of drivers liked it and wanted to see it extended to other sections of motorways. Similar results were found in a survey of M42 users, where 72% wanted variable speed limits expanded to elsewhere on the motorway network.Source: Highways Agency, 2004 and Harbord et al., 2006.

Source: Highways Agency, 2004 and Harbord et al., 2006

4.33 CfIT and the Motorists' Forum (MF) are jointly considering the effects that the introduction of a Voluntary Intelligent Speed Adaptation (ISA) system across the road network would have in reducing deaths and injuries on the UK roads and in reducing carbon emissions, other pollutants, and fuel consumption. The Speed Limit Adherence and Its Effects on Climate Change and Road Safety research project will be completed in summer 2008.

Carbon savings: 0.7 MtC in 2020

4.34 In the case of ensuring sustained and stable fuel prices, we have not included an estimate of savings, as any intervention would depend, among other things, on future pre-tax fuel prices and as such its scale is impossible to anticipate. The supporting document (Anable and Bristow, 2007) offers some calculations if carbon prices are increased by certain amounts. However, given the uncertainty in the underlying market price, we have not included savings here.

4.35 For eco-driving, on the basis of the evidence presented in this chapter, we have used traffic growth figures and emissions factors to 2020 and assumed that the proportion of drivers practising eco-driving will start slowly in 2008 with 5% of drivers and gradually increase, reaching 40% in 2020. At any time, as a result of this initiative we assume that drivers are achieving 4.5% efficiency savings.[14] This delivers savings of around 0.3 MtC in 2020 and applies to cars only; savings made by driver-training programmes in the lorry and van fleet are included under the freight section (Recommendation 4).

14 This is almost half of the savings found by drivers practicing eco-driving in the UK (see Chapter 3). However, we feel it is sensible to use a figure of 4.5% efficiency saving in our calculation as this avoids double counting with speed enforcement and allows for the fact that drivers will not continuously achieve optimum savings.

4.36 On speed limits, we have used as a basis the Government's own figures for the savings to be achieved from enforcing the 70 mph limit on motorways and dual carriageways (Defra, 2007a). As a stand-alone measure, the Defra calculation assumes 100% compliance from the outset by drivers of all classes of road vehicles currently breaking the law on 70 mph limit roads. This results in an estimated saving of 0.6 MtC per year. We have assumed only 75% of these savings pertain to car and motorcycle traffic and that compliance will start out at 50% in 2009 and reaching a maximum 80% compliance by 2015. This results in 0.4 MtC in 2020.

Cost-effectiveness

4.37 In the case of stabilising fuel prices, although the process of implementing this would be very different from the approach adopted under the old fuel duty escalator, we note that the Government's own assessment identified this now-abandoned measure as a very cost-effective way of reducing carbon emissions with a net benefit per tonne of carbon of £250t/C (Defra, 2006a).

4.38 For eco-driving, drivers should see a benefit in terms of fuel savings. Research by the Energy Saving Trust showed that 36% of drivers would consider paying £50 for a two-hour eco-driving lesson if this were to pay for itself in fuel savings within 8 months – a realistic period for a typical car and private driver (EST, 2005). Although the impact of promoting eco-driving is relatively small, these measures are cost-effective as long as savings are maintained in the longer term. The costs of promotion vary widely depending on the efforts put in place: while an introduction to eco-driving as part of the driving licence tuition may be cheap to implement, a large-scale campaign to raise awareness amongst all drivers, notably those that would not voluntarily participate in training courses, would require more financial input. In the Netherlands, eco-driving has formed part of the driving test since 2001, plus about 1.5% of existing drivers had been reached by training programmes by 2004. Together with an information campaign, the cost is estimated to be around £13 per tonne of carbon saved (Eco-drive, 2005) although a recent estimate by Harmsen et al. (2007) put it at around £22 per avoided tonnes of carbon, based on eco-driving programme costs of about £1.4 million annually (including subsidised training programmes and communication campaigns). This rises to to £169–246 per tonne of carbon if the costs of the tax exemption on in-car devices is included, and depending on assumptions about usage levels.

4.39 On speed limits, Government assessments of a blanket enforcement of the 70 mph limit (as well as a reduction to 60 mph) suggest a very high cost for this policy compared to other measures. Assuming 100% compliance, enforcement at 70 mph could save 0.6 MtC in 2010 at £410 t/C; enforcement at 60 mph saving 0.9 MtC at £190 t/C (Defra, 2007a). This is partly because the Government assumed this measure would be enforced comprehensively using blanket coverage of SPECs (time-over-distance) speed cameras in order to deliver the carbon saving with a very high degree of certainty. The cost assumptions are based on the latest-type approved technology for enforcement, but future developments in this area look likely to reduce these costs (see Anable and Bristow, 2007 for a discussion). However, it may be possible to achieve a high level of certainty in this policy by a combination of measures to raise awareness of the link between speed and carbon emissions, real-time messaging, controlled speed zones on congested parts of the network as well as police and camera enforcement. This policy will also have clear safety and network capacity benefits that need to be factored into any cost assessment. More work is needed to assess the costs of a combination of measures and their expected carbon benefits, which would vary according to the levels of compliance achieved and the methods employed, but such an approach may show significant potential over time as public attitudes towards excessive speed moderated.

Recommendation 3

Secure more intensive application of smarter choices to reduce car use, reinforced by improvements to the carbon efficiency of public transport.

Smarter choices

4.40 Smarter choices aim to encourage use of less carbon-intensive alternatives to the car for passenger travel. These can include:

- destination-based measures to reduce car use, e.g. workplace or school travel plans;
- changing access to cars, e.g. car clubs and car-sharing schemes;
- action to increase individual awareness of alternatives to the car, e.g. public transport information and marketing, travel awareness campaigns and personalised marketing; and
- measures to reduce the need to travel, e.g. teleworking or home shopping.

4.41 The *Smarter Choices* study (Cairns et al., 2004) reports case study evidence of what can be achieved. Its assessment suggests that, within approximately ten years, smarter-choice measures have the potential to reduce national traffic levels by about 11%, with reductions of up to 21% in peak period urban traffic.

4.42 Research on the impact of Smarter Choices found significant modal shift is possible: 50% of all local car trips in non-metropolitan towns could be replaced by walking, cycling and/or public transport (Sustrans/Socialdata 2005). The potential offered by cycling and walking as a means of transport is often underestimated, because the bicycle is primarily a mode of transport for short distances. However, nearly a quarter of car journeys are less than 2 miles and over half of all journeys made by car are less than 5 miles (DfT, 2006j), a distance over which use of walking and cycling can bring time advantage over the car. Also, vehicle emissions are particularly high over short journeys because fuel consumption is disproportionately high because of the cold engine and because the catalyst is not yet working at full efficiency. For these reasons, the emissions reduction effect, including for local air quality, when journeys otherwise made by car are made on foot or by bicycle, is particularly high. There are also significant health benefits from the uptake of non-motorised modes.

4.43 The Cairns et al. study and more recent experience on the ground has demonstrated the scale and rapidity with which Smarter Choices are being implemented. The DfT has funded three Sustainable Travel Towns to assess the results of the intensive implementation of packages of Smarter Choices in one locality. The emerging results appear to be in line with the Cairns et al. 2004 study (Exhibit 4.7).

Exhibit 4.7

Smarter Choices and Sustainable Travel Towns

Teleconferencing

Replacing business travel with teleconferencing has allowed British Telecom (BT) to avoid more than 860,000 face-to-face meetings worldwide and saved at least 97,000 tonnes of carbon emissions. Air travel accounted for only 8% of avoided trips but 48% of avoided miles (James, 2007).

Workplace travel plans

Percentage reductions in car use achieved by workplace travel plans at 40 companies showed a median reduction in car use is 14%. Typical companies achieve reductions of 10–25% (Cairns et al., 2002).

Car clubs

The commercial car-club sector in the UK is expanding at a rate of 200% per year – a much higher estimate than assumed in the Cairns et al. analysis. Approximately 200,000 members are projected by 2012. Despite increasing access to car ownership for some, reduced car ownership, increased public transport usage and the use of more efficient cars means carbon savings per member are significant (Haefeli et al., 2006; Millard et al., 2005). Commercial operators in the UK are concentrating resources on mainly city-based, middle-class areas in London and other major towns. There is a need for national support for a network to seed-corn other areas, including rural areas, and to make links with public transport operators. A recent assessment calculated annual carbon savings of 0.03 MtC p.a. by 2010 from publicly-supported wider rolling-out of car clubs and a high benefit: cost ratio (UKERC, 2007).

Exhibit 4.7 *continued*

Sustainable Travel Towns

The Government has allocated £10m over 5 years to fund three Sustainable Travel Towns to become showcases of 'smarter choice' packages. Interim results indicate the scope for encouraging a shift to less carbon intensive forms of transport from a more significant application of Smarter Choices. Darlington is both a Sustainable Travel Town and a Cycling Demonstration Town, so receives an additional £1.5 million for the development of new cycle routes. Research has monitored progress in the specific target areas for the 'individualised marketing' programmes (which involve travel advisors visiting households offering travel information tailored to that household, and collecting comments from residents about how their experience of local travel could be improved) and in the rest of the Darlington urban area. In the whole town, walking has increased by 11%, cycling by 54% and trips as a car driver have reduced by 6%. Isolating these wider effects, the individualised marketing has resulted a 14% increase in walking and cycling, a small increase in public transport patronage and a corresponding reduction in trips as a car driver (–5%) and as a passenger (–12%). In addition, individualised marketing is resulting in a relative reduction of 5% car kilometres against baseline levels. These are impressive results from monitoring after two years of implementation (Socialdata/Sustrans, 2007).

4.44 Measures aimed at promoting Smarter Choices need much greater policy emphasis than hitherto to galvanise and mainstream their potential to secure travel behaviour change through relatively low cost and publicly acceptable measures. To date, only 27% of local authorities have significantly implemented Smarter Choices packages (DfT, 2007g). Transport research based on case study evidence defined the '*high-intensity'* scenario as '*an expansion of activity, commitment and resources to a substantially higher level than that in place at the time of the report, which would still be consistent with practical and realistic experience, and feasible levels of expenditure, given the known constraints of staffing and funding generally'* (Cairns et al., 2004). We believe this high-intensity scenario to be achievable if the Government's recent activity is rolled out more widely across the country and in the supportive policy environment provided by the other measures included in our recommendations.

Exhibit 4.8

Actions to help mainstream Smarter Choices

Anable et al. (forthcoming) canvassed opinion from policy makers and researchers in this area of policy and identified a number of areas as having the greatest potential to lead to a major change in the priority accorded to all smart measures at the local level:

- More flexible use of capital funding, as smart choice programmes mainly require revenue funding, rather than capital funding;
- Grant funding to facilitate the allocation of staff resources;
- Changes to the planning system to make widespread implementation of Workplace Travel Plans far more rigorous and effective, coupled with fiscal changes to make the adoption of travel plans attractive to companies;
- Priority to personalised travel planning, since this appears to have substantial potential to deliver change. Here, the priority should be to assist local authorities in building internal capacity to deliver large-scale personalised travel planning programmes;
- Support for the development of the newer smart measures, such as car clubs, residential travel plans and visitor travel planning. At present, the potential for these newer measures to reduce car travel either appears insignificant or is completely unknown (and hence, assumed to be insignificant). This is exactly how workplace travel planning looked a decade ago. In the case of workplace travel planning, the Government provided funding for workplace travel advisers, made changes to the tax system, and funded research on the effectiveness of the intervention. The same combination of support is likely to be needed in the case of the newer smart measures.

The Transport Innovation fund (TIF) makes £18 million available between 2005–06 and 2007–08 for local authorities to support planning for local demand management schemes where road pricing is a major element. From 2008–09, the fund is forecast to grow from £290 million to over £2 billion by 2014–15 (DfT, 2006k). This funding could potentially support and increase the effectiveness of large-scale Smart Choice programmes, if these were implemented alongside road pricing. Likewise, smart choices could support the implementation of demand management schemes, by increasing travel choices and information about these choices. This could speed-up the implementation of the harder ‘stick’ measures, such as road pricing by influencing the public acceptability of these measures.

Carbon savings: 1.0 MtC in 2020

4.45 We have calculated savings based on a much wider implementation of present good practice – i.e. a high implementation scenario. Using traffic growth figures and emissions forecasts to 2020 and a start date for intensification of activity of 2008, we estimate a total reduction in car traffic below a base of 7% in 2020 (11% in urban areas and 5% in rural areas and motorways). This compares to the estimation by Cairns et al. of a 15%

reduction in car traffic nationally after 10 years of high intensity implementation and the Defra analysis of a 5.3% reduction (central scenario) after 15 years (Cairns et al., 2004; Defra, 2007a). Our calculation results in a saving of 1.2 MtC in 2020. As explained in Chapter 3, the CCP baseline already accounts for a low-intensity roll-out of these measures equating to 0.2 MtC. We have calculated a net saving by subtracting the 0.2 MtC savings from the high-intensity scenario to provide an estimate of 1.0 MtC in 2020.

Cost-effectiveness

4.46 The case study evidence reviewed in the Cairns et al*.* study revealed that, on average, these measures represent very good value for money, with schemes potentially generating benefit: cost ratios which are in excess of 10:1. A recent Government assessment of Smarter Choices – assuming implementation at less intense levels than in Cairns et al, but more than current levels – produces a net benefit of £6 t/C (Defra, 2007a).

Public transport measures

4.47 Measures to improve the attractiveness of modes such as bus and rail are an important part of strategies to reinforce Smarter Choices. Although modal shift from private road transport or domestic air travel to public transport offers limited potential for carbon savings, and while public transport emissions represent a small share of overall UK transport emissions, where growth in public transport does occur it should be as carbon efficient as is cost-effectively possible. Opportunities for reducing emissions include action in three areas – technological (covering engine and vehicle design, as well as power source), operational and improved passenger loadings.

4.48 In the case of buses, diesel–electric hybrids can reduce CO_2 emissions by 25–35% in urban bus operations, compared to an equivalent diesel (Overgaard and Folkesson, 2007; LEK, 2007): there would also be significant air pollution benefits in urban areas. Options such as these, however, are expensive in the short to medium term. The CCP baseline also incorporates savings from the move to 5% biodiesel, and we have not assumed any further developments in this area. Trials are currently under way by some bus operators using higher blends of biodiesel, but National Express has recently announced its withdrawal from first-generation biofuel trials on environmental grounds, preferring to wait until second-generation fuels are available or 'issues relating to the sustainability of the production have been addressed' (National Express Group, 2007).

4.49 We would favour greater focus on two other areas instead. Research suggests that adoption of eco-driving in the bus industry could yield savings in fuel consumption of between 2 and 10% (Allen, 2007). There is as yet little evidence of this in practice in the UK bus sector, but it should be promoted through professional driver schemes as with the van and lorry sectors.

4.50 A further opportunity lies with reform of the Bus Service Operators Grant (BSOG). CfIT has elsewhere argued that replacing BSOG – which effectively gives bus operators a rebate of 80% on fuel duty paid, amounting to a subsidy of around £400 million each year in the UK – with an incentive per passenger subsidy, would be a better way of using public support to increase bus patronage.[15] If successful, this could improve bus loadings and thus operational carbon efficiency. It could also help remove some of the current cost penalty for hybrid buses relative to conventional diesel; additional measures such as capital grants and VED linked to CO_2 emissions by class of bus could help further in this respect. CfIT continues to examine the implementation issues related to an incentive per passenger scheme.

Exhibit 4.9

FirstGroup's Climate Change Strategy

The UK's largest transport provider, FirstGroup plc, and the parent company of local bus operator First, is looking to reduce its carbon dioxide emissions by 25% throughout its UK bus and rail operations by 2020. Plans include reducing emissions from buildings and the bus fleet, investments in new technology including trialling alternative fuels and encouraging employees to rely less on private transport.

4.51 In the case of rail, ATOC estimate that longer-term growth could see energy per passenger halved through a mix of technological developments combined with increased load factors (ATOC, 2007). The Government's recent White Paper *Delivering a Sustainable Railway* and supporting *Rail Technical Strategy* anticipate that both hybrid and lighter-weight trains could be operational in the near term (DfT, 2007d and e). Trials and projects are either in hand or planned over the next five years within the industry and also cover other areas, such as the use of existing capacity for regenerative braking[16] and use of biofuels. Options beyond then include energy metering on the electric fleet, new-generation electric and diesel train units, accelerated development of hybrid traction and exploration of hydrogen trains. One review of longer-term measures identified as having most potential suggests that these sorts of initiatives could yield total annual saving in emissions of under 0.1 MtC (Peckham, 2007).

4.52 We believe that savings in rail emissions could also be secured in the short-to-medium term through changes in operational behaviour (see Table 4.1). From the evidence, it would seem reasonable to conclude that savings of 10% in CO_2 emissions from rail yielding a net benefit to operators could be achieved and maintained in the short term, a view expressed in the DfT's *The Case for Rail* (2007f). The measures in the table themselves are expected to yield savings of 0.16 MtC per annum by 2015. Two reasons

15 Refer to CfIT commissioned research by LEK Consulting (2007) available from www.cfit.gov.uk.

16 Regenerative braking is a way of using the motors as generators and returning the surplus energy, otherwise wasted as unwanted heat, back to the grid via the overhead wire. 60% of the electric train fleet is capable of regeneration, but only 20% uses this capability. However, significant progress is now being made by Network Rail and train operators in enabling a wider range of rolling stock to regenerate.

why these measures (with their positive paybacks) have not already been taken up by the rail industry may be linked to how Network Rail charges the train operators for electricity consumption and how franchise contracts are designed. We recommend the Government considers these issues and the need for any appropriate action.

Table 4.1
Short-run, easily implemented measures to reduce energy consumption in rail operations

Measure	Savings to operator	Savings, MtC
Disconnect electric vehicles from supply when stabled.	+ within one year if unplug, 2.5 years if add intelligent control.	0.040
Running shorter trains when existing capacity not required	+ within one year	0.035
Reduce diesel engine idling	+ payback 2 to 3 years	0.026
Energy-efficient driving and train regulation	+ 3 to 4 year payback	0.041
Additives to increase diesel engine efficiency	Net 1 to 2% saving in fuel bill	0.021

Source: Adapted from material in Peckham, 2007.

Carbon savings: 0.3 MtC in 2020

4.53 The supporting analysis (Anable and Bristow, 2007) outlines three scenarios for emissions savings from bus and rail, depending on the emissions savings assumed per hybrid bus and whether or not regenerative breaking is included in this package. In view of the uncertainties involved and in some cases the high cost of implementing new technologies, we have adopted a conservative set of assumptions.

4.54 For buses, calculating potential carbon savings depends on the rate of fleet replacement assumed, the emissions factors used and the efficiency gains secured from hybridisation. The average age of the bus fleet has fallen in recent years to 8–9 years, but this may not be sustainable in the long run (SMMT, 2007b). We assume a 15-year turnover of the fleet, commencing in 2008, thus we do not see the full benefit by 2020. Carbon savings from buses are secured by accelerating the uptake of hybridisation in the urban bus fleet from the policies outlined above – and we have modelled these as 25% saving over 2005 emissions for each new bus. Vehicle efficiency improvements in the rural, coach and minibus fleets of 10% by 2020 are assumed. No savings are included for eco-driving.

4.55 For rail, savings from both short and longer-term measures covered in recent Government announcements are not apparent in the baseline. We have included some savings as part of our package in order to emphasise what can be achieved by promoting savings from this sector. We have not included savings from regenerative braking.

Cost-effectiveness

4.56 Encouraging take-up at scale of new technological options in buses and trains does not represent a cost-effective way of reducing emissions in the short term, but demonstration projects, such as the newly announced Government initiative on public procurement for small fleet demonstration programmes (DfT, 2007c), or introduction by Transport for London of trials of fuel cell and diesel-electric hybrid single and double deck buses, provide opportunities to accelerate developments in this area and potentially drive down costs for the longer term. Other fiscal incentives might include excise duties related to CO_2 emissions and grants for clean vehicles, which would again increase competitiveness and, as market penetration increases, costs would be expected to fall. Low carbon buses are currently considerably more expensive than standard vehicles, though the price differential is expected to fall as the technology matures. Although the capital costs are partly off-set by lower fuel costs, low carbon buses currently perform poorly in terms of cost-effectiveness – around £452 per tonne of carbon in the medium term at current rates of fuel subsidy (E4tech, 2006).

Recommendation 4

Secure carbon savings through technological, purchasing and operational changes in the fleets of van and lorry vehicles.

4.57 Work done for CfIT by McKinnon (2007) highlights the significance of seven key ratios in determining the relationship between freight tonnage and CO_2 emissions:

- number of specific journeys made by individual products (the handling factor);
- mean length of each link in the supply chain (average length of haul);
- modal split;
- average load carried when laden;
- proportion of distance running empty;
- fuel efficiency with which vehicles are operated (such as driving style); and
- fuel source.

4.58 Notwithstanding the overall increase in emissions linked to moving freight (although there is some question of the precise scale of increase – see Chapter 2), McKinnon says that, between 1990 and 2004, trends in most of these key ratios moved in a direction which reduced the carbon intensity of the freight transport system per tonne of freight moved (e.g. reduced empty running, net consolidation of loads, and improved fuel efficiency). The Government's *Freight Best Practice* initiative highlights case studies[17] of the savings in fuel, CO_2 and money that hauliers can make through a range of measures: aerodynamic styling (7 to 15% saving), lower rolling resistance tyres (5 to 13%), consolidation (38%) and the provision of independent site-specific advice (18%). To date, over 7000 lorry drivers have received training under the UK Government's Safe and Fuel Efficient Driving scheme (known as SAFED), achieving variable savings (DfT, 2006 e, f, g and h and 2003b).

4.59 However, particularly in view of the Government's own analysis of the relative cost-effectiveness of measures to promote sustainable distribution, we feel that more can be done in these areas to achieve greater carbon savings than are currently assumed in the CCP baseline. McKinnon sets out two scenarios (see Exhibit 4.10): one characterised as 'steady state' where there is relatively significant growth in freight movement but little positive change in the key ratios; and another more 'aspirational' one where growth in freight movement involves more significant modal shift and reasonable uptake of improvements in areas such as vehicle utilisation and energy efficiency.

4.60 The essence of McKinnon's outlook is that improvements over many aspects of freight distribution could in aggregate generate significant emissions reduction. He also highlights that the freight sector is quite diverse in terms of performance: similar companies competing in the same market can require widely varying amounts of fuel to move the same quantity of product the same distance. In the case of the food distribution, for example, a government-funded benchmarking survey in 2002 revealed that, if all companies could raise the energy-efficiency of their truck fleets to the mean achieved by the top third of companies in their sub-sector, overall fuel savings of 19% could be secured. Incorporating road freight transport as part of proposals for surface transport in the EU emissions trading scheme could provide a further impetus for change.

4.61 Further opportunities to promote emissions savings might be possible through public policy measures such as taxation – for example, vehicle excise duty. Incentives to purchase more fuel-efficient or alternatively-fuelled vans and large goods vehicles are, at present, solely through the fuel price. For example, VED for lorries could account for CO_2 alongside size and number of axles. An additional measure could be to establish a mandatory regime to improve the carbon performance of new lorries. However, the need to consider the freight being carried by such vehicles (and in some cases the desirability of lorries capable of taking heavier and/or larger loads to maximise carrying capacity) make measuring the carbon efficiency of lorries more complicated than for cars and vans. The first step towards any such agreement would be to establish a database of lorry fuel and carbon performance.

4.62 We have already noted the significance of growth in van traffic for road transport emissions. Very little is known about the composition of this demand and, up until recently, data have not been collected on the carbon performance of vans sold, because

17 http://www.freightbestpractice.org.uk

there has been no standard test cycle for these vehicles. For the first time, the latest CEC proposals (2007b) propose targets for light vans of 175 g CO_2/km by 2012 and 160 g by 2020, from 201 g in 2002.[18] This is a vital part of the proposals for the successor to the current Voluntary Agreements that should be supported, as in the case of cars, with a package of measures to help transform the market and encourage optimal use of these vehicles on the road. This will include the restructuring in VED, labelling of vans and components, and driver training programmes. In addition, more than half of all vans exceed the speed limit on motorways, with almost a fifth exceeding the limit by more than 10%. Our speed calculations above do not include emissions from vans, but the stricter enforcement of the 70 mph speed limit should play an important role in helping to secure efficiency gains here.

Exhibit 4.10

Carbon savings from freight

McKinnon sets out two scenarios looking ten years out from a base year of 2004 to illustrate the combined effect on CO_2 emissions of changes in key freight transport parameters.

The ‘steady state’ scenario envisages CO_2 staying broadly at today’s levels. The volume of freight movement is assumed to rise by over 11%, including a 10% increase in tonne-kilometres carried by large goods vehicles, a doubling of the freight moved in vans and a 15% increase in rail tonne-kilometres. Operational improvements which help reduce emissions are limited to increased loading factors on vans, a 5% improvement in both lorry and van energy efficiency, and some switching to less carbon intensive fuels for both lorries and vans.

A second, ‘aspirational’, scenario envisages instead an emissions cut of around 28% (2.7 MtC) over ten years. This assumes a more modest increase in freight movement of 7%, but rail and waterborne freight play a bigger role than in the ‘steady state’ scenario (growing by 30% and 10% respectively). This scenario envisages a much wider (and in some cases more intensive) implementation of carbon reduction initiatives, based on:

- operators taking the initiative in increasing vehicle utilisation, modal shift and improvements in fuel efficiency through driver training, idling reduction, speed enforcement, raising the standards of vehicle maintenance and the deployment of fleets to maximise efficiency;
- greater assistance being given to operators to operate more efficiently with higher uptake of the Freight Best Practice programme and its possible extension. For example, the Dutch government has run a programme called ‘transport prevention’, which provides companies with consultancy advice on how to reduce their total demand for freight transport, not just how to secure efficiency gains;

18 Until the introduction of Directive 2004/3/EC in 2004, there was no requirement for manufacturers of vans to measure emission levels or fuel consumption. Given the scheduling of the voluntary and compulsory compliance timeframes set by the Directive (2005-2008), complete figures on vans may not be available until 2010. There may be some barriers to the immediate implementation of some of our recommendations as a result.

Exhibit 4.10 *continued*

- incentives to buy differently: for example through VED incentives to purchase lower-carbon or alternatively-powered vehicles and grant programmes. In Sweden, vans that operate on electricity or electric hybrid vans are exempt from annual vehicle tax for the first five years;
- the carbon intensity of lorry and van fuel will decline by, respectively, 10% and 20% for lorries and vans by 2015.

Source: McKinnon, 2007

Carbon savings: 2.7 MtC in 2020

4.63 This is a sector with significant potential for emissions savings, using existing technology and in many cases delivering financial benefits to the operators. We have based our calculations on the analysis by McKinnon, but, taking a conservative approach and assuming only a 5% biodiesel take-up to be consistent with our caution on this issue, we have assumed that a carbon reduction of 20% between 2008 and 2020 for both the van and lorry fleet (as opposed to his estimation of 28% in the decade to 2015). These changes intensify towards the end of the period to allow time for restructuring and logistical developments to filter through the fleet. Altogether, measures to support changes in vehicle efficiency and operation of vans and large goods vehicles could save 2.7 MtC in 2020.

Cost-effectiveness

4.64 Available data suggest that the measures currently being applied are relatively cost-effective in terms of CO_2 saved per £ of public expenditure. The analysis recently reported by Defra (2007a) shows a net benefit per tonne of carbon saved of £130 for an extension to the sustainable distribution programme, estimated to save 0.5 MtC by 2020. Given the evidence to date on the effectiveness of the activities in this domain and the value for money for operators, this policy deserves stronger support.

Recommendation 5

Extend EU-ETS to cover aviation as early as possible, and actively consider other options for reducing emissions from aviation.

4.65 Opportunities to reduce emissions from aviation, as elsewhere, lie in three broad areas – technological improvements (e.g. related to engines, aircraft design and fuel type), operational improvements (e.g. different routing of services or increased passenger loading of aircraft) and behavioural change (e.g. modal shift by users to alternative forms of travel).

4.66 Chapter 3 highlighted the lack of information on the cost-effectiveness of possible measures to reduce emissions from aviation and the prevailing wisdom that action is likely to be expensive relative to other transport and non-transport options for carbon abatement. Nevertheless, the aviation sector has a long track record of fuel efficiency improvements, and there are currently a number of aviation initiatives in the UK and abroad that seek to address climate change impacts (see Exhibit 4.11).

Exhibit 4.11

Aviation industry initiatives

The Advisory Council for Aeronautics Research in Europe (ACARE) brings together EU policy makers, the aerospace industry, airlines, airports academia and others. ACARE has set improvement targets for fuel efficiency and NO_x emissions of 50% and 80% for new aircraft in 2020 against a 2000 baseline, as well as a target to cut noise levels.

In the UK, the Sustainable Aviation initiative was launched in June 2005, with eight main goals and three priority areas for action, including climate change. The initiative includes organisations and companies representing some 90% of UK airlines, airports and air navigation service providers, as well as all major UK aerospace manufacturers. Apart from contributing towards ACARE goals and taking other collective action, members of Sustainable Aviation are also engaged in individual initiatives:

- Virgin has committed £1.66 billion over the next 10 years to help combat global warming. It has said that future dividends and proceeds from the sale of assets, including shares in Virgin's airline and train operations, will be invested in renewable energy initiatives;
- European regional airline Flybe has invested more than £2bn in new state-of-the-art relatively efficient aircraft and provides its customers with data showing fuel use, CO_2 emissions and the noise patterns of its planes. This data helps passengers choose which route or aircraft is the least environmentally damaging and whether they wish to carbon-offset emissions from that journey;
- British Airways, which has improved its fuel efficiency by 28% since 1990, has recently announced a new target to improve fuel efficiency further by 25% by 2025, and has been an active promoter of the use of emissions trading in aviation. Recent and on-going initiatives include refined take-off and landing procedure, more direct routings and replacing older aircraft;
- BAA has a target to reduce CO_2 emissions from fixed sources (e.g. related to their buildings) by 15% on 1990 levels by 2010 and by 30% by 2020, while also seeking to have a positive influence on the energy efficiency of other organisations at their sites.

Improvements in air traffic management could deliver emissions reduction of up to 12%, though initiatives such as the development of a streamlined European-wide approach to air traffic control; operational improvements could save a further 2–6% (IPCC, 1999; DfT, 2004a). Further progress in this area requires international agreement and is strongly supported across the international aviation industry.

4.67 We very much welcome the initiatives currently being taken forward. But there is a strong case to strengthen the public policy framework relating to aviation, both to maintain the incentive for pursuing these initiatives and to stimulate further opportunities for reducing the carbon impact of aviation. While this is often regarded as a politically contentious area, public opinion research commissioned by CfIT suggests there is some public appetite for change (see Exhibit 4.12).

Exhibit 4.12

Ipsos MORI survey on attitudes to aviation and climate change

Ipsos MORI, commissioned by CfIT, conducted over a thousand face-to-face interviews and a subsequent one and a half day deliberative event involving members of the public, with stakeholders from the aviation industry, environmental lobby and academia:

- Nearly three-quarters of survey respondents thought the UK should 'set an example' on tackling climate change, rather than wait for international agreement. The idea that people in the UK should not be expected to reduce their air travel because 'we cause less damage than other countries' received more opposition than support. Most (59%) saw it as Government's responsibility to take the lead in addressing the climate impacts of aviation;
- There was most support for measures that do not restrict individual action, such as education and support for teleconferencing, though rationing on the basis of a carbon tax received qualified support. In the qualitative discussions, a system where everyone would be able to fly once a year free of environmental taxes and then be taxed for further flights according to their environmental impact was seen as equitable;
- Other measures that did not have 50%+ support, but did show significantly more support than opposition, included refusing planning permission for additional airports, runways or airport terminals, and increasing the costs of flights to be at least as high as rail;
- Half of the respondents thought that it would be acceptable to pay higher prices to cover the environmental damage caused by flights and that increasing the costs of air travel was seen as likely to have the biggest effect on individual behaviour of all the policy measures considered in the survey;
- For short-haul leisure flyers, a price rise from £100 to £124 would discourage 25% of people from flying, while the same percentage increase for long-haul leisure flyers (from £500 to £620) would discourage 60% from flying. The higher implied fare elasticities for long-haul (–2.5) than for short-haul (–1.04) leisure trips runs counter to the existing technical literature, but may be explained by people considering substitution of a long distance destination for a short-haul one if price rises are significant;
- Support for increased taxes or charges on aviation are greatest if the money is hypothecated for environmental purposes (echoing numerous studies of road pricing and previous studies on attitudes to aviation and taxation).

Source:
Ipsos MORI, 2007

4.68 In our view, there are essentially two broad options that need to be considered. First, tax or charges to air transport users or operators could play a role in influencing demand or other (e.g. operational) changes. We note the Government's efforts to work through the International Civil Aviation Organisation to reach agreement on the tax treatment of aviation fuel. However, international agreement is unlikely for some time. Other options might include:

- increasing current levels of Air Passenger Duty. One effect of this could be to dampen growth in demand for air travel: given fare elasticities of demand, such an effect would be expected to be more pronounced for leisure (particularly short-haul) travel – which accounts for 75% of air travel to and from UK airports – than for business travel. However, such an approach would have its limitations, as it sends an imperfect signal to passengers (e.g. the tax is not really linked to distances flown) and it does not incentivise the airlines, airports or air traffic control to become more efficient (e.g. APD is still paid at the same rate even if airlines improve passenger loadings or replace aircraft with more fuel efficient ones);
- impose VAT on tickets. Many of the existing exemptions in VAT are designed to help social and environmental objectives and as such the rationale does not exist for the lack of VAT on air tickets. VAT could be added to domestic tickets without international agreement as a straightforward way of implementing the 'polluter pays' principle for air travel and as an instrument to influence demand for domestic flights. But, again, such a tax is poorly linked to actual emissions, and adding VAT to international tickets is logistically and legally complex;
- link air navigation charges and other infrastructure charges (e.g. airport charges) to CO_2 and NO_x emissions in a revenue-neutral way. The recent Civil Aviation Bill enables airports to include an element within their landing charges to reflect local environmental issues: Heathrow and Gatwick already do this (in regard to NO_x and noise), while others, such as Manchester and BAA's Scottish airports, have noise-related surcharges. However, work would need to be carried out to establish how such changes might effectively be designed and remain compliant with the Chicago Convention and other ICAO guidance.

Exhibit 4.13

EU en-route emissions charging

A feasibility study carried out in 2002 looked at en-route emissions charging implemented at EU level and levied on all flights connecting to EU airports (Wit and Dings, 2002). The study identified that the resulting reduction in forecast CO_2 ranged from almost 2% at the lowest charge level (€10 (£7) t/CO_2) to 13% at the highest charge considered (€50 (£34)) in comparison, road transport fuels are currently taxed at around £200 t/CO_2, although this tax does cover the cost of other externalities such as congestion, accidents and local air quality. The emissions reductions were made up equally from reduced demand and technical and operational improvements.

The EU Commission's evaluation of the study concluded that these charges would have a progressive redistributive (not detrimental) effect on GDP; would not adversely affect the competitive position of EU and non EU carriers, provided the charge was levied on both; would have a marginal effect on air freight; and would favour short-distance tourist destinations (CEC, 2006c).

Source: CEC, 2006c; Wit and Dings 2002

4.69 A second option is to create a market for carbon reduction in aviation through emissions trading. This approach has the merits of setting a target for emissions reduction, providing flexibility to participants in finding the most cost-effective way of meeting their obligations and is appropriate to international nature of the sector.

4.70 An EU proposal to incorporate aviation into the EU Emissions Trading Scheme from 2011 is actively being discussed and brings with it a reasonable prospect of strengthening the policy framework for aviation regarding carbon emissions. We therefore support the Government's commitment to include aviation within EU emissions trading arrangements (and ultimately to promote the use of trading globally). But the level of emissions savings is dependent on the design of the scheme and the cap set for the sector: the Government therefore needs to encourage EU-wide agreement on some key issues:

- The degree of stringency applied to the sector through a combination of factors such as the emissions level at which the cap is set and the degree to which aircraft operators are able to meet their allocations through the purchase of credits from non-aviation sectors. The latter is potentially important for other parts of the European economy: if, as is widely anticipated, aviation turns out to be a significant net buyer of carbon credits, this could push up the cost of carbon for other sectors, potentially leading to some relocation of industry outside the EU (EAC, 2006). In addition, to the extent that airline operators purchase non-aviation credits, this potentially defers early action and 'locks in' dependency, some of which might be more expensive to address in future;

- Whether supplementary measures should be adopted alongside trading. For example, parallel 'flanking' instruments may be needed to address potential non-CO_2 impacts on climate change, such as airport charges based on NO_x emissions and flight routing to prevent contrail and enhanced cirrus cloud formation, though there remains considerable uncertainty about, for example, the net benefit of the latter, which needs to be researched more thoroughly;

- Our survey also highlights that there is a job to be done in communicating the mechanics of emissions trading and overcoming public scepticism and concern that it could either lead to monopoly control in the airline industry or that it will not provide enough incentive for meaningful emissions reductions (Ipsos MORI, 2007).

Level and cost-effectiveness of emissions savings from aviation

4.71 We believe the Government should seek to crystallise and develop further the emissions reduction potential from the range of initiatives currently being progressed through the following:

- Secure early agreement on extending emissions trading to aviation in the EU as a priority. Achieving this may mean that the scheme at least initially applies a moderate degree of carbon constraint on aviation. The important point is to establish within the sector the practice of trading and 'learning by doing', and to understand more about the impact in practice on other economic sectors currently covered by trading and the potential for cost-effective emissions reduction within aviation. But there should be a clear signal that, in future allocation periods, greater constraint will be applied through one or other methods such as adoption of more challenging emission caps or use of auctioning etc;
- Consider replacing APD with an emissions charge on aviation fuel when international agreement is reached on this issue and aligning it alongside the future version of ETS, in order that the two combined might send a clear signal to aircraft operators and air travellers about the climate consequences of their decisions to fly;
- Use measures targeted at environmental impacts rather than VAT or increased APD to reflect the carbon impact of aviation. However, if either VAT or increased APD are pursued, any additional revenue should be recycled to reinforce positive change. Thought might be given to providing a financial reward to airlines who deliver on significant commitments now to reduce emissions pre-ETS (i.e. pre-2011); incentivising more rapid take-up of carbon-efficient aviation technologies by appropriate changes to the UK capital allowances scheme; or helping fund other initiatives, (e.g. provision of information to air transport users about the carbon impact of flying). The principle of ring-fencing in this area has already been recognised by Government, which has made clear that the UK contribution to its Millennium Development Goals will be drawn from existing APD revenue; and
- Review the potential to link air navigation charges and other infrastructure charges (e.g. airport charges) to CO_2 and NO_x emissions in a revenue-neutral way.

4.72 Unlike other recommendations in this report, we have not sought to quantify savings from action we favour, given some of the challenges we have faced in identifying material on the potential cost-effectiveness of measures in this area. Any reductions arising from our priorities in this area would thus be additional to the abatement arising from our favoured programme, specified in the following section of this chapter.

4.73 Nevertheless, while Chapter 3 highlighted that aviation emissions can be expected to grow even with abatement action, various studies have concluded that the impact of emissions trading on ticket prices would be marginal and have little effect on the demand for air travel, with most of the reductions coming from other sectors (DfT, 2004a; Wit et al. 2005). By way of indication, the DfT has estimated that charging air transport users for the social costs of carbon could reduce aviation emissions themselves only by 1.7 MtC in 2050, compared with what would otherwise have been under a central forecast (DfT, 2004a). In further analysis, looking this time to 2020, a partial impact assessment based on all departing flights suggests that savings in the UK across all sectors and credits bought oversees would be 3.2–6.3 MtC by 2020 (Defra and DfT, 2007). The Energy White Paper identified 0.2–0.4 MtC by 2020 as resulting from the inclusion of domestic flights only.

4.74 On cost-effectiveness, again by way of indication, the Commission's (CEC, 2006b) impact assessment of the inclusion of aviation activities in the EU-ETS concluded: if air transport were included in a closed system of trading, permit prices would be between €114 and €325 by 2020, depending on the baseline growth assumptions used. In a completely open system, the permit price would be around €6. The comparison illustrates the relatively high cost of emissions reduction in air transport and the economic and social benefits of an approach based on emissions trading that allows the market to find the most cost-effective reductions, wherever they can be achieved.

Overall impact of our recommended package by 2020

4.75 The measures identified above have the potential to achieve significant additional carbon savings from the transport sector by 2020 in a cost-effective, efficient and acceptable way. Quantifying the potential carbon savings for each individual measure has been a challenge, but we have relied on published estimates in the literature and informed our assumptions with the best available and most recent evidence. We have also erred on the side of caution with respect to our estimates of potential savings. Our figures should therefore be seen as indicative, rather than definitive, of the types of savings possible.

4.76 The potential reductions delivered by each measure are shown in Table 4.2, yielding additional savings of around 7.0 MtC in 2020 to those anticipated under the CCP. Policies targeted at aviation and shipping would be additional to this. Air travel is treated qualitatively, reflecting its exclusion from the baseline measures and due to issues highlighted earlier (aside from some business-as-usual improvements to domestic flights).

4.77 The evidence and explanation of the numbers may be found in the supplementary document by Anable and Bristow, (2007), as well as a summary in Annex 3 of this report. In all cases, we have generally opted to include the more conservative estimates found in the literature. However, in the supporting evidence we have indicated where we think the potential could be higher than the estimates included in the table.

Table 4.2

Impact of additional measures proposed by CfIT (surface transport)

Measure	Carbon Saving 2010 (MtC)	Carbon Saving 2015 (MtC)	Carbon Saving 2020 (MtC)
Cars			
Mandatory EU target on vehicle efficiency (100 g CO_2/km): measures to influence car purchase behaviour (steeper VED bands, company car tax, car labelling, procurement, information)	0.1	1.1	2.4
Measures to support changes in driver behaviour (Smarter Choices, eco-driving, speed limit adherence)[21]	0.5	1.2	1.7
Cars total	**0.6**	**2.3**	**4.1**
Public transport			
Improved efficiency in bus and rail operations; re-targeting subsidy; revised VED and procurement; demonstration projects in clean bus and rail technologies	0.1	0.2	0.3
Public transport total	**0.1**	**0.2**	**0.3**
Lorries and vans			
Vehicle efficiency and operation of large goods vehicles	0.1	0.6	1.7
Vehicle efficiency of vans	0.0	0.4	1.0
Lorries and vans total	**0.1**	**1.0**	**2.7**
Overall savings	**0.8**	**3.5**	**7.1**

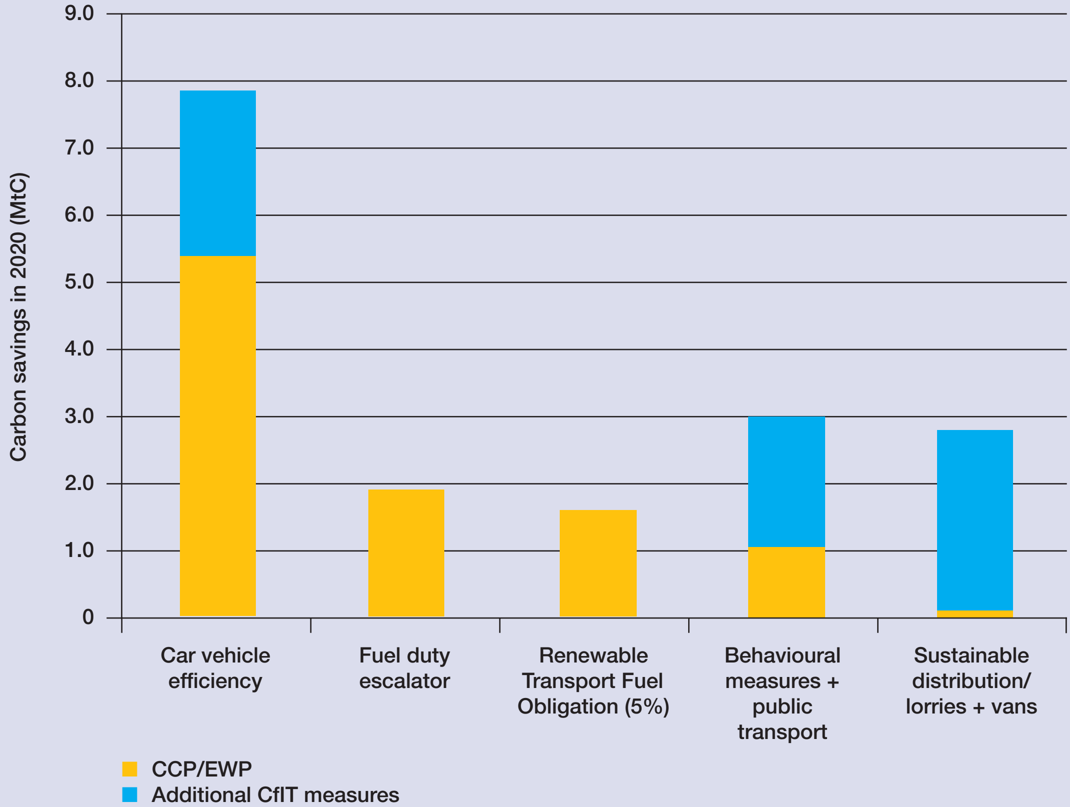
4.78 In total, the package of measures outlined above increases the carbon savings expected from the CCP by 71% by 2020. We assume that none of the measures we have put forward can begin before 2008, and that the majority are implemented from 2009 onwards. Consequently, our recommendations result in modest additional savings by 2010, 11% above the CCP, although we believe our measures will also serve to ensure the CCP savings themselves are more likely to be delivered.

21 Note that some of these measures would also impact on freight, buses and coaches, but are counted here for simplicity.

4.79 Figure 4.1 illustrates how the favoured scenario would deliver additional savings from car vehicle efficiency whilst complementing these with savings from behaviour change in the private travel and fleet sectors.

Figure 4.1

Carbon savings in 2020: CCP/EWP baseline and additional measures proposed by CfIT



4.80 The above chart also shows how the vast majority of savings in the Government's current approach are from passenger vehicles, whereas our approach would place as much additional emphasis on vans and lorries. The proportionate savings are shown in Table 4.3.

Table 4.3

Proportion of savings from each type of measure in 2020

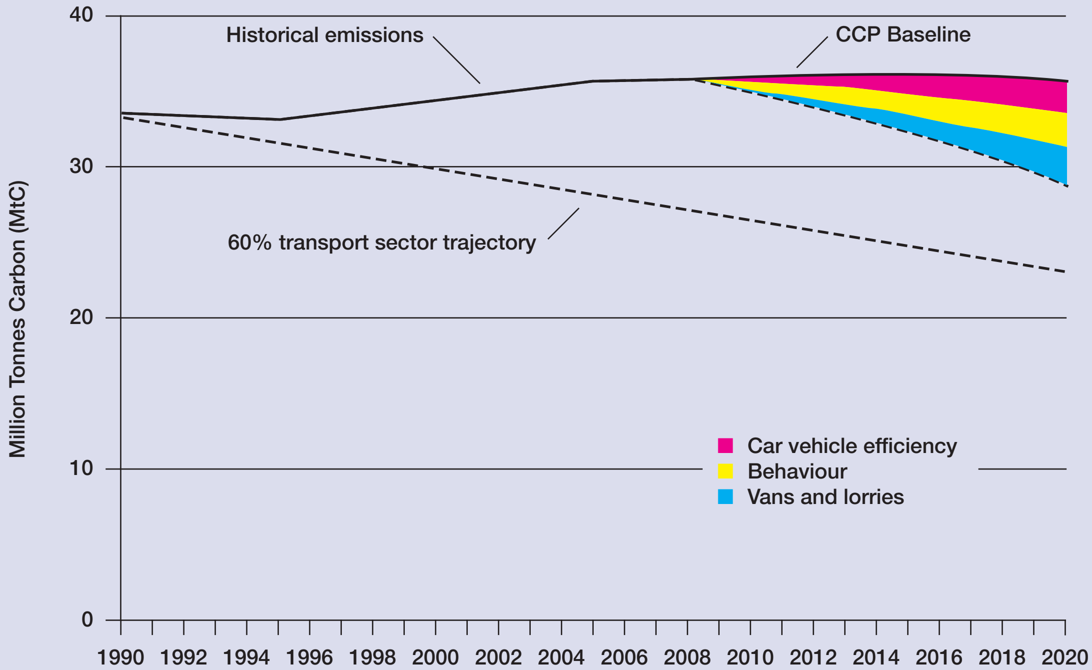
	CCP (%)	CfIT (%)	Total (%)
Vehicle efficiency	54	35	46
RTFO	16	0	9
Behavioural measures (Smarter Choices, eco-driving, speed limit adherence, public transport)	10	28	18
Fuel duty escalator	19	0	11
Sustainable distribution/lorries and vans	1	38	16
	100	**100**	**100**

NB: In the CCP, behavioural measures also include sustainable distribution in England at 0.1 MtC.

Figures may not sum due to rounding.

4.81 Figure 4.2 illustrates the CCP baseline to 2020, together with the additional measures proposed by CfIT. Unlike the CCP, the favoured package would ensure emissions from the transport sector start to fall below their 1990 levels, though it does not put the sector fully on a linear path to achieving a 60% reduction. Taken together with the CCP package of measures, the policies we have identified could reduce emissions from the sector to around 29 MtC in 2020 from its present level of around 36 MtC.

Figure 4.2
Emissions savings to 2020 over the CCP baseline from additional measures proposed by CfIT



Source:
Historical emissions from Defra, 2006(a), Table 4: CCP baseline calculated using DTI, 2007b, Table 4.2: Central carbon savings by source; central fossil fuel prices; not including off-road or savings from inclusion of aviation in EU-ETS. In both cases interim years are interpolated (i.e. between 2005 and 2010 etc.)

Filling gaps in the current knowledge base

4.82 We have made a number of observations in this report on areas requiring further analysis and have highlighted the following areas of uncertainty. Improving our understanding of these areas, we believe, will add greater focus and clarity to the UK climate change programme.

Policy packages and cost effectiveness

4.83 There is a real need for the assessment of combinations of measures, to identify synergies and enhance the design of carbon reduction measures.

International transport

4.84 Government targets, projections and modelling exclude emissions from international aviation and shipping, which are beyond the scope of current international agreements on greenhouse gas reduction. Yet emissions in these sectors are increasing and, in the case of aviation, are of particular concern because of the greater impact of emissions at altitude. This report attempts to address international movements and makes it clear where these activities are included in the figures. However, we acknowledge that further analysis is urgently needed, to understand both the current contribution to total emissions from aviation and shipping, and the potential effectiveness, including cost-effectiveness, of measures to reduce emissions from these modes. This includes the possibility of introducing shipping as well as aviation into the EU-ETS.

Vans

4.85 Vans are multi-functional vehicles, so it may be misleading to assign their entire output of CO_2 to the freight sector. Freight collections and deliveries may only account for only around 35% of total van-kilometres (McKinnon 2007). However, these van-kilometres produce a substantial proportion of CO_2 emissions from the freight sector (around 13%), and this proportion is rising sharply as a result of online retailing. The substitution of van deliveries to the home for conventional shopping trips needs further investigation, alongside the other purposes for which such vehicles are used. CfIT acknowledges this is an area that requires further analysis and is undertaking new research to better understand the light commercial vehicle market.

Freight

4.86 We have already noted in Chapter 2 that trend emissions figures for lorries and vans can vary by a factor of 3, depending mainly on whether industry-derived or official data are used, according to research carried out for CfIT (McKinnon, 2007). There is a need for work to ensure there exists an accurate picture for emissions from freight, and to strengthen the evidence base that currently appears weak on the potential for and cost-effectiveness of technological change in large goods vehicles.

Preparing for the longer term after 2020

Understanding technology pathways

4.87 A common theme among the economy-wide analyses of carbon abatement opportunities highlighted in Chapter 3 is the significant role potentially to be played in the longer term by major technological advances in transport. A wide range of options exists in both vehicle and fuel technologies, in road transport but also in public transport and aviation.

4.88 Less clear is the optimum trajectory from near-term technology change towards the longer term – for example, in the case of road transport, from heavy dependence on internal combustion engines powered by oil-based fuels to potentially hydrogen and/or fuel cell based technologies. Industry players are relying on various transition strategies (e.g. through the development of hybrid, biofuel, flexifuel, and pure electric options). There are, however, significant technical and cost challenges that will need to be overcome if these and other technologies in different modes are to become cost-effective ways simultaneously of satisfying the demand for mobility and reducing carbon emissions from transport.

4.89 In this regard, we welcome the Government's Low Carbon Transport Innovation Strategy (Defra, 2007b). We also welcome the review being led by Professor Julia King to examine vehicle and fuel technologies that, over the next 25 years, could help to decarbonise road transport, particularly cars.

Road pricing

4.90 Road pricing may well play a major role in Government policy, but, as highlighted earlier in this chapter, careful integration with other policies is required with any strategy for reducing CO_2 from transport. Further analysis is needed on the potential to design a scheme to deliver both congestion and CO_2 reductions.

Land-use planning and adaptation

4.91 The implications of Government land-use policy at micro-level (local co-location of different activities, e.g. housing, employment, shopping, recreation) and at a more macro-level (e.g. intra- and inter-regional distribution of economic activity) on transport-generated CO_2 emissions could be significant but are as yet under-researched. This should be addressed as a matter of priority and could be an early task for the proposed Climate Change Committee. In addition, the consequences of unavoidable climate change (in terms of more volatile weather patterns) have a particular bearing on the UK's transport network. Work has begun in this area, but more needs to be done to improve our understanding of the implications for the resilience of the network and what action needs to be taken.

Behaviour and attitudes

4.92 The success of carbon abatement policy in the transport sector as well as other sectors depends on public acceptance and informed debate of the issues. Public attitudes to the causes, consequences and responsibilities related to climate change are shifting rapidly (DfT, 2007a and see Anable et al., 2006 for a review). Effective policy design requires sufficient understanding of consumer responses to carbon abatement strategies and how these can be better communicated and targeted. This includes monitoring policy changes, such as the recent reforms to VED.

Use of trading mechanisms

4.93 Trading mechanisms in principle offer significant opportunities to cut emissions in the most cost-effective manner, and EU proposals to extend trading to aviation are currently under discussion. Other options exist, such as extending emissions trading to surface transport (where it might apply to one or other of three groups – fuel producers, vehicle manufacturers and individual motorists/hauliers). Research undertaken for this study provides an evaluation of trading options, including the EU-ETS, domestic tradable quotas and personal carbon trading (Watters and Tight, 2007).

4.94 There are significant practical issues associated with all of these mechanisms (including the most advanced proposals, relating to aviation), but we feel further work is needed to establish whether trading could represent an effective solution to surface transport emissions. Personal carbon allowances (PCAs) are a yet further option and again, while this may be something that in the medium to longer term might provide a way of tackling individuals' transport emissions (among others), further work is needed to establish the practicality of such an approach.

Conclusions

4.95 In this chapter we have identified an integrated approach to increase greatly the potential carbon reductions from the transport sector over the short to medium term in a cost-effective manner.

4.96 We have identified five key packages of measures to deliver additional carbon savings from transport by 2020:

- A mandatory EU target for new car sales of 100 g CO_2/km but with a deadline (2020) that allows a more cost-effective response by the industry, combined with measures to stimulate demand for lower-emission vehicles;
- A carrot-and-stick approach to promoting more efficient use of cars through the price of fuel, greater promotion of eco-driving and better enforcement of speed limits;
- More intensive promotion of Smarter Choices to encourage take-up of alternatives to car travel, supported by improvements to the carbon performance of public transport;
- Measures to capture the significant opportunities for carbon reduction in the van and lorry fleets; and
- Measures to supplement the move towards emissions trading to stimulate carbon savings in aviation.

4.97 The combined effect is to increase carbon reductions from transport by 2020 by 71% over current plans. With regard to surface transport, the proposed package would see a greater balance of contribution towards emissions reduction between technological and behavioural change, and between cars and vans/lorries.

4.98 There are gaps to be filled in our understanding about emissions and international transport, light commercial vans and freight more generally.

4.99 There are issues that need to be tackled now with regard to the longer-term contribution of transport to emissions reduction, such as the pathway for future technological change, and the roles that road pricing, land-use policy and emissions trading can play as part of a longer strategy to address transport emissions.

Chapter 5: Conclusion

5.1 In this report, we have sought to draw attention to what is known about the cost-effectiveness of measures to reduce transport emissions. While there is useful material to help guide policy makers, we conclude that there is also work to be done in improving the quality of available information on this topic, particularly as regards the cost of packages of complementary measures and instruments designed to reduce carbon emissions from the aviation sector.

5.2 We also conclude that, notwithstanding shortcomings in the existing knowledge base, there is scope to improve both the cost-effectiveness of the current Climate Change Programme to deliver transport emissions, as well as the scale and deliverability of emissions savings. Fundamental to our approach is the principle that packages of reinforcing measures tend to be more effective than a range of individual interventions by ensuring that incentives are consistent, that consumers and manufacturers are given long-term signals to change and that the savings from efficiency gains are locked in. We feel the Government could go much further than it has to date in adopting this approach.

5.3 In proposing these packages, we have not included all potential measures implemented to the greatest degree possible. Some will have been rejected on the basis that they did not appear to be cost-effective; for others we have not had sufficient detail on which to make a judgement.

5.4 Our proposals are thus not intended to be definitive, but an indication of what might be possible and desirable. Our proposals indicate that, with regard to reducing transport emissions, more can be done cost-effectively in the short term and more needs to be done to prepare for the long term.

5.5 We recognise that the Government has already been taking this issue seriously. Transport is a significant element in the existing Climate Change Programme to reduce UK emissions, and the 2007 Energy White Paper included welcome commitments to develop understanding in important areas of the debate about transport emissions (e.g. on shipping and longer-term technological options).

5.6 However, it is also clear that achieving the interim target proposed under the draft Climate Change Bill (to cut UK CO_2 emissions by 26–32% against 1990 levels by 2020) is going to be very challenging, based on the measures set out in the Energy White Paper. There is also a developing scientific and political argument in favour of going beyond the existing commitment to a 60% by 2050 target.

5.7 We therefore believe that there is a strong case for Government now to be considering how it might best capture further opportunities for cost-effective carbon reduction in transport as well as in other areas of the economy. Significant responsibility for identifying and implementing appropriate measures will certainly rest with the Department for Transport, but it is vital to see this agenda as a cross-Whitehall one, given the responsibility of other departments, for example in fiscal policy or technological innovation. We hope this report will help inform how a range of departments might work together to realise opportunities for carbon abatement in transport.

Annex 1: Glossary

The following list provides a brief definition of terms frequently referred to within the body of this report:

- Air passenger duty (APD): is a duty levied by the Government on tickets for flights leaving any UK airport.
- Carbon dioxide (CO_2): a greenhouse gas produced by the burning of petroleum, peat, natural gas or coal.
- Carbon dioxide equivalent (CO_2 eq.): Greenhouse gas emissions are typically reported in terms of CO_2 equivalent to provide a common unit of measures, and because CO_2 is the most prevalent of all GHGs.
- Carbon footprint: is a measure of the amount of CO_2 emitted through the combustion of fossil fuels in the case of an organisation, business or enterprise, as part of their everyday operations; or in the case of an individual or household, as part of their daily lives; or for a product or commodity in reaching market.
- Carbon sink: is the opposite of a carbon 'source'. The main natural sinks are the oceans and growing vegetation. Both remove carbon from the atmosphere by incorporating it into biomass such as plankton and trees.
- Carbon off-setting: involves the use of natural sinks, such as trees, to offset carbon emissions. For instance, a company may choose to plant trees to minimise the environmental harm caused by their day-to-day operations.
- Emission trading schemes: A country (or group of countries or even regions/states) caps its carbon emissions at a certain level (this is known as cap and trade) and then issues permits to firms and industries that grant the firm the right to emit a stated amount of carbon dioxide over a time period. Firms can then trade these credits in a free market. The idea behind carbon trading is that firms that can reduce their emissions at a low cost will do so and then sell their credits on to firms that are unable to easily reduce emissions. A shortage of credits will drive up the price of credits and make it more profitable for firms to engage in carbon reduction. In this way the desired carbon reductions are met at the lowest cost possible to society.
- 'End user' emissions: emission figures that include a share of emissions from power stations and other fuel-processing industries reallocated approximately to the end user according to their fuel use (i.e. as opposed to 'source' classification). This can also be known as 'well-to-wheel' emissions. For the transport sector, this classification adds around 20% to the total CO_2 produced and thus gives the most complete account of the relationship between emissions and the production of goods and services. However, these figures are also subject to more uncertainty than 'source' figures.

- **Fossil fuels**: are hydrocarbons, primarily coal and petroleum (fuel oil or natural gas), formed from the fossilised remains of dead plants and animals by exposure to pressure in the Earth's crust over hundreds of million so years.
- **Greenhouse gases** (GHG): are components of the atmosphere that contribute to the greenhouse effect. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities such as the burning of fossil fuels. These include carbon dioxide (CO_2), water vapour (H_2O), methane (CH_4) and nitrous oxide (N_2O).
- **Lorries:** (heavy goods vehicles) are over 3.5 tonnes maximum gross weight.
- **MtC**: Figures given in MtC (million tonnes of carbon) refer to the mass of the carbon component of the CO_2 molecule multiplied by 44/12 to give the mass of CO_2.
- **Radiative forcing**: is the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends on average to warm the surface of the earth, while a negative forcing tends to cool the surface. One kilogram of methane is estimated to have the same radiative forcing effect as 21 kilograms of CO_2.
- **Radiative forcing index***:* The radiative forcing index (RFI) is an extension of the concept of radiative forcing and is simply the radiative forcing of a gas with respect to that of carbon dioxide. The radiative forcing index is the ratio of the total radiative forcing compared to that of carbon dioxide alone.
- **Source emissions**: emission figures presented according to the sector from which they are directly emitted (i.e. as opposed to 'end user' classification). This can also be known as 'tailpipe' emissions.
- **Vans:** (including car-based vans) or small goods vehicles (including pick-up trucks) which are licensed for private and light goods use (PLG) for vehicles up to 3.5 tonnes maximum gross weight.

Annex 2: About the Commission for Integrated Transport

The **Commission for Integrated Transport** (CfIT) was established by the 1998 Integrated Transport White Paper. Following an independent review of CfIT in 2003, the Commission's remit includes:

A) **Providing policy advice via evidence based reports on:**

- Future policy options, so-called 'blue-sky thinking' on future strategic issues;
- Policy issues spanning departmental boundaries (i.e. environment, social etc.);
- Best practice amongst local authorities and delivery agencies to encourage improved performance and to highlight barriers to best practice;
- Comparisons with European and/or international policy initiatives and dissemination of best practice;
- The impact of new technology on policy options;
- Specific issues as requested by the Department for Transport.

B) **Refreshing the transport debate**, based on published reports and with a view to raising the overall level of the 'Transport Debate' and, where possible, to build consensus among stakeholders.

Report Working Group

Thanks go to the members of the Climate Change Working Group for their time and expertise in guiding this analysis.

Michael Roberts, (Chairman), CBI and CfIT Commissioner

Simon Barnes, Society of Motor Manufacturers and Traders

Nigel Campbell, Department for Transport

Edmund King, RAC Foundation

Tim Larner, Passenger Transport Executive Group

Martin Nesbit, Department for Environment, Food and Rural Affairs

Eirik Pitkethly, Department for Transport

Archie Robertson, Highways Agency and CfIT Commissioner

Andrew Sentance, Bank of England and CfIT Commissioner

Lynn Sloman, Transport for Quality of Life and CfIT Commissioner

Jason Torrance, Transport 2000

Richard Turner, CfIT Commissioner and formerly The Freight Transport Association

Malcolm Watson, United Kingdom Petroleum Industry Association

CfIT would like to thank all those who advised the Working Group on this report.

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Supporting evidence

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Annex 3: Summary of methodology to calculate carbon savings

Measure	Assumptions	Evidence base/data	Carbon savings per annum (MtC) 2010	2015	2020
Successor to Voluntary Agreements	■ 2009 start ■ 100 g CO_2/km by 2020 (ave. new cars) ■ starting at 2% p.a. reduction moving to 5% p.a. towards 2020	■ New analysis for EWP (DTI, 2007c) provides CO_2 savings for a number of targets ■ An average per g/km CO_2 saving was calculated and used to estimate 100 g/km target	0.1	1.1	2.4
Eco-driving	■ 2008 start ■ No. of drivers practicing eco-driving builds up over time – 5% in year 1 to 40% year 2 ■ Each secures 4.5% efficiency savings over 100% of distance ■ Savings apply to cars only	■ Traffic growth forecasts to 2020 from DfT (2005)and emissions factors from NETCEN (2003) ■ Literature suggests around 10% savings achieved in the short term, lower in long term	0.1	0.2	0.3
70mph Speed Enforcement	■ 2009 start ■ Motorways and dual carriageways only ■ Applied to car only (75% of distance travelled on these roads) ■ Compliance starts at 50% and increases to 80% (max.) by 2015 ■ DfT modelling assumes 54% exceeding speed limit; ave. speed is 79 mph, dropping to 70 mph with compliance	■ Analysis for EWP (DTI, 2007c) provides CO_2 savings for 70 mph enforcement assuming 100% compliance ■ *Vehicle Speeds* GB (DfT, 2006)	0.3	0.4	0.4
Smarter Choices	■ 2008 start ■ Total reduction in car traffic below base of 7% in 2020 (11% urban; 5% rural and motorways) ■ CCP baseline savings of 0.2 MtC p.a. for low-intensity application subtracted from our results	■ Traffic growth forecasts to 2020 from DfT (2005) and emissions factors from NETCEN (2003)	0.1	0.6	1.0

Measure	Assumptions	Evidence base/data	Carbon savings per annum (MtC) 2010	2015	2020
Bus	■ 2008 start ■ 15-year average fleet replacement assumed ■ Assume composition of fleet stays constant (i.e. 25% coaches) ■ Urban single + double decker: – 250 low carbon (hybrid buses) in 2008, increasing in steps to 2000 a year by 2015 – Hybrids secure 25% saving (34% also modelled) ■ Rural buses and coaches: – 10% efficiency improvement achieved by 2020 on ■ Mini buses: – Emissions factor for mini-buses from NAEI (using LGV figure), 10% improvement by 2020	■ Bus fleet statistics from DfT (2006i) ■ Bus emissions factors for 2005 from NAEI online database ■ Hybrid efficiency gains from: LEK Consulting (2007); E4tech (2006); Overgaard and Folkesson (2007)	0.0	0.0	0.1
Rail	■ 2008 start ■ Short/medium-term savings 0.16 by 2015 from 'behaviour change' ■ Scenario including regenerative braking also modelled	■ Carbon savings from Peckham (2007)	0.1	0.2	0.2
Lorries	■ 2008 start ■ 20% carbon reduction by 2020 ■ Rate of growth of efficiency gains increase over time to allow time for restructuring to enter into the fleet	■ Assumptions for carbon savings from McKinnon (2007) ■ Emissions in base year (2005) from Defra (2007b), extrapolated growth from previous years to 2008	0.1	0.6	1.7
Vans	■ As lorries, but gains from vehicle technology not included	■ As for lorries	0.0	0.4	1.0
TOTAL			**0.8**	**3.5**	**7.1**

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This report identifies scope for an integrated set of measures that could significantly increase the carbon savings from the UK transport sector, reducing transport emissions by 14% against 1990 baseline levels by 2020 in a cost-effective way. Key features of our approach are a focus on tackling either the largest or fastest growing areas of transport emissions and an emphasis on measures to encourage behaviour change by transport users as a way of locking in the benefits from technological developments.