Carbon Pathways Analysis

Informing Development of a Carbon Reduction Strategy for the Transport Sector

July 2008
Contents

Executive Summary ................................................................................................. 3
Chapter 1: Introduction ......................................................................................... 10
Chapter 2: Carbon Pathways by Mode ................................................................. 18
Chapter 3: Carbon Pathways by Type of Journey .............................................. 49
Chapter 4: The Impact of Mode Switch on Emissions ....................................... 82
Chapter 5: International Comparisons ............................................................... 89
Chapter 6: The Challenge for Transport ............................................................. 106

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Executive Summary

1. Averting dangerous levels of climate change presents one of our biggest challenges. It will require international action, but – if actions are taken early and are well designed – can be addressed at manageable cost. Evidence from the Stern Review suggests that the cost of action to ensure that the worst impacts of climate change are avoided might be around 1% of global GDP, and perhaps a little more in developed countries. This compares to a cost associated with inaction equivalent to losing at least 5% of global GDP each year, now and forever.

2. To abate greenhouse gas emissions to the levels required, all sectors will have to play a part. The transport sector currently accounts for around 24% of UK domestic emissions of carbon dioxide (CO₂) – one of the main greenhouse gases. Transport will be required to play a full role in reducing these emissions and contribute to meeting our overall economy-wide targets. This is why we proposed a goal, in our “Towards a Sustainable Transport System” (TaSTS) framework document published in October 2007, for the UK transport sector:

“To address climate change by cutting emissions of carbon dioxide and other greenhouse gases”.

3. We also set out in TaSTS our intention to do further work to consider potential cost-effective emissions reduction pathways for different types of journey and different transport modes. We intend to develop a Carbon Dioxide Reduction Strategy for transport alongside our White Paper on wider transport strategy in Spring 2009. This will also inform the Government’s response to the recommendations from the Committee on Climate Change about the levels of CO₂ emissions reductions to be delivered within the first 3 five-year carbon budget periods to 2022. Further work is therefore underway to consider the abatement potential attached to possible options for reducing CO₂ emissions, and their related economic costs.

4. The work reported here starts to take forward the analysis promised in TaSTS. In particular:

- updating projections of transport CO₂ emissions, given existing policies, clarifies the scale of the challenge facing transport; and
- consideration of the drivers of transport demand should help in the identification of options for CO₂ reduction – whether by mode, type of user, or journey purpose. We have previously conducted analysis of transport emissions by mode, and this paper also reports our new analysis which relates CO₂ emissions from transport to journey purpose and journey length.

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1 The Stern Review (2006), *The Economics of Climate Change*, Cambridge University Press. Available at [http://www.hm-treasury.gov.uk/independent_reviews/sterneview_economics_climate_change/sternreview_index.cfm](http://www.hm-treasury.gov.uk/independent_reviews/sterneview_economics_climate_change/sternreview_index.cfm)
The Scale of the Climate Change Challenge

5. UK and EU targets will set the context for the scale of reduction in CO₂ emissions required from the transport sector. The stringency of the constraint will depend on the balance of effort required from the “traded sector” of the economy (those sectors, such as electricity generation, covered by an emissions trading scheme) and the “non-traded sector” (predominately transport and domestic heating). It will also depend on the extent to which burdens may be transferable between sectors, or allow for trading through international carbon markets.

6. We should have greater clarity on the scale of the reduction required following the recommendations on UK carbon budgets from the Committee on Climate Change, due by 1 December 2008, and the conclusion of negotiations on the European Commission’s proposed Climate and Energy package.

7. As it currently stands, the Commission’s proposals would require a 16% reduction by 2020 (on 2005 levels) of greenhouse gas emissions from the UK non-traded sector. However, if international agreement can be reached, this required reduction would be increased.

8. Figure 1 below shows historic and forecast domestic transport emissions. There are a number of uncertainties attached to these estimates, and these are explored further in the main paper.

Figure 1: Historic and forecast CO₂ emissions from UK domestic transport

Source: Historic data (apart from rail emissions) from the National Atmospheric Emissions Inventory 2006, rail data from DfT analysis (passenger trains only); forecasts from DfT analysis
9. Figure 1 also shows where we would expect transport emissions to be if measures had not already been taken to reduce CO₂ emissions. These measures are expected to contribute to a substantial reduction in CO₂ emissions (around 29 MtCO₂ in 2020) compared to where they would otherwise be. Nevertheless, forecast transport emissions in 2020 are only a little below current levels. Even if we cannot yet draw a line for exactly where they need to be in 2020 and beyond, it is clear that substantial further reductions are likely to be required.

CO₂ Emissions by Mode

10. In producing this assessment of projected transport CO₂ emissions, we have:

- updated our projections for the road sector, taking account of updated assessments of savings from existing measures;

- undertaken new work to look at emissions from the rail sector. These projections include the impact of initiatives that train operators are taking or planning, including measures aimed at improved fleet management (reducing “empty” mileage for fuelling, berthing and maintenance activities) and improved driver technique. It is estimated that these initiatives could reduce rail emissions in 2020 by 10 - 14% below what they would otherwise be;

- incorporated projections of CO₂ emissions from domestic aviation². With rising demand as incomes grow, continued growth in domestic aviation emissions is projected. Inclusion in the EU Emissions Trading Scheme (ETS) would set a cap on these emissions; and

- undertaken new work to consider CO₂ emissions from domestic shipping. There are significant data issues surrounding our understanding of historic shipping emissions, and which also make projections difficult. This is discussed further in the paper.

11. It remains clear that emissions from road traffic dominate the domestic transport sector: they accounted for 92% of the total in 2006. To reduce transport emissions significantly, those from road transport must be tackled. The Government is pressing the European Commission to set a longer-term target for new car CO₂ emissions of 100g/kilometre by 2020. If this target were to be adopted, it could further reduce UK CO₂ emissions by around 5 million tonnes in 2020. This potential for further reduction is also illustrated in Figure 1.

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² These aviation forecasts have been updated since the published DfT forecasts in November 2007, taking into account improvements in methodology.
CO₂ Emissions by Type of Journey

**Passenger Travel**

12. We have used data from the National Travel Survey to conduct new analysis on carbon pathways by journey type for households in Great Britain, covering both journey purpose and journey length. The analysis considers the CO₂ emissions associated with the reasons why people travel. This is intended to inform option generation – to aid consideration of where it may be most cost-effective to focus policies to reduce emissions from the transport sector.

13. The analysis has confirmed that transport CO₂ emissions are generated by a range of journey motivations as people travel for a wide number of reasons and by a variety of modes. There is therefore no single solution to significantly reduce CO₂ emissions in the transport sector – a variety of measures are required to target emission reductions most cost-effectively across transport modes and journey purposes.

**Figure 2:** Estimated CO₂ emissions from all modes of passenger transport by journey purpose, GB, 2002/2006 average

![Pie chart showing CO₂ emissions by journey purpose](chart.png)

Source: DfT analysis

14. The distribution of CO₂ emissions by journey purpose closely follows the distribution of distance travelled by purpose. But there are some differences:

- Commuting trips account for a higher share of transport CO₂ emissions than distance travelled. The main paper looks at this in more detail, but one of the main factors behind this is the high
proportion of car commuting trips that are single (driver only) occupancy.

- Holidays and day trips account for a lower share of transport CO₂ emissions than distance travelled, partly reflecting higher vehicle occupancy rates on these journeys but also different average speeds.

15. Figure 3 shows the estimated distribution of CO₂ emissions by journey length.

**Figure 3:** Cumulative trips, passenger distance and CO₂ emissions from household car journeys by trip length, GB, 2002/2006 average


- most trips are short – 57% of car journeys are under 5 miles. These account for under 20% of CO₂ emissions from cars;
- there are a large number of journeys (37%) between 5 and 25 miles. These account for a similar share (43%) of CO₂ emissions;
- only 7% of trips are over 25 miles. They account for 38% of CO₂ emissions from cars.

17. Policy implications do not necessarily flow easily from this. The potential to reduce emissions will depend on other travel options available, and these may well also vary by trip distance. But combining the analysis with indications of journey purpose may help. For example:
• the school run is often held up as an area where most journeys are short and where there may be other lower CO₂ travel options. However, only around 4% of CO₂ emissions from all passenger surface transport modes are accounted for by trips to school; and most (65%) of shorter education trips (under 2 miles) are already undertaken by foot or bicycle. There are indeed likely to be CO₂ reductions as well as other benefits, such as in relation to health and congestion, if more trips to school undertaken by car can be shifted to other modes. But to make a real impact on overall transport CO₂ emissions we also need to look elsewhere.

• for trips between 10 and 25 miles, emissions associated with commuting trips by car are high (over one-third of the total). Average car occupancy rates are lowest for commuting trips and for business trips. They also have the highest proportion of single occupancy trips, at 91% and 87% respectively.

• larger cars are used more for business journeys than other purposes (and many of these are single occupancy trips). These are factors that will be associated with higher CO₂ emissions, but at the same time a relatively high proportion of these trips are made in diesel fuelled cars (which generally have lower CO₂ emissions per kilometre than cars fuelled by petrol).

Freight

18. The movement of goods represents a further significant source of transport emissions – approaching an estimated 40 million tonnes of CO₂ (30% of total UK CO₂ emissions) in 2006. These freight emissions in the UK – as in other developed countries – are dominated by road transportation.

19. Understanding the use of vehicles for freight is not straightforward – for Light Goods Vehicles (LGVs) in particular, the same vehicles are used for passenger transport as well. However, making certain assumptions, we can derive an estimate of forecast CO₂ emissions from the movement of freight. A key assumption is forecast changes in freight traffic – Heavy Goods Vehicle (HGV) traffic is forecast to continue to grow, but at a fairly low rate to 2025. LGV traffic has been increasing fast in recent years, and this is forecast to continue, suggesting growth in CO₂ emissions from LGV traffic of around 30% to 2025. However, they are still projected to account for less than a fifth of road transport emissions in 2025.

20. Our forecasts of freight CO₂ emissions allow for the impact of existing measures – via grants to encourage mode shift, the Freight Best Practice scheme and driver training. Further work to consider additional measures

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3 DfT analysis
4 Projections from the DfT’s National Transport Model
to abate emissions will look at the potential to extend such measures to further encourage mode shift where this would result in a reduction in CO₂ emissions, and to improve fuel efficiency.

Modal Shift

21. Average emissions per passenger kilometre are relatively high for domestic aviation. They are lower for bus and rail than for car traffic.

22. In considering the potential for emission reductions from mode shift, however, it is important to consider the extent to which any improvement of an alternative mode generates additional trips. The effect on CO₂ emissions will vary depending on the capacity of each mode. Therefore, estimates of savings in road related emissions on account of a shift to rail or bus are best made on the basis of detailed multi-modal models that capture the full range of impacts. For example, an option which encourages greater use of existing rail capacity at off-peak times will not result in an increase in overall emissions from rail, and potentially an associated emission reduction from road transport.

International Comparisons

23. The UK has a transport emissions performance similar to that of other developed countries. The number of passenger kilometres travelled per capita is broadly in line with the other countries considered, and UK journeys are not significantly CO₂ intensive. However, analysis of the specific drivers of the UK’s emissions performance shows that the average CO₂ emissions of new cars in the UK is slightly higher than the EU-15 average. Set against this is the relatively low average age of the UK passenger car fleet. The UK has a lower proportion of less carbon intensive diesel cars than Spain, France and Belgium but performs well relative to the EU average.

Conclusion

24. The summary of the carbon pathways analysis as reported above is preliminary at this stage. The analysis of CO₂ emissions by type of journey, in particular, is at an early stage. We should be grateful to hear views on its implications, and suggestions for how it could be further extended.

25. We will refine this analysis and use it to underpin the development of policy measures to further abate CO₂ emissions from transport in line with our TaSTS goal on climate change. The evidence should help us to understand better the impacts of the barriers to action identified by our stakeholders, and in the longer-term enable us to measure our progress towards addressing these challenges.
1. Introduction

1.1 Transport has been fundamental to economic progress and has led to significant improvements in our quality of life. Transport growth is both an enabler and a consequence of economic growth, and has a vital role to play in increasing world trade. However, transport is also a significant contributor to the UK’s atmospheric emissions: in 2006, transport accounted for about 24% (approximately 130 million tonnes) of the UK’s domestic emissions of carbon dioxide (CO₂) – one of the main greenhouse gases contributing to climate change. The majority of these emissions (92%) came from road transport.

Figure 1.1: CO₂ emissions from domestic transport by source, UK, 2006

Total CO₂ emissions from domestic transport = 131 Million tonnes CO₂

Note 1: ‘Other’ includes Liquid Petroleum Gas emissions (all vehicles); other road vehicle engines, and other mobile sources and machinery.
Note 2: The emissions from rail given above are from diesel trains only, consistent with the UNFCCC reporting guidelines.
Source: National Atmospheric Emissions Inventory 2006

1.2 Climate change, as a result of rising greenhouse gas emissions, threatens the stability of the world’s economy and communities. One of the 5 goals put forward in "Towards a Sustainable Transport System: Supporting Economic Growth in a Low Carbon World" (TaSTS) (DfT, 2007) is to address climate change by cutting emissions of CO₂ and

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5 See The Eddington Transport Study (December 2006) for a greater discussion of the link between transport and the UK’s economic productivity. Available at http://www.dft.gov.uk/about/strategy/transportstrategy/eddingtonstudy/.
6 Available at http://www.dft.gov.uk/about/strategy/transportstrategy/hmtsustaintranssys.
other greenhouse gases from transport. It will require international action, but – if actions are taken early and are well designed – can be addressed at manageable cost. Evidence from the Stern Review\(^7\) suggests that the cost of action to ensure that the worst impacts of climate change are avoided might be around 1% of global GDP, and perhaps higher in developed countries. This compares to a cost associated with inaction equivalent to losing at least 5% of global GDP each year, now and forever.

1.3 This paper is the first stage of fulfilling a commitment in TaSTS, to examine:

“…potential cost-effective emissions reduction pathways for different types of journey and different transport modes.”

1.4 The intention of the pathways analysis is to improve our understanding of transport emissions by considering how people travel and why people travel, as well as the CO\(_2\) impact of freight movements. This will inform our thinking about how domestic transport emissions might be reduced below our forecasts, towards our long term targets. The next stage of this analysis will be to consider additional options to reduce CO\(_2\) emissions, including their abatement potential and their cost. This will then be used to inform policy decisions in order to ensure that policy measures are focused on reducing emissions from transport where it is most cost-effective to do so.

**Box 1: Targets to Reduce CO\(_2\) Emissions and the Transport Sector**

The extent of the reduction in CO\(_2\) emissions required from the transport sector is dependent on targets set at EU and UK level. The European Spring Council, in March 2007, endorsed an EU commitment to reduce greenhouse gases by 20% by 2020 (rising to 30% with wider international agreement). Subsequently, the European Commission has proposed an energy and climate package, including how effort could be shared among member states to achieve these targets. Within each member state, effort will be shared between the ‘traded sector’ (those sectors of the economy involved in emissions trading, such as electricity generation companies, commercial and industrial sectors subject to the EU Emissions Trading Scheme) and the non-traded sector (primarily transport and domestic heating).

The European Commission’s current proposal includes a 16% reduction in greenhouse gas emissions on 2005 levels from the UK non-traded sector by 2020. This required reduction from the non-traded sector would be increased if international agreement were to be reached (and the 30% emissions reduction target for the EU agreed).

The UK’s Climate Change Bill will also require a reduction in UK domestic CO\(_2\) emissions of at least 26% by 2020 and of at least 60% by 2050 from 1990 levels.

\(^7\) The Stern Review (2006), *The Economics of Climate Change*, Cambridge University Press. Available at [http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm](http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm)
The Committee on Climate Change (CCC), to be established under the provisions of the Climate Change Bill, will be tasked with advising Government on the level of the first three carbon budgets for the periods 2008–2012, 2013–2017, and 2018–2022 in order to meet the UK’s targets in 2020 and 2050.

The CCC will also advise on how achievement of the budgets should be split between the traded and the non-traded sectors. Most domestic transport CO$_2$ emissions come within the non-traded sector; the main exception is the emissions from electricity used to power electric trains (which are assigned to the power sector)$^8$. Domestic aviation emissions would also become part of the traded sector if the aviation industry joins the EU Emissions Trading Scheme in 2012, in line with the European Council decision.

Whilst the CCC will not be required to advise on a specific target for the transport sector, achieving the budgets will require contributions from all sectors of the economy, including transport.

1.5 One of the greatest challenges for the transport sector in terms of reducing CO$_2$ emissions is that the demand for travel, represented by average distance travelled, has been increasing over time. Data from the National Travel Survey (2006)$^9$ suggests that average distance travelled per person in Great Britain has increased by over 50% since the early 1970s, whilst the average number of trips has increased over this period by much less. Thus most of this increase in distance is due to longer trips, rather than a greater frequency of trips.

1.6 Figure 1.2 below shows how CO$_2$ emissions from domestic transport have changed over time, as well as our forecast of CO$_2$ emissions from domestic transport and the impact of our existing policy measures to 2020.

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$^8$ As transport emissions, rail emissions from electric trains are included within our analysis of rail in later chapters of this paper.

**Figure 1.2**: Historic and forecast CO$_2$ emissions from domestic transport, UK

Source: Historic data (apart from rail emissions) from the National Atmospheric Emissions Inventory, 2006, rail data from DfT analysis (passenger trains only); forecasts from DfT analysis

**International Aviation and Shipping**

1.7 The targets in the Climate Change Bill are currently set in terms of domestic CO$_2$ emissions. However, the CCC will be tasked with considering the implications of both the inclusion of other greenhouse gases within the UK’s targets, and also the inclusion of emissions from international aviation and shipping. These international emissions are not currently included in UK targets because there is no agreed way to allocate national responsibility.

1.8 Reflecting this difficulty in allocation, and the domestic scope of proposed targets, this paper will also focus on CO$_2$ emissions from domestic transport$^{10}$. However, this does not mean we are ignoring the importance of international emissions. It should be noted that:

i. The UK has led the debate within Europe for aviation’s inclusion in the EU Emissions Trading Scheme (ETS). The terms of aviation’s inclusion are still subject to negotiation, but in line with the outcome of the Environment Council in December 2007, the current proposal is that all flights arriving and departing European airports will join the scheme from 2012 and that airlines would be allocated

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$^{10}$ Defined as those emissions from UK transport attributed to the UK’s inventory under the UNFCCC reporting guidelines.
allowances equivalent to their emissions at average 2004-06 levels (approximately 216 million tonnes CO₂). This means that once part of a trading scheme, any additional aviation emissions above that level would lead to no increase in total emissions, since airlines would have to either themselves abate, or pay for the equivalent emissions reductions in other sectors.\textsuperscript{11}

\textbf{i.} the EU target for a 20\% reduction in greenhouse gas emissions from 1990 to 2020 (rising to a 30\% reduction with wider international agreement) is on a base which includes emissions from international aviation.\textsuperscript{12} It is a tighter target than would be required for a base excluding aviation.

\textbf{1.9} To show the relative extent of emissions from international transport, Figure 1.3 reports emissions by mode in 2006, including international aviation and shipping on the basis of the UK’s reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC). This measure is based on bunker fuel sales to aviation and shipping operators within the UK.

\textbf{1.10} However, this allocation method is not a very accurate reflection of a country’s emissions – planes and ships routinely “tanker” fuel from countries with lower fuel prices, and the amount of fuel sold in the UK does not capture some emissions for which the UK is, in some sense, “responsible”. For example, by this measure, UK shipping emissions have remained roughly constant since about 1980, even though seaborne trade has increased significantly. This is likely to be because UK shipping fuel sales are largely determined by the relative price of fuel between international ports, rather than reflecting the UK’s share of international seaborne trade.

\textsuperscript{11} There is provision, in the Commission’s proposals for amendment of the ETS in subsequent phases, for this allocation to tighten.

\textsuperscript{12} The targets proposed by the European Commission are on a base which – in the Commission’s Impact Assessment – includes emissions from outbound flights. On the Commission’s proposals, emissions attached to inbound flights from outside the EU will only be included in the EU ETS if third countries do not take equivalent measures to control emissions.
**Figure 1.3:** CO₂ emissions from domestic and international transport by source, UK, 2006

![Pie chart showing CO₂ emissions from various transport sources in 2006.]

Total CO₂ emissions from transport = 173 Million tonnes CO₂

Note 1: ‘Other’ includes LPG emissions (all vehicles); other road vehicle engines, and other mobile sources and machinery.

Note 2: The emissions from rail travel given above are from diesel trains only, consistent with the UNFCCC reporting guidelines.

Source: National Atmospheric Emissions Inventory 2006

**Mapping Emissions**

1.11 Maps of domestic transport emissions are also available on a regional basis¹³, using data from the National Atmospheric Emissions Inventory (NAEI). Figure 1.4 shows domestic transport CO₂ emissions across the UK in 2005. The relative concentration of transport emissions on major routes and in large urban conurbations as against rural locations is clear. Major transport routes across the UK and the major urban conurbations such as Birmingham, London and Manchester are clearly identifiable.

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¹³ See [http://www.naei.org.uk/mapping/mapping_2005.php](http://www.naei.org.uk/mapping/mapping_2005.php). Hot exhaust emissions are calculated within the NAEI using fuel consumption and emission factors for each vehicle type. These in turn are calculated on the basis of the composition of the vehicle fleet (age profile and fuel mix) from the DVLA’s national licensing data and are based on the assumption that the fleet mix is the same everywhere on the UK road network. There are therefore no regional variations in either the age of the fleet or the fuel mix.
Figure 1.4: Domestic transport CO$_2$ emissions as carbon, UK, 2005
1.12 Figure 1.5 shows domestic transport CO₂ emissions in London. These are predictably concentrated around the centre of the city and also around airports (Heathrow to the west of London).

**Figure 1.5:** Domestic transport CO₂ emissions for London, 2005

1.13 Maps like these can help to highlight those transport routes associated with the greatest level of CO₂ emissions.

1.14 The rest of this paper is structured as follows. Chapter 2 considers how people travel and sets out our estimates of carbon pathways by mode, including an assessment of historic and forecast emissions; key drivers of emissions for each mode; and the sensitivity of the forecasts to key variables. Chapter 3 considers why people travel, and how goods are transported. It presents estimates of carbon pathways by journey type, including journey purpose and journey length. Chapter 4 considers the impact on CO₂ emissions of modal switch. Chapter 5 then considers international comparisons using a selection of indicators related to transport and climate change. Finally, chapter 6 sets out the challenges for transport to 2022 and beyond.

1.15 This document does not propose a set of solutions for the transport sector in meeting the challenges associated with climate change. It does not include analysis of additional policy options to reduce CO₂ emissions – this is for further work. By setting out our current forecasts across all modes, including the impact of existing measures, and looking at drivers, the intent is to stimulate thinking about where we might most cost-effectively focus additional policy options in the transport sector.
2. Carbon Pathways by Mode

Key Messages

Road transport accounts for 92% of domestic transport emissions. Road transport emissions are forecast to roughly stabilise around 2006 levels, falling very slightly from about 120 MtCO₂ in 2006 to just under 116 MtCO₂ in 2020 with current and proposed policy measures in place.

The key drivers of road transport emissions are income; employment; population and travel costs. The combination of these drivers means that CO₂ emissions are forecast to increase to 144 MtCO₂ in 2020 in the absence of policy action. Existing policy measures are therefore forecast to save about 28 MtCO₂ in 2020 (a reduction of about 20%).

The NAEI assigns 1.7% (2.2 MtCO₂) of UK domestic transport emissions to diesel powered rail transport. Total rail CO₂ emissions inclusive of emissions from electricity generation for electric trains are estimated at 3.3 MtCO₂ in 2006/07, of which 2.7 MtCO₂ is from passenger rail and 0.6 MtCO₂ from freight rail. Planned industry initiatives mean that in 2020, total rail CO₂ emissions are forecast to be lower than they would otherwise be by 10 - 14%, at about 3.6 to 3.8 MtCO₂.

The key drivers of rail demand are GDP per capita, employment and population growth. However, how this translates into CO₂ emissions will depend on whether these demand changes result in changes to service provision – without any change in service provision, increasing demand actually results in no change in total rail CO₂ emissions.

In 2006, UK domestic aviation emitted 2.3 MtCO₂ – about 1.8% of total domestic transport CO₂ emissions. These emissions are forecast to increase by about 26% to 2.9 MtCO₂ in 2020. As per the European Council decision, inclusion within the EU Emissions Trading Scheme from 2012 would ensure that aviation’s emissions net of reductions it purchases elsewhere would remain at average 2004-2006 levels.

Emissions of CO₂ from aviation are directly dependent upon the amount of fuel used. This is primarily driven by the growth in passenger demand and aircraft fuel efficiency. Key drivers of the growth in domestic air passenger demand are economic factors, such as growing consumer spending or GDP, and the declining cost of air travel.

UK domestic shipping accounted for about 4.2% (about 5.5 MtCO₂) of domestic transport CO₂ emissions in 2006. These emissions are forecast to increase by about 13% to 6.2 MtCO₂ in 2020. Domestic shipping CO₂ emissions are again dependent on the amount of fuel used, and this is driven by the number of ships operating domestically in the UK; distance travelled; and changes in the speed of existing ships and other ship management practices that affect fuel efficiency.
Introduction

2.1 This chapter considers the different modes by which people and freight travel – road transport, rail, domestic aviation and domestic shipping. For each mode, it sets out historic and forecast CO₂ emissions, the key drivers behind these emissions, and the sensitivity of the forecasts to key variables.

Road transport

**Historic and Forecast CO₂ Emissions**

2.2 Road transport accounts for 92% of emissions from domestic transport in the UK. This is made up of 52.5% of domestic transport emissions from passenger cars; 19.8% from heavy goods vehicles; 15.2% from light goods vehicles and 4.5% from other road transport (such as buses).

2.3 Figure 2.1 shows historic data and forecast emissions from the road transport sector for Great Britain. The estimated impact of existing policy measures is also shown.

**Figure 2.1**: Historic and forecast emissions from the road transport sector, GB

Source: Historic emissions from the National Atmospheric Emissions Inventory 2006; forecasts from the DfT National Transport Model; impact of policy options from DfT analysis.
2.4 The forecasts are from the DfT’s National Transport Model (NTM) for Great Britain. They show that CO₂ emissions from road transport will broadly stabilise at current levels until 2015, with a gradual reduction thereafter. This fall reflects further improvements in vehicle fuel economy and the adoption of policies encouraging the use of biofuels which, when combined, more than offset the CO₂ effects of traffic growth.

2.5 The voluntary agreement package refers to policy measures in place over the period 1998-2009 which are aimed at improving new car fuel efficiency. These include:
   - EU voluntary agreements on new car fuel efficiency;
   - graduated Vehicle Excise Duty; and
   - company car tax.

2.6 It is difficult to isolate the impact of these individual policies on vehicle fuel efficiency since all are contributing to the same outcome. Since apportioning the resultant carbon savings to individual measures is difficult, the analysis evaluates these measures as a ‘package’.

2.7 The voluntary agreements: During the late 1990s, the European Commission secured voluntary agreements with car manufacturer associations in Europe (ACEA), Japan (JAMA) and Korea (KAMA) to reduce new car CO₂ emissions to 140g/kilometre by 2008/09. This represents a cut of around 25% on 1995 levels. Despite early improvements in fuel efficiency, progress has slowed in recent years and it is likely that the target will be missed.

2.8 The 140gCO₂/kilometre target was a sales-weighted average to be met at a European level by each of the three associations. This gave manufacturers a degree of flexibility over levels of achievement in different countries. The UK started from a higher than average position and is expected to be higher than average in out-turn. The central DfT forecast for the UK is for new cars to emit in the region of 162gCO₂/kilometre in 2008.

2.9 Graduated Vehicle Excise Duty (VED): VED was reformed in 2001, with the annual VED payment linked to the CO₂ emissions of the vehicle. There are currently seven VED bands for private vehicles: cars in the lowest, band A (for cars emitting up to 100gCO₂/kilometre), currently pay £0, and cars in the highest, band G (for cars registered from 23 March 2006 emitting over 226gCO₂/kilometre), currently pay £400. Budget 2008 announced structural reform of VED to further strengthen environmental incentives to purchase and develop fuel efficient cars, introducing six new VED bands from 2009/10 and a new ‘first year’ rate from 2010/11.

2.10 Company Car Tax: The Company Car Tax regime was reformed in April 2002 to base the charge primarily on the approved CO₂ emissions figure for the car and its list price. Under this system there is a significant incentive for employers and drivers to choose cars with lower CO₂
emissions.

2.11 The voluntary agreement package is assessed against a counterfactual of no improvements in fuel efficiency in the absence of these measures. This reflects an assumption that any 'natural' improvements in fuel efficiency would otherwise be offset by increases in vehicle weight and power, based on analysis of historical trends. The estimate of CO₂ savings takes account of the rebound effect - that is, the expectation that as cars become more fuel efficient, the cost of driving per kilometre falls, incentivising people to drive more.

2.12 Although the voluntary agreement package is only in place to 2009, carbon savings continue to accrue beyond this date. New cars, purchased in 2009 or before, are expected to remain in the fleet for some time. They emit less CO₂ (relative to the counterfactual) over their entire lifetime.

2.13 Average new car emissions have fallen in every year in the last decade – new cars produce 12% fewer CO₂ emissions than those in 1997. Average new car CO₂ emissions in the UK were around 167g/km in 2006, although the average for the whole UK fleet is probably in the region of 180g/km.

2.14 **New Car CO₂ targets:** In December 2007 the European Commission published legislative proposals for a mandatory target on new car CO₂ emissions to replace the current voluntary agreements. The proposal sets an EU target for tailpipe emissions of new cars of 130gCO₂/kilometre by 2012. Non-compliance will incur fines. These start at relatively low levels (€20/g) in 2012 but increase in subsequent years, reaching €95/g in 2015.

2.15 Technology costs of improving fuel efficiency are such that manufacturers may, in the early years, find it cheaper to pay the penalty than meet the target – our analysis suggests that the target is unlikely to be fully met until 2015. We have therefore modelled CO₂ savings in the UK on this basis, assuming that the UK experiences similar rates of improvement as those required at EU-level in order that the 130g/kilometre target is met by 2015.

2.16 The UK is also pressing the European Commission to introduce a longer term target of 100g/kilometre by 2020. The additional CO₂ savings that would arise in the UK from this longer term EU target are presented separately in Figure 2.1 above. In the same way as for the voluntary agreement package analysis, the counterfactual is of no fuel efficiency improvements in the absence of this measure.

2.17 **Renewable Transport Fuels Obligation (RTFO):** The RTFO is a regulatory requirement that the fuel industry supply a proportion of their road fuel from a renewable source – primarily biofuels. The RTFO commenced from the middle of April 2008 and will initially require the fuel industry to supply 2.5% of road fuel from a renewable source. This
2.18 Estimated CO\textsubscript{2} savings from the RTFO are based on an assumption that the obligation remains at 5\% from 2010-11. It is further assumed that, without the RTFO, there would not be any CO\textsubscript{2} savings from biofuels over this time horizon. It also assumes that biofuels will be relatively competitive compared with hydrocarbon road fuels and that all fuel suppliers meet the obligation and will not buy out of the obligation. The emission savings are based on the CO\textsubscript{2} content of the displaced hydrocarbon road fuels, as according to IPCC guidance the burning of renewable fuels do not add to overall domestic CO\textsubscript{2} emissions.

2.19 **Sustainable Distribution:** CO\textsubscript{2} savings arising from transport measures set out in the Ten Year Plan (2000) and the Future of Transport White Paper (2004) were estimated in the Climate Change Programme (2006) using DfT’s NTM. The bulk of the savings were expected to come from the Sustainable Distribution Programme which provides drivers and fleet operators with best practice advice on fuel-saving measures and promotes safer and more fuel-efficient driving. The impact of sustainable distribution policies in Scotland is also included.

2.20 Added to this are estimates of the impacts of Local Authority transport policies, modelled by the Department for Business, Enterprise and Regulatory Reform (BERR) (previously the DTI) in the Energy White Paper (2007)\textsuperscript{14}, and the impacts of the Smarter Choices campaign - techniques for influencing people's travel behaviour towards more sustainable options such as encouraging school, workplace and individualised travel planning.

2.21 Figure 2.2 below summarises the expected savings from our road transport policy measures. Over the summer, we will continue to review the CO\textsubscript{2} savings from existing policy measures to reflect any updates in assumptions, such as fuel prices, population figures and GDP forecasts. It is possible that this review will lead to a change in the estimated savings outlined below.

2.22 In aggregate, our current projections show that existing policy measures in the road transport sector, including the European Commission’s proposal for mandatory new car CO\textsubscript{2} standards, are forecast to save about 28 million tonnes of CO\textsubscript{2} in 2020. This reduces forecast road transport emissions from about 144 million tonnes of CO\textsubscript{2} in 2020 in the absence of policy measures, to about 116 million tonnes (a reduction of about 20\%).

Figure 2.2: Estimated CO₂ savings from existing policy measures in the road transport sector, GB

<table>
<thead>
<tr>
<th></th>
<th>Voluntary Agreements package</th>
<th>New car CO₂ European Commission proposal</th>
<th>New car CO₂ UK long term target proposal (additional savings)</th>
<th>RTFO - 5% biofuels</th>
<th>Sustainable Distribution, local measures and Smarter Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>8.6</td>
<td>0.2</td>
<td>0.0</td>
<td>5.3</td>
<td>4.2</td>
</tr>
<tr>
<td>2015</td>
<td>11.8</td>
<td>2.8</td>
<td>0.0</td>
<td>5.3</td>
<td>4.0</td>
</tr>
<tr>
<td>2020</td>
<td>13.0</td>
<td>6.1</td>
<td>5.2</td>
<td>5.1</td>
<td>4.0</td>
</tr>
<tr>
<td>2025</td>
<td>14.1</td>
<td>4.4</td>
<td>4.0</td>
<td>5.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Note: The projected savings for the new car CO₂ mandatory targets have been estimated using more up-to-date fuel price assumptions than the other measures shown. Further modelling will take place over the Summer to update the estimates onto a consistent basis.

Source: DfT analysis

Key Drivers

2.23 Traffic growth is forecast by the NTM to increase from 2003 levels by 21% to 2015, and by 31% by 2025. The key drivers of traffic growth in the NTM are changes in income, employment, population and falling running or travel costs, as a result of fuel economy improvements. The results set out in this chapter are based on a set of assumptions about the values of each of the key drivers. However, since these NTM forecasts were produced, the oil price projections have been updated by BERR, and the population and employment projections have been updated by the Government Actuary Department and the Office for National Statistics respectively.

2.24 The latest oil price projections for 2025 are higher than in our current projections. Current oil prices are at historic highs. This would be expected to decrease forecast traffic growth, if all else remained unchanged, due to an increase in the cost of car travel. However, the forecasts for population and employment growth have also been increased, and this would be expected to increase forecast traffic growth, if all else remained unchanged. The NTM forecasts are currently being updated in light of the latest projections for the forecasting assumptions.

2.25 Population and employment: The assumptions used in the NTM to generate the forecasts given above include an increase in the population of 8.5% between 2003 and 2025 and an increase in employment of around 10% over the same period. Employed people tend to make more trips and travel further. These two demographic changes account for around 20% of the growth in traffic.

2.26 Partly offsetting these factors is that the structure of the population is expected to age over time, with the proportion of over-65 year olds set to grow. Currently the population of over 65 year olds is around 30% of the
size of the employed group. In 2025 this is forecast to grow to just under 45%. This has implications for the forecasts as people aged over 65 currently make fewer and shorter distance trips than other segments of the population. Evidence from the National Travel Survey (NTS) suggests that, in 2006, people aged 65 and over made on average 27% fewer trips a week and travelled 47% less distance per week than adults of working age.

2.27 These differences may, however, be lessening over time. NTS data also suggests that the proportion of older people who have a driving licence is increasing - and will continue to increase as younger adults with a licence move through the age cohorts. Similarly, travel by car is also increasing among older people. Over the last ten years, the average annual distance travelled as a car driver by people aged 65 and over has increased by 26% among men and by 77% among women.

2.28 **Income:** Growth in travel is closely associated with increasing incomes. Rising incomes explain over 60% of the forecast growth in traffic. In a thriving economy with growing GDP, people travel more and businesses move more goods across transport networks. Economic growth is assumed to be about 2.5% per annum over the period as a whole\(^{15}\).

### Box 2: Travel Patterns and Income

Differences in travel patterns can be observed between different income groups: average distance travelled increases with income group. In 2006, people in the highest household income quintile (the top 20% of household incomes) travelled, on average, nearly three times as far as people in the lowest income quintile, at around 11,590 miles a year compared with around 4,120 miles respectively. This reflects:

- number of trips. In 2006, for example, people in the highest household income quintile made 31% more trips on average than people in the lowest income quintile. However, between 1995/97 and 2006, the number of trips made has fallen in the highest income groups and remained about the same in the lower quintiles\(^{16}\). The result is that the average number of trips made now varies less across the income quintiles.

- average trip length. This increased from 6.4 miles in 1995/97 to 6.9 miles in 2006. The average length of trip by people in the highest income group, at 10.0 miles, was more than double that of those in the lowest income group, at 4.7 miles. There is less difference in average trip length between the income groups in 2006 than in 1995/97.

There was a slight fall in average annual distance travelled by the two highest income groups in 2006 compared with 1995/97. There has been an increase by the lowest quintile of 32% over the same period. The difference in the average distance travelled between income groups has therefore reduced since 1995/97.

2.29 Rising incomes are also closely associated with increasing car ownership. Data from the NTS shows that the proportion of households

\(^{15}\) Growth is assumed to slow in the latter half of the forecast period, in line with official forecasts.

with no access to a car has fallen from 30% in 1995/97 to 25% in 2006. At the same time the proportion of households with access to two or more cars has increased from 25% in 1995/97 to 32% in 2006. The proportion with one car has remained stable at around 44%.

Figure 2.3: Household car availability (percentage of households), GB

<table>
<thead>
<tr>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>No car</th>
<th>One car</th>
<th>Two or more cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>60</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>1997</td>
<td>50</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>1998</td>
<td>40</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>1999</td>
<td>30</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>20</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: National Travel Survey

2.30 Travel varies considerably by car availability. On average, people in households with access to two or more cars make more trips, and travel much further, than those households with one car. Similarly, those households with access to one car make more trips and travel further than those without access to a car at all.

2.31 Nevertheless, there is a saturation point in car ownership. This occurs when households with high incomes reach a point where they are unlikely to want to own another car even if their incomes continue to rise. A similar phenomenon is observed in the relationship between income and trip lengths, where trip length increases tend to diminish with rising income.

2.32 Motoring costs: The cost of motoring includes costs of purchasing a car, tax, insurance, fuel prices and maintenance costs. The major variable cost of running a vehicle is the fuel cost per kilometre. This is reliant on two factors: firstly, fuel prices and hence oil prices and secondly, the fuel economy of the vehicle – how much fuel it consumes to drive a kilometre.

2.33 The NTM projections use the forecast oil prices produced by BERR. It is clearly important to consider different scenarios for the oil price, but the central forecasts used here imply a real increase in the price of fuel of around 8% in 2025 compared to 2003 levels. Due to fuel economy
improvements, however, the overall impact on the cost of driving is a 23% fall for the average car (1.2% per annum). Falling fuel costs per kilometre account for around 15% of the forecast traffic growth. Sensitivity to a higher oil price is considered below, and we will be doing further work to reflect higher assumptions for future oil prices.

2.34 The slowing of forecast traffic growth after 2015 reflects both the assumptions about an aging population and car ownership saturation, explained above.

2.35 The relative impact of each of the drivers discussed above is presented in Figure 2.4 below. This shows the implied elasticities derived from running the NTM for each individual driver, whilst keeping the other drivers fixed (these elasticities measure the percentage change in the variables listed in the first row, in response to a percentage change in each driver set out in the first column).

**Figure 2.4: Implied Elasticities in 2025**

<table>
<thead>
<tr>
<th>Driver</th>
<th>CO₂ emissions</th>
<th>Traffic (vehicle kilometres)</th>
<th>Congestion (seconds per kilometre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>0.40</td>
<td>0.40</td>
<td>0.71</td>
</tr>
<tr>
<td>Value of time</td>
<td>0.03</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Fuel efficiency</td>
<td>-0.85</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>Fuel price</td>
<td>-0.13</td>
<td>-0.15</td>
<td>-0.23</td>
</tr>
</tbody>
</table>

Source: DfT

2.36 The bold values highlight which driver has the most effect on forecast CO₂ emissions, traffic and congestion. So, while GDP is the underlying driver for traffic and congestion, this is not the case for CO₂ emissions. The NTM CO₂ forecasts are primarily driven by the assumptions made regarding fuel economy: for a 1% increase in fuel efficiency, CO₂ emissions are forecast to fall by 0.85%. CO₂ emissions fall by less than the increase in fuel efficiency because an improvement in fuel efficiency will result in lower fuel and therefore travelling costs for a given journey. Lower travelling costs will tend to encourage people to drive more, and therefore raise traffic levels. This increase in traffic levels offsets some of the emissions savings from the improvement in fuel efficiency.

**Sensitivity of the Forecasts**

2.37 Sensitivity analysis has been used to illustrate the impact of uncertainty around the assumptions used to produce the forecasts. Slight changes in the key assumptions are analysed individually, and each set of alternative assumptions then combined to create two scenarios in addition to the central case – one where car fuel efficiency improves faster, associated also with faster traffic growth (the high efficiency scenario) and a second where fuel efficiency improves more slowly (the low efficiency scenario).
2.38 When forecasting a complex transport system over long time horizons, many assumptions and simplifications have to be made. Some alternative views of the future are intrinsically impossible to model reliably, such as revolutionary technological advances. The sensitivities used here are based on historical experience of the variability of the key drivers.

2.39 The variation in the assumed values of the key drivers for the central, low efficiency and high efficiency scenarios are set out in Figure 2.5 below.

**Figure 2.5:** Variables used in the NTM sensitivity testing scenarios.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Central Scenario</th>
<th>Low efficiency scenario</th>
<th>High efficiency scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>71% growth between 2003 – 2025 (or 2.5% per annum)</td>
<td>62% growth (or 2.25% per annum)</td>
<td>81% growth (or 2.75% per annum)</td>
</tr>
<tr>
<td>Value of time</td>
<td>For work trips: 0.5 times GDP growth</td>
<td>No growth</td>
<td>For work trips: 1 times GDP growth</td>
</tr>
<tr>
<td></td>
<td>For non-work trips: 0.4 times GDP growth</td>
<td></td>
<td>For non-work trips: 0.8 times GDP growth</td>
</tr>
<tr>
<td>Oil prices in 2025</td>
<td>US$50 per barrel</td>
<td>Near US$80 per barrel</td>
<td>Near US$25 per barrel</td>
</tr>
<tr>
<td>(2004 prices)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel efficiency</td>
<td>Car fuel economy improves by 1.15% per annum for petrol cars and 1.35% for diesel. Due to an assumed shift towards more diesel cars, the average car fuel economy improves by 1.5% annually. Fuel economy of Heavy Goods Vehicles (HGVs) is assumed to improve by 16% by 2025 (equivalent to 0.8% per year).</td>
<td>Annual fuel economy improvement rates in the central scenario decreased by 50%</td>
<td>Annual fuel economy improvement rates in the central scenario increased by 50%</td>
</tr>
</tbody>
</table>

*Source: DfT*

2.40 In the high efficiency scenario, lower fuel costs (and hence the lower cost of motoring) drives an increase in traffic levels. However, even accounting for the ‘rebound effect’ of the increase in traffic, forecast CO₂ emissions from road transport in 2025 in England are 11% lower than in 2003 and lower than under the central forecast.

2.41 Conversely, the low fuel efficiency in the low fuel efficiency scenario suppresses demand through higher motoring costs, but still results in an increase in overall forecast CO₂ emissions in 2025 of 1% higher than 2003 levels. The main results from running the different scenario’s in the model are given in Figure 2.6 and Figure 2.7 below.
**Figure 2.6:** Forecast change in 2025 compared to 2003, England

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Traffic (Vehicle kilometres)</th>
<th>Congestion</th>
<th>Average Journey Time</th>
<th>CO₂ road traffic emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>39%</td>
<td>48%</td>
<td>7%</td>
<td>-11%</td>
</tr>
<tr>
<td>Central</td>
<td>31%</td>
<td>28%</td>
<td>4%</td>
<td>-5%</td>
</tr>
<tr>
<td>Low</td>
<td>20%</td>
<td>19%</td>
<td>3%</td>
<td>1%</td>
</tr>
</tbody>
</table>

*Source: DfT analysis*

**Figure 2.7:** NTM forecasts of CO₂ under the High, Central and Low Efficiency scenarios, GB

*Source: DfT analysis*

**Rail**

*Historic and Forecast CO₂ Emissions*

2.42 The National Atmospheric Emissions Inventory assigns 1.7% of UK domestic transport emissions to rail. This reflects the emissions associated with diesel trains only, consistent with the UNFCCC reporting guidelines. This is because the emissions associated with rail electricity use are assigned to the power generation sector and are therefore included within the ‘traded sector’. However, as the carbon pathways analysis will be used to help inform transport’s contribution to the UK
carbon budgets, emissions from both diesel and electric trains are considered within this analysis.

**Box 3: Historic Rail CO₂ Emissions**

Total rail CO₂ emissions are estimated at 3.3 million tonnes for 2006/07, of which 2.7 million tonnes is from passenger rail and 0.6 million from freight rail. Currently about 40% of the rail network is electrified. This accounts for about 60% of passenger kilometres as the electrified lines tend to be on more densely used routes. Freight traffic is almost entirely (95%) diesel as freight operators require the “go-anywhere” flexibility that diesel provides. So, of the total CO₂ emissions from rail, approximately 43% is from electric trains (included within the ‘traded sector’) and 57% is from diesel (included within the ‘non-traded sector’).

There are some gaps in obtaining robust data about rail’s historic CO₂ performance, not least because only the emissions from diesel trains are reported in the UK inventory. However, using historic traction electricity consumption data for England and Scotland from Network Rail, estimates of historic CO₂ emissions from passenger movements produced by the Association of Train Operating Companies (ATOC) and the DfT are shown in Figure 2.8. This suggests that absolute passenger rail emissions reduced between 1990 and 2005 despite a significant increase in passenger traffic.

**Figure 2.8: Historic passenger rail CO₂ emissions (diesel and electric), GB**

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CO₂ emissions (million tonnes)</td>
<td>2.81</td>
<td>2.68</td>
</tr>
<tr>
<td>CO₂ emissions per passenger (g/pkm)</td>
<td>85</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: DfT analysis; ATOC: 2005 Baseline Statement, with additional work for 1990.

2.43 To develop an indicative trajectory of rail CO₂ emissions, three main scenarios have been considered: a base case, and “business as planned” or reference scenarios which assume either a low or a high take up of the initiatives reviewed by the industry.

2.44 **Base Case Scenario:** This scenario assumes that the rail industry does not implement any new initiatives to reduce CO₂ emissions and also that technology does not deliver additional CO₂ savings. It assumes that:

- rail growth occurs in line with the High Level Output specification (HLOS)/Freight Route Utilisation Strategy estimates and is accommodated through additional trains to maintain crowding at constant levels and running additional freight services;

- new trains coming into service have the CO₂ performance of recent “off the shelf” designs;

- the electricity generating mix becomes cleaner over time based on BERR projections; and
regenerative braking is in place across the AC network.

2.45 “Business as planned” scenarios: These scenarios take account of CO₂ saving initiatives that are either planned or that are expected to take place. The amount of savings anticipated has been expressed as a range bounded by maximum and minimum anticipated levels of saving. The scenarios include:

- the same assumptions about growth, crowding, electricity generation and AC regenerative braking as the “base case” scenario;
- new trains coming into service reflect an increased emphasis on energy efficiency (e.g.: IEP, Thameslink, next generation DMUs) compared with recent designs;
- rail uses a 5% biofuel mix from 2010; and
- Train Operating Companies (TOCs) and Freight Operating Companies (FOCs) introduce a range of energy saving initiatives e.g.: driver training, improved idling and stabling policies.

Box 4: Forecasting Rail CO₂ Emissions

The demand forecasting methodology used by DfT is an elasticity based model which takes trip information from ticket sales for a given base year. This base demand is combined with growth assumptions for a number of demand drivers and elasticities of response to changes in these drivers by market segment to generate future year rail demand. These key elasticities are estimated from econometric time series analysis of the relevant rail passenger flows and demand drivers.

The forecasts of rail patronage are derived from the Network Modelling Framework (NMF). The model includes industry-agreed assumptions and parameters for rail demand forecasting. The forecast of rail emissions (including freight) has been based on a further model constructed to use the NMF timetable information, combined with data and assumptions of energy consumption for each class of rolling stock that is expected to be in operation in the forecast year.

The modelling of rail emissions relies on estimating the fuel use for each type of rolling stock on the rail network, taking into account the characteristics of the service operated (and so includes factors such as the number of stops). These estimates are needed because data on actual consumption is not available. The timetable based estimates of energy use are then grossed up to equate to the data on total consumption of electricity and diesel fuel by each train operator. The emissions modelling will be improved once data on actual fuel use for each train service becomes available to replace the estimated figures. This will also allow more

17 In March 2007 ATOC published a Baseline Energy Statement (www.atoc-comms.org/dynamic/publications/15/Baseline-energy-statement) using the latest data available to calculate the CO₂ emissions of passenger rail and compare rail’s performance with other modes. This information has been used to calibrate the environmental module of DfT’s Network Modelling Framework (NMF). ATOC subsequently issued an updated paper in October 2007 (www.atoc-comms.org/dynamic/publications/21/Energy-and-Emissions-Statement)
2.46 The relatively long life of rail assets such as the rolling stock constrains the amount of CO₂ savings that may be achieved in the short term. Rolling stock and locomotives, for example, typically have an operational life of around 30 – 35 years, compared with around 14 years for the automotive sector. Although there are some environmental/CO₂ advantages from having long life assets (for example, a reduction in the energy required to build and recycle them) this could also inhibit the rapid introduction of new low CO₂ technologies.

2.47 As a result of significant Government and industry investment in new rolling stock, the average age of passenger trains in Britain has reduced from 23 years in 1995 to 13 years in 2007. Britain now has one of the youngest train fleets in Europe. However, this also means that many of the trains operating now will still be operating in 2022, with limited opportunity to replace them with more efficient rolling stock designs in the short to medium term.

**Figure 2.9: Average age of rolling stock, GB**

2.48 **Passenger rolling stock profile:** The UK rolling stock fleet is currently composed of about 11,000 passenger vehicles. These are divided approximately equally into AC electric, DC electric and diesel powered vehicles. The type of rolling stock in use in the UK has a direct impact on CO₂ emissions based on its design, the number of miles individual trains travel each year and the CO₂ intensity of the traction energy source (diesel or electric).

2.49 In July 2007, the rail white paper and accompanying High Level Output
specification announced 1,300 new vehicles would be procured by 2014 to accommodate increased passenger demand and reduce overcrowding. These are split approximately 45%, 35% and 20% between the AC electric, DC electric and diesel powered types. This reflects that the growth is strongest on the denser parts of the network which are more likely to be electrified.

2.50 The aim of the extra vehicles is to reduce overcrowding. Appraisal suggests there are significant economic benefits resulting from this\(^{18}\), but even taking account of modal switch from road transport, these additional vehicles will result in a net increase in CO\(_2\) emissions.

2.51 There are opportunities to improve new rolling stock designs to reduce energy consumption (e.g. lightweight designs, regenerative braking, more efficient motors and engines and better train management systems). However, this may be partly offset by the need to incorporate features such as power doors and air conditioning. Indeed, new trains may also have to operate in a more carbon intensive way e.g.: higher acceleration, deceleration and top speeds, in order to deliver greater capacity on the network.

2.52 Three other projects will deliver new vehicles in significant numbers:

- Thameslink will require around 1,100 new vehicles of which some 400 are additional vehicles to allow for growth;

- the Intercity Express Programme envisages a fleet of up to 1,400 new vehicles to replace existing high speed train fleets; and

- Crossrail will require around 600 vehicles.

2.53 The Scottish Executive is also working on a rolling stock strategy that will considerably increase the size of the ScotRail fleet.

2.54 **Freight rolling stock profile:** The vast majority of rail freight - about 95% - is hauled by diesel locomotives. As noted above, this is because diesel locomotives provide the ‘go-anywhere’ flexibility that is so important to freight operators, particularly given the frequent need to use diversionary routes should main lines be closed for maintenance or renewal and dealing with distribution ‘spurs’.

2.55 Freight operators have invested significant sums in recent years in purchasing new diesel locomotives, primarily the Class 66 and 67s which now form the backbone of the rail freight industry. These vehicles and freight wagons have a similar lifespan to passenger vehicles. Consequently, many of the existing rail freight vehicles are likely to be in use up to and beyond 2022.

2.56 The base case (do-nothing) trajectory has been derived by scaling up

\(^{18}\) Further details of DfT’s appraisal methodology can be found at: [www.webtag.org.uk](http://www.webtag.org.uk).
the current provision of services to meet the forecast increase in demand. In particular, the increase in demand is assumed to be accommodated by adding more rolling stock based on recent designs. This type of stock is also assumed to replace the old stock that is taken out of service. No new designs of stock enter the base case trajectory.

2.57 The business as planned trajectory includes the CO2 impact of a number of CO2 saving measures. Consequently, emissions are forecast to be lower than they would be if no action were to be undertaken. In 2020, forecast rail CO2 emissions are lower than the base case by 10 - 14%.

2.58 Figure 2.10 and Figure 2.11 below summarise the output of the analysis of the likely paths of rail CO2 emissions. The projections for 2020 anticipate a near 50% reduction from 1990 levels in terms of CO2 emissions per passenger kilometre.

**Figure 2.10:** CO2 emissions under ‘Business as Planned’ maximum and minimum take up of measures, GB

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
<th>2014</th>
<th>2020</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX</td>
<td>MIN</td>
<td>MAX</td>
<td>MIN</td>
</tr>
<tr>
<td>Of which –</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electric trains</td>
<td>1,425</td>
<td>1,432</td>
<td>1,450</td>
<td>1,540</td>
</tr>
<tr>
<td>diesel trains</td>
<td>1,271</td>
<td>1,273</td>
<td>1,280</td>
<td>1,355</td>
</tr>
<tr>
<td>Freight rail (all diesel)</td>
<td>644</td>
<td>644</td>
<td>600</td>
<td>640</td>
</tr>
<tr>
<td>Total rail</td>
<td>3,340</td>
<td>3,349</td>
<td>3,298</td>
<td>3,495</td>
</tr>
</tbody>
</table>

*Source: DfT and rail industry analysis*
Figure 2.11: Forecast CO₂ emissions from the rail sector, GB

Source: DfT and rail industry analysis

2.59 To inform the “business as planned” trajectory, ATOC commissioned a survey of all its members (franchised passenger train operators), which involved face-to-face interviews with the engineering and environmental teams. Within the timescales of this paper, 11 major train operators franchises were covered, with the rest to follow.

2.60 The interviews explored the local CO₂ saving initiatives that train operators had underway, were actively planning or thought could potentially and realistically be achieved within their franchise periods, i.e. predominantly ending 2012-14. The results were then extrapolated across the TOCs not covered by the survey and fed into the Network Modelling Framework (NMF). The maximum and minimum range for passenger rail reflects uncertainties with regard to both the number of initiatives TOCs will implement and their likely impact on energy consumption (summarised in Figure 2.12).

Figure 2.12: Indicative CO₂ savings from planned TOC initiatives

<table>
<thead>
<tr>
<th>Measure</th>
<th>CO₂ savings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Hotel Load’ Management (1) Stabling Loads</td>
<td>2-3%</td>
<td>Ensuring trains are wholly or partly shut down when not in traffic so heating/lighting is not fully ‘on’ – a mixture of operational steps and improved technology for auto switch-off.</td>
</tr>
<tr>
<td>‘Hotel Load’ Management (2) Lighting and Heating Settings in Service</td>
<td>1-2%</td>
<td>Energy efficient lighting, revised thermostat settings and improved control technology.</td>
</tr>
<tr>
<td>Driving Technique</td>
<td>3-5%</td>
<td>‘Eco-driving’ techniques allied to improved timetabling and traffic regulation.</td>
</tr>
</tbody>
</table>
Engine/Traction system Management  
Degree of opportunity varies with traction type/service group. Solutions including limiting maximum power, selective shut-down of power packs etc.

Fleet Mileage Management  
Matching supply/demand; reducing ‘empty’ mileage for fuelling, berthing and maintenance activities.

Note 1: The CO₂ savings presented here reflect the potential savings from the individual initiatives separately, and are not necessarily cumulative.

Source: DfT and industry analysis

2.61 The ranges for freight are a consequence of those initiatives shown in Figure 2.13. Overall, the freight industry estimates that these initiatives will collectively deliver CO₂ emissions reductions of between 15% and 21%.

Figure 2.13: Indicative CO₂ savings from planned FOC initiatives

<table>
<thead>
<tr>
<th>Measure</th>
<th>CO₂ savings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary Power Units</td>
<td>4-8%</td>
<td>These small engines would reduce the need for engine idling and hence provide significant fuel saving.</td>
</tr>
<tr>
<td>Relocation fuel points</td>
<td>2-4%</td>
<td>Optimise position of fuel points to reduce unnecessary mileage</td>
</tr>
<tr>
<td>Driver Advice System</td>
<td>7-10%</td>
<td>Provide drivers with in-cab advice on whether to slow down or speed up based on the topography of the route.</td>
</tr>
<tr>
<td>Driver and Ground Staff Best Practice</td>
<td>3-5%</td>
<td>Training drivers in fuel-efficient driving techniques and paying more attention to marshalling train formations to reduce aerodynamic drag. Also improving general maintenance standards (air leaks etc)</td>
</tr>
</tbody>
</table>

Note 1: The CO₂ savings presented here reflect the potential savings from the individual initiatives separately, and are not necessarily cumulative.

Source: DfT and industry analysis

Key Drivers

2.62 During the period 1999/00 to 2006/07 train kilometres increased by 11% while passenger kilometres (pkm) rose by 21%.

2.63 The main demand drivers taken into account in the NMF include economic factors, such as GDP per capita and employment; population growth; and the impact of other modes, such as air passenger growth, car ownership, motoring costs, air, bus and underground fares; as well as endogenous factors such as committed timetable changes, rail reliability and fares, and levels of crowding.

2.64 Of these drivers, the key variables have been GDP per head (used to forecast increases in full and reduced fare ticket sales, which are mainly used by non-commuters), employment (used to forecast increases in season ticket sales, which are mainly used for the journey to work) and population.
**Sensitivity of the Forecasts**

2.65 There are a number of uncertainties around the robustness of forecasts based on this approach. Specifically:

- the demand drivers: uncertainties about their future values (such as employment in London or GDP forecasts for the shorter term);
- elasticities: these are assumed to be constant over time, though in practice we might expect them to decline in the future, as has occurred in the case of road travel;
- the future mix between diesel and electric of the rolling stock fleet, which will depend, inter alia, on the business case for electrification.

**Domestic aviation**

*Historic and Forecast CO₂ Emissions*

2.66 There were 25 million passengers travelling on flights between UK airports in 2006. This equates to 50 million domestic ‘terminal passengers’ at UK airports, and accounts for 22% of the 228 million total UK terminal passengers. The domestic total comprised 39 million passengers making purely domestic air journeys, and 11 million connecting with international flights.

2.67 Heathrow served the most domestic passengers (6 million), closely followed by Edinburgh (6 million) and Glasgow (5 million). London airports together accounted for 15 million (30%) of domestic terminal passengers, and therefore the majority (60%) of domestic air passengers were travelling to or from a London airport.

2.68 The journey purpose of those travelling on domestic air services (including both direct trips and those transferring onto other flights) is currently split evenly between leisure and business. However, leisure demand has grown faster in recent years, raising its share of domestic air travel from 43% in 1991 to 56% in 2006.

2.69 In 2006, UK domestic aviation emitted 2.3 million tonnes of CO₂ (MtCO₂) (6% of total aviation emissions including international emissions assigned to the UK on the basis of the IPCC guidelines), and less than 2% of domestic transport emissions. Figure 2.14 shows historic and

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19 Demand at airports is measured by ‘terminal passengers’, the number of passengers taking off or landing at an airport. A domestic flight involves one take-off and one landing, so one domestic flight is equivalent to two terminal passengers.

20 ‘London airports’ is defined here in line with the CAA’s definition in Airport Statistics Table 10.2, and includes Heathrow, Gatwick, Stansted, Luton, London City, and Southend.

21 CAA survey data for 1990 is not available.

22 National Atmospheric Emissions Inventory 2006.
It shows that emissions have grown steadily in the past, and that further growth is expected. CO₂ emissions from domestic aviation are forecast to increase by 26% between 2006-2020\textsuperscript{25}, due to demand rising (as incomes rise and air fares continue to decline) faster than improvements in fuel efficiency. However, the forecast growth is not completely smooth. This is due to the impact of capacity constraints (which are likely to limit domestic demand growth) and their relaxation when, in line with the Air Transport White Paper, additional capacity is assumed to be added at Stansted (2015) and Heathrow (2020).

**Figure 2.14:** Historic and 'business as usual' forecast domestic aviation CO₂ emissions, UK

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**Key Drivers**

Emissions of CO₂ from aviation are directly dependent upon the amount of fuel used. This is driven by factors such as the number of air traffic movements (ATMs), the distance flown, and aircraft fuel efficiency.

\textsuperscript{23} The 'business as usual' forecast differs marginally from that used for the appraisal of additional airport capacity in that it does not include a charge additional to air passenger duty (APD) on routes where APD does not already fully meet aviation's climate change costs. See 'UK Air Passenger Demand and CO₂ Forecasts', available at: http://www.dft.gov.uk/pgr/aviation/environmentalissues/ukairdemandandco2forecasts/airpassdemandfullreport.pdf.

\textsuperscript{24} The emissions data relate to CO₂ only.

\textsuperscript{25} These aviation forecasts have been updated since the published DfT forecasts in November 2007, taking into account improvements in methodology.
2.72 The number of ATMs and the distance flown are driven by growth in passenger demand and its distribution. Figure 2.15 illustrates this, by showing how growth in historic CO\textsubscript{2} emissions from domestic aviation has broadly tracked that of domestic terminal passengers. For example, between 1990 and 2006, domestic terminal passengers increased by 104\% and CO\textsubscript{2} emissions from domestic aviation grew 93\%.

**Figure 2.15:** UK domestic aviation terminal passengers and CO\textsubscript{2} emissions.

![Graph showing UK domestic aviation terminal passengers and CO\textsubscript{2} emissions.]

Source: *Transport Statistics Great Britain 2007; National Atmospheric Emissions Inventory 2006*

2.73 Key drivers of the growth in domestic air passenger demand are economic factors, such as growing consumer spending or GDP, and the declining cost of air travel. The demand for domestic aviation is strongly linked to changes in incomes. Our analysis shows that for a 1\% rise in GDP, domestic aviation trips tend to increase by 1.1\%.\textsuperscript{26} However, domestic demand is less responsive to price changes, with only a 0.15\% reduction in demand for a 1\% increase in fares.

2.74 Our analysis also shows that these drivers vary by journey purpose, with leisure demand being more responsive to both incomes and air fares. The income elasticity of domestic air travel demand is 1.3 for leisure, and 1.0 for business, while the price elasticity for leisure travel is found to be -0.3, with no significant price effect being found for business travel.

2.75 Incomes have risen steadily over recent decades, and are forecast to continue growing. Business and leisure air fares have declined in real

\textsuperscript{26} As mentioned earlier, aviation demand is usually measured by terminal passengers, not flights or trips. However, for comparability with other modes, trip elasticities are presented here. The elasticity of domestic trips with respect to incomes or fares is half that of terminal passengers with respect to the same variables.
terms by 17% and 18% respectively between 1990 and 2006. The overall domestic passenger fare has declined by 26% as the proportion of leisure passengers paying lower fares over the period has increased. Whilst the recent uplift in BERR’s oil price projections is likely to offset this trend in the near term, we expect the downward trend then to continue into the medium term, after which air fares are projected to flatten out. Combined with the demand elasticities, these projections mean domestic aviation demand growth is forecast to continue, driven largely by income growth and (to a lesser extent) by further declines in air fares.

2.76 Average domestic flight distance is projected not to change significantly in the future. Aviation fuel efficiency has improved steadily over recent decades, as technological advances and fleet turnover have delivered more efficient operations. The Intergovernmental Panel on Climate Change (IPCC) found that aviation fuel efficiency improved by 2.6% per annum between 1960 and 1980, then slowed to 1.2% per annum between 1980 and 2000. Our analysis projects this trend to continue, with efficiency for the UK fleet as a whole rising by 1% per annum from 2005 to 2030.

Sensitivity of the Forecasts

2.77 Our forecasts of domestic aviation demand and CO₂ emissions are found by applying central assumptions about the key drivers of demand and emissions within our aviation forecasting models. However, we also examine the sensitivity of the forecasts to varying the key assumptions (including oil prices, non-fuel airline costs, income growth, and fuel efficiency) within reasonable bounds.

2.78 Using the central assumptions, domestic aviation CO₂ is forecast to grow from 2.3 MtCO₂ in 2006 to 2.9 MtCO₂ in 2020. The sensitivity tests give a range around this forecast of 2.9 MtCO₂ to 3.0 MtCO₂. The range for 2020 is relatively narrow because the sensitivity tests which define the range (e.g. variations in GDP and oil price assumptions) lead to changes in domestic demand both directly, and indirectly via changes in international demand in a capacity-constrained airport system. These effects broadly offset in years when capacity constraints are tighter (e.g. before 2020). However, the range widens in later years, rising to 3.1-3.4MtCO₂ in 2030.

2.79 It is important to note that these 'business as usual' forecasts of domestic aviation emissions do not reflect the impact of one of the UK’s key domestic aviation policies: including aviation in the EU Emissions Trading Scheme. If introduced as currently proposed, all departing and arriving flights in the EU would be included and emissions from aviation (including international) would be capped at the average of 2004-06 emissions levels.

2.80 If introduced in 2012 in line with the European Council decision, the aviation sector would therefore have to purchase reductions in emissions from elsewhere in the scheme to cover all emissions above the cap. This would mean that after 2012, aviation’s emissions net of reductions it
purchases elsewhere would remain at 2004-06 levels (see the illustration for the EU in Figure 2.16).

**Figure 2.16:** CO₂ emissions from EU aviation (all departing and all arriving flights) after inclusion within the EU ETS.

![Graph showing CO₂ emissions from EU aviation (all departing and all arriving flights) after inclusion within the EU ETS.](image)

*Source: DfT*

**Domestic shipping**

*Historic and Forecast CO₂ Emissions*

2.81 Between 1970 and 1996, CO₂ emissions from UK domestic shipping, as measured by the NAEI (based on sales of marine bunker fuels for national navigation within the UK) fluctuated around a relatively stable long-run average (Figure 2.17). However, the decade from 1996 was characterised by a much greater degree of volatility than in previous years, with recorded bunker fuel consumption by domestic shipping (and hence CO₂ emissions as measured by the NAEI) declining by 45% between 1996 and 2002, and climbing again to 38% above 1996 levels by 2006.

2.82 The recent volatility of measured CO₂ emissions from national navigation is not consistent with changes in the volume of freight passing through UK ports. The volume of freight moved by domestic shipping, as measured on a tonne-kilometre basis, grew by 22% between 1996 and 2006.

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28 The Intergovernmental Panel on Climate Change (IPCC) defines “domestic shipping” to include Domestic Waterborne Navigation, Fishing and Naval emissions.

29 CO₂ emissions should follow the number of tonne-kilometres moved around the UK coast more closely than tonnes of freight, because the measure accounts for distance travelled by the goods as well as weight. However, for modelling purposes tonnes of freight are used and distance travelled is assumed constant.
2002, but has since declined to 6% below 1996 levels in 2006\textsuperscript{30}. Figure 2.17 plots indices of NAEI measured CO\textsubscript{2} emissions, freight moved and freight lifted at ports.

2.83 Over most of the period from 1970 to 2006, the three series have followed similar trends. However, two periods of significant divergence are apparent: in the late 1970s the domestic shipping industry changed dramatically with the increasing production and transportation of North Sea oil and gas. This affected traffic volumes and distances significantly but is not reflected in increased UK sales of bunker fuel to domestic shipping, and thus measured CO\textsubscript{2} emissions. In the last ten years traffic and emissions trends have also diverged.

**Figure 2.17:** Domestic shipping CO\textsubscript{2} emissions, freight tonnes and freight tonne-km of port traffic, UK

![Graph showing indices of CO\textsubscript{2} emissions, freight moved, and freight lifted at ports from 1970 to 2005.]


2.84 Achievement against the UK’s CO\textsubscript{2} targets will be measured by the NAEI. Consequently, it is necessary to understand fluctuations in the NAEI series and produce forecasts consistent with NAEI that may be used to inform policy.

2.85 NAEI bases its calculation of CO\textsubscript{2} emissions on the amount of fuel sold to all ships in the UK, as recorded by BERR. Fuel sales are disaggregated by sales to ships operating domestically and ships operating internationally. Emission factors are then applied to the fuel sales data to obtain tonnes of CO\textsubscript{2} for domestic and international

\textsuperscript{30} Transport statistics bulletin: Waterbourne freight in the United Kingdom. Figures pertain to tonne-kilometres of freight.
Carbon Pathways Analysis

Chapter 2: Carbon Pathways by Mode

2.86 For example, prior to 1997, ships could dump oily water and other fuel residues at sea if they were not suitable for combustion. In 1997 the Merchant Shipping Act banned this practice and encouraged ships to deposit these by-products at port reception facilities. Recycled fuel residues are netted out of sales of fuel oil, so the quantity of fuel recorded as sold to domestic shipping, and therefore the quantity of CO₂ emitted, appeared to decline in the years immediately before and after this change by much more than the change in domestic shipping traffic.

2.87 In 2006, BERR also changed the way in which fuel sales were assigned between domestic and international shipping. This is likely to have increased the fuel figure for domestic shipping and hence led to an increase in the NAEI measure of CO₂ emissions.

Box 5: Domestic Shipping in the Global Context

Shipping operates in national and international markets and shipping companies have weak links to individual nation states in terms of ownership, management and operations. Therefore, UK domestic shipping needs to be placed in the global context:

- Slow global economic growth in 2001 and 2002 caused lower demand growth for global shipping services, particularly in the containerised sector, and depressed freight rates. Oil prices remained strong despite this slowed growth, so ships experienced declining revenue and relatively higher operating costs. This would have an impact on both the number of ships operating and their fuel efficiency decisions.

- 2002 coincided with the trough of a global shipping cycle, with new capacity coming on-line at a time when demand growth was flat in many markets. As new-build prices and freight rates fell, demand began to recover, and 2003 saw the start of the longest sustained up-swing in the cyclical global shipping market since the early 1970s. 2003 also saw significant rises in commodity prices, making bulk shipping more profitable.

- Between 2003 and 2006 there was very strong demand for tankers in the US and Asia, but a low level of fleet growth which led to large rises in freight rates. Similarly, the expansion of the Chinese economy (the “China effect”) since China joined the World Trade Organisation in 2001 has increased demand for dry bulk vessels importing iron ore and for container ships to export manufactured goods.

2.88 Modelling: With the characteristics of the NAEI National Navigation series in mind, we have attempted to explain the series in an
econometric model, with a view to projecting domestic shipping CO₂ emissions into the future. A model of emissions explained by domestic shipping tonnes lifted and Brent crude oil price, estimated over the years 1976 to 2006, gives an unexpected statistically significant positive coefficient on the oil price variable. This appears to suggest that higher shipping costs increase the demand for shipping. However, when the model is estimated over the period 1976 to 2002, a statistically insignificant negative price variable is found. Whilst the effects of oil prices on CO₂ are further investigated, forecasts are based upon forecasts of tonnes lifted by domestic ships alone.

2.89 The simple model finds that an increase of 1 million tonnes of traffic lifted at UK ports is associated with an increase of around 23,000 tonnes CO₂ emissions from domestic shipping in the same year.

2.90 DfT port traffic forecasts for domestic sea freight are input into the 1976-2002 model to determine CO₂ growth rates, which are applied to the 2006 outturn level of NAEI measured CO₂ emissions to forecast domestic shipping CO₂ emissions to 2022.

**Figure 2.18:** Forecast CO₂ emissions from UK domestic shipping

<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast million tonnes CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>2006</td>
<td>n/a</td>
</tr>
<tr>
<td>2010</td>
<td>7.1</td>
</tr>
<tr>
<td>2015</td>
<td>6.8</td>
</tr>
<tr>
<td>2020</td>
<td>6.5</td>
</tr>
<tr>
<td>2022</td>
<td>6.5</td>
</tr>
</tbody>
</table>

*Source: DfT analysis*

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31 A model containing a single lag of oil price was found to have a price coefficient of -0.015, significantly different from zero at 75% confidence. This is considered too low a confidence level to be sure that oil price had any affect on CO₂ emissions beyond its effect on tonnes lifted by domestic shipping.

32 Diagnostic tests reveal that tonnes lifted by domestic shipping at ports are highly significantly correlated to levels of CO₂ emissions although there is evidence of an omitted relevant variable in this simple model.
Figure 2.19: Historic and forecast CO₂ emissions from UK domestic shipping

Source: Historic CO₂ emissions data for national navigation from the National Atmospheric Emissions Inventory. Historic oil prices are taken from the BP Statistical Review of Global Energy 2007 and historic port traffic data are from DfT Maritime Statistics 2006. BERR oil price projections and DfT forecasts of port traffic\(^{33}\) up to 2030.

2.91 The model does not satisfactorily explain the years 2003-2005, and cannot account for the change in allocation methodology of the NAEI series in 2006. However, the circumstances of the past five years that led simultaneously to flat demand and a rise in NAEI measured CO₂ emissions are not expected to continue.

2.92 To consider these circumstances in more detail, the key drivers section below pays special attention to the unusual market conditions that may have led to a decline in fuel efficiency in some sectors of the market in spite of rising operating costs and flat demand.

**Key Drivers**

2.93 Domestic shipping CO₂ emissions are a by-product of fuel combustion. Increases in demand for fuel arise most notably from:

- additional ships operating domestically in the UK;
- ships operating over longer distances; and
- increases in the speed of existing ships and other ship management practices that affect fuel efficiency.

2.94 The forecasts assume the distance travelled by freight around the coast

will remain constant over the forecast period\textsuperscript{34}. This discussion therefore concentrates on demand for more ships and fuel efficiency.

2.95 **Demand for water freight**: Unlike many industries, water freight demand is thought to have a low price elasticity, at least in the short to medium run\textsuperscript{35}. In addition, increases in freight rates in recent years have done little to dampen increasing international seaborne trade and we believe the same is true for the domestic market. Consequently, the primary drivers of demand for ships operating domestically in the UK relate to consumption of the goods these ships are carrying.

2.96 At a very general level, the demand for domestic shipping is affected by GDP growth and international trade. As more international freight arrives at UK ports, some of it will be distributed around the UK by ship. The main categories of domestic freight that move by sea are crude oil and petroleum products, unitised traffic (containerised and roll-on roll-off trailers and lorries) and aggregates.

**Box 6: Domestic Shipping Freight**

Around 20% of the crude oil\textsuperscript{36} that is extracted on North Sea platforms is transported by sea to storage facilities on the coast of the UK, contributing to domestic demand for liquid bulk shipping. Furthermore, movements between these storage facilities and refineries tend to be by sea, contributing to coastwise domestic shipping. There is no indication that refinery capacity will change significantly in the UK over the forecast period, despite domestic demand for refinery products exceeding domestic supply, and as extraction of North Sea oil declines after 2010, liquid bulk traffic is also expected to decline.

Demand for aggregates is driven by the construction industry. Road construction and maintenance and housing account for around 60% of consumption of aggregates, in roughly equal measure. Public expenditure on road building and maintenance and the state of the housing market are therefore key determinants of domestic movements of "other dry bulks" (the cargo category that includes aggregates). In line with the 2001 report, *National and Regional Guidelines for Aggregates Provision in England 2001-16*\textsuperscript{37}, demand for other dry bulks is expected to grow steadily over the next 15 years.

2.97 **Fuel efficiency**: the average efficiency of ship engines is expected to remain constant in the domestic shipping fleet over the forecast period. This is because there is not expected to be significant technological innovation and the turnover of the large stock of vessels is slow.

2.98 However, a vessel’s speed can have a very significant effect on fuel efficiency. Where profits can be increased from faster delivery of goods,

\textsuperscript{34} There is no trend of increase or decrease in the average distance travelled by domestic waterborne freight. In 2006, domestic waterborne freight travelled on average 411km, compared to 483km in 2002 and 389km in 1996. Source: Waterborne Freight in the United Kingdom 2006, DfT.

\textsuperscript{35} See for instance Stopford, M. Maritime Economics 2\textsuperscript{nd} ed. p143. London, Routledge

\textsuperscript{36} In 2003, 23 million tonnes was transported by sea, compared to 83 million tonnes by pipeline.

\textsuperscript{37} Published by the Office of the Deputy Prime Minister.
fuel efficiency is often sacrificed, and this is generally the case when freight rates are high compared to operating costs. In short, rises in freight rates may significantly increase CO₂ emissions per tonne-kilometre.

2.99 If a ship travels at only moderately higher speeds, fuel efficiency dramatically decreases. For instance, fuel consumption may be up to one third higher for a vessel travelling at 24 knots compared to the same vessel at 20 knots. There is a trade-off to be made between faster delivery of goods, incurring higher fuel costs, and slower delivery but lower fuel costs. In a commercial setting the optimal speed will be chosen to maximise profits, so where sea freight rates are high compared to fuel prices and other operating costs, faster speeds are likely.

2.100 Over the last decade, sea freight rates and oil prices have followed broadly the same trend, rising and falling around the same time (see Figure 2.20). Sea freight rates have tended to be more extreme in their fluctuations, so as oil prices rise, freight rates have tended to rise further.

**Figure 2.20**: Index of oil prices and sea freight rates

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Source: Historic oil prices are taken from the BP Statistical Review of Global Energy 2007 and sea freight rates are taken from various editions of ISL shipping statistics yearbooks.
Box 7: Oil prices and Domestic Shipping Fuel Efficiency

The finding that higher oil prices may recently have been associated with lower fuel efficiency is counter-intuitive. To understand this, recall that sea freight is thought to be unresponsive to changes in the cost of shipping in the short to medium run. This includes both demand for sea freight and supply of ships. A rise in the oil price increases costs to all users of sea freight, but demand is not reduced significantly. It also takes a number of years to build new ships, and a number of months to bring existing ships into a new high-demand market (longer if refits are needed). This combination of unresponsive supply and demand affords scarcity profits to ship operators, allowing them a degree of discretion over sea freight rates.

For container ships, as fuel prices have continued to rise there have been reports that some container shipping lines have chosen to slow their ships to conserve fuel at a time when new vessel capacity is coming into service.

The liquid bulk sector is responsible for transporting oil. Oil products are primarily used as transport fuels, for which there is little ready substitute. As oil prices have risen, therefore, demand for oil has not appreciably slackened (it will be interesting to see if this remains the case as oil prices have continued to rise). In addition, rules scrapping single hull tankers have tightened vessel supply. These factors have allowed sea freight rates to rise in line with, if not faster than, the oil price.

Internationally, oil is also used for energy provision. The primary substitute for oil in energy markets is coal, which is transported by the dry bulks sector. A rise in oil prices can therefore be expected to result in a rise in demand for coal. However, bringing extra ships on line to meet this additional demand for coal takes time, so in the mean time to restore market equilibrium for dry bulks, freight rates rise. It is thought that the demand for sea freight has a low price elasticity, so freight rates must rise significantly to reduce demand by only a small amount. This would account for the relative volatility of freight rates compared to oil prices.

It may therefore be the case that, since 2003, freight rates have reacted to oil prices, but can be expected to re-adjust over the medium term as increasing shipping capacity comes on stream.

This suggests that fuel efficiency can partly be explained by sea freight rates. However, investigation of models including freight rates returned insignificant and unsatisfactory results. Furthermore, it is not currently possible to forecast freight rates so inclusion in the model would not have improved its explanatory power.

Sensitivity of the Forecasts

2.101 We have generated a forecast range for CO₂ emissions around the 95% confidence interval (shown in Figure 2.19 above) of the coefficient on tonnes lifted by domestic shipping. The high and low emissions scenarios help to indicate the scale of uncertainty in the forecasts but there are also other important sensitivities and limitations:

- The model uses DfT forecasts of domestic sea freight at major ports, defined as those that handle at least one million tonnes of domestic and international freight annually. Future domestic traffic
at minor ports and on inland waterways is not an explicit input to the emissions forecasting model.

- The DfT central forecast of future domestic sea freight at major ports is based upon an econometric model for the containerised sector and judgements about future policy, market and societal trends up to 2030 for other commodities. Errors in these judgements could lead to inaccuracy of the CO$_2$ emissions forecast.

- Crude oil and petroleum products and aggregates are major sectors of domestic traffic so the emissions forecasts will be particularly sensitive to any shocks in these sectors.

- It is likely that operating costs have a significant impact on CO$_2$ emissions by affecting efficiency decisions. However, using oil price to pick up this effect produced unexpected results and it was not unambiguously a relevant variable. We continue to investigate the effects of oil price and will update the forecasts as necessary.

- 2006 saw a change in the way bunkers are defined as domestic or international, which may have led to an upward shift in the inventory of emissions from domestic shipping. It is not clear how much of the increase between 2005 and 2006 (from 4.2 to 5.5 million tonnes of CO$_2$) is the result of this change, and how much is a result of a real increase in emissions.

- The 1997 Merchant Shipping Act banned the dumping of oily bilge water at sea, and required it to be recycled (as discussed above). The scale of this impact cannot be assessed from the statistics, but it coincides with a year-on-year reduction of emissions to 2002. It may be that this period represents a step-change that the model cannot account for.

- It has not been possible to model historic or future fleet management strategies that can have an effect on fuel efficiency.

- The forecasting model that links tonnes passing through UK ports and oil prices to CO$_2$ emissions relies on consistent CO$_2$ data, which the NAEI series may not represent.

2.102 A modelling approach that maps all shipping movements in terms of distance travelled and time taken, and one which employs fuel use data and emission factors for specific engine types, might yield much more robust disaggregated CO$_2$ forecast estimates. The Department for Environment, Food and Rural Affairs (Defra) is currently funding research into the feasibility of this approach.
3. Carbon Pathways by Type of Journey

Key Messages

In 2006, passenger travel and (non-freight) van travel was estimated to account for about 90 MtCO₂ (about 70% of domestic transport emissions) and freight transport for about 40 MtCO₂ (about 30%).

CO₂ emissions from passenger travel: Our analysis of passenger travel by journey purpose suggests that certain purposes are associated with a greater proportion of CO₂ emissions than the proportion of passenger distance travelled. For example, commuting trips are associated with 19% of passenger distance travelled, but 24% of CO₂ emissions from all modes of passenger travel. Conversely, holidays and day trips account for 11% of passenger distance travelled, but only 8% of CO₂ emissions.

Analysis of journey length shows that short car driver trips (of less than 5 miles) account for a large proportion (57%) of total trips made by household car (and therefore travel decisions), but produce under 20% of CO₂ emissions. Longer trips (of over 50 miles) only account for 2.3% of trips made, but produce about 23% of CO₂ emissions from household cars.

Commuting and business trips are associated with relatively low average car occupancy, and this results in relatively high CO₂ emissions per passenger per car. These journeys also tend to be made at the busiest times of the day and week, resulting in slower average speeds, which are associated with higher emissions.

Larger cars, which generally have higher emissions per kilometre, are also used in greatest proportions for business trips, although the proportion of business mileage driven in diesel vehicles (which generally have lower CO₂ emissions per kilometre) is higher than for other purposes.

CO₂ emissions from freight: Fuel efficiency improvements in Heavy Goods Vehicles since the 1980s has limited the increase in CO₂ that would otherwise have resulted from the increase in road freight activity. These changes have been driven by customer pressure on manufacturers to deliver vehicles with improved fuel economy and, initially, the effect of better engine management systems required to meet European-wide air quality emissions standards introduced from the early 1990s. However, progressive tightening of air quality standards since then has reversed the trend of year-on-year improvements in vehicle fuel economy.
Introduction

3.1 The previous chapter looked at how people travel, and how goods are transported, by mode. This chapter looks at why journeys are made, and their associated CO₂ emissions. It provides an outline of initial analysis undertaken to produce carbon pathways by journey type, in terms of both journey purpose and journey length. With further information (on costs and technologies, for example), this can then be used to help inform decisions about whether it may be most cost-effective, in terms of carbon abatement, to focus policies to reduce CO₂ emissions on particular types of journey.

3.2 The chapter is split into two sections covering passenger travel (section 1) and freight (section 2). In 2006, passenger travel and (non-freight) van travel was estimated to account for about 90 MtCO₂ (about 70% of domestic transport emissions) and freight transport for about 40 MtCO₂ (about 30%). The section below estimating CO₂ emissions from passenger travel accounts for about 65 MtCO₂, due to the limited coverage of the DfT model (discussed further below).

Section 1: Passenger Travel

CO₂ Emissions by Journey Type

3.3 The National Atmospheric Emissions Inventory provides historic estimates of CO₂ emissions by mode (how people travel), as set out in chapter 2. However, it does not provide estimates by journey purpose, or why people travel. DfT has therefore carried out some analysis and developed a model to estimate the relative contribution to CO₂ emissions of different types of journeys.

3.4 Our model is primarily based on data from the National Travel Survey (NTS). CO₂ emissions have been estimated for all surface modes of transport 38 and for domestic aviation.

Box 8: The National Travel Survey

The National Travel Survey (NTS) is a continuous household survey which collects information on travel patterns in Great Britain. The survey collects data from approximately 8,000 households, containing around 19,000 individuals, each year. Information on the household, each individual within the household and any vehicles to which the household has access, is collected via a face to face interview. Each household member is then asked to record details of their trips over a 7 day period. Data on travel patterns can therefore be linked to information on individual, household and vehicle characteristics.

38 Surface transport includes household cars/vans, taxis, buses, coaches, surface rail, underground, light rail, motorcycles, walking and cycling. Shipping is excluded from the estimates because all shipping kilometres are classed as freight for the purposes of this paper. In reality, there may be a small percentage of domestic shipping kilometres which are undertaken for the purpose of carrying passengers, but all movements are assigned to freight here for simplicity in the estimates.
3.5 Our analysis presented in this section is subject to various constraints relating to the coverage and design of the NTS. The results should therefore be interpreted with care and the following points should be taken into account:

- As the NTS is a household survey, it excludes travel by people not living in households, such as students in halls of residence and tourists or other visitors from abroad.

- The NTS only collects information on personal travel; this is travel for private purposes, or for work, or for education. Trips made in the course of work are included provided that the purpose of the trip is for the traveller to reach a particular destination. However, travel to deliver goods, or to convey a vehicle or passengers (e.g. a bus driver or taxi driver), or as a driver/crew of public service vehicles (e.g. fire engines, police cars, ambulances), is not covered.

- Information on vehicle type (fuel type and engine size) is only available for trips made by household vehicles. Therefore car travel by non-household vehicles is not included in the model.

- In line with conventional presentation of NTS data, travel by household vans is included with 'car' travel. However, as the model only includes personal travel by household vehicles, a significant proportion of overall van travel is excluded.

3.6 These exclusions mean that the CO₂ emissions estimated by the model are lower than those given in the domestic transport sector of the National Atmospheric Emissions Inventory. Moreover, these issues are likely to have a disproportionate affect on some purpose categories, such as business.

3.7 Throughout this section, the following journey purpose classification has been used:

- **commuting**: trips from home to a usual place of work, or from work to home;
- **business**: trips in the course of work, including a trip made in the course of work back to work;
- **education/escort education**: trips to educational institutions such as a school or college, by students and those escorting students;
- **shopping**: trips to shops or from shops to home, even if there was no intention to buy;
- **other personal business/escort**: visits to services such as hairdressers, libraries, laundrettes, banks, doctors and accompanying others on a trip;
- **visiting friends at private home**: visits to meet friends, relatives or acquaintances at someone’s home;
- **visiting friends elsewhere**: visits to meet friends, relatives or acquaintances at a pub, restaurant, etc;
• **holiday/day trip**: trips (within Great Britain) to or from any holiday (including stays of 4 or more nights with friends or relatives), or trips for pleasure within a single day; and
• **other leisure**: all types of entertainment or sports, clubs and voluntary work, etc.

**All Passenger Transport Modes**

3.8 Figure 3.1, Figure 3.2 and Figure 3.3 show the distribution of travel by purpose using three different measures: trips\(^{39}\), distance and CO\(_2\) emissions.

**Figure 3.1**: Trips by all modes of passenger transport by journey purpose, GB, 2002/2006 average

\[\text{Source: DfT analysis}\]

\(^{39}\) The NTS defines a trip as a one way course of travel with a single main purpose. A trip consists of one or more stages, where a new stage is defined when there is a change in the form of transport or a change of vehicle requiring a separate ticket. Estimates of distance travelled by mode are based on stage distance and therefore include travel by different modes as part of a single trip.
**Figure 3.2:** Passenger distance travelled by all modes of passenger transport by journey purpose, GB, 2002/2006 average

- Holiday/day trip: 11%
- Visit friends elsewhere: 4%
- Visit friends at private home: 15%
- Shopping: 13%
- Other personal business/escort: 15%
- Other leisure: 7%
- Commuting: 19%
- Business: 10%
- Education/escort education: 5%

*Source: DfT analysis*

**Figure 3.3:** Estimated CO₂ emissions from all modes of passenger transport by journey purpose, GB, 2002/2006 average

- Holiday/day trip: 8%
- Visit friends elsewhere: 3%
- Visit friends at private home: 13%
- Shopping: 14%
- Other personal business/escort: 15%
- Other leisure: 6%
- Commuting: 24%
- Business: 13%
- Education/escort education: 4%

*Source: DfT analysis*
3.9 Data on trips give an indication of the proportion of individual travel decisions associated with each purpose category (Figure 3.1).

3.10 As the average trip length varies by trip purpose, the distribution of travel by purpose is different when using number of trips compared with distance travelled. For example, as education and escort education trips tend to be relatively short, they account for 11% of trips but only 5% of distance travelled. Commuting trips, on the other hand, tend to be longer than average and commuting therefore accounts for a smaller proportion of trips (16%) than distance (19%) (Figure 3.2).

3.11 The distribution is different again when considering CO₂ emissions. For example, commuting trips are associated with 19% of passenger distance, but 24% of CO₂ emissions from all modes of passenger transport. Conversely, holiday/day trips account for 11% of passenger distance, but only 8% of CO₂ emissions (Figure 3.3).

3.12 Figure 3.4 shows distance travelled by main mode of transport for different journey purposes.

**Figure 3.4:** Total distance travelled per person per year by purpose and main mode of transport, GB, 2006

![Figure 3.4: Total distance travelled per person per year by purpose and main mode of transport, GB, 2006](image)

*Source: National Travel Survey 2006*

3.13 For most journey purposes, at least 75% of the total distance travelled is by car (as a driver or passenger); the exception being education/escort education, where car is the main mode for 53% of journeys. The majority of the distance travelled for commuting and business – about 66% and 74% respectively – is as a car driver. This compares to about 51% of
distance travelled for shopping trips, 41% for other leisure trips and 31% for day trips/holidays.

3.14 The mode of travel also varies depending on the trip length. Figure 3.5 and Figure 3.6 show this relationship for commuting and education/escort education respectively. For example, in 2006, 78% of commuting trips and 81% of education trips which were under a mile were made by walking or cycling. Only a negligible percentage of trips over 5 miles are made by these modes.

Figure 3.5: Mode of travel for commuting trips by trip length, GB, 2006
Figure 3.6: Mode of travel for education/escort education trips by trip length, GB, 2006

Note: ‘Other’ includes travel by taxi, surface rail, light rail, London Underground and motorcycle.
Source: National Travel Survey 2006

Estimating CO₂ Emissions by Mode and Purpose

3.15 When estimating the CO₂ emissions associated with different modes for each journey purpose, the methodology used in this paper to determine the estimates for car journeys differs from that for other modes.

3.16 For journeys by car, each unit of capacity – the car – is more likely to carry passengers for a single journey purpose. Certain purposes may then be associated with car trips that generate higher CO₂ emissions than others. The reasons for this therefore need to be considered in order to best inform how policy might be targeted to reduce emissions from travel for different journey purposes. These reasons are explored below.

3.17 The estimates that follow for household car journeys have been derived using a model based on data from the National Travel Survey (distance travelled and average speed by journey purpose), fuel consumption speed curves and fuel to CO₂ conversion factors. The estimates take into account the fuel type (petrol or diesel) and the engine size of the car by each journey purpose. A fleet average for Euro Standard is applied.

3.18 There are limitations to the approach. The model does not include:

- explicit fuel penalties associated with cold starts;
- the type of car driven (make, model and age), though the fleet Euro Standard partly reflects age; or
• the road type the journey is made on (such as motorway or local road).

3.19 Also, it is likely that the average speed data derived from the NTS is underestimated for short journeys.

3.20 The estimates produced by the model for fuel consumption are not constrained to the total fuel consumption data held by BERR, nor are the resulting CO₂ emissions estimates grossed up to the total recorded in the NAEI.

3.21 It is important to note that the level of disaggregation of the NTS necessary to carry out the analysis presented in this section means that some results are based on small samples. The model also uses a large number of variables, each of which is an estimate; combining these estimates in a model amplifies the level of uncertainty associated with the results. The results presented here should therefore be treated as preliminary findings and any conclusions drawn should be used with caution.

3.22 Fuel penalty estimates associated with cold starts could be introduced to the model and the impacts calculated by combining methods used in COPERT⁴⁰ and ARTEMIS⁴¹. Our initial analysis suggests that taking account of the impact of cold starts on emissions would not change the broad picture of relative emissions by journey distance band. However, we intend to investigate further the potential impacts of cold starts on the CO₂ emissions from household cars and will look to get advice from experts on how to incorporate this variable into our model. The journeys likely to be affected most by cold starts are ones which are shortest.

3.23 In terms of the other modes of passenger travel, for journeys made by coach or rail, for example, one unit of capacity – a coach or a rail carriage – can carry a range of passengers who are each travelling for different purposes. The average emissions per passenger are therefore assumed to be the same across the different journey purposes. Emission factors per passenger kilometre from Defra’s Company Reporting Guidelines⁴² have been combined with distance travelled data from the NTS to determine these emissions.

3.24 CO₂ emissions from journeys by plane between two GB airports have been estimated using DfT’s UK Air Passenger Demand and CO₂ Forecasting model. The NTS records journeys by plane as the survey asks respondents to record all journeys made during a particular week. However, because not many people make a domestic flight in an average week, the sample sizes become too small when analysed by journey purpose to give robust results. The coverage of the estimated aviation emissions includes the domestic part of domestic-international

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⁴⁰ For further information on COPERT see http://lat.eng.auth.gr/copert.
⁴¹ For further information on ARTEMIS see http://www.trl.co.uk/ARTEMIS.
transfer journeys (about a fifth of trips). Trips made by foreign passengers are also included in these estimates of aviation CO$_2$ emissions.

**Historic CO$_2$ Emissions from Household Car Journeys**

3.25 The following section looks in more detail at those journeys made by car. All references in this section to car journeys refer to travel in household cars and vans made by people living in households and for personal travel purposes only.

3.26 Figure 3.7 and Figure 3.8 below set out estimated historic CO$_2$ emissions by journey purpose for journeys by car in Great Britain, based on DfT analysis.

**Figure 3.7:** Estimated CO$_2$ emissions from household car journeys by journey purpose, GB, 1996 - 2006

*Source: DfT analysis*
### Figure 3.8: Estimated passenger distance travelled and CO₂ emissions from household car journeys by journey purpose, GB, 1996 - 2006

<table>
<thead>
<tr>
<th></th>
<th>1996 CO₂ pkm</th>
<th>2000 CO₂ pkm</th>
<th>2003 CO₂ pkm</th>
<th>2006 CO₂ pkm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuting</td>
<td>27</td>
<td>20</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Business</td>
<td>14</td>
<td>11</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Education/escort ed.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Shopping</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Other personal</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Visiting friends</td>
<td>14</td>
<td>17</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Visiting friends</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Holiday/day trip</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Other leisure</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>All purposes</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Totals: MtCO₂ / million pkm**

- 1996: 57 MtCO₂ / million pkm
- 2000: 486.988 million pkm
- 2003: 506.691 million pkm
- 2006: 503.091 million pkm

*Source: DfT analysis*

#### 3.27

The estimates reported in Figure 3.7 and Figure 3.8 show that CO₂ emissions from car journeys by journey purpose have stayed relatively stable over time. Figure 3.9, Figure 3.10 and Figure 3.11 show estimated trips, passenger distance travelled and estimated CO₂ emissions respectively from household car journeys by journey purpose in 2006.
Figure 3.9: Trips by household cars by journey purpose, GB, 2006

Source: DfT analysis

Figure 3.10: Passenger distance by household cars by journey purpose, GB, 2006

Source: DfT analysis
3.28 In 2006, as in previous years, the estimates suggest that commuting trips were responsible for the greatest proportion of CO2 emissions (25%), followed by other personal business/escort (16%). Shopping, visiting friends at home and business journeys all accounted for similar proportions (12%-14%). Car journeys to visit friends elsewhere (not at a private home) and for education contributed the least amount to CO2 emissions (3% each).

3.29 This closely follows the proportion of emissions by journey purpose for all passenger modes, reflecting the fact that the majority of journeys are made by a car.

**Forecast CO2 Emissions from Car Journeys**

3.30 Figure 3.12 shows base year emissions (2003) and forecast emissions from car journeys by journey purpose from the National Transport Model (NTM)\(^\text{43}\). The NTM forecasts a slight increase in the proportion of CO2 emissions associated with "discretionary other" (recreation, visiting friends, holidays/day trips). Emissions associated with commuting and employer's business trips are forecast to fall slightly as a percentage of the total. Emissions from other journey purposes are forecast to change very little.

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\(^{43}\) Car emissions from the NTM differ from those estimated by our model based on NTS data. The NTM represents all cars, not just household cars, and is constrained to the CO2 emissions total for GB in the NAEI. The NTM also uses different journey purpose categories.
Figure 3.12: Forecast CO₂ emissions by NTM journey purpose from cars, GB, 2003 - 2025

Key Drivers of CO₂ Emissions from Car Journeys

3.31 Figure 3.10 and Figure 3.11 show that CO₂ emissions from household car journeys reflect quite closely the proportion of passenger distance travelled across the journey purposes. However, this relationship is not exact - for example, commuting trips account for 19% of car passenger distance, but 25% of CO₂ emissions.

3.32 The emissions from car journeys associated with each journey purpose depend on a range of factors, including:

- the total distance travelled (a product of average journey length and number of trips made by purpose);
- the journey speed;
- the type of vehicle (fuel used and engine size); and
- the vehicle occupancy rate.

Distance Travelled

3.33 Estimates of CO₂ emissions by journey length are shown in Figure 3.13 below. This suggests that a significant proportion (about a quarter) of CO₂ emissions from household car journeys are generated by trips of between 10 and 25 miles. Journeys under 5 miles account for about 20% of CO₂ emissions while journeys over 50 miles account for about 23%.
Figure 3.13: Estimated CO₂ emissions from household cars by journey length, GB, 2002/2006 average

Source: DfT analysis

3.34 These estimates are broken down further into estimates of CO₂ emissions from car journeys by journey purpose and journey length (Figure 3.14). These CO₂ estimates are calculated using the same methodology as set out in paragraph 3.17, but include additional breakdowns of average speed for each distance band. Results are based on 2002-2006 averages. The limitations of the modelling discussed earlier still hold. In particular, the exclusion of cold start fuel penalties will have a greater affect on the shorter distance bands, but are not expected to change the broad picture.

3.35 The analysis suggests that of those journeys between 10 and 25 miles, over a third of the emissions are from commuting, with other personal business/escort and shopping both accounting for about 15% each. Holiday/day trips take up increasing proportions of emissions as journey length increases. It is also notable that business trips account for the highest proportion of emissions for trips of 50 miles and over.
Figure 3.14: Estimated CO₂ emissions from household cars by journey purpose and journey length, GB, 2002/2006 average

![Graph showing CO₂ emissions by journey purpose and length.]

Source: DfT analysis

3.36 Figure 3.15 shows cumulative trips, passenger distance and CO₂ emissions from household car journeys by journey length. This indicates that nearly 20% of CO₂ emissions arise from journeys of less than 5 miles, and 62% of emissions arise from journeys of less than 25 miles.
Figure 3.15: Cumulative trips, passenger distance and CO₂ emissions from household car journeys by trip length, GB, 2002/2006 average

Source: DfT analysis

3.37 Figure 3.16 shows the proportion of trips against associated CO₂ emissions by distance band. It suggests that for journeys under 10 miles, the number of trips made is a greater proportion that the proportion of CO₂ emissions. The converse is true for journeys of over 10 miles in length.

Figure 3.16: Proportion of trips and CO₂ emissions from household car journeys by trip length, GB, 2002/2006 average

Source: DfT analysis
3.38 In policy terms, the number of trips, and therefore the number of individual travel decisions to influence, is much higher for shorter journeys. Looking just at household car trips (for all purposes), the analysis in Figure 3.15 shows that 23% of trips were under 2 miles, and 57% were under 5 miles (2002/2006 averages). The results of the National Travel Survey show that these proportions have remained fairly constant over the last 10 years.

3.39 Policy measures or technology options which impact on journeys over 5 miles would be aimed at less than half (43%) of trips (and therefore travel decisions) made, but the analysis indicates that this would target about 80% of CO₂ emissions from household cars.

3.40 Another factor to consider is that some shorter trips may be on the way to or from somewhere else. For example, in 2006, 71% of escort education trips were followed by a trip to home; 9% were followed by a trip to work or on business, and 4% by a trip to the shops. Considering only those trips taking children to school in the morning, 59% were followed by a trip home and 17% were followed by a trip to work or business. Therefore switching short car trips to more sustainable modes will not necessarily eliminate all the car emissions associated with these trips.

Figure 3.17: Purpose of next trip by previous trip, GB, 2006

<table>
<thead>
<tr>
<th>Previous trip purpose</th>
<th>All purposes</th>
<th>Work or business</th>
<th>Escort education</th>
<th>Shopping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next trip to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work or business</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Education/ escort education</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Shopping</td>
<td>12</td>
<td>5</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Other personal business/ escort</td>
<td>11</td>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Visit friends</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Holiday/ day trip</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other leisure</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Home</td>
<td>42</td>
<td>73</td>
<td>71</td>
<td>78</td>
</tr>
<tr>
<td>All purposes</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: National Travel Survey 2006

3.41 To summarise, based on 2002/2006 averages, the distance travelled analysis suggests that:

- short car driver trips (of less than 5 miles) account for a large proportion (57%) of the total trips made (and therefore travel
decisions) and produce about 20% of CO₂ emissions by journey length (11 MtCO₂); and

- longer trips (of over 5 miles) only account for 43% of trips made, but produce about 80% of CO₂ emissions (47 MtCO₂).

3.42 Policy will need to look to reduce CO₂ emissions from both shorter and longer trips. However, the policies chosen should take account of the ability of travellers to switch between modes (which may be greater for shorter trips), and the number and type of travel decisions which would need to be influenced in order to effectively reduce total CO₂ emissions from domestic travel. For example, technological improvements may be more effective at reducing overall emissions when trying to influence the travel decisions of a large group of travellers than measures aimed at behavioural change; fiscal measures which apply per mile driven may have less of an impact on short journeys if travel decisions are taken on a journey-by-journey basis, rather than considering the total miles driven over a year.

Journey Speed

3.43 For car trips, the CO₂ emissions by journey purpose will also depend on relative average speed\textsuperscript{44}. The average speed will be influenced by the time of day the trip was made (for example, a trip made by car in the morning rush hour is likely to have a lower average speed than a trip made when the roads are less busy) and the type(s) of road on which the journey is made (for example, average speed is likely to be higher on a motorway than on local roads). A vehicle’s speed is important because of the observed relationship between speed and CO₂ emissions; emissions tend to be higher at very low and very high speeds. There will also be a CO₂ penalty associated with greater fuel use from more stop-start conditions (compared to a smooth traffic flow).

3.44 The time of day when trips are made for each journey purpose is shown below for week days (Figure 3.18) and for Saturdays (Figure 3.19).

\textsuperscript{44} For other modes, average speed is assumed to be the same across all journey purposes, as passengers travel in the same vehicle (such as railway carriage or coach) whatever the purpose of their journey.
Figure 3.18: Car driver trips by purpose and hour of day, GB, 2002/2006 average, Monday to Friday

Source: National Travel Survey

Figure 3.19: Car driver trips by purpose and hour of day, GB, 2002/2006 average, Saturday

Source: National Travel Survey
3.45 The figures show that during the week, commuting and education trips are clustered around the morning and evening ‘rush hours’, with fewer trips taken at other times of the day. Trips for personal business and recreation tend to be spread more evenly during the middle of the day. Given these peaks in the numbers of trips being made, it is likely that the average speed of journeys made at these times will be lower than the average speed of a journey made at a quieter time of day.

3.46 On Saturdays, trips for all purposes are more evenly spread throughout the day after about 10am, and gradually decline over the evening.

3.47 In policy terms, this might suggest focusing policy on trips made during peak times, such as facilitating home-working or teleworking. This might also have benefits in terms of congestion and improved fuel efficiency of remaining trips. However, it should be noted that a reduction in congestion may encourage people to undertake more or longer trips, which may partially offset some of the emission reduction benefits from the original reduction in peak hour travel.

Vehicle Type

3.48 Where the car is chosen as the main mode with which to make a trip, the size and fuel type of the vehicle driven will have an impact on CO₂ emissions – under the same driving conditions, cars with less powerful engines generally emit less CO₂ per kilometre driven than cars with larger engines. Similarly, petrol cars generally emit more CO₂ per kilometre than diesel cars of equivalent size (although there will be a trade-off as the latter is likely to emit relatively more local air pollutants, such as nitrogen oxides and particulate matter).

3.49 **Vehicle size:** The majority (60%) of car driver mileage is driven in medium sized cars (1401-2000cc), with only a minority (12%) in larger cars (2001cc and above). The proportion of mileage driven in small cars is lower for business trips than for trips of other purposes, and highest for trips with an educational purpose.

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45 The evidence for the potential contribution to reducing travel demand (and therefore CO₂ emissions) from teleworking is mixed. See, for example, *Smarter Choices – Changing the way we travel*, available at [http://www.dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt/chapter10teleworking](http://www.dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt/chapter10teleworking). However, there may still be CO₂ benefits in terms of, for example, reducing travel demand at the most congested times of day, thereby enabling the remaining traffic to flow more smoothly.
Figure 3.20: Average distance travelled as a car driver per person per year by purpose, fuel type and vehicle size, GB, 2002/2006 average

<table>
<thead>
<tr>
<th>Engine size:</th>
<th>Up to 1400cc</th>
<th>1401–2000cc</th>
<th>2001cc and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel type:</td>
<td>Petrol</td>
<td>Diesel</td>
<td>Petrol</td>
</tr>
<tr>
<td>Commuting</td>
<td>28</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>Business</td>
<td>12</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>Education/escort education</td>
<td>36</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>Shopping</td>
<td>31</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Other personal business/escort</td>
<td>29</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Visit friends at private home</td>
<td>31</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Visit friends elsewhere</td>
<td>29</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Holiday/day trip</td>
<td>24</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Other leisure</td>
<td>28</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>All purposes</td>
<td>27</td>
<td>1</td>
<td>39</td>
</tr>
</tbody>
</table>

Source: National Travel Survey

3.50 Fuel type: The proportion of distance travelled as a car driver in a petrol vehicle, as opposed to a diesel vehicle, has fallen over the last ten years for all purpose categories. The proportion of business mileage driven in petrol vehicles is lower than for other purposes; this may partially offset the fact that larger vehicles are often used for business purposes.

Figure 3.21: Average distance travelled as a car driver per person per year: Proportion travelled in a petrol (as opposed to a diesel) vehicle, GB

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<tbody>
<tr>
<td>Commuting</td>
<td>82</td>
<td>82</td>
<td>82</td>
<td>80</td>
<td>78</td>
<td>75</td>
<td>75</td>
<td>72</td>
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<td>Business</td>
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<td>Education and escort education</td>
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<td>88</td>
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<td>89</td>
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<td>85</td>
<td>81</td>
<td>81</td>
<td>75</td>
<td>73</td>
</tr>
<tr>
<td>Shopping</td>
<td>89</td>
<td>88</td>
<td>86</td>
<td>85</td>
<td>84</td>
<td>82</td>
<td>80</td>
<td>80</td>
<td>77</td>
<td>74</td>
</tr>
<tr>
<td>Other personal business and escort</td>
<td>86</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>82</td>
<td>78</td>
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<td>Visiting friends at private home</td>
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<td>87</td>
<td>86</td>
<td>85</td>
<td>84</td>
<td>83</td>
<td>80</td>
<td>79</td>
<td>78</td>
<td>74</td>
</tr>
<tr>
<td>Visiting friends elsewhere</td>
<td>91</td>
<td>87</td>
<td>87</td>
<td>87</td>
<td>87</td>
<td>83</td>
<td>80</td>
<td>83</td>
<td>75</td>
<td>74</td>
</tr>
</tbody>
</table>
### Holiday/day trip

<table>
<thead>
<tr>
<th></th>
<th>87</th>
<th>87</th>
<th>86</th>
<th>82</th>
<th>82</th>
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<th>70</th>
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<tbody>
<tr>
<td>Other leisure</td>
<td>86</td>
<td>83</td>
<td>84</td>
<td>83</td>
<td>83</td>
<td>81</td>
<td>78</td>
<td>75</td>
<td>72</td>
<td>71</td>
</tr>
<tr>
<td>All purposes</td>
<td>83</td>
<td>82</td>
<td>82</td>
<td>81</td>
<td>80</td>
<td>77</td>
<td>75</td>
<td>73</td>
<td>70</td>
<td>68</td>
</tr>
</tbody>
</table>

Source: National Travel Survey

3.51 In policy terms, there may be scope to reduce CO₂ emissions by encouraging households that own more than one car to choose the smaller car in preference to the larger car, such as through the provision of information about their relative CO₂ impacts. Whether or not to encourage the use of diesel vehicles in place of petrol vehicles will depend on the value placed on the relative damage caused by CO₂ emissions and local air pollutants. Policies such as the voluntary agreements with the car manufacturers to reduce CO₂ emissions from new cars (and the proposed mandatory successor policy) and the 'Euro Standards' that set maximum vehicle emissions of local air pollutants, may result in a narrowing of the differences in emissions per kilometre between petrol and diesel cars.

### Vehicle Occupancy Rates

3.52 For travel by car, CO₂ emissions per passenger kilometre will be affected by the average occupancy rate of the vehicle. Figure 3.22 below shows average occupancy rates by journey purpose, as well as the percentage of trips made with only the driver in the vehicle.

#### Figure 3.22: Car occupancy by trip purpose, GB, 2002/2006 average

<table>
<thead>
<tr>
<th></th>
<th>Average occupancy</th>
<th>Single occupancy rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuting</td>
<td>1.1</td>
<td>91%</td>
</tr>
<tr>
<td>Business</td>
<td>1.2</td>
<td>87%</td>
</tr>
<tr>
<td>Education/escort education</td>
<td>2.0</td>
<td>37%</td>
</tr>
<tr>
<td>Other personal business/escort</td>
<td>1.7</td>
<td>49%</td>
</tr>
<tr>
<td>Shopping</td>
<td>1.7</td>
<td>51%</td>
</tr>
<tr>
<td>Visit friends at private home</td>
<td>1.7</td>
<td>53%</td>
</tr>
<tr>
<td>Visit friends elsewhere</td>
<td>2.1</td>
<td>32%</td>
</tr>
<tr>
<td>Holiday/ day trip</td>
<td>2.1</td>
<td>37%</td>
</tr>
<tr>
<td>Other leisure</td>
<td>1.7</td>
<td>57%</td>
</tr>
<tr>
<td>All journey purposes</td>
<td>1.6</td>
<td>61%</td>
</tr>
</tbody>
</table>

Source: National Travel Survey

3.53 Commuting trips tend to have the lowest vehicle occupancy of each of the journey purposes, followed by business trips. Trips for leisure, such as visiting friends both at a private home and elsewhere, tend to have the highest vehicle occupancy. The education category includes escort
education, and this may therefore help to explain why this journey purpose also has a relatively high average vehicle occupancy.

3.54 Emissions per car per passenger kilometre are therefore higher, on average, for commuting journeys than for leisure (or education) journeys. In policy terms, there may be considerable scope for reducing CO₂ emissions from transport by reducing single occupancy car use\(^{46}\), for example through car sharing or car pool schemes. A recent DfT report\(^{47}\) examined the current extent of car sharing in Great Britain, and how this varies across different socio-demographic groups, as well as the reasons why people car share and the nature of car sharing trips. The study found that 22% of respondents shared a lift because of cost-related factors, whilst 7% of respondents shared a lift for environmental reasons.

3.55 Increasing average occupancy rates would potentially also bring about other benefits, such as reduced congestion. As with reducing congestion during peak hours, however, there may be some compensating increase in travel as a result of the reduction in congestion, which would partially offset the potential emission reductions.

\(^{46}\) This is one of the aims of the DfT’s Smarter Choices programme. For more information on Smarter Choices, see [http://www.dft.gov.uk/pgr/sustainable/smarterchoices/](http://www.dft.gov.uk/pgr/sustainable/smarterchoices/).

Section 2: Freight

Historic and Forecast CO₂ Emissions

3.56 Freight can be defined as “goods being moved for hire and reward or sale to third parties”. The wider sector of logistics can be defined as “having the right thing in the right place at the right time”. Some logistics operations do not move goods for hire and reward – for example, infrastructure replacement where materials are moved to and from site. Since the same type of "goods" vehicle is used for both freight movement and logistics operations in practice it can be difficult to separate the vehicle usage (particularly for road and rail operations) in each sector.

Box 9: Estimating Historic Freight CO₂ Emissions

Because of differences in the use of the same types of goods vehicles, estimates of CO₂ emissions from freight operations can vary significantly. It is difficult to identify pure “freight” data from vehicle sectors that include some passenger transport, such as the operation of vans, or “Light Goods Vehicles”, and wider "logistics" operations which use goods vehicles for the purpose of moving tools and materials to worksites or machine servicing purposes, and are not considered as “freight”.

It is necessary to derive CO₂ estimates from sources of data accumulated for different purposes. For example, for road transport, data from the NAEI is based on derived emission factors and traffic count data for the UK – and includes both some wider logistics operations and vehicles registered outside the UK, whereas DfT data from the Continuing Survey of Road Goods Transport uses estimates of fuel consumption for differing classes of vehicle, supplied by a survey of GB freight operators scaled up to national levels.

3.57 Figure 3.23 below is based on NAEI data. It uses an assumption that 35% of Light Goods Vehicle (LGV) operations⁴⁸, 4% of domestic aviation movements⁴⁹ and 100% of domestic shipping⁵⁰ are applicable to freight. It shows that CO₂ emissions from the movement of freight are dominated by the road sector, whilst CO₂ emissions from rail and domestic aviation assigned to freight movements are very low (aviation freight emissions are only 0.3% of total freight emissions in 2006). The trend for water freight shows significant fluctuations since 2002. This is largely due to global shipping market effects and changed methodology in calculating the data series.

3.58 The trend for rigid Heavy Goods Vehicles (HGVs) shows an uncharacteristic rise in 2004 as a result of lower recorded fuel consumption (miles per gallon, or mpg) in DfT's Continuing Survey of Road Goods Transport (CSRGT) data for the lighter vehicles in that

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⁴⁹ Estimated from Civil Aviation Authority Airline Statistics, tables 1.7.4 & 1.8.4.
⁵⁰ In reality, this figure is likely to be just under 100%. However, 100% is assumed here for simplicity.
3.59 In general, the decline in rigid vehicle CO₂ emissions from 2003/04 is in part explained by the increase in emissions from LGVs as some of the activity previously generated by the lighter end of the HGV sector (3.5 tonnes to 7.5 tonnes) transferred to LGV operations. LGV activity has increased through several mechanisms, including the increase in internet home deliveries and multiple parcel operators. In addition, the change in driver licensing categories effective from the late 1990s now requires an HGV Licence above 3.5 tonnes so that newly qualified drivers are no longer able to drive vehicles up to 7.5 tonnes. This seems to have resulted in the lower weight HGVs (historically those up to 7.5 tonnes gross vehicle weight) being displaced by the largest LGVs.

3.60 Road transport activity forecasts for England are derived from the DfT’s National Transport Model (Figure 3.24).

![Image of Figure 3.23: Estimated historic CO₂ emissions from freight (all modes), UK](image_url)

Source: National Atmospheric Emissions Inventory 2006; DfT analysis

3.59 Work is currently underway to review the fuel consumption time series for all HGV categories and new mpg data will be published later in 2008.
3.61 The NTM forecasts are currently being updated in light of the latest projections for various forecasting assumptions, such as oil prices, GDP and population growth. We have therefore undertaken some off-model analysis to generate forecasts of CO₂ emissions from freight movements.

3.62 The forecasts are shown in Figure 3.25 below. The "projected base economy" case for both HGV and LGV traffic is calculated from the traffic growth forecasts from the NTM, illustrated in Figure 3.25. They assume no major changes in the fleet fuel economy for HGVs over the period, until the gradual introduction of more economical new vehicles to the fleet from 2015 after the Euro 6 Standard has been implemented. For LGVs, a gradual improvement for the fleet of around 1% per year is assumed to 2010 but no change thereafter. The forecasts further assume that the relative proportions of rigid HGVs and articulated HGVs remain at current levels. No account is made for the CO₂ impact of any increases in congestion to 2025.

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52 The Euro Standards are limits on local air quality pollutants, particularly for emissions of nitrogen oxides and particulates. The Euro 6 Standard will require all vehicles equipped with a diesel engine to substantially reduce their emissions of nitrogen oxides. However, reducing these emissions will involve a fuel penalty, and therefore a reduction in fuel efficiency unless compensating fuel efficiency improvements can be found.
**Factors Influencing CO₂ Trends**

3.63 HGV fuel efficiency improvement since the 1980s has limited the increase in CO₂ that would otherwise have resulted from the increase in road freight activity. Over the last twenty years, HGV traffic has grown more slowly than car traffic, and this is forecast to continue through to 2025. However, LGV traffic is forecast to increase most rapidly, with expected growth of 67% over the forecast period. This may be partly due to the trend of increasing home deliveries. Growth in LGV traffic has historically tended to increase in line with GDP, and this is forecast to continue. Despite this, LGVs are expected to account for only around 15% of total traffic in 2025 (up from 12% in 2003).

3.64 Fuel efficiency changes since the 1980s have been driven by customer pressure on manufacturers to deliver vehicles with improved fuel economy and, initially, the effect of better engine management systems required to meet European-wide air quality emissions standards introduced from the early 1990s. Fuel efficiency is expected to continue to improve but at a lower rate than past years, as improvements in engine efficiency reach practical limits. Overall vehicle improvements to meet continuing industry pressure are expected through techniques such as better matching of transmissions, aerodynamic improvements and optimisation of engine size. However, the progressive tightening of air quality standards on HGVs will limit - and possibly reverse – the trend of year-on-year improvements in vehicle fuel economy.
3.65 Other CO₂ saving initiatives include the use of electric or hybrid vehicles which are now appearing in forms which have practical applications in the logistics industry. Range and payload of electric vehicles now available are sufficient to displace conventional diesel engined vehicles for some short-haul duties. However, the cost of purchasing or leasing them is currently significantly higher. These economic factors will limit the potential shift from fossil fuel in this sector.

3.66 DfT’s key policies to reduce emissions from the movement of freight are modal shift support, the Freight Best Practice scheme and driver training through the Safe and Fuel Efficient Driving programme.

3.67 **Freight Mode Shift support:** three types of grants are provided by the DfT: the Freight Facilities Grant (FFG) helps to offset the capital cost of providing rail and water freight handling facilities; the Rail Environmental Benefit Procurement Scheme (REPS) secures the safety, journey reliability, climate change and quality of life benefits associated with running rail freight transport instead of road; and the Waterborne Freight Grant (WFG) assists companies for up to three years with operating costs associated with running water freight transport instead of road. All schemes provide funding where the benefits obtained are greater than the costs.
Box 10: Freight Mode Shift

Rail locomotives are generally now quite new, relatively clean and fuel efficient (see chapter 2). The older rolling stock has largely been replaced. DfT has an active grants programme to promote and support mode shift where it is sensible and beneficial to do so. Figure 3.26 below shows two examples of the CO₂ emissions benefits of the current mode shift grants for transfer of container traffic from road to rail.

Figure 3.26: Example impacts of mode shift grants, 2007\(^{53}\)

<table>
<thead>
<tr>
<th>Felixstowe to Midlands</th>
<th>Southampton to Midlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>133,771 containers moved</td>
<td>78,051 containers moved</td>
</tr>
<tr>
<td>3,819 tonnes of CO₂ saved</td>
<td>1,975 tonnes of CO₂ saved</td>
</tr>
<tr>
<td>£4,800,768 paid in grant</td>
<td>£2,073,323 paid in grant</td>
</tr>
</tbody>
</table>

Source: DfT analysis

In the majority of cases only a single container can be moved on a road vehicle, whilst a typical container train may carry around 30 containers. However, even when rail is used for the primary trunking of containers there is a necessity of a road leg for final delivery. Where rail is used for domestic traffic there is usually a road leg at both ends of the rail journey.

Total grant aided container flows from the principal container ports of Southampton and Felixstowe for 2007 are set out below.

- Felixstowe: 364,379 containers saving 15,399 tonnes CO₂
- Southampton: 252,880 containers saving 10,290 tonnes CO₂

The success of mode shift to water has been less easy to assess. The variation in type of shipping used, its relative fuel consumption and the distance of the final road leg to delivery point vary for each operation and is has not been possible to estimate the CO₂ effects in a generic model in the same way as road and rail operations. Forecast increases\(^{54}\) in container numbers in Twenty-foot Equivalent Units (TEUs) through the two ports to 2030 are as follows:

Figure 3.27: Forecast TEU container numbers

Source: UK Port demand forecasts MDS Transmodal 2007

Market analysis of container usage shows that 66% of TEUs are 40 foot containers and 32% are 20 foot containers\(^{55}\). Applying this ratio to flows through the above ports gives the approximate numbers of containers.

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\(^{53}\) Net CO₂ saving with allowances for road leg delivery from the rail head to final destination.

\(^{54}\) UK Port demand forecasts MDS Transmodal 2007

\(^{55}\) Containerisation International census 2005
Following on from the experience gained in considering predominantly road operations, the FBP programme is now moving to consider other modes and actively promote multimodal solutions. Use of rail on appropriate routes can displace significant numbers of road vehicles (about 30 containers on a train would remove 30 lorries) but allowance has to be made for road journeys from rail terminals to final loading and destination points. Benefits of planning and driver training can be obtained in all modes. For example, as with road transport, rail operations running at constant speed would improve fuel consumption.

### Figure 3.28: Forecast total container numbers

<table>
<thead>
<tr>
<th>Thousand containers</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felixstowe</td>
<td>2935</td>
<td>3599</td>
<td>4199</td>
<td>5020</td>
<td>6094</td>
</tr>
<tr>
<td>Southampton</td>
<td>1709</td>
<td>2204</td>
<td>2573</td>
<td>3039</td>
<td>3198</td>
</tr>
</tbody>
</table>

Source: UK Port demand forecasts MDS Transmodal 2007

At present, around 22% of container volumes through Felixstowe move onward by rail with the equivalent figure for Southampton at around 29%. The increase in container volumes indicates there is scope for further CO₂ savings by greater modal shift. However, rail capacity through both ports is finite and at this stage no analysis has been carried out on the longer term capability of the rail infrastructure to absorb significant increases in freight traffic from these ports.

#### 3.68 Freight Best Practice

DfT’s Freight Best Practice (FBP) scheme attempts to reduce CO₂ emissions through the provision of advice and operational tools for the freight industry to improve its efficiency. The programme embraces techniques to monitor fuel usage, Key Performance Indicator studies and increased utilisation, choosing the optimum vehicle, loading of vehicles, assessment of fuel saving techniques, and so on.

**Box 11: Freight Best Practice**

Two impact assessments of the programme have shown that it is actively used by some 9% of all HGV fleets in 2006, compared with 5% of fleets in 2003. For the two years 2005 and 2006, direct use of FBP tools saved around 240,000 tonnes of CO₂. Fleets using FBP in conjunction with other efficiency tools saved an estimated 547,300 tonnes of CO₂.

FBP is a continuing programme and we expect market penetration to increase at a rate of at least 2% per annum. In addition to the DfT sponsored FBP scheme, fleets have adopted other fuel monitoring and saving programmes so a 2% penetration of “best practice” is a realistic assumption. The scheme was driven by the need for operators to reduce fuel consumption and operating costs (the impact assessment quantified savings for the two years 2005 and 2006 as £190m, or £1,900 per vehicle per annum). Scheme take-up is therefore likely to be sensitive to fuel prices.

The FBP programme is not unique and other techniques are used by industry to improve efficiency. The latest impact assessment of FBP also considered other fuel saving initiatives used by operators. The estimated total CO₂ saving of all efficiency schemes in the two years 2005 and 2006 is 1,742,000 tonnes CO₂.

Following on from the experience gained in considering predominantly road operations, the FBP programme is now moving to consider other modes and actively promote multimodal solutions. Use of rail on appropriate routes can displace significant numbers of road vehicles (about 30 containers on a train would remove 30 lorries) but allowance has to be made for road journeys from rail terminals to final loading and destination points. Benefits of planning and driver training can be obtained in all modes. For example, as with road transport, rail operations running at constant speed would improve fuel consumption.
3.69 **Driver training**: Driver training has a significant influence on fuel consumption, and hence CO$_2$ emissions. DfT has set up the Safe And Fuel Efficient Driving (SAFED) scheme, currently operating for both HGVs in the aggregates industry and for LGVs under Government funding (DfT and Defra’s Aggregates Levy and Sustainability Fund) and on a commercial basis. The scheme has been shown to save up to 5% of fuel per driver in HGV operations. Initial assessments from LGV training days show slightly better improvements, but a full impact assessment of the LGV scheme has yet to be carried out.

**Box 12: SAFED and Related Programmes**

The impact assessment has quantified the CO$_2$ savings for the 12,000 HGV drivers trained under DfT funding as 87,000 tonnes of CO$_2$. The use of similar training courses has also been assessed. In total it is estimated that 104,000 tonnes of CO$_2$ were saved in the study period through SAFED and directly linked driver training initiatives (i.e. including commercially delivered SAFED). Overall, the use of all driver training across the HGV sector has saved 509,600 tonnes of CO$_2$ over the two year study period.

The introduction of mandatory Driver Certificate of Professional Competence (CPC) training from September 2009$^{56}$ will require drivers to undertake 5 days of training every 5 years. By 2014, therefore, all drivers of HGVs and Passenger Carrying Vehicles (PCVs) (such as buses) will have received the training. SAFED is not compulsory but is recognised as a Driver CPC training course. It is likely that SAFED or similar type courses will make up a large percentage of the required training, since these offer rapid benefits to the operators (and quick recovery of course costs).

3.70 It is expected that the benefits of driver training for the HGV fleet will penetrate at a rate of 2% per annum whilst training is voluntary, but that this will increase substantially to 10% per annum given the driving force of Driver CPC regulation from 2009. Penetration of the LGV fleet will be lower as take up is currently voluntarily, with no regulatory drivers. For the purpose of this analysis, a penetration rate of 1% per annum has been assumed.

3.71 Figure 3.29 shows the our off-model forecasts of the impact of current policies - the take up by industry of FBP and similar efficiency practices; increased driver training such as SAFED; and fuel economy improvements.

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$^{56}$ The Driver CPC is a scheme for drivers of LGVs (over 3.5 tonnes gross vehicle weight) who drive professionally throughout the UK. It is being developed as a requirement of EU Directive 2003/59, which is designed to improve the knowledge and skills of professional drivers of LGVs and Passenger Carrying Vehicles throughout their working life.
Figure 3.29: Forecast CO$_2$ emissions from freight movements by road, UK

Source: DfT analysis
4. The Impact of Mode Switch on Emissions

Key Messages

Any policy which induces the transfer of a car driver to rail saves an average of around 106g CO₂ per passenger kilometre travelled, as long as neither rail’s consumption of energy nor that of road users other than the motorist who has switched to rail is affected.

In practice, a detailed multi-modal model is required to best estimate any savings in CO₂ emissions from mode switch. The DfT is currently developing its key multi-modal model – the NTM – by linking it to its new rail model, the NMF. Currently the NTM estimates show that a change in the relative cost of rail travel that generates a 10% increase in rail kilometres results in a 2.6% reduction in car driver kilometres and a 2.0% reduction in car passenger distance travelled.

Policies which result in an increase in demand for rail travel that require an increase in rail capacity may actually lead to an increase in overall CO₂ emissions, even if the increase in demand comes from people switching from car driving. This is because the marginal emissions associated with increasing rail capacity may be higher than for car travel, despite much lower average CO₂ emissions per passenger kilometre.

The greatest reduction in overall CO₂ emissions from modal switch may therefore result from policies which encourage a shift to rail during off-peak times, when existing capacity can meet the increase in demand.

The CO₂ impact of modal shift from car to bus depends on any subsequent changes to bus service provision levels.

Bringing about modal shift is complex – different segments of the population will require a different range of incentives to encourage them to switch. Social research suggests that cost differences between modes may not be sufficient.
Introduction

4.1 Travel by different modes will have differing impacts in terms of emissions of CO₂ per passenger kilometre. The aim of this chapter is to consider the overall impact of passenger travel mode switch on transport CO₂ emissions (freight mode shift is discussed in chapter 3). The results of model runs from the NTM and the DfT’s rail model (the NMF) have been reviewed to draw some conclusions about the circumstances in which a policy which induces mode shift will meet the desired environmental objectives.

4.2 Defra’s Company Reporting Guidelines⁵⁷ (CRG) published in June 2008 enable the CO₂ emissions per passenger kilometre of the various modes to be compared. Figure 4.1 shows these factors on an average CO₂ emissions per passenger kilometre basis.

Figure 4.1: CO₂ emissions per passenger kilometre by mode

<table>
<thead>
<tr>
<th>CO₂ emissions per passenger kilometre from:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td></td>
</tr>
<tr>
<td>Average petrol car</td>
<td>130g (109g¹)</td>
</tr>
<tr>
<td>Average diesel car</td>
<td>124g (96g¹)</td>
</tr>
<tr>
<td>Average petrol motorbike</td>
<td>106g</td>
</tr>
<tr>
<td>Average bus and coach</td>
<td>69g</td>
</tr>
<tr>
<td>Air</td>
<td></td>
</tr>
<tr>
<td>Domestic flights</td>
<td>191g (175g²)</td>
</tr>
<tr>
<td>Rail</td>
<td></td>
</tr>
<tr>
<td>National rail</td>
<td>60g</td>
</tr>
<tr>
<td>London Underground</td>
<td>65g</td>
</tr>
<tr>
<td>Light rail and tram</td>
<td>78g</td>
</tr>
</tbody>
</table>

Note 1: The figures given in brackets are vehicle use weighted figures. See paragraphs 4.4 and 4.5 below for explanation.

Note 2: The figure in brackets shows g CO₂ per pkm. However, in line with evidence from the IPCC, an uplift factor of 9% has been applied to account for non-direct routes, circling and congestion to give 191g CO₂/pkm.

Source: Defra’s Company Reporting Guidelines 2008

4.3 For road, the factors used in the guidelines are estimated values for the average petrol and diesel car in the UK car fleet. This has been divided by an average car occupancy rate of 1.6 passengers to derive average emissions per passenger kilometre.

4.4 The CRG factors provide estimates of the average CO₂ emissions from an average petrol or diesel car. However, they do not take account of how much individual cars are driven within the UK fleet. The CRG factors differ from the result obtained by dividing total CO₂ emissions from all cars (total car fuel sales) by total car kilometres driven; that is, the emission factor for the average car kilometre driven in the UK. This is because lower CO₂ emitting cars, such as newer cars and diesel cars, are on average driven more than higher CO₂ emitting cars, such as older

cars and sports cars. Thus, a use or traffic weighted average car emission factor will be significantly lower than these CRG factors and hence the CRG factors do not correlate to national emissions.

4.5 For comparison purposes with other modes, a use weighted factor may be more appropriate. A vehicle use weighted figure that reflects the average (petrol and diesel) car kilometre driven for the UK fleet is currently around 170g CO₂/kilometre, or about 106g per passenger kilometre. It is these use weighted factors that are used in the DfT’s National Transport Model (NTM). Furthermore, car fuel economy is expected to continue improving over time and so these factors will likewise continue to fall.

4.6 For rail, the national estimate refers to an average emission factor for diesel and electric trains in 2005. The London Underground rail factor is based on the Underground’s annual electricity consumption. The light rail and tram factors were based on an average of the annual electricity consumption and passenger kilometre data provided by the network operators in 2005, and a CO₂ emission factor for electricity generation on the national grid from the UK Greenhouse Gas Inventory.

4.7 For aviation, the emission factor is an aggregate representation of the typical CO₂ emissions from illustrative types of aircraft for the three types of air services. Actual CO₂ emissions will vary significantly according to the type of aircraft in use, the load, cabin class, etc.

Policies which induce mode shift by changing perception rather than relative costs

4.8 Figure 4.1 above indicates that average emissions from rail in 2005/06 were 60g of CO₂ per passenger kilometre. Total rail emissions change only when the service provision or specification is changed in some way. An increase in demand, if not associated with an increase in the number or length of trains operated, has no impact on overall rail emissions. In this circumstance, as passenger numbers increase, the average emissions per passenger kilometre falls. Any policy which then induces the transfer of a car driver to rail therefore saves around 106g CO₂/passenger kilometre travelled on average (the emissions of the car). This is only true if the policy itself affects neither rail’s consumption of energy nor that of road users other than the motorist who has switched to rail.

4.9 As with rail, the CO₂ impact of a modal shift from car to bus is not clear cut. If increases in bus patronage cause an increase in bus service levels then emissions would be greater than if no change in service levels arose. The net effect of the offsetting changes in car and bus kilometres is uncertain and could be determined only by detailed analysis of the relevant case.
Box 13: Inducing Mode Shift

Policies to induce mode shift might include providing car users who had previously overestimated the generalised costs\textsuperscript{58} of rail and buses with the correct information. The likely effectiveness of such a policy can only be determined by surveys and analysis of travel behaviour. Whether such policies have an overall net benefit depends on the external costs and benefits of the switch - for example, additional rail passengers might increase the cost of travel for existing users if they are travelling in crowded conditions.

Bringing about modal shift and indeed other policy measures that might reduce the need to travel is complex. We know that different segments of the population are likely to require a different range of incentives to change, and that this segmentation is quite complex. We cannot rely on cost differences alone; for example, we know from social research on pricing structures that some people across all income bands will actively disengage from attempts to get them to think about the costs of making their journeys in different ways. Social research is currently being undertaken by the DfT (to report in the summer 2008) to give us a better understanding of the barriers to overcoming behavioural change, and hence provide pointers to appropriate policy measures that would be most effective in different circumstances.

4.10 Estimates of the savings in road related CO\textsubscript{2} emissions on account of modal shift are best made from a detailed multi-modal model. Some of these models can show whether a shift to rail involves the use of a car to access the station. However, in the absence of detailed modelling it is reasonable to assume that, for each car driver kilometre transferred to rail, the emissions saved by this shift at the margin are the same as the average emissions per car driver kilometre (see paragraph 4.8). Where the transfer from road to rail involves a car passenger, there is usually no reduction in car kilometres and so no impact on emissions on either mode.

4.11 In many cases (e.g. on the DfT Transport Direct website\textsuperscript{59}) the CO\textsubscript{2} emissions impact of rail patronage is quoted as the average for existing users (60g CO\textsubscript{2}/per passenger kilometre). However, the impact on emissions of one additional passenger switching to rail travel is likely to be minimal – train operations are franchised over a period of 7 years or more and during this period marginal changes in demand have minimal impact on the services operated and hence on total rail emissions.

4.12 Even over a longer period, the impact on emissions of capacity changes to accommodate sustained changes in demand are likely to be very different from the average. The effect on emissions of capacity changes is covered below.

\textsuperscript{58} The ‘generalised cost’ is the sum of the monetary costs (such as the fare on public transport or the cost of fuel) and non-monetary costs of a journey (such as the time spent making the journey).

\textsuperscript{59} See http://www.transportdirect.info/web2/.
Policies which cause mode shift by raising the generalised costs of road

4.13 Most multi-modal models can provide estimates of the effect on demand for car travel and for other modes of policies which make car travel less attractive. Invariably, the greatest impact is on the number of car kilometres driven, with transfers to other modes making up the rest. Recent use of the NTM to show the impact on travel demand of stopping planned Highways Agency capacity expansion shows that a shortening of road trips accounts for some 80% of all car driver kilometres that stop using road because of the longer journey times, while only 6% transfer to rail and 12% to bus.

4.14 Reductions in emissions follow straight from changes in car kilometres, either using an average estimate or one from the transport model that reflects the characteristics of the trip which transfers. Any offsetting increase on other modes depends on whether the model includes any supply response to accommodate the change in demand. In addition, estimates of the overall effect will differ according to whether or not the model included the effect of crowding or congestion on the mode to which transport users switch and the impact of this on mode choice.

Policies which induce mode shift to buses

4.15 Paragraph 4.9 above notes that many policies which induce a mode shift from car to bus result in an increase in bus kilometres operated. So the effect on overall emissions from transport cannot be determined simply.

4.16 However, policies which improve the efficiency of bus operations, such as the provision of well designed bus priority measures that reduce bus queuing times without affecting road capacity, can result in a reduction in emissions per bus journey which offset any net increase caused by the increase in service provision. Similar outcomes will result from improvements in technology, such as integrated ticketing and pre-pay systems which reduce the boarding and dwell time of a bus journey. Encouraging mode switch towards buses will, however, be especially difficult in rural areas where offering exhaustive bus services may not be cost-effective.

Policies which induce mode shift by increasing the attractiveness of rail

4.17 Policies which make rail more attractive by reducing the generalised cost of rail increase rail patronage. Rail models use an elasticity based approach, with the strength of the demand response varying according to the characteristics of the flow – commuter, business or leisure, area (London, rest of South East etc.) and by journey distance band.

4.18 There is a lack of firm evidence on the extent to which additional demand is a result of mode shift, and in particular mode shift from car driver, or the extent to which it reflects longer or more frequent trips by rail. This is explained by the lack of multi-modal models with sufficient
coverage of rail travel (which account for only 2% of trips made by households). The best estimate comes from the NTM, which has been used to find that a change in the generalised cost of rail which delivered a 10% increase in rail kilometres resulted in a 2.6% reduction in car driver kilometres, and a 2.0% reduction in car passenger distance\textsuperscript{60}.

4.19 Estimates of the CO\textsubscript{2} impact of measures which improve the attractiveness of rail depend upon the policy implemented. Most of these will increase rail's overall CO\textsubscript{2} emissions and the initiatives analysed as part of the High Level Output Specification (HLOS) show a net increase in overall transport emissions. HLOS provided additional capacity with additional spending on reducing journey times on some services. The HLOS options are intended to reduce high levels of crowding on rail and provide capacity for the forecast growth of employment in London and other conurbations. The benefits in this respect were estimated at around 70 times greater than the additional CO\textsubscript{2} costs, and the overall benefits were more than 50% greater than the project costs.

4.20 While average emissions from rail were estimated at 54g per passenger kilometre for 2014, the level of emissions at the margin, defined as the additional emissions divided by the additional passenger kilometres, was 319g per passenger kilometre. Given that this marginal level was 2 times the forecast average emissions per car kilometre in 2014 (which, as suggested above, can be taken as a proxy for the emissions from the marginal car driver kilometre transferred to rail), the HLOS, as specified in the Network Modelling Framework, would result in a net increase in emissions even if 100% of the rail passenger kilometres generated had been switched from car driver. Further work is in hand using more detailed models to ensure efficient utilisation of the additional vehicles which may well result in some reduction in the initial estimate of the programme's impact on emissions.

4.21 In policy terms, this analysis therefore suggests that, of the policies intended to reduce transport's CO\textsubscript{2} emissions through mode shift, those which encourage a shift at off-peak times of the day are likely to be the more successful. During the peak hours rail lacks the capacity to carry additional passengers without either investing in more trains, thus causing additional CO\textsubscript{2} emissions, or increasing crowding and making travelling conditions worse.

Availability of alternative modes

4.22 The ability to switch modes will in any case depend on the availability of alternative modes of transport. London provides a good example, where travel patterns are different to the rest of the country. In particular, average distance travelled by bus has increased by over 40% over the last ten years among London residents (compared to a decline in bus

\textsuperscript{60} This estimate is based on a national average of responses by those for whom rail is an option and the emissions savings can likewise be estimated in terms of national averages per car kilometre.
patronage outside of London), while distance travelled as a car driver has fallen by over 15%.

**Figure 4.2:** Distance travelled as a car driver by London residents.

![Graph showing distance travelled as a car driver by London residents](image1)

*Source: National Travel Survey*

**Figure 4.3:** Distance travelled as a car driver by residents of Great Britain, excluding London.

![Graph showing distance travelled as a car driver by residents of Great Britain, excluding London](image2)

*Source: National Travel Survey*

4.23 Whilst recognising some circumstances particular to London (the congestion charge has contributed to an increase in bus use, as part of an integrated package of bus priority, pedestrian and cycling measures, parking restraint and increased bus support), the experience of London can provide useful lessons for policy in other parts of the country. The progress London has made on buses might be replicated in the big conurbations in the rest of England. The challenge is greatest for rural areas and urban fringes, where bus services may not be commercially viable without additional support. Where this is the case, services may be reliant on additional funding, such as though the DfT’s Rural Bus Subsidy Grant.
5. International Comparisons

Key messages

The UK has a transport emissions performance similar to that of other developed countries, both in terms of domestic transport CO₂ emissions per capita and per $m of purchasing power parity adjusted GDP.

The two main drivers of domestic transport emissions are the amount of passenger kilometres travelled and the carbon intensity of these trips. Passenger kilometres per capita are broadly in line with other developed countries, although nearer the higher end of the countries considered. The UK has a relatively low transport carbon intensity.

The UK’s share of car travel is at about the average of the countries analysed. The UK has a relatively low share of bus and rail travel but a relatively high share of air travel, which is a comparatively carbon intensive form of transport.

The average CO₂ emissions of new cars varies across the countries considered. The UK average for both new petrol and diesel cars is very similar to the average across the EU-15 as a whole. However, the average age of a petrol car in the UK in 2001 was 5.9 years, compared to an EU-15 average age of 7.4 years. The ratio between passenger car new registrations and the passenger car fleet in 2000 was also relatively high, at 8.9%, suggesting a relatively high proportion of new cars within the UK fleet.

Diesel cars generally emit less CO₂ than petrol cars per kilometre travelled. In the countries analysed, no country has more diesel than petrol cars, although almost half the Austrian car fleet runs on diesel. The UK’s proportion of diesel cars lies approximately at the mid-point of the countries analysed.

In most countries, petrol and diesel prices are quite similar. The UK is the only country with higher diesel prices than petrol prices.
Introduction

5.1 The aim of this chapter is to compare transport sector CO₂ emissions in the UK with those in other developed countries, in order to consider whether there are lessons to be learned from international experience. The UK’s emissions are compared with other developed countries after controlling for both population and Gross Domestic Product (GDP) – a measure of national income.

Relative Performance of the UK

GDP and Transport CO₂ Emissions

5.2 GDP is a key driver of the demand for travel. People living in countries with higher GDP tend to travel more, they may take more holidays, they have more cars per family and are less reluctant to pay higher fuel costs. When comparing transport emissions in the UK to other countries it is therefore important to understand the link between GDP and transport emissions. It is also interesting to compare emissions in the UK while removing the potential effects of differences in GDP across countries.

5.3 Making comparisons across countries using GDP data is inevitably problematic. Different countries have different national income accounting practices and there are difficulties in converting figures into a common price base. Any comparison of GDP per capita across countries will need to convert GDP in particular domestic currencies into a common price base (most commonly US dollars). Purchasing power parity (PPP) exchange rates are based on how the price of a basket of goods varies across countries, and therefore represent the most effective way of measuring wealth variation across countries. Despite this, however, there still remain problems associated with using PPP exchange rates to compare wealth across countries and therefore these estimates should be treated with caution.

5.4 Figure 5.1 and Figure 5.2 below plot the carbon intensity of domestic transport for various countries against PPP adjusted GDP per capita for two different years: 1990 and 2005. Carbon intensity of transport is defined here as transport emissions in tonnes of CO₂ (tCO₂) per US$m of GDP.
**Figure 5.1**: Domestic transport CO₂ emissions and PPP adjusted GDP per capita, 1990

Source: GDP per capita from International Monetary Fund, World Economic Outlook Database, October 2007. Figures adjusted for PPP; CO₂ per $m calculated from European Environment Agency data and WEOD, IMF respectively.

**Figure 5.2**: Domestic transport CO₂ emissions and PPP adjusted GDP per capita, 2005

Source: GDP per capita from International Monetary Fund, World Economic Outlook Database, October 2007. Figures adjusted for PPP; CO₂ per $m calculated from European Environment Agency data and WEOD, IMF respectively.
5.5 It would appear that relative positions have altered significantly. In 1990, France and Germany performed very similarly to the UK. However, in 2005, the UK had slightly lower CO₂ emissions per $m GDP than Germany, and quite significantly lower than France. This may be partly explained by the UK experiencing a lower rise in transport demand (of 23%) between 1990–2004, compared to 36% in Germany and 31% in France.

5.6 The United States and Luxembourg are outliers – both show much higher tCO₂ per $m than other countries – and have therefore been excluded from the figures. Transport constituted 59% of Luxembourg’s overall emissions in 2005. Luxembourg has one of the highest car ownership rates in the EU, at 669 cars per 1,000 inhabitants (this compares to 469 cars per 1,000 inhabitants in the UK). However, the emissions from ‘domestic’ transport will include drivers from nearby France, Germany and Belgium taking advantage of lower Luxembourg fuel taxes.

5.7 Transport carbon intensity of the US fell significantly from 257MtCO₂/$m in 1990 to 155MtCO₂/$m in 2005, despite a rough doubling of emissions from trucks in all size classes. This is perhaps due to the slow growth in emissions from domestic aviation and static emissions from automobiles against strong GDP growth. However, the US remains an outlier from the main group even in 2005, which may be explained by the large proportion of travel accounted for by air transport and also its very high car usage. In 2005, the US had a car ownership rate of 777 cars per 1,000 inhabitants.

5.8 Overall, it appears that transport CO₂ emissions do not correlate with (PPP adjusted) GDP per capita very well – there are significant differences in transport CO₂ emissions at similar levels of economic development. This suggests that, due to the travel decisions that people make, geographical influences, cultural differences and – potentially – government policy, GDP growth does not necessarily have to be accompanied by a proportionate increase in domestic transport CO₂ emissions.

5.9 Figure 5.3 below shows transport CO₂ emissions per $m of GDP for various countries. Between 1990 and 2005, UK carbon intensity has reduced, both in absolute and relative terms.

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61 Climate for a transport change, EEA report No 1/2008.
63 Climate for a transport change, EEA report No 1/2008.
65 Climate for a transport change, EEA report No 1/2008.
## Figure 5.3: Domestic transport CO₂ emissions per $m GDP, 1990 and 2005.

<table>
<thead>
<tr>
<th>1990 Domestic Transport emissions (in PPP)</th>
<th>2005 Domestic Transport emissions (in PPP)</th>
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<tbody>
<tr>
<td>Finland 144</td>
<td>Spain 89</td>
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<tr>
<td>Germany 117</td>
<td>Austria 85</td>
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<tr>
<td>France 116</td>
<td>Portugal 82</td>
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<td>Sweden 115</td>
<td>France 75</td>
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<td>Belgium 109</td>
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<td><strong>United Kingdom</strong> 64</td>
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<tr>
<td>Austria 81</td>
<td>Netherlands 62</td>
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Source: As Figures 5.1 and 5.2

5.10 Spain had relatively moderate domestic transport CO₂ emissions per $m of GDP in 1990. However, by 2005, Spain had the highest level of CO₂ emissions per $m of GDP. With the exception of the Netherlands and Belgium it also had the highest level of CO₂ emissions when international transport emissions are included on the basis of bunker fuel sales in each country. This could be partly explained by the significant increase in the volume of new car registrations, which increased by around 50% over this period⁶⁶ and the increase in average distance travelled (as shown in Figure 5.7 below). Counteracting this to some extent is the proportion of new registrations of diesel cars, from 14% in 1990 increasing to 68% in 2005, exceeding the EU average of 50% in 2005.

5.11 When international transport emissions based on bunker fuel sales are included, a slightly different picture emerges (Figure 5.4). The Netherlands and Belgium are placed significantly worse. This is likely to be largely due to Rotterdam in the Netherlands being the largest seaport in the EU, and Amsterdam-Schipol one of the largest airports in the world.

5.12 Transport CO₂ emissions (including international aviation and shipping emissions based on bunker fuel sales) per $m of GDP are given in Figure 5.4. On the basis of this measure the UK again improves its position both relatively and in absolute terms. Between 1990 and 2005, UK CO₂ emissions per $m of GDP fell by more than 35%. In 2005, the UK had comparable emissions per $m of GDP to Germany, France and Italy.

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⁶⁶ Source: AAA (Association Auxiliaire de l'Automobile).
Figure 5.4: Domestic and international transport CO\textsubscript{2} emissions per $m of GDP, 1990 and 2005.

<table>
<thead>
<tr>
<th>1990 Transport emissions including international aviation and shipping</th>
<th>2005 All transport emissions including international aviation and shipping</th>
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<tr>
<td><strong>CO\textsubscript{2}$/m (in PPP)</strong></td>
<td><strong>CO\textsubscript{2}$/m (in PPP)</strong></td>
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<td>Netherlands</td>
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<td>Belgium</td>
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<td>Austria</td>
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</table>

Source: As Figures 5.1 and 5.2

Population and Transport CO\textsubscript{2} Emissions

5.13 An alternative indicator of emissions is to consider how transport CO\textsubscript{2} emissions per capita have changed over time, and across countries. Figure 5.5 shows CO\textsubscript{2} emissions from domestic and international transport per capita in 2005. It suggests that when population is accounted for the UK has relatively low transport CO\textsubscript{2} emissions.\textsuperscript{67}

5.14 CO\textsubscript{2} emissions per head have increased since 1990 in all countries except Germany, which has stayed fairly constant. Several countries have experienced large increases: notably the Netherlands, Belgium and Ireland. These increases are partly attributable to an expansion of international air travel (the Netherlands and Ireland) and sea travel (Belgium) (see Figure 5.9 and Figure 5.10).

\textsuperscript{67} This measure includes emissions from international transport which is partly dependent upon geography, development of the aviation industry etc.
Figure 5.5: Domestic and international transport CO₂ emissions per capita, selected countries, 2005

Source: As Figures 5.1 and 5.2

5.15 Population density: We might expect that more densely populated countries have lower transport CO₂ emissions as people don’t have to travel as far to access jobs and enjoy leisure activities. Figure 5.6 shows domestic transport CO₂ emissions plotted against population per square kilometre.

5.16 This generally appears to support the premise that lower population density is associated with higher domestic transport emissions per capita. However, the UK has a relatively high population density, but has the same carbon intensity of less densely populated countries like Italy and Sweden. Conversely, Germany has a similar population density to the UK, but lower transport CO₂ emissions per head. This could suggest that how a population is spread across a country and the extent to which the population is concentrated in urban areas is also an important factor. For example, while countries such as Sweden have a relatively low population density, much of their population and travel is concentrated in urban areas, so the effect of population density on transport emissions may be less important.
**Figure 5.6:** Domestic transport CO₂ emissions and population density, selected countries, 2005

![Graph showing domestic transport CO₂ emissions and population density for selected countries in 2005.](image)

**Source:** As Figures 5.1 and 5.2

**CO₂ Intensity of Passenger Travel**

5.17 To the extent that the UK’s transport CO₂ emissions, relative to GDP or population, are lower than comparable countries this could be due to the UK population travelling less than those in other countries, and/or the UK’s transport modes having relatively low CO₂ emissions per kilometre. It is therefore worth looking at the relative carbon intensity of UK transport by calculating CO₂ emissions in the UK per passenger kilometre.

5.18 **Passenger kilometres and population:** A comparison of passenger kilometres (including international travel) per capita (Figure 5.7) indicates how much individuals across different countries travel.

5.19 The general trend is for distance travelled per person to increase over time. This is likely to be associated with increases in income (see chapter 2). Spain, Portugal and Ireland show significant increases in passenger kilometres between 1990 and 2004, consistent with relatively large increases in GDP per capita over the period. Figure 5.7 also shows that the number of passenger kilometres travelled by the UK population is broadly in line with the other countries considered, but nearer the higher end for the group.

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68 IMF World Economic Outlook Database, April 2008
Figure 5.7: Passenger kilometres per capita, thousands


5.20 Emissions per passenger kilometre: Figure 5.8 compares domestic transport CO₂ emissions per million kilometres of passenger travel. This suggests that the UK performs well relative to other countries in terms of carbon intensity - only Germany, France, Sweden and Italy perform better. There is significant variability in the performance across nations with the carbon intensity of Portugal almost double that of Italy.
**Figure 5.8:** Million tonnes of domestic transport CO₂ emissions per million passenger kilometres (excluding aviation and shipping), 2005

**Source:** European Environment Agency data

**Modal split**

5.21 Chapters 3 and 4 discussed the issue that the mode chosen to undertake a journey will be a significant factor in determining overall transport emissions. For example, Figure 4.1 suggests that travel by bus and coach is more carbon intensive on average than travel by national rail, but less carbon intensive than travel by car or air. The proportion of passenger distance travelled by 4 key modes in selected countries is shown in Figure 5.9 and Figure 5.10 in 1990 and 2004 respectively.

5.22 Figure 5.9 shows that, in general, most developed countries had a similar modal mix in 1990. Car travel accounted for the largest proportion of passenger distance travelled, while a much smaller percentage of passenger travel was accounted for by bus, domestic and intra-European air and rail. The share of UK passenger travel by air was slightly higher than that of rail and bus combined.
**Figure 5.9:** Passenger distance travelled by mode for selected countries (includes international aviation), 1990


5.23 Compared to 1990, Figure 5.10 suggests that the share of air travel in 2004 has generally increased at the expense of bus and rail. Ireland and Germany (to a lesser extent) bucked this trend with domestic and
European air travel expanding at the expense of car travel. In the UK, air travel has expanded at the expense of private cars.

5.24 There are some interesting outliers in the data shown in Figure 5.10. The growth of low-budget air travel and geographical location is likely to account for Ireland’s far higher share of air travel. Greece has low car ownership and a very high share of bus journeys - there are only 355 cars per 1000 inhabitants in Greece compared with 469 in the UK\textsuperscript{69}. Japan has a relatively high share of rail transport, far higher than the UK. This may result from Japan’s proficient rail network, the average delay per departure in 2007 on Japan’s Shinkansen trains was 0.3 minutes\textsuperscript{70}.

5.25 The Eurobarometer survey\textsuperscript{71} found that only 19\% of respondents in the UK stated that if public transport improved they would not use their car less. While it is likely that actual behaviour changes will be less substantial than stated behaviour changes, this suggests there may be scope for improved public transport in the UK to reduce car use. Certainly the experience of Japan shows that it may be possible to shift people away from cars and towards public transport if the appropriate public transport infrastructure is in place (although no assessment is made here of the associated costs of achieving this).

5.26 With the exception of the US, Italy had the highest proportion of car travel in 2004, and yet it is the least carbon intensive of all of the countries shown in Figure 5.8. This compares with Belgium, which is relatively carbon intensive, yet has a very high proportion of car use. In fact, all three of the countries which have a lower carbon intensity than the UK have higher proportions of car use. The UK has a relatively high proportion of air transport, however.

**Car Travel**

5.27 Given the dominance of the car as a means of transport (Figure 5.9) it is important to look at the carbon intensity of cars across countries.

5.28 **Average new car CO\textsubscript{2} emissions:** Since most passenger distance travelled is by car, the fuel mix of cars is an important factor in determining CO\textsubscript{2} intensity. Figure 5.11 reports average car CO\textsubscript{2} for new petrol and diesel cars. It shows that new diesel cars emit less CO\textsubscript{2} per kilometre on average than petrol cars. It also illustrates that average new car CO\textsubscript{2} varies greatly across the EU and that the UK average is slightly higher than the EU-15 average. Italy and France have very low carbon intensities and also have very efficient diesel and petrol cars.

5.29 Italy also has a high proportion of motorised two-wheeler use: approximately a third of motorbikes and mopeds covered by European...
Environment Agency statistics are registered in Italy\textsuperscript{72}. Defra’s Company Reporting Guidelines suggest that, on average, two wheelers produce lower CO\textsubscript{2} emissions per passenger kilometre than cars – average CO\textsubscript{2} emissions per passenger kilometre for petrol motorcycles is 106g, compared to 130g for the average petrol car\textsuperscript{73}.

**Figure 5.11:** Average new car CO\textsubscript{2} g/km for selected countries, 2004


5.30 Trends in new car CO\textsubscript{2} emissions do not map directly onto trends in carbon intensity due to differences between emissions from new cars and emissions from the car fleet as a whole (which will include emissions from older cars), as well as the extent of travel by other modes. For example, Portugal has relatively high domestic transport emissions per passenger kilometre as shown in Figure 5.8 above, and yet it has almost the most efficient new cars in the sample.

5.31 By contrast, Germany has relatively low emissions by distance travelled, yet the average CO\textsubscript{2} emissions of new cars is relatively high. This may be partly explained by the average age of the German car fleet – newer cars generally tend to have lower emissions than older cars, due to advances in lower CO\textsubscript{2} technology over time\textsuperscript{74}. The average car age can therefore be used as an indicator of the CO\textsubscript{2} emissions across the car fleet. In this respect, Germany performs well relative to France and Italy.

\textsuperscript{72} Climate for a transport change, EEA report No 1/2008.


\textsuperscript{74} This has been partly offset by the increased weight, power and equipment of new cars.
In 2001, the average age of German passenger cars was 6.8 years, compared to 7.5 and 8.1 years for France and Italy respectively\textsuperscript{75}.

5.32 In the UK, the average age of a petrol car in 2001 was 5.9 years compared to an EU-15 average age of 7.4 years. The ratio between passenger car new registrations and the passenger car fleet in 2000 was also relatively high, at 8.9\%\textsuperscript{76}. This may help to explain the UK’s relatively low transport carbon intensity despite a share of car travel around the EU average.

5.33 **Fuel mix:** As identified above, diesel cars generally emit less CO\(_2\) than petrol cars per kilometre travelled, although there is a trade off with relatively higher local air pollutants from diesel cars. Figure 5.12 shows the percentage of petrol, diesel and alternative fuel cars registered in selected countries in 2004.

**Figure 5.12:** Fuel mix of the passenger car stock in selected countries, 2004

![Fuel mix of the passenger car stock in selected countries, 2004](source)


5.34 Figure 5.12 indicates the low proportion of diesel cars compared to petrol cars in the UK. This is consistent across Europe - no country has more diesel than petrol cars, although almost half the Austrian fleet runs on diesel. In 2004, the UK and Germany had very similar proportions of petrol and diesel cars. This is despite the fact that unlike Germany, diesel prices in the UK are higher than petrol prices. The French had a


\textsuperscript{76} Ibid, Table 1 and Table 2.
very high proportion of diesel cars, partly driven by a disparity between the pump price of diesel and petrol, as shown in Figure 5.13 below.

5.35 Vehicles run on alternative fuels generally emit both lower CO₂ emissions and lower local air pollutants. In 2004, the UK was one of four EU countries with a significant proportion of alternative fuel in cars (this includes hybrids), the others being Poland, the Netherlands and Belgium.

5.36 **Fuel prices:** Figure 5.13 below shows the cost of petrol and diesel, including taxes, across selected European countries.

**Figure 5.13:** Relative petrol and diesel prices, selected countries, current prices, 2006

![Relative petrol and diesel prices, selected countries, current prices, 2006](image)

*Source: Transport Statistics Great Britain 2007*

5.37 In most countries petrol and diesel prices are quite similar. The UK is the only country with higher diesel prices than petrol prices, which will partly reflect relative tax rates within individual countries. This compares to the Netherlands, which has relatively high petrol prices but much lower diesel prices. Despite this, the Netherlands actually has a lower proportion of diesel cars than the UK. However, the Netherlands had some of the highest diesel prices in the EU in 1996 which may have influenced the make-up of the existing car stock (the expected average life of a vehicle is about 14 years\(^7\)).

5.38 Despite relatively high pump prices, Figure 5.7 suggests that UK passenger kilometres are nearer the top of the range of the countries considered. This could suggest a relatively low fuel price elasticity of

\(^7\) See [http://www.cfit.gov.uk/docs/2001/scot0122/scot0122/02.htm](http://www.cfit.gov.uk/docs/2001/scot0122/scot0122/02.htm).
demand for transport. The NTM generates an implied fuel price elasticity in the UK of -0.15 (see chapter 2).

Travel by Bicycle

5.39 Figure 5.14 shows cycling rates across the EU-15 in the year 2000. It shows that there are vast differences in cycling rates across Europe. The UK ranks relatively low in its cycling use. Increasing cycling rates could result in benefits other than reducing CO\textsubscript{2} emissions, such as health benefits and potentially a reduction in congestion levels.

5.40 However, cycling rates may be affected by a number of disparate factors, such as the geography of a country and weather conditions. Further, the impact that increasing the rate of cycling may have on reducing other journeys is unclear. If increasing cycling rates could reduce the number of trips undertaken by car, it is likely that this would only replace short journeys. Chapter 3 (Figure 3.13) suggests that car journey’s of under 5 miles only contribute about 20% of CO\textsubscript{2} emissions from domestic transport.

Figure 5.14: Cycling rates across the EU-15 (2000)

Freight Transport

5.41 Figure 5.15 illustrates the modal distribution of freight transport across road, rail, and inland waterways for selected countries in 2006. There is far greater variability across countries compared to the mode split for passenger travel.

**Figure 5.15:** Freight modal shares, selected countries, 2006


5.42 The majority of freight transport CO₂ emissions in the UK are likely to originate from the movement of freight by HGV’s and LGV’s i.e. road transport (see chapter 3). This seems common across other developed countries, as in all cases the majority of million tonne kilometres associated with freight journeys are made by road. Nevertheless, compared to the UK, Germany transports a far greater amount of freight by inland waterway and rail, at 12.8% and 21.4% respectively, compared to 0.1% and 11.8% for the UK. ²⁷⁸

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²⁷⁸ *Climate for a transport change*, EEA report No 1/2008.
6. The Challenge for Transport

**Key Messages**

We do not have a CO₂ emissions reduction target specific to the transport sector. However, targets to be set at both the UK and the EU level will require CO₂ emission reductions from all sectors of the economy, including transport.

A cost-effective solution to meeting the targets is unlikely to require an equal proportionate reduction in emissions across all sectors.

Modelling suggests that the potential for significant, cost-effective reductions from transport is greater in the medium to longer term. It also reinforces the need to ensure that the foundations are laid now for the transport sector to be in a position to deliver these savings, and to avoid ‘locking-in’ higher CO₂ transport options.

Emission reductions will be required from transport over the shorter term. The policy framework should include the three essential elements identified by the Stern Review: carbon pricing, technology policy, and the removal of barriers to behavioural change.

Over the longer term, technology and innovation will be key to achieving CO₂ emission reductions.

The flexibility to meet targets in the most cost-effective way is vital to ensure that the transport sector contributes to our climate change goals, consistent with supporting delivery of DfT strategic objectives and other wider Government goals.
The Challenge for Transport:

a) to 2020

6.1 The transport sector as a whole does not currently have a target level of CO₂ emissions reductions to achieve by a certain date. However, the Climate Change Bill will put into statute a requirement for the UK to reduce its emissions of CO₂ by at least 26% from 1990 levels by 2020. As explained in Chapter 1, the Committee on Climate Change will also provide advice to the Government, by 1 December 2008, on the level of the first three carbon budgets to 2022. This advice will include the suggested contribution from those sectors involved in emissions trading, and those not (primarily transport and domestic heat). The European Commission has also proposed a target for the non-traded sectors in the UK of a 16% reduction from 2005 levels by 2020. This target would be increased if an international climate agreement were to be reached.

6.2 The challenge for the transport sector to 2020 is the extent of the “gap” between forecast emissions from domestic transport and any implied or hard targets for the transport sector. Without further measures, our forecasts suggest that domestic transport emissions will fall by just over 1% in 2020 from 2005 levels. If the mandatory new car CO₂ target in 2020 proposed by the UK is adopted by the EU, UK domestic transport emissions in 2020 are forecast to be just over 5% lower than in 2005. By comparison, the current EU proposed target for greenhouse gas emissions from the non-traded sector is a 16% reduction by 2020 over 2005 levels, although this does not specify how the burden would be shared between transport and the rest of the non-traded sector.

6.3 It is therefore clear that the transport sector will need to do more - achieving our climate change goals will require contributions from all sectors of the economy, including transport. We also need to deliver a transport system that both supports the economy and the UK’s productivity and competitiveness. It is highly unlikely that a cost-effective approach will mean equal proportionate CO₂ emission cuts in every sector. A cost-effective solution means that we need to determine how the transport sector can make a contribution towards meeting our targets at least cost, consistent with achieving our other strategic goals and wider Government objectives, such as maximising the productivity and competitiveness of the UK.

6.4 The Stern Review79 of the economics of climate change recommended that policy to reduce CO₂ emissions should be based on three essential elements: carbon pricing, technology policy, and the removal of barriers to behavioural change. Chapter 2 sets out some of the existing policies under each of these elements: for example, carbon pricing is achieved through measures such as company car tax and graduated VED; the

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79 See [http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm](http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm) for the final report.
new car CO\textsubscript{2} targets will continue to incentivise the development of innovative, lower carbon technologies; and behavioural change is encouraged through measures such as Smarter Choices and the Act on CO\textsubscript{2} campaign.

6.5 Additional measures under each of these elements will be needed to ensure that our climate change goal for transport is achieved cost-effectively, whilst still achieving our other transport goals of competitiveness and productivity; safety, security and health; quality of life; and equality of opportunity\textsuperscript{80}.

\textit{b) to 2050}

6.6 The Stern Review emphasised the importance of urgent and cost-effective action on climate change across all sectors of the global economy, whilst also noting that:

\begin{quote}
\textit{“Transport is one of the more expensive sectors to cut emissions from because the low carbon technologies tend to be expensive and the welfare costs of reducing demand for travel are high. Transport is also expected to be one of the fastest growing sectors in the future. For these two reasons, studies tend to find that transport will be among the last sectors to bring its emissions down below current levels.”}
\end{quote}

6.7 Even if the potential for significant short-term cost-effective abatement in the transport sector is limited, in the long-term it is likely to be much higher. The UK MARKAL Macro model was used to undertake analysis for the Energy White Paper (2007) to estimate the most cost-effective emissions ‘pathway’ for each sector of the UK economy to an overall 60% CO\textsubscript{2} reduction in 2050. The model produces a set of results based on the scenario being run – it does not produce forecasts of CO\textsubscript{2} emissions.

6.8 Figure 6.1 shows the results of the model under one possible scenario for how domestic emissions might most cost-effectively reduce over the period to 2050. It suggests that, with appropriate measures, reductions of 40-60% from domestic transport are possible by 2050 – less than in energy, but more than other sectors. These reductions would happen later in the transport sector than elsewhere. As the figure demonstrates, if we are to tackle CO\textsubscript{2} emissions cost-effectively, it is likely that different emitters and sectors will make different contributions to emissions reduction and to different timescales, and that flexibility will be required across the economy to enable us to respond to unforeseen challenges and opportunities.

\textsuperscript{80} For more detail on the Government’s goals for transport, see DfT (2007), \textit{Towards a Sustainable Transport System}, available at http://www.dft.gov.uk/about/strategy/transportstrategy/pdfsustaintranssystem.pdf
The above analysis does not mean that short-term action to address emissions from transport is not necessary or will have no effect (as noted in chapter 2 above, estimates suggest that CO₂ emissions from road transport, for example, will be 20% lower in 2020 than they would have been in the absence of policy). However, it does underline the importance of laying the longer-term foundations for low CO₂ transport technologies and for looking at the whole system – we need to take action now to pave the way for cost-effective reductions in CO₂ emissions from transport in the future. This will be even more important if the Committee on Climate Change advise that the target for 2050 should be increased towards an 80% reduction in CO₂ emissions. The Committee’s advice on this is expected by 1 December 2008.
Box 14: The King Review of Low Carbon Cars

Part I of the King Review of Low Carbon Cars suggested that, by 2050, almost complete decarbonisation of road transport in the developed world is a realistic ambition. The review concluded that with substantial progress in solving electric or other innovative vehicle and fuel technology challenges and, critically, decarbonisation of the power sector and an expansion in supply to fuel a large proportion of road transport energy demand, per kilometre emissions reductions of around 90% could be achievable for cars. If the rate of road transport growth projected by the Eddington Review and largely consistent with the National Transport Model continues, and road use in the UK approximately doubles by 2050, this would deliver an 80% reduction in total road transport CO₂ emissions, relative to 2000 levels.

Part II of the King Review set out a number of recommendations for policy and actions by government, businesses and consumers, including:

- consideration should be given to options to facilitate the efficient use of electric vehicles (such as smart-metering, time-of-day pricing, and fast charging points);
- a proposal that demand-side measures should be strengthened to enable and encourage customers to choose more fuel efficient vehicles which are the best in their class on the DfT’s Best On CO₂ rankings. This could be through strengthened regulation of advertising and expanding the Act on CO₂ campaign to highlight the fuel efficiency labels; and
- proposals to enhance the effectiveness of the Act on CO₂ campaign via more face-to-face engagement with consumers and greater emphasis on the financial benefits to consumers.

In Budget 2008, the Government undertook to respond to the King Review in the summer.

6.10 The DfT’s approach to encourage innovation in the transport sector and the steps we are taking are set out in the Low Carbon Transport Innovation Strategy (LCTIS) published in May 2007. It includes increasing the amount of funding for, and providing crucial coordination of, Research and Development (R&D) activities. The DfT, the Technology Strategy Board and the Engineering and Physical Sciences Research Council is supporting a new "Innovation Platform" for UK R&D into lower CO₂ vehicles of the future. The first £20m call for proposals under this new initiative was launched in September 2007 and projects will commence from 2008. A further £70m programme under the Innovation Platform will also be launched in 2008.

6.11 To help ensure the public sector leads by example, in the Energy White Paper (2007) the government committed to achieving a new target on the CO₂ efficiency of new passenger cars used by central government for administrative purposes: by 2010/11, these will emit on average

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83 Available at www.dft.gov.uk/pgr/scienceresearch/technology/lctis/lowcarbontis.
130gCO₂/km or less across the new car fleet. The DfT is also developing a new programme supporting public procurement of lower CO₂ vehicles. The DfT has appointed Cenex, the UK Centre of Excellence for lower carbon and fuel cell technologies, to deliver the programme on its behalf. Initially, up to £20 million of funding is available for the first phase of the programme, which will focus on support for the procurement and operation of lower CO₂ emitting vans.

6.12 The DfT also expects to support low CO₂ transport technology research within the Energy Technologies Institute.

6.13 For the purpose of the next stage of our analysis, we are not taking as a given the premise that measures to reduce CO₂ emissions from transport are only cost-effective in the long-run. The analysis reported here looks again at recent data to inform understanding of what's driving transport demand and its associated emissions. We are looking at the costs and CO₂ savings attached to a range of potential measures to further reduce CO₂ emissions from transport.

6.14 In taking this work forward, the key guiding principles are:

(i) there is a long-term gap between forecast UK CO₂ emissions and our target in 2050;

(ii) we need to retain some flexibility in how we go about meeting that gap to ensure that it can be met most cost-effectively;

(iii) we should therefore favour options and packages of options that provide some flexibility and don't 'lock in' higher CO₂ emissions; and

(iv) we need innovation in all sectors.

6.15 The analysis set out in this paper will help provide a solid underpinning of evidence for considering the additional options that will help to further reduce CO₂ emissions from UK domestic transport most cost-effectively. We should then be in a position to ensure that the transport sector contributes towards our climate change goal and the achievement of our climate change targets to 2050, consistent with supporting our other strategic objectives and wider Government goals.