Leeds City Region Partners

Leeds City Region Transport Strategy

Carbon Assessment – Delivering Low Carbon Connectivity to Promote Faster Economic Growth

FINAL ISSUE

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Carbon Assessment – Delivering Low Carbon Connectivity to Promote Faster Economic Growth

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Executive Summary

Introduction

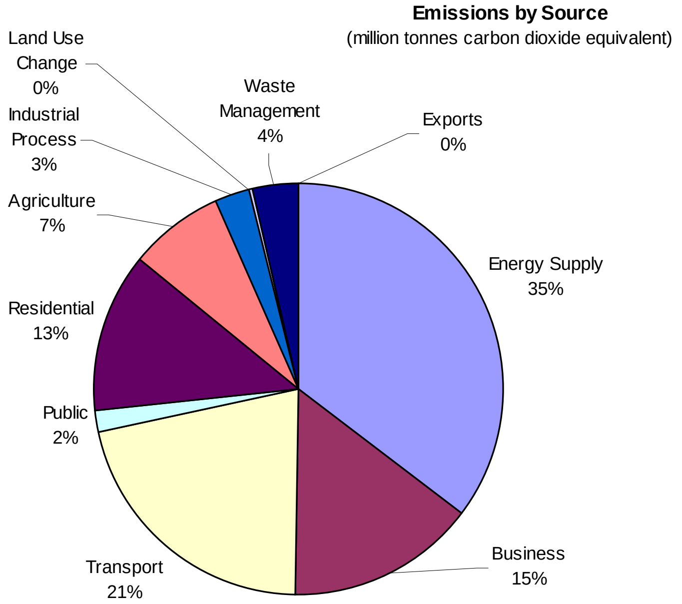
Ove Arup and Partners Ltd. (Arup) has been appointed by the Leeds City Region Partners to assist with the update of the Leeds City Region Transport Strategy (LCRTS). As part of this commission, Arup has undertaken this carbon foot printing study. The purpose of this study was to understand the contribution that personal transport within the Leeds City Region (LCR) is making to climate change through the carbon dioxide emissions arising from vehicle use, and help to influence the potential choice of interventions. The study has considered the baseline transport related emissions arising from residents of the LCR and the potential for the interventions presented within the LCRTS to reduce those emissions. A range of potential interventions have been considered. It is hoped that this study will assist the Leeds City Region Partners in understanding the role that climate change mitigation can play in shaping the transport system in the LCR.

Drivers

UK policy asks how to best reduce climate change impacts by reducing global emissions of Greenhouse Gases (GHGs). On signing the Kyoto Protocol, which came into force in 2005, the UK Government has made a legally binding agreement to reduce emissions of GHGs to 12.5% below 1990 levels by the year 2012. The UK's Climate Change Act (2008), the first national legislation of its kind, sets out the government's commitment to reducing carbon dioxide emissions to 80% below 1990 levels by 2050. This national level legislation is being supported by a host of regional, local and sectoral policies and initiatives. In 2007, the DfT set out their position on sustainability and climate change in the framework document "Towards a Sustainable Transport System (TaSTS) which included a goal to "*address climate change, by cutting emissions of carbon dioxide (CO_2) and other GHGs".* TaSTS also established the government's intention to develop a Carbon Dioxide Reduction Strategy for transport in 2009 and to work with the newly formed Climate Change Committee to establish the abatement potential in the transport sector. The need to tackle greenhouse gas emissions from transport is also referenced as a driver in the DfT's 2008 report, Delivering a Sustainable Transport System.

The UK Carbon Footprint

The UK's annual carbon footprint currently sits at approximately 623.8 million tonnes of GHG emissions.[1] In 2007, the transport sector contributed 21% of the UK's total carbon emissions. This placed transport as the second highest source of emissions behind energy supply at 35%.

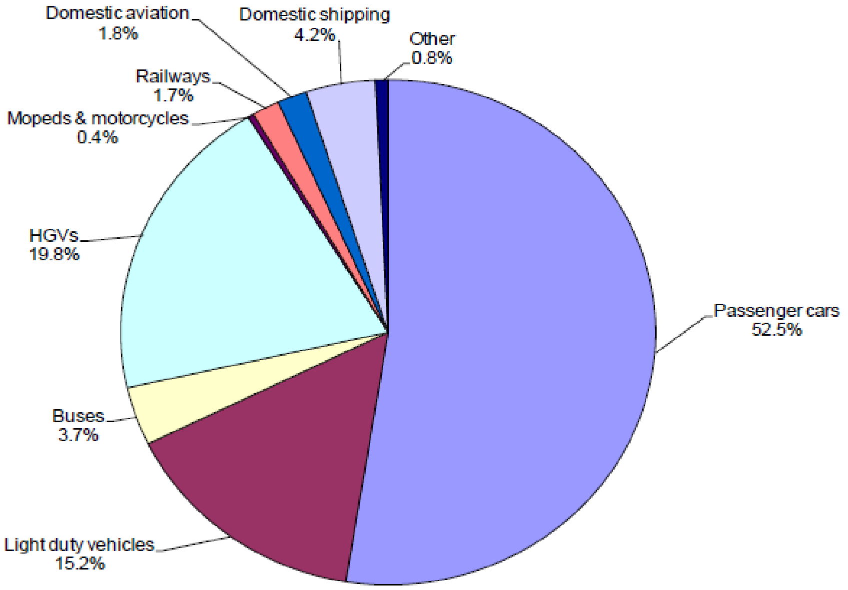


UK GHG emissions by Source (2008)
Source: National Statistics 2008 (provisional figures)

The transport related emissions included within the national statistics data are made up of the following categories:

- Road transport (public and private),
- Domestic shipping, and
- Domestic aviation.

Of these three categories, the major contributor is road transport, accounting for over 90% of all transport related emissions. Within the road transport category, passenger car journeys far exceed all other categories in their contribution to overall emissions (52.5%).



CO_2 emissions from domestic transport by Source, UK, 2006
Source: National Atmospheric Emissions Inventory 2006, cited in *DfT (2008) Carbon Pathways Analysis*

[1] National Statistics (26 March 2008) published by DECC (provisional figures). Figures are for CO_2 equivalent emissions for the Kyoto Protocol GHG.

Of these trips, **commuting journeys** make the most significant contribution to carbon dioxide emissions arising from personal transport; for passenger car or other modes. This is followed by journeys to key services and shopping.

The Leeds City Region Transport Carbon Footprint

As part of this study, a model was developed to assess the baseline travel patterns within the Leeds City Region.[2] The model used the 2001 Census Journey to Work database ('the census data') to create a baseline for existing transport behaviours within the LCR. The study has calculated the number of trips to city and town centres across the LCR and used average journey distances to build up the travel profile for the City Region. DEFRA emissions factors (kgCO_2 per km travelled) were applied to the calculated total vehicle kilometres to calculate the carbon dioxide emitted by the journeys. The model resulted in the following baseline emissions for the City Region.

Modeled baseline emissions (tCO2 / year)			
Barnsley	201,961	**Kirklees**	388,072
Bradford	497,976	**Leeds**	1,257,305
Calderdale	204,198	**Wakefield**	396,138
Harrogate	163,358	**York**	204,198
LCR Total			**3,313,206**

Source: REAP

The LCR Transport Strategy Interventions

In order to assess the carbon emission implications of the Transport Strategy on the baseline footprint, the potential changes in emissions arising from a number of interventions were modelled. These interventions are outlined below.

Scale	Intervention
City Region interventions	Smarter Choices – A marketing initiative to make people aware of alternative transport options.
	Low Emission Vehicles - The increase in use of cars with lower carbon impacts such as the use of electric vehicles powered by renewable electricity.
	Demand Management - Strategies and policies to reduce private transport demand e.g. parking controls.
	Bus Priority and Quality Enhancements - Extending the network of bus priority lanes and upgrading outdated buses with higher quality models.
	Cycling - Encouraging increased cycling rates such as improving infrastructure.
	Expansion of Bus Network - Expansion of the bus network to reach more areas.
	Affordability of Bus Fares - Improving the affordability of bus fares for all.
	Home to School - The use of school busses to transport children from home to school.

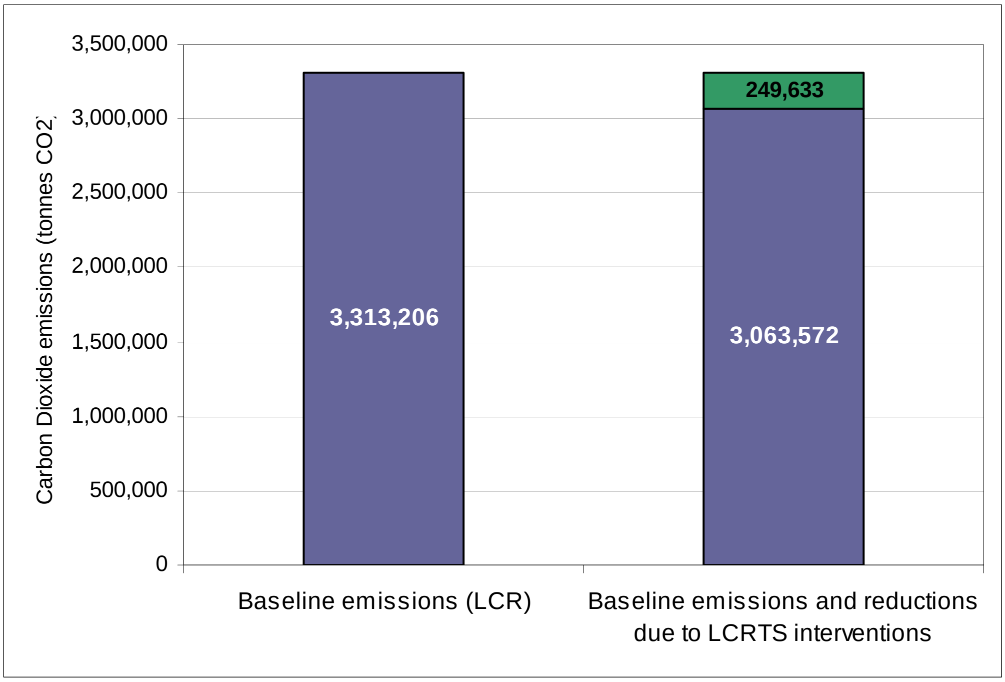
[2] The carbon dioxide emissions arising from travel in Craven have been omitted from this study as it is assumed that the interventions outlined in the LCRTS will not greatly influence travel patterns in this area.

Corridor interventions	Rail Electrification - Conversion of existing diesel rail routes to electrified systems.
	Active Traffic Management - Active regulation of car speed on motorways to improve traffic flow and reduce congestion.
	Rapid Transit Network – Proposed trolleybus scheme to provide 'new generation' electrified buses on dedicated lanes with priority at junctions.
	Targeted Highway Improvements - The improvement and expansion of roads where necessary across the LCR.
	Alternative Rail Technologies - Installation of a tram-train that will allow for the extension of train lines.
	Park and Ride - Implementation of park and ride schemes in York and Birstall.
	New railway Stations – Construction of new stations in the LCR on the existing railway network.
	Express Bus/Coach Network - Implementation of a rapid coach between key cities.

Each intervention was modelled to assess the resultant gain or loss in carbon dioxide emissions. The 'losses' represent the contribution that the intervention makes to reducing carbon dioxide emissions. This is either through a reduction in vehicle kilometres or an improvement in the efficiency of vehicles. The 'gains' represent an increase in carbon emissions arising from the intervention, typically through an increase in vehicle kilometres including both cars and public transport vehicles.

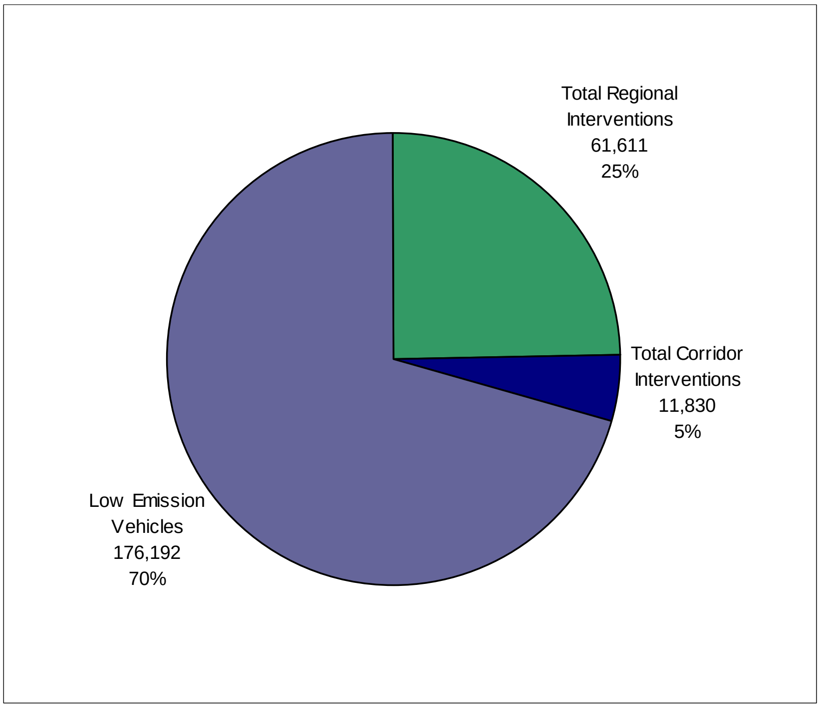
Results

Cumulatively, the interventions modelled contribute an annual saving of close to 250,000 tonnes of carbon dioxide. This represents a 7.5% reduction when compared to the modelled baseline for the LCR (3,313,206 tonnes CO_2/year).



Source: REAP

By far the greatest contribution to emissions reduction arises from Low Emission Vehicles; this intervention alone contributes 70% of the overall reductions. This is followed by Demand Management and Smarter Choices.



Contributions from Interventions (grouped) (tCO2)

Source: REAP

It is clear that these interventions alone fall short of achieving the levels of carbon emissions reduction that will be required to meet the UK government's carbon reduction targets. More must be done to focus the development of transport interventions around measures that will deliver significant and lasting reductions in carbon emissions. To achieve this, a reduction in carbon emissions must lie at the heart of a transport strategy. LCR must respond to this challenge by, during the implementation of the Strategy, being mindful of the opportunities to reduce emissions and take the steps required to do so.

Next Steps

In moving forward from this study, LCR should seek to undertake the following actions:

- **Understanding the Climate Change agenda** - Understanding the challenges that climate change will pose to the transport sector. Empower stakeholders of the LCRTS to identify opportunities within their respective spheres of influence.
- **Objective and Targets -** Establish an objective and target for the reduction of carbon dioxide emissions. The target should be specific, measurable, and achievable and have a timescale.
- **Action Plan** - Interventions should be developed and implemented with a specific focus on achieving reductions in carbon emissions. Different stakeholder groups should have responsibility for delivering against the climate change targets.
- **Monitoring** - There should be a greater focus on monitoring the progress of the interventions in changing transport behaviours across the LCR to provide robust data for future analysis.
- **Reporting -** In order to drive improved transparency and accountability, the LCR should undertake to report on the successes and emissions savings arising from the LCRTS.

1 Introduction

1.1 Background to the Study

Ove Arup and Partners Ltd. (Arup) has been appointed by the Leeds City Region Partners to assist with the update of the Leeds City Region Transport Strategy (LCRTS).

Climate change is emerging as one of the key drivers for the transport sector in the UK and as a result, the LCR Partners are taking the opportunity, through the refresh of the LCRTS, to understand the climate change implications of transport in the Leeds City Region (LCR).

Arup has undertaken this carbon foot printing study to consider, at a high level, the contribution that personal transport within the LCR makes towards climate change and the carbon emissions reductions that could potentially be achieved through the interventions outlined within the LCRTS.

1.2 Leeds City Region Transport Strategy

1.2.1 Leeds City Region

The LCR Partnership was established to facilitate working between local authorities; based on the recognition that the environmental, social and economic challenges facing the region are not constrained to the local authority boundaries. The LCR includes the following 11 local authorities; Barnsley, Bradford, Calderdale, Craven, Harrogate, Kirklees, Leeds, Selby, Wakefield, York, and North Yorkshire County. The region has a population of approximately 3 million people with a workforce of 1.2 million.[3]

1.2.2 The Transport Strategy

The LCR Transport Vision was published in 2006 as part of the City Region Development Programme. The Transport Vision built upon the Regional Transport Strategy and presented the long term strategic priorities for transport within and beyond the City Region. The purpose of the Vision was to set the priority for the region working as a single economy; linking the main urban centres, regeneration areas, transport hubs and airports. A refresh of the Transport Vision is currently underway to develop a more focused transport strategy for the region and to incorporate the emerging national policy in the DfTs 'Delivering a Sustainable Transport System' (DaSTS).

1.3 Purpose of the Study

The purpose of this study was to gain a greater understanding of the contribution that personal transport within the Leeds city region is making to climate change through the carbon dioxide emissions arising from vehicle use. In this context, the study has considered the baseline transport related emissions arising from residents of the LCR and the potential for the interventions presented within the LCRTS to reduce those emissions. A range of potential interventions have been considered, including schemes that could be applied to an area or region, and projects relating to specific transport corridors. It is hoped that this study will assist Leeds City Region Partners in understanding the role that climate change mitigation can play in shaping the transport system in the city region.

1.4 Scope of the Report

This report is divided into three main sections.

The first section sets out the background to, and drivers for, climate change mitigation in the UK. The basic science behind climate change and greenhouse gas mitigation is presented along with the UK's current carbon footprint, and the greenhouse gas emissions arising from

[3] http://www.leedscityregion.gov.uk/aboutus.aspx

the transport sector. The section also sets out some of the impacts of climate change that we may expect to experience in the future both globally and locally and how these may affect the transport sector; particularly in the Yorkshire region.

The second section sets out the carbon dioxide modelling work that has been undertaken as part of this study. The modelling work establishes the baseline transport related carbon dioxide emissions within the LCR that arise from different journey types and modes. The modelling then sets out the potential emission reductions that could be achieved by the range of transport interventions and scenarios that are being presented as part of the LCRTS.

The final section discusses a number of factors that, while not included within the quantitative emissions study, will continue influence the emissions arising from transport in the Yorkshire region.

The report is set out as follows:

Section 2 - Introduction to Climate Change: What is Climate Change and how will it affect us.

Section 3 - UK Transport's Carbon Footprint: The contribution of transport sector to climate change, emissions arising from personal transport and trends in emissions.

Section 4 - Approach to the Study: General approach and scope of this study including approach to calculating baseline emissions, scope of interventions and exclusions.

Section 5 - Results of the Study: Baseline carbon emissions arising from transport in the LCR (calculated) and the modelled contribution of the interventions to reducing those emissions.

Section 6 - Further Influencing Factors: Additional factors that are likely to play an influencing role in carbon emissions arising from personal transport in the LCR including further information on low emission vehicles and changing driver behaviour.

2 Introduction to Climate Change

2.1 Climate Change and Carbon Management

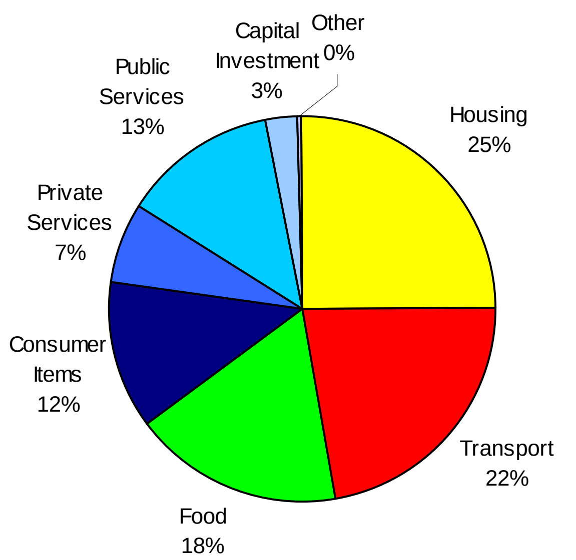
2.1.1 What is Climate Change?

Climate change is the term commonly used to describe the changes in the earth's climate that are arising due to warming of the earth's surface. This change is occurring because of a build up of greenhouse gases[4]; trapping solar radiation entering the earth's atmosphere resulting in a warming of the atmosphere. This warming has been and will continue to be the catalyst for a range of climatic changes around the globe.

2.1.2 What are GHG emissions?

Greenhouse gas (GHG) emissions arise from a range of natural and man-made sources. Our current approach to climate change mitigation focuses on man-made (anthropogenic) GHG emissions, arising primarily through the combustion of fossil fuels (coal, oil, natural gas). These emissions can occur directly through the combustion of fossil fuels (i.e. we are directly responsible for the combustion of petrol in our vehicles) or indirectly at a remote source (i.e. we are indirectly responsible for emissions associated with the generation of electricity at a power station). In addition, we are also responsible for embodied carbon emissions (or embodied energy) which represent the GHGs that were emitted to produce and provide the goods and services that we use. These embodied emissions can occur anywhere in the world because the goods and services we use are produced in a global economy. The following table and graph present an overview of the direct, indirect and embodied GHG emissions generated through the consumption activities of an average UK resident. As can be seen, housing (which includes the energy consumed for lighting and heating) and personal transportation have the largest impacts.

Activity	Carbon Footprint[5] (tonnes CO2e[6]/capita)
Housing	4.11
Transport	3.59
Food	2.89
Consumer Items	2.03
Private Services	1.08
Public Services	2.13
Capital Investment	0.46
Other	0.06
Total	**16.34**



[4] The six main anthropgenically derived GHGs targeted by the Kyoto protocol are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Perfluorocarbons (PFC), Sulphur Hexafluoride (SF_6), Hydrofluorocarbons (HFC).

[5] Source: REAP (2006) The Resource and Energy Analysis Programme (REAP) is a software tool that assesses the environmental impacts of consumption for people living within each local authority in the UK. The above data represents the total footprint (including direct and indirect emissions).

[6] GHG emissions are often measured as carbon dioxide equivalent (CO_2 e) as each GHG has a different global warming potential (GWP). The GWP is a measure of the degree to which the GHG contributes to global warming relative to Carbon Dioxide which has a GWP of 1.

2.1.3 How did we arrive at this point?

At current rates of activity and production, the Earth's biomass[7] cannot absorb carbon dioxide emissions as quickly as they are generated by human activities. This leads to a build up of carbon dioxide concentrations (and concentrations of other GHGs) in the atmosphere beyond those which would be found naturally. It has been reported that global carbon dioxide concentrations reached 379ppm in 2005 which far exceed the range of 180 – 300 ppm exhibited over the past 650,000 years.[8] There is now a strong consensus amongst the scientific community that global warming is a result of anthropogenically derived GHG emissions.[9]

2.1.4 What will happen?

As a result of rising concentrations of GHGs in the earth's atmosphere, our climate is changing and will continue to do so into the future. Records have shown that eleven of the past twelve years (1995 – 2006) were amongst the twelve warmest years on record since records began in 1850.[10] A global average warming of 2°C is currently viewed as a critical threshold.[11]

Under a 'business as usual' scenario there is at least a 50% risk of exceeding 5°C global average temperature change during the following decades. This 5°C increase would result in catastrophic impacts on the human population as we know it. An illustration of the scale of such an increase is that we are now only around 5°C warmer than in the last ice age.[12]

2.1.5 What are the impacts likely to be if we start to manage our carbon emissions now?

Assuming that we are able to act now to avert the worst impacts of climate change, there will still be unavoidable changes to our climate. While there will be global trends, not all parts of the world will be affected in the same way. Here in the UK, we are most likely to see the following climatic trends[13]:

- The UK will continue to get warmer;
- Summers will continue to get hotter and drier;
- Winters will continue to get milder and wetter;
- Some weather extremes will become more common (heat waves & winter flooding), others less common (winter cold snaps); and
- Sea level will continue to rise.

Specific work has also been done to understand how these general trends will particularly affect the Yorkshire and Humber region up to 2050 as part of a regional adaptation study.[14]

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[7] The earth's plant matter (biomass) absorbs carbon dioxide (through photosynthesis) and release it (through respiration) as part of the biological carbon cycle.
[8] UN Intergovernmental Panel on Climate Change (2007a)
[9] UN Intergovernmental Panel on Climate Change (2007b)
[10] *ibid*.
[11] HM Treasury (2006) Stern Review: The Economics of Climate Change
[12] *Ibid.*
[13] UK Climate Impacts Programme (UK CIP) Climate Projections 2009 (UK CP 09) Key Findings. Available at: http://ukclimateprojections.defra.gov.uk/content/view/515/675/
[14] Yorkshire and Humber Adaptation Study (2009). Full report available at: http://www.adaptyh.co.uk/

- **Temperature -** Increase in annual average daily temperatures by almost 2°C and summer temperatures more regularly reaching 34°C.
- **Precipitation -** Greater seasonality of rainfall, with increases in winter (+17%) combined with significant reductions in summer (-25%) with an overall reduction in annual rainfall of up to 6%. Overall there will be an increase in the number of extreme rainfall events and dry periods. There will be a significant reduction in the number of days of frost and snow (50% to 90% reduction in winter snowfall).
- **Wind** - Marginal increases in winter average wind speeds, although summer and autumn speeds reduce slightly.
- **Soil moisture content**[15] - Moisture content will decrease by around 10%.
- **Sea Levels** - Sea levels will rise by around 0.35 metres.

2.1.6 UK Legislation and Policy

UK policy asks how to best reduce climate change impacts by reducing global emissions of GHGs. On signing the Kyoto Protocol, which came into force in 2005, the UK Government has made a legally binding agreement to reduce emissions of GHGs to 12.5% below 1990 levels by the year 2012. The UK's Climate Change Act (2008), the first national legislation of its kind, sets out the government's commitment to reducing carbon dioxide emissions to 80% below 1990 levels by 2050. This national level legislation is being supported by a host of regional, local and sectoral policies and initiatives.

2.2 Climate Change, Carbon and Transport

2.2.1 Transport related emissions - Transport's contribution to climate change

The transport sector contributes to the emission of GHGs, and hence climate change, in a number of ways. The combustion of fossil fuel in vehicles gives rise to tail pipe emissions of the GHGs carbon dioxide, methane and nitrous oxides. Equally, the use of electricity, from non-renewable sources to power electrified trains, trams and associated transport infrastructure (e.g. stations, signage and lighting), generates GHG emissions. Considered more widely, transport and spatial planning as a process has influence over the transport decisions that people make and as a direct result, the GHG emissions associated with those choices.

Further information on the detailed GHG emissions from transport is provided in Section 3.

2.2.2 Transport Climate Change Policy – Transport's contribution to reducing emissions

> *"A fundamental goal of transport policy must be to ensure that the transport sector plays its proper role in our fight to tackle climate change."* DfT (2007) TaSTS

The goal of reducing GHG emissions is playing an increasing role in the UK's transport policy. Since 2005, the Department for Transport (DfT) has had shared responsibility with Department of Environment, Food and Rural Affairs (Defra) for the Government's Climate Change Public Service Agreement (PSA) target. The target requires DfT and Defra to work towards meeting the UK government's Kyoto Protocol targets (12.5% reduction in emissions by 2008 - 2012 based on 1990 levels) and the UK's domestic target to reduce CO_2 emissions by 20% by 2010 based on 1990 levels.[16]

[15] Changes in soil moisture content holds relevance to the transport sector as a result of potential changes to ground stability and surface water run-off characteristics.
[16] PSA Target 7. DfT response available at: http://www.dft.gov.uk/about/howthedftworks/psa/psatarget7

In 2007, the DfT set out their position on sustainability and climate change in the framework document “Towards a Sustainable Transport System (TaSTS). The report had three aims:

- To outline the Government’s response to the Eddington study[17] into transport and economic growth and carbon reduction;
- To establish the DfT’s policy and investment plans up to 2014; and
- To propose a new approach to strategy setting.

The TaSTS framework outlines the six main goals which will drive the UK government’s transport agenda. One of these goals is to “*address climate change, by cutting emissions of carbon dioxide (CO_2) and other GHGs”.* TaSTS also established the government’s intention to develop a Carbon Dioxide Reduction Strategy for transport in 2009 and to work with the newly formed Climate Change Committee[18] to establish the abatement potential in the transport sector.

UK Carbon Budgets

In April 2009, the UK government announced their commitment to the first three five-year carbon budgets which will guide the UK on their path to meeting the 80% reduction target established in the Climate Change Act. The first interim budget sets the target of a 34% reduction in UK emissions by 2020. Where an international deal is agreed, this figure could be increased to an intended budget of 42%. In support of the budgets, the Climate Change Committee (CCC) has outlined their assessment of potential abatement approaches and emissions reductions pathways to deliver these reductions.

For the transport sector, the CCC identified potential abatement scenarios including:

- Current Ambition – 5Mt CO_2 (6.3% of an overall reduction of 79 $MtCO_2e$)
- Stretch Ambition – 30$MtCO_2$ (22.9% of an overall reduction of 131 $MtCO_2e$)

The CCC suggests that this reduction could be achieved through the promotion and financial support of more fuel efficient vehicles alongside behavioural changes.

The DfT published a further report in 2008, outlining their approach to implementing the proposed approach presented in TaSTS. The 2008 report, ‘Delivering a sustainable Transport System (DaSTS) reinforced the DfT’s goal to:

> *“reduce transport’s emissions of carbon dioxide and other greenhouse gases, with the desired outcome of tackling climate change.”*

Particular areas of focus in working toward this goal included:

- Improving the carbon efficiency of all transport modes;
- Promoting behavioural change;
- Providing lower carbon intensity transport options (including rail electrification and the decarbonisation of electricity generation); and
- Non-transport factors including spatial planning.

2.2.3 Impacts of Climate Change on Transport

In their report ‘The changing climate: its impact on the Department for Transport’ (2004), the DfT outlined what they considered to be the key risks to transport infrastructure arising

[17] The Eddington study was commissioned in 2005 by the Chancellor of the Exchequer and the Secretary of State for Transport to look at the strategic and long term links between transport and the UK economy; taking into account the wider commitments to sustainable development.
[18] The Committee on Climate Change (CCC) is an independent body established under the Climate Change Act to advise the UK Government on setting carbon budgets, and to report to Parliament on the progress made in reducing GHG emissions. (www.theccc.org.uk)

from the more likely and immediate climate change impacts. The DfT identified the following risks:

- Increased winter flooding may affect all modes of transport, either in floodplains or where drainage is affected.
- Coastal stretches of road and railway may be at increased risk of inundation during periods of high wind and tide. Over an extended period, coastal erosion will also impact on this infrastructure.
- More extreme heat will impact on passengers travelling on some forms of public transport, particularly during periods of delay.
- Decreased frequency of difficult driving conditions due to snow and ice but a potential increase due to rain and high winds.

3 UK Transport's Carbon Footprint

3.1 The UK Carbon Footprint

3.1.1 Overall Footprint

The UK's annual carbon footprint currently sits at approximately 623.8 million tonnes of GHG emissions.[19] This footprint includes emissions that arise from sources within the UK territorial boundary. In 2007, the transport sector contributed 21% of the UK's total carbon emissions (CO_2 equivalent). This placed transport as the second highest source of emissions behind energy supply at 35%. The relative contribution of each sector is shown in Figure 1 below.

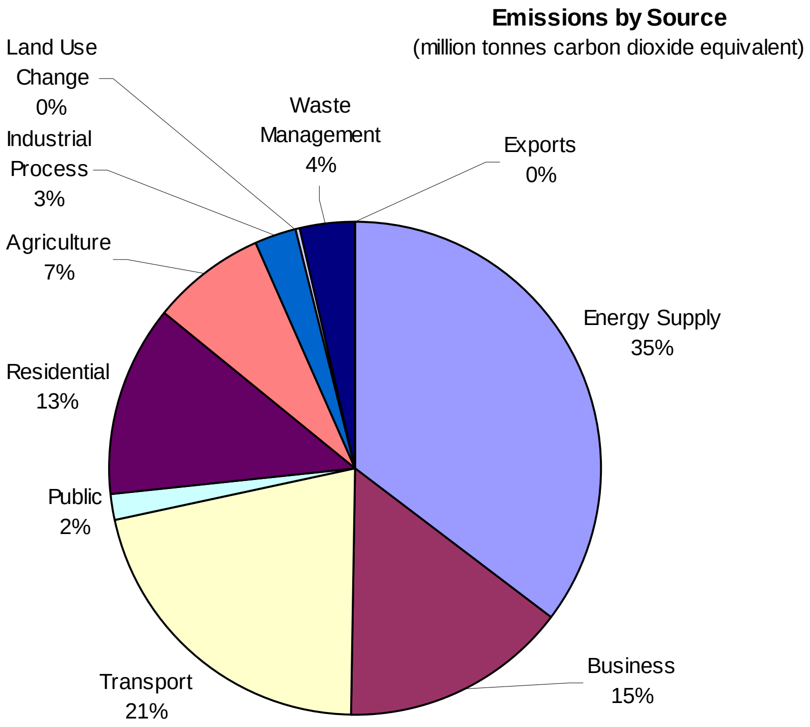


Figure 1. UK GHG emissions by Source (2008)

Source. National Statistics 2008 (provisional figures)

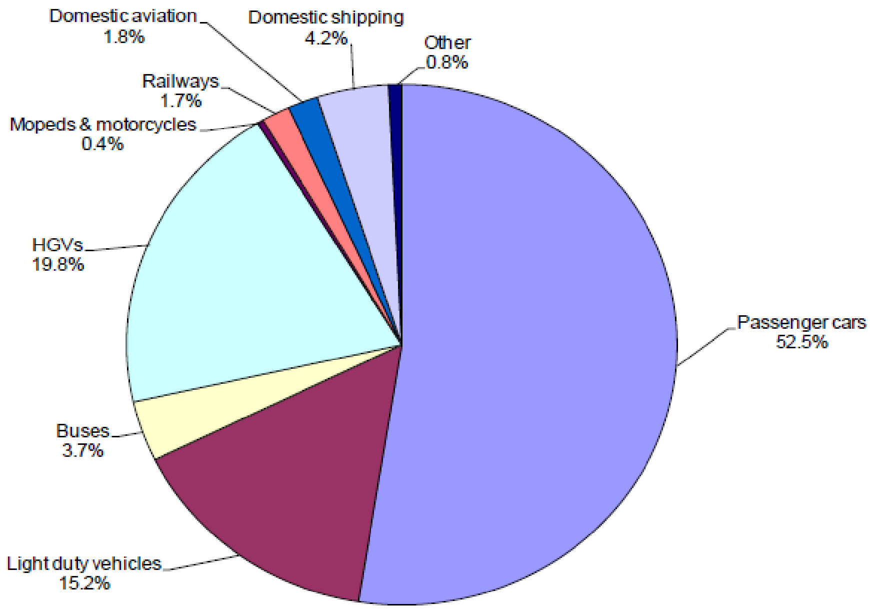
3.1.2 Transport Footprint

The transport related emissions included within the national statistics data are made up of the following categories:

- Road transport (public and private),
- Domestic shipping, and
- Domestic aviation.

Of these three categories, the major contributor is road transport, accounting for over 90% of all transport related emissions. Within the road transport category, passenger car journeys far exceed all other categories in their contribution to overall emissions (52.5%) as shown in Figure 2.

[19] National Statistics (26 March 2008) published by DECC (provisional figures). Figures are for CO_2 equivalent emissions for the Kyoto Protocol GHG.

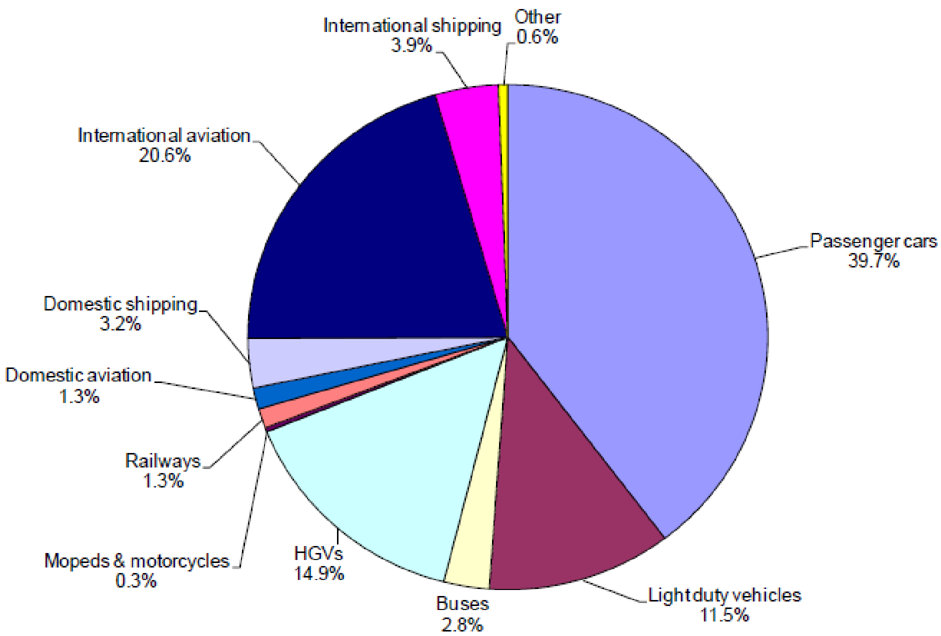


Notes: Total carbon footprint from domestic transport = 131 million tonnes CO_2

Figure 2. CO_2 emissions from domestic transport by Source, UK, 2006

Source: National Atmospheric Emissions Inventory 2006, cited in *DfT (2008) Carbon Pathways Analysis*

Although international aviation and international shipping are currently excluded from the standard UK annual emissions data, their importance in the UK's carbon budgets was recognised in the Climate Change Act (2008), and their relative contribution to overall transport emissions are shown in Figure 3 below.



Notes: Total carbon footprint from domestic and international transport = 173 million tonnes CO_2

Figure 3. CO_2 emissions from domestic and international transport by source, UK, 2006

Source: National Atmospheric Emissions Inventory 2006, cited in *DfT (July 2008) Carbon Pathways Analysis*

Implications for LCRTS

The above data shows that the most significant source of transport related carbon dioxide emissions is road transport; of this, private car use is the most significant contributing mode.

3.2 Analysis of Personal Transport Footprint

The following analysis considers individual travel with regard to both the purpose and length of individual journeys. When considering the reasons why people travel, journey purpose is divided into the following categories:

- Commuting (trips to and from a place of work);
- Business (trips in the course of work);
- Education (trips to educational institutions);
- Shopping (trips to and from shops);
- Other personal business/escort (visits to key services);
- Visiting friends at private home; and
- Visiting friends elsewhere.

Of these journey purposes, commuter travel is the most significant source of emissions; whether considering commuter travel on all transport modes or commuter travel by private vehicle. Commuting is followed by trips to key services and shopping journeys. Again, these results hold true whether considering the emissions from all modes of passenger transport or just car journeys.[20] The following graph presents the carbon dioxide emissions by journey purpose for all transport modes.

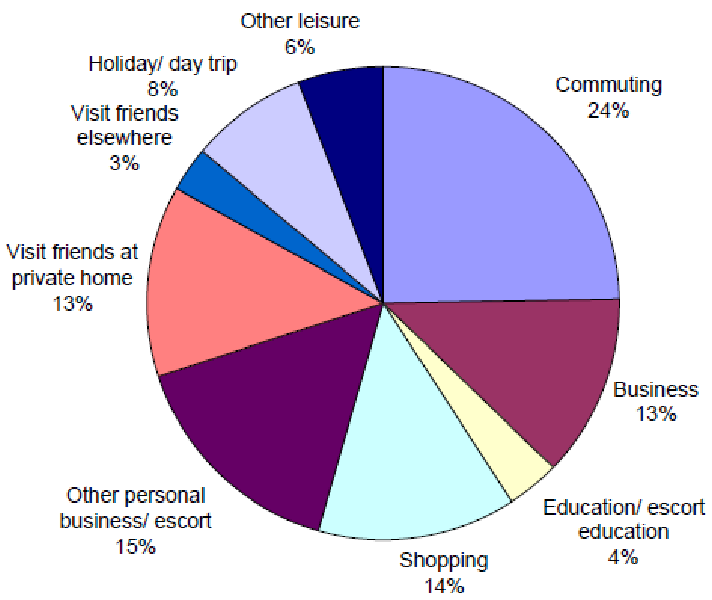


Figure 4. Estimated CO_2 emissions from all modes of passenger transport by journey purpose (UK, 2002-2006 average).

Source: DfT (July 2008) Carbon Pathways Analysis

[20] DfT (2008) Carbon Pathways Analysis

The following two graphs provide further information and clarification around the distribution of trip lengths and how this affects mode choice and in turn carbon dioxide emissions.

For journeys under one mile, most trips are made on foot. For all other journey lengths, the car is the dominant means of transport.

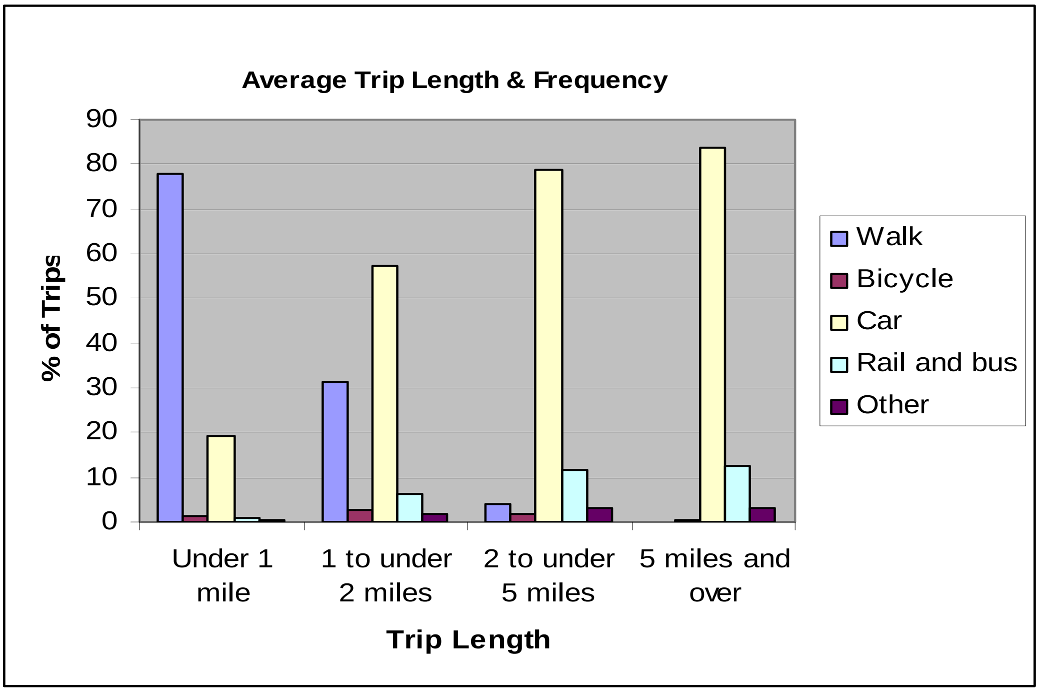


Figure 5. Mode choice versus trip length.

Source: Graph generated from National Travel Survey Data (2006)

Figure 6 shows how, while the average household makes less longer journeys than shorter ones, it is these longer journeys that make up the greater contribution to overall carbon dioxide emissions.

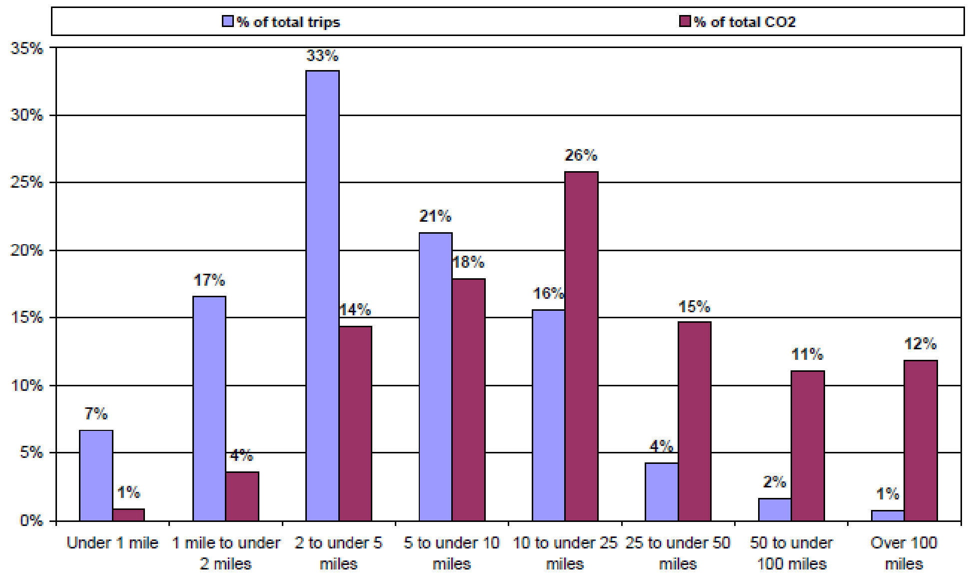


Figure 6. Proportion of trips and CO_2 emissions from household car journeys by trip length (GB, 2002-2006 average).

Source: DfT (July 2008) Carbon Pathways Analysis

Further research shows that commuter travel contributes a disproportionately high level of carbon dioxide emissions relative to the distances travelled.

> Short car driver trips (less than 5 miles) account for a large proportion (57%) of total trips made by household car but produce under 20% of CO_2 emissions. Longer trips (of over 50 miles) only account for 2.3% of trips made, but produce about 23% of CO_2 emissions from household cars. Commuting and business trips are associated with low average car occupancy, and this results in relatively high CO_2 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.
>
> *Source: DfT (2008) Carbon Pathways Analysis*

> **Implications for LCRTS**
>
> **The above data highlights that commuting journeys make the most significant contribution to carbon dioxide emissions arising from personal transport; for passenger car or other modes. This is followed by journeys to key services and shopping.**

3.3 Trends in Emissions

Transport related GHG emissions are continuing to rise, despite existing policy interventions, however the rate of increase is slowing.

> Between 1990 and 2007:
>
> - Domestic transport CO_2 emissions, by source, increased by 12% with the majority being from road transport.
> - CO_2 emissions from road transport increased by 11%.
> - CO_2 emissions from railways (*diesel trains only*) rose by 32%.
> - CO_2 emissions from domestic aviation rose by 72%.
> - CO_2 emissions from international aviation more than doubled (+123%).
>
> *Source: DfT (2009) Overview of UK Transport and Climate Change, Factsheet 1*

4 Approach to the Study

This study has assessed the carbon emissions associated with transport in the LCR. Estimates are made of the emission reductions that could potentially be achieved by adopting the transport interventions outlined within the LCRTS. The emission reduction potential has been modelled for a range of interventions including programmes that could be applied to a geographic area or region and specific projects that would apply to strategic transport corridors.

The following section provides an overview of the generic methodology employed in this study and a description of the assumptions made.

4.1 General Approach

As highlighted in Section 3.2, personal vehicle use accounts for a significant portion (over 50%) of transport related carbon emissions (see Figure 2).

As a result, reducing the number of kilometres travelled in private vehicles is seen as a key driver in reducing transport related carbon emissions. In addition, commuting journeys contribute a significant portion (24%) of the carbon emissions arising from personal vehicle use.

The interventions which have been recommended by the LCRTS are predominantly aimed at improving the efficiency of the transport system during the busiest hours of the day. Typically, these are at peaks hours (7-10AM and 4-7PM) when the majority of people travel to and from work. It is anticipated that these improvements in the efficiency of the transport system will give rise to a modal shift away from private vehicle use to more sustainable modes of transport. This modal shift will serve multiple benefits including reduced congestion, improved journey time reliability, and potentially reduced carbon emissions.

Throughout the study, we have estimated the extent of this modal shift as a change in the total number of vehicle kilometres (vkm) travelled by residents in the LCR. We have then applied carbon emissions factors (carbon emissions arising per kilometre of travel) to quantify the resulting carbon emissions reductions. In some instances there has been an increase in carbon emissions arising from an intervention, both in terms of increased car travel and increased public transport requirements. These increases have also been calculated.

There are two exceptions to this approach. The first is forecasting the uptake of electric vehicles (EVs) as an alternative to traditional internal combustion vehicles (ICVs). The effects of this scenario on transport emissions have been based on the forecast uptake of low emission vehicles in the UK. The second is estimating the impacts of controlled traffic flow on sections of motorway. The effects of this scenario on transport emissions have been based on average emissions estimates of vehicles travelling at different speeds.

The interventions developed through this study are presented in Section 4.3 and discussed in detail in Appendix A.

4.1.1 Exclusions

This study has not considered the following issues, each of which will have an impact on transport related carbon emissions in the City Region:

- The study considers direct tail pipe emissions only and no account has been made for the increase or decrease in embodied emissions associated with the improvement to or addition of new infrastructure in the City Region.
- The study does not take into account the likely increases in vehicle efficiency that are forecast to occur over time. (See Section 6.3)

- The study does not consider the aviation emissions arising from Leeds Bradford International Airport or surface travel for the purpose of accessing the airport as a destination specifically. (See Section 6.5)
- This study has considered the carbon footprint of the LCRTS. However, it does not consider other environmental impacts arising from transport, such as air and noise pollution, waste generation and non-renewable resource depletion, as well as wider sustainability criteria, such as local job creation.

4.2 Development of Baseline Carbon Emissions

In order to assess the impact of the LCRTS interventions, a baseline carbon footprint for transport in the LCR was developed to provide a basis for comparison.

4.2.1 Data Sources

The 2001 Census 'Journey to Work' database ('the census data') has been used to create a baseline for existing transport behaviours within the LCR. Based on the census data, the study has calculated the number of trips to city and town centres across the LCR and used average journey distances to build up the travel profile for the City Region. The following city and town centres were included in this study:

- Barnsley;
- Bradford;
- Calderdale;
- Harrogate;
- Kirklees;
- Leeds;
- Wakefield; and
- York.

As the majority of interventions proposed will improve travel options for those accessing employment in the city and town centres, the approach to the calculation of carbon emissions reflects this focus.

The carbon dioxide emissions arising from travel in Craven have been omitted from this study as it is assumed that the interventions outlined in the LCRTS will not greatly influence travel patterns in this area.

4.2.2 In-scope trips

The 'journey to work' trips made by car drivers to destinations in city and town centres across the LCR were analysed at the ward level.[21] Distances from origin wards to city and town centre destination wards were calculated, based on straight-line distances between ward centre points. This allowed a calculation to be made of the average number of kilometres travelled for journeys to city and town centres in the LCR each day. In addition, the database was used to calculate the total number of commuter trips within the City Region as a whole.

The 'journey to work' trip data was scaled up to reflect the travel patterns across the whole LCR. DfT statistics indicate that about 15% of all trips are journeys to work[22]. Until the completion of the Leeds multi-modal model in early 2010, there are relatively limited details of journeys to work, in terms of the actual origin and destination expressed at ward level.

[21] Actual journey to work travel data was used for Bradford, Calderdale, Kirklees, Leeds and Wakefield. Data was interpreted, based on population numbers for Barnsley, Harrogate and York.
[22] DfT: http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/factsheets/traveltowork.pdf

The Strategic Transport Model developed for Leeds only includes journey to work trips. Whereas a number of Districts have developed their own SATURN models, the representation of neighbouring areas is relatively poor. However, there are a number of limitations affecting the census data, and these are summarised in Table 4.1 below.

Table 4.1 Summary of Data Limitations

Limitation	Effect	Mitigation
Scope of data	The database only contains data on commuting trips and therefore trips for other purposes (business, leisure, social) are not included.	Addressed by scaling up the data to reflect all journeys. The journey to work trip data was considered to reflect approximately 15% of all trips.
Age of Data	The dataset is eight years old. In this time, trip patterns are likely to have changed significantly, particularly in Leeds, where large-scale development has occurred in the city centre.	The journey to work database still represents the most accurate data currently available on trip patterns in the UK.
Ward based approach to in-scope trips	For some urban areas (e.g. Leeds), the city centre is covered by a single ward. This allows simple calculation of in-scope trips. For other urban areas, up to four wards may cover the city centre (e.g. Bradford). As a result, more trips to these destinations have been included, even though the overall size of the urban area may be less. Some of these trips may have destinations that otherwise would be considered out of scope as they could be located some distance from the true city centre.	None applied

It is also recognised that there are significant areas of employment land located outside city and town centres and due to the approach taken to calculating ‘in-scope’ trips, these journeys have been excluded from the modelling. These sites are typically more challenging to serve by public transport and the current proposed interventions would have a minimal impact on stimulating modal shift for journeys to these locations. It should be recognised that review of land-use patterns and provision of public transport to out-of-centre sites should be considered as part of a future transport strategy for the LCR.

4.2.3 Calculation of carbon emissions

In order to calculate the carbon emissions arising from the baseline transport patterns, a model was developed (the ‘vehicle kilometre model’). Within the model, DEFRA emissions factors (kgCO_2 per km travelled) were applied to the calculated total vehicle kilometres for in-scope journeys. This calculation provided an amount of carbon emitted as a result of the in-scope journeys.

The modelled results were compared to the transport related emissions data held within REAP[23] to check for consistency. The scale of emissions was found to be comparable across all LCR areas.

[23] The Resource and Energy Analysis Programme (REAP) is a software tool that assesses the environmental impacts (including greenhouse gas emissions) of consumption for people living within each local authority in the UK.

4.3 Development of Interventions

In order to assess the implications of the LCRTS on baseline carbon emissions, the potential change in emissions arising from a number of interventions was modelled. The interventions modelled are outlined in Table 4.2 below and detailed in Appendix A.

4.3.1 Scope of Interventions

Within this study, the following scenarios and interventions have been assessed.

Table 4.2 Summary of Interventions

Scale of Intervention	Intervention
City Region interventions	Smarter Choices – A marketing initiative to make people aware of alternative transport options.
	Demand Management - Strategies and policies to reduce private transport demand e.g. parking controls.
	Bus Priority and Quality Enhancements - Extending the network of bus priority lanes and upgrading outdated buses with higher quality models.
	Cycling - Encouraging increased cycling rates through measures such as improving infrastructure.
	Expansion of Bus Network - Expansion of the bus network to service more areas.
	Affordability of Bus Fares - Improving the affordability of bus fares for all.
	Home to School – Improving uptake of school busses to transport children from home to school.
	Low Emission Vehicles - The increase in use of cars with lower carbon impacts such as electric vehicles and plug-in hybrid.
Corridor interventions	Rail Electrification - Conversion of existing diesel rail routes to electrified systems.
	Active Traffic Management - Active regulation of car speed on motorways to improve traffic flow and reduce congestion.
	Rapid Transit Network – Proposed trolleybus scheme to provide 'new generation' electrified buses on dedicated lanes with priority at junctions.
	Targeted Highway Improvements - The improvement and expansion of roads where necessary across the LCR.
	Alternative Rail Technologies - Installation of a tram-train that will allow for the extension of train lines.
	Park and Ride - Implementation of park and ride schemes in York and Birstall.
	New Railway Stations – Construction of new stations in the LCR on the existing railway network.
	Express Bus/Coach Network - Implementation of a rapid coach between key cities.

4.3.2 Impact of Interventions on Vehicle Kilometres

To understand the likely impact (on baseline carbon emissions) of each of the transport interventions, the role that each intervention could play in reducing vehicle kilometres was assessed.

For each intervention, the potential scope for mode shift and the resultant impact on vehicle kilometres was estimated. Estimates were based on data collated from a variety of sources and case studies, both domestic and international. Estimates from the UK were prioritised over those from abroad. The evidence collected from this exercise was used to calculate the total potential reduction in car kilometres that could occur following the implementation of the interventions. The evidence collected for each intervention is discussed further in Appendix A.

There are some limitations to this approach. First, interventions in the UK have often been introduced as part of a suite of solutions. For example, cycling and walking improvements may have accompanied the development of enhanced bus priority along with a series of demand management measures. As a result, it can be difficult to determine the extent of the modal shift that should be attributed to the bus priority element of this scheme alone. Secondly, some of the interventions were not assessed using modal split indicators, but instead demonstrated the impact in terms of improved journey time reliability or cost saving benefits. In such instances it was difficult to estimate whether there was any modal shift as a result of the intervention. Finally, the effectiveness of an intervention is partially determined by the scale of investment it receives. For example, a programme of Smarter Choices with an annual budget of £1m will have a significantly greater impact than one with a budget of £50,000. Effort was made during the literature review task to understand the cost and scale of each intervention, however, this information was not always readily available.

Where specific evidence of modal shift was not available, a range of case studies, previous Arup projects and professional judgement have been employed develop reasonable estimates.

In addition to this data, efforts have been made to estimate the increased number of public transport vehicles required on the roads to support each intervention.

For the intervention relating to Low Emission Vehicles (LEVs) where no modal shift was anticipated, publically available data on the potential uptake of LEVs in the UK car fleet was accessed along with a reduced vehicle emission factor.[24]

4.3.3 Impact of Intervention on Baseline Carbon Emissions

For each intervention, an assessment has been conducted to understand the total increase or decrease in carbon emissions that could arise from its implementation. The carbon calculations have been conducted using the most appropriate carbon emissions factors for each scenario. These included rates of carbon dioxide production per kilometre of vehicle travelled (gCO2/km) from Defra emissions factors[25] and REAP data.

The basis for the change in carbon emissions arising from the interventions is outlined in Table 4.3 below.

In some instances it was not possible to fully account for all carbon impacts of a scenario due to insufficient data or where the modelling required extended beyond the scope of the current study.

[24] BERR (2008) Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug-in Hybrid Vehicles

[25] Defra (2008) Guidelines to Defra's Greenhouse Gas Conversion Factors for Company Reporting

Table 4.3. Basis for change in carbon emissions

Intervention	Basis for change in carbon emissions
Smarter Choices	Reduced vehicle kilometres (vkm) (cars)
Demand Management	Reduced vkm (cars)
Bus Priority and Quality Enhancements	Reduced vkm (cars)
Cycling	Reduced vkm (cars)
Expansion of Bus Network	No Impact
Affordability of Bus Fares	No Impact
Home to School	Reduced vkm (cars) and increased vkm (buses)
Low Emission Vehicles	Reduced rate of car emissions (gCO2/km)
Rail Electrification	Reduced vkm (cars) and reduced rate of rail emissions (gCO2/km)
Active Traffic Management	Reduced rate of car emissions (gCO2/km)
Rapid Transit Network	Reduced vkm (cars)
Targeted Highway Improvements	Reduced rate of emissions (gCO2/km)
Alternative Rail Technologies	Reduced vkm (cars) and increased vkm (rail)
Park and Ride	Reduced vkm (cars) and increased vkm (buses)
New railway Stations	Reduced vkm (cars)
Express Bus/Coach Network	Reduced vkm (cars) and increased vkm (coaches)

4.4 Assumptions

4.4.1 General Assumptions

In calculating the overall impact of the LCRTS interventions, the impact on vehicle kilometres and carbon emissions of each intervention has been considered in isolation. To generate the overall impact, interventions have been summed.

This approach does not necessarily reflect reality. In some cases, a combination of interventions may have a greater or lesser impact than the sum of each due to their combined impact. For example, if one group of people who are prone to change behaviour have changed their behaviour through the implementation of one of interventions (e.g. bus service improvements) then it may be harder to further change the behaviour of the population through implementing the next intervention (e.g. cycle improvements) as those people that are likely to undertake a mode shift have already done so.

4.4.2 Detailed Assumptions

A breakdown of vehicle kilometre reduction achieved by each intervention is provided in Appendix A.

5 Results

5.1 LCR Baseline Transport Emissions

The vehicle kilometre model developed for this analysis and described in section 4.2 has been used to calculate the baseline carbon emissions for the LCR. The resulting emissions have been cross checked with the REAP database and the two separate data sets provide broadly similar results as demonstrated in Table 5.1 below.

The results in column A have been calculated from the 'journey to work' census data using the vehicle kilometre model (see section 4.2.1). The results in column B have been extracted from REAP software.[26] The REAP data represents the impact of the purchase of fuels for private automotive vehicles only. It is directly comparable to the data generated though the journey to work database model which is based on transport undertaken in private vehicles.

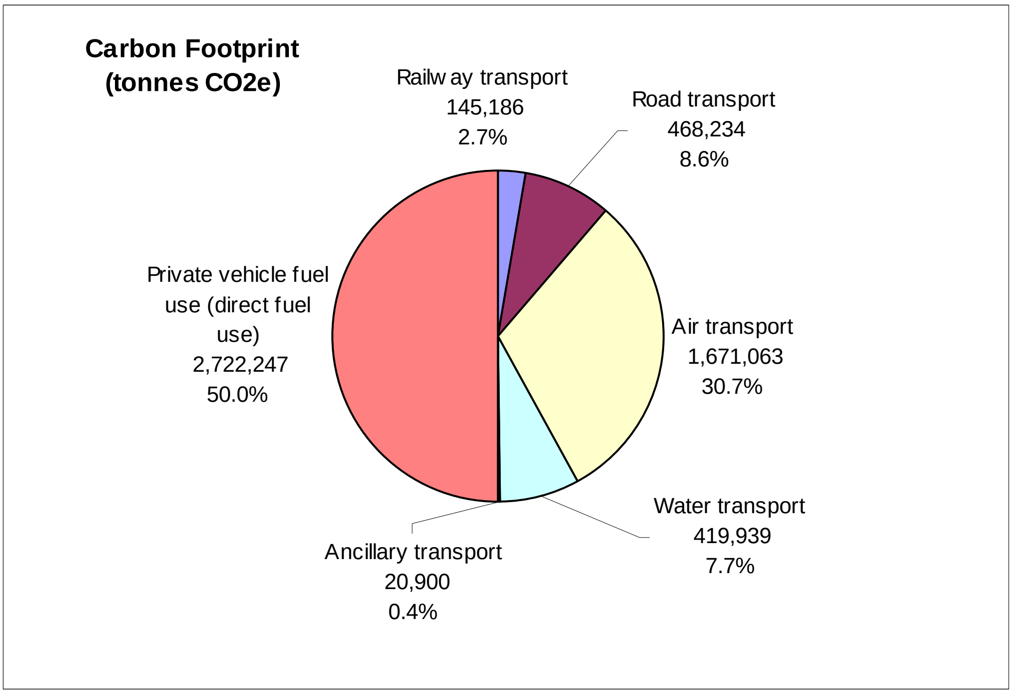
Table 5.1. Personal travel carbon emissions

Data Source	Column A Vehicle Kilometre model baseline emissions (tCO2 / year)	Column B REAP baseline emissions (tCO2e[27] / year)
Barnsley	201,961	210,530
Bradford	497,976	450,599
Calderdale	204,198	200,371
Harrogate	163,358	200,088
Kirklees	388,072	398,326
Leeds	1,257,305	737,736
Wakefield	396,138	318,128
York	204,198	206,468
LCR Total	**3,313,206**	**2,722,247**

As discussed in Section 3.1.2, personal transport accounts for a significant portion of all domestic transport emissions, but it should be remembered that the results shown in (Table 5.1) represents only a portion of total transport emissions for the LCR. The REAP software data set is able to provide a more extensive summary of all emissions arising from all activities associated with personal travel of the residents living in the LCR. This summary is presented in Figure 5.1.

[26] Data extracted from the Resource and Energy Analysis Programme (REAP). The data represents the emissions arising from the combustion of fuel in personal vehicles.
[27] GHG emissions are often measured as carbon dioxide equivalent (CO_2 e) as each GHG has a different global warming potential (GWP). The GWP is a measure of the degree to which the GHG contributes to global warming relative to Carbon Dioxide which has a GWP of 1.

Figure 5.1. Personal transport Emissions of LCR residents

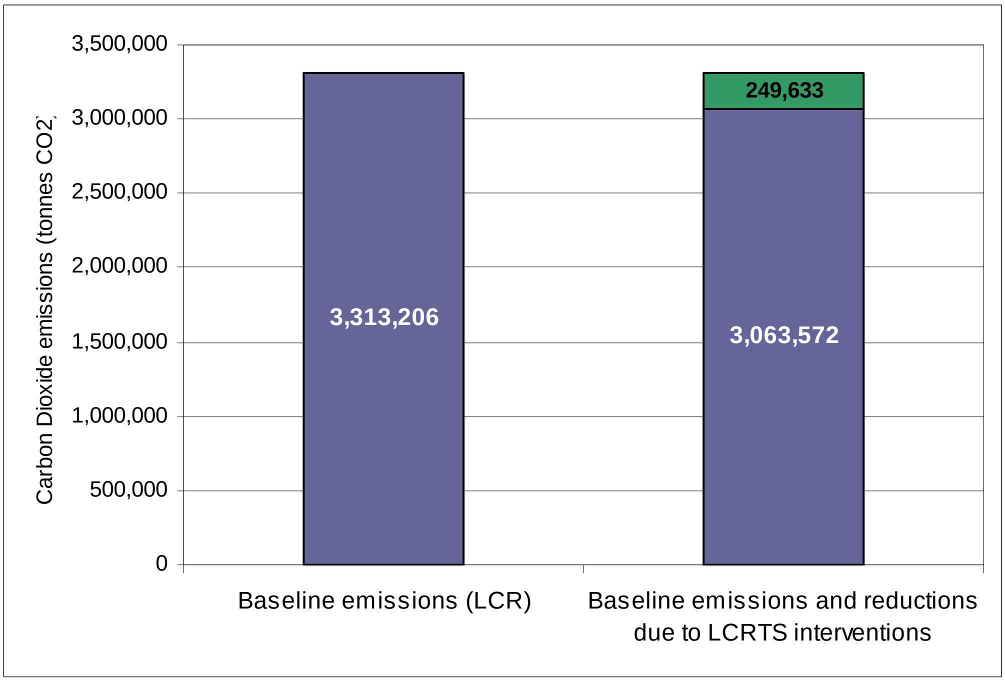


Source: REAP (2006)

5.2 LCRTS Transport Intervention Emissions

The potential carbon emissions savings for the key interventions outlined within the LCRTS were modelled using the approach outlined in Section 4. Cumulatively, the interventions modelled contribute an annual saving of close to 250,000 tonnes of carbon dioxide. This represents a 7.5% reduction when compared to the modelled baseline for the LCR (3,313,206 tonnes CO_2/year). The number of trips by motorised modes using existing fuel sources would be reduced.

Figure 5.2. Reduction in Emissions Compared to Baseline



Source: REAP (2006)

The contribution from each of the interventions is displayed in Table 5.2 and Figure 5.3 below. The 'losses' represent the contribution that the intervention makes to reducing carbon dioxide emissions. This is either through a reduction in vehicle kilometres or an improvement in the efficiency of vehicles. The 'gains' represent an increase in carbon emissions arising from the intervention, typically through an increase in vehicle kilometres including both cars and public transport vehicles.

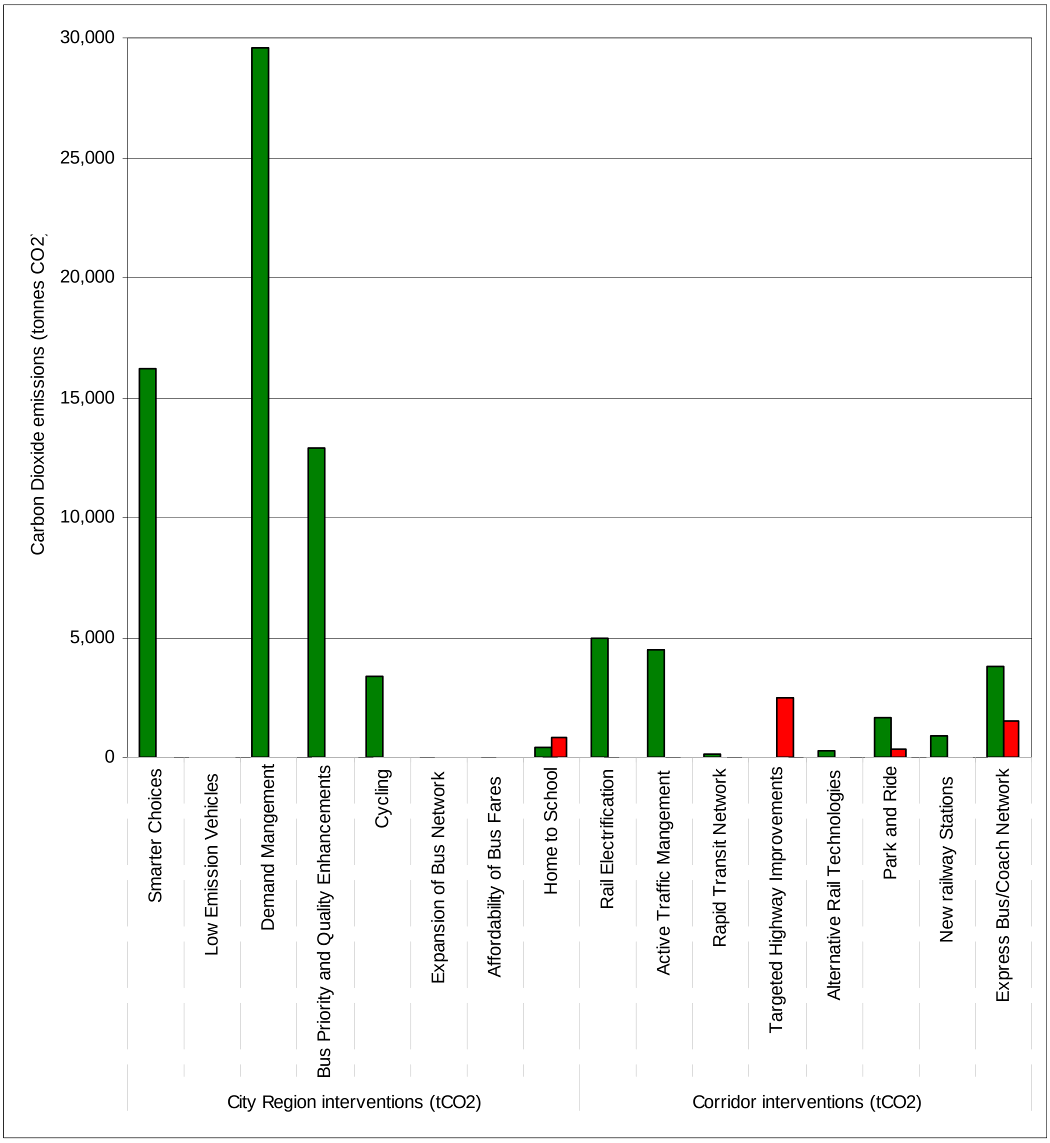
Table 5.2. Carbon Emission Gains / Losses by Intervention (tonnes CO2 / Year)

Intervention		Losses	Gains
City Region interventions	Smarter Choices	16,220	
	Low Emission Vehicles	176,192	
	Demand Management	29,604	
	Bus Priority and Quality Enhancements	12,866	
	Cycling	3,352	
	Expansion of Bus Network	0	
	Affordability of Bus Fares	0	
	Home to School	404	835
Corridor interventions	Rail Electrification	4,986	
	Active Traffic Management	4,510	
	Rapid Transit Network	160	
	Targeted Highway Improvements	0	2,485
	Alternative Rail Technologies	244	5
	Park and Ride	1,651	333
	New railway Stations	874	0
	Express Bus/Coach Network	3,770	1,542
TOTAL GAINS / LOSSES		254,833	5,199

Source: REAP (2006)

By far the greatest contribution to emissions reduction arises from Low Emission Vehicles (LEV) followed by Demand Management and Smarter Choices. The level of CO2 reduction from Low Emission Vehicles is significantly higher than the other interventions, and the inclusion of this value in Figure 5.3 would distort the representation of the other data.

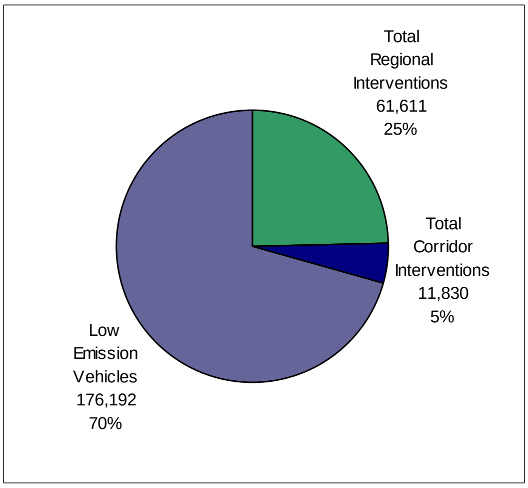
Figure 5.3. Carbon Emission Gain/Losses by Intervention



Source: REAP (2006)

Figure 5.4 Contributions from Interventions (grouped) (tCO2)

LEV use has been removed from Figure 5.3. The emissions savings from the LEV intervention can not be displayed on the same graph as the other interventions due to the difference in scale between their contributions. This intervention alone contributes 70% of the overall reduction as shown in Figure 5.4. Further information on Low Emission Vehicles can be found in Section 6.3.

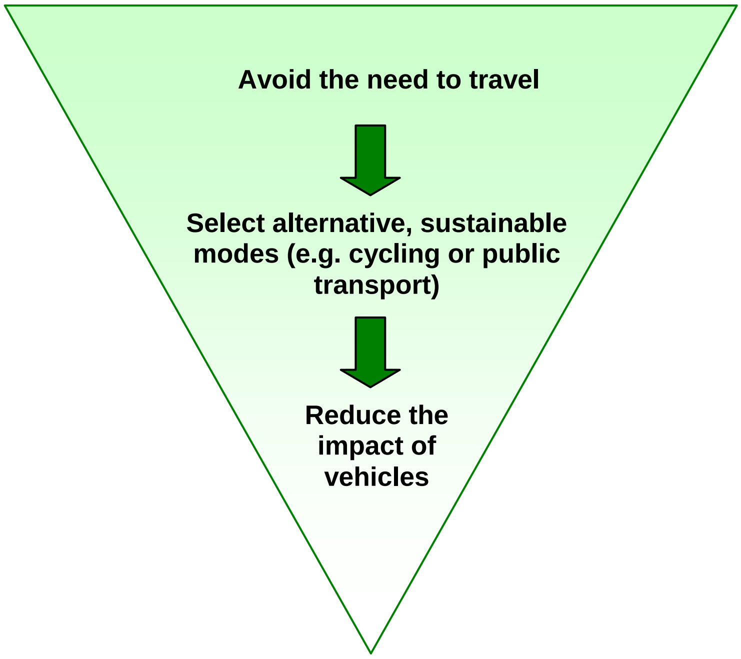


Source: REAP (2006)

6 Further Influencing Factors

As part of this study, the carbon emission reductions associated with a range of transport interventions have been modelled. The results of this modelling were presented in Section 5. In addition to these interventions, a number of factors will continue to play a role in influencing the emissions arising from transport in the LCR. When promoting sustainable transport choices; a decision making hierarchy emerges.

Figure 6.1: Decision Making Hierarchy



6.1 Avoiding the Need to Travel

The first premise for reducing carbon emissions from personal transport must be to promote and develop communities where the need to travel is avoided or reduced. Planning Policy Statement 1 (Delivering Sustainable Development) identifies development planning as a mechanism for ensuring that sustainable transport systems are embedded in our approach to spatial planning and that development should be delivered in such a way that communities have ready access to the key facilities, services and employment opportunities that they require; without the need to travel.

The planning process should actively seek to utilise existing transport networks and site developments in or near existing public transport networks.

Equally, individuals and businesses should be encouraged to use the goods and services that are available locally, again avoiding the need for freight transport and travel and supporting the development of strong and resilient local economies

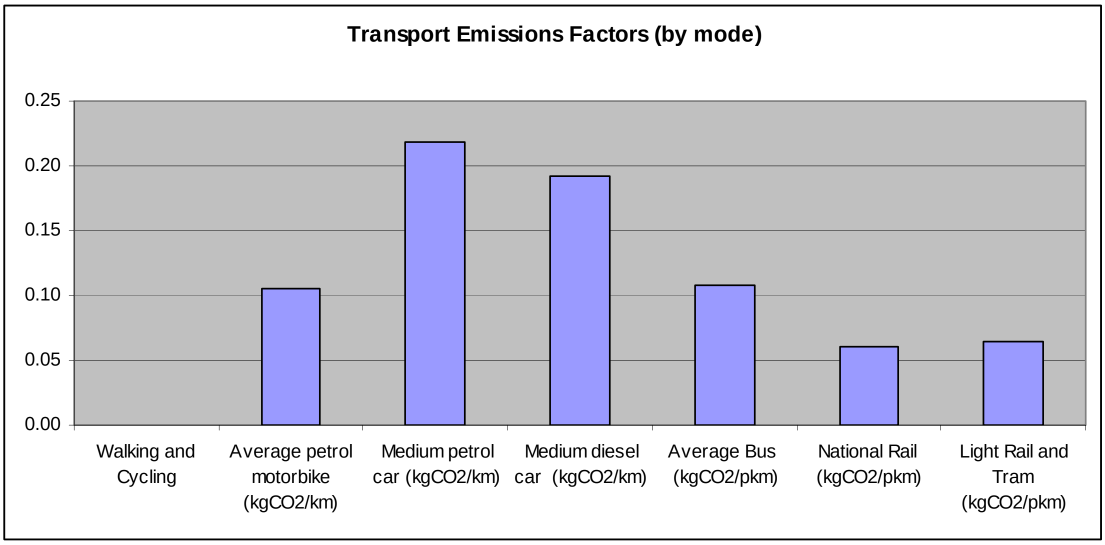
Decoupling the need to travel from access to key facilities, services and employment can assist in addressing issues of social exclusion that can arise due to inadequate access to transport facilities arising from physical or socio-economic barriers.

6.2 Selecting Alternative Transport Modes

Carbon dioxide emissions from personal travel are currently dominated by private car use. Where journeys are unavoidable, there must be a move to encourage a shift to more sustainable transport modes. The potential emissions savings for the LCR arising from mode shift as a result of the interventions were modelled as part of this study (Section 5).

From a carbon perspective, reducing the average amount of carbon dioxide emitted per kilometre will result in overall reduction in carbon. Figure 6.2 displays the relative carbon emissions of a range of different modes.

Figure 6.2. Transport Emissions Factors (by Mode)



Source: Defra (2008) Guidelines to Defra's GHG Conversion Factors

The DfT has acknowledged in its 'Carbon Pathways' report (2008) that bringing about modal shift is a complex process requiring different stimulus for different segments of the and that social research suggests that cost differences between modes on its own is not a sufficient motivating factor.

The LCR should continue to promote a range of alternatives to encourage shift to more sustainable transport alternatives.

6.3 Reducing the Impact of Vehicle Use

Recognising that private vehicle transport will continue to be the mode of travel which dominates transport related carbon emissions, there is increasing focus on reducing the impact of vehicle travel; both through technological advances in vehicles and changes in driver behaviour.

6.3.1 Low emission vehicles

As shown in Section 5.2, LEVs have the potential to offer significant carbon dioxide and greenhouse gas emissions reductions over time compared to conventional petrol/diesel vehicles powered by an internal combustion engine (ICVs). The UK Government has supported the EU's New Cars CO_2 Regulation[28] with a view to stimulating innovation across the vehicle manufacturing sector. The regulation contains the targets for vehicle emissions; 130gCO_2/km by 2015 and 95gCO2/km by 2020. This clearly establishes the government's commitment to the rollout of low carbon vehicles. BERR's ultra low emission vehicles strategy sets out the following short, medium and long term trajectory for the industry.

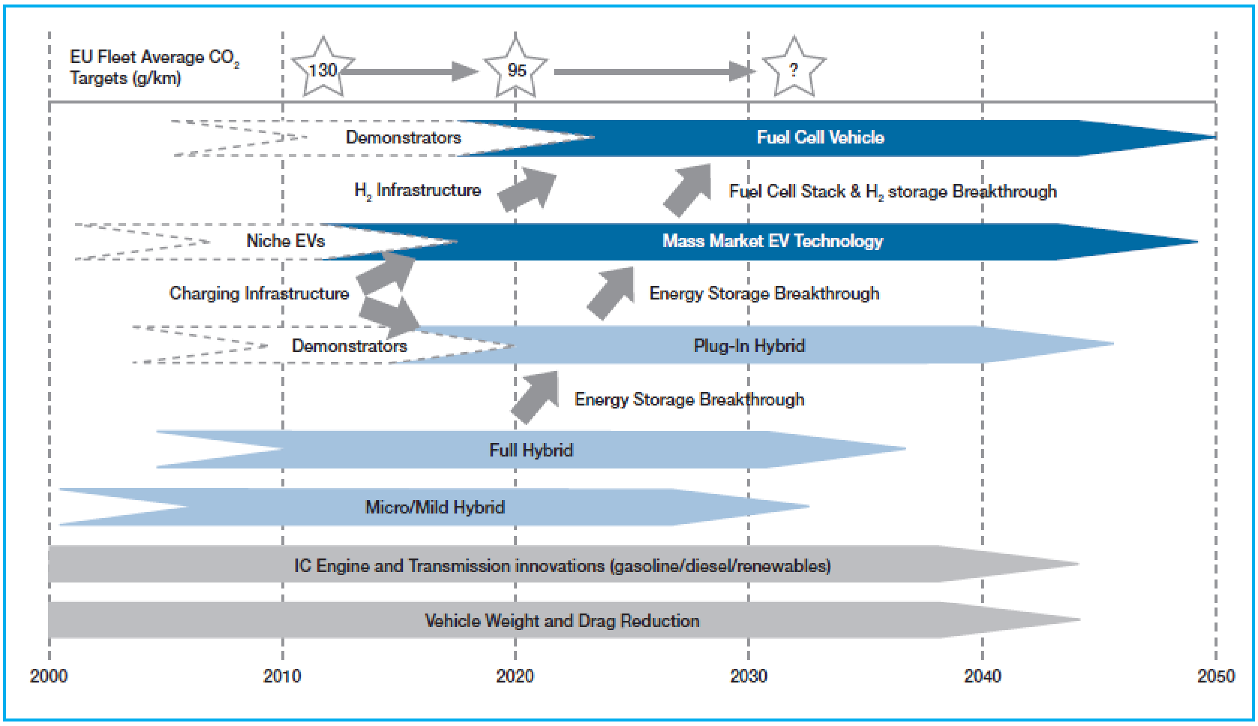
[28] European Commission (2009) Regulation (EC) No 443/2009

Table 6.1: Summary of Possible Interventions

Timescale	Possible Interventions
Short term (next 5 years)	• Incremental improvements to efficiency of new cars. • Increased take-up of new model hybrids. • Interested cities and regions developing electric vehicle charging infrastructure. • Gradual emergence of early market ultra-low carbon vehicles.
Medium term (5–10 Years)	• Continued improvements to efficiency of new cars. • Continued take-up of new model hybrids. • Increased coverage of electric vehicle charging infrastructure enabling wider use. • Ultra-low carbon vehicles enter large scale production.
Longer term (10 Years +)	• Combinations of hybrid vehicles, lighter rail rolling stock and lightweight vehicles become dominant. • Continued rollout of charging infrastructure. • Mass market development of ultra-low carbon vehicles leading to significant market penetration.

Source: Arup proposals

Figure 6.3: Strategy for the Development of Low Emission Vehicles



Source: BERR (2009) Ultra-Low Carbon Vehicles in the UK

BERR has reported[29] that a 60% saving in carbon dioxide emissions could be achieved over an conventional petrol vehicle when compared to the Defra long term marginal emissions factor and 38% when considering the vehicle on a full life cycle basis, which takes account of emissions from power generation, and emissions relating to production and disposal.

These savings have the potential to become much greater with further decarbonisation of the UK national grid electricity supply which is forecast to occur over time.

6.3.2 Changing Driver Behaviour

In their 2008 report[30], the UK CCC identified that role that changing driver behaviour could play in reducing transport emissions. The contribution was divided into supply side and demand side measures.

Supply side measures included:

- Establishing a maximum vehicle emissions rate (suggested at 130gCO2/km) complemented by a tax/bonus schemes around vehicle emissions rates.
- Providing car buyers with greater information about vehicle emissions (e.g. energy performance certificate for the vehicle).

Demand side measures focused on promoting more eco-friendly driving styles to achieve greater levels of fuel efficiency. Adopting a smoother driving style, with less aggressive use of the accelerator and brake can significantly improve fuel efficiency, even without reducing average of maximum vehicle speeds. Evidence suggests that average fuel efficiency can be improved by 5-10% when the range of eco-driving principles are adopted together.[31]

6.4 Network Operation

The fuel efficiency and subsequently vehicle emission rates per kilometre are dependent on the speed of the vehicle. As a result, managing the traffic flows through the network at optimal speeds can have the benefits of improving traffic flow rates, reducing accidents and reducing carbon emissions.

Table 6.2 shows the variation in vehicle emission rate relative to vehicle speed.

Reducing the speed limit to 60 mph on motorways and A-roads where the speed limit is currently above this would result in an additional 2 MtCO2 emissions reduction in 2020.[32]

Table 6.2. Change in efficiency with speed for typical car

Speed (mph)	Emissions (gCO2/km)	% Decrease in efficiency for increase of 10mph
40	157	
50	161	3
60	173	7
70	191	10
80	219	15

Source: NAEI, cited in CCC (2008) Building a low-carbon economy (p288). (direct reproduction)

[29] BERR and DfT (2008) Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug-in Hybrid Vehicles (p.13)
[30] Climate Change Committee (2008) Building a low-carbon economy: The UK's contribution to tackling climate change
[31] *Ibid. (p286)*
[32] *Ibid.*

This intervention was modelled as part of the LCRTS interventions for a total 55 kilometres of motorway. However, it was felt that a wider application of the network operation opportunities beyond the LCR could yield greater improvements. This would require joint working with other road administrators and user bodies such as the Highways Agency and local highways authorities to administer effectively.

6.5 Aviation

The Leeds Bradford International Airport (LBIA) lies within the LCR and currently serves around three million passengers per year on short and medium haul flights to domestic and European destinations. The airport has plans for the future expansion of the facilities and current proposals indicate that by 2030, the airport could handle 8.2 million passengers per year.[33]

Based on these proposals, the plans for expansion have the potential to result in increased carbon dioxide emissions in the order of 500 million tonnes CO_2 per year arising from aircraft movements alone by 2030.[34] Table 6.3 displays the forecast growth in emissions arising from the airport over the next 20 years.

Table 6.3. Forecast Growth in Passenger numbers and Emissions from LBIA

	Annual passenger volume[(a)]	Average trip length[(b)]	Annual Average passenger kilometres	Short-haul international emissions factor[(c)]	Forecast Emissions	Increase over 2006 baseline
	(Million passengers / year)	(km)	(Million p.km/yr)	($kgCO_2$/p.km)	(Million tonnes CO_2/year)	(Million tonnes CO_2/year)
2005	2.6	1,010	2,626	0.0983	258.1	-
2006	3.2		3,232		317.7	-
2011	4.3		4,343		426.9	109.2
2016	5.2		5,252		516.3	198.6
2030	8.2		8,282		814.1	496.4

(a) Annual forecast passenger kilometres. Source: Leeds Bradford International Airport Expansion Masterplan (2005 - 2016), Available at: http://www.leedsbradfordairport.co.uk/airportcompany-airportmasterplan.php

(b) Airlines departing from LBIA fly to a range of destinations around the UK and Europe. An average trip distance of Leeds – Geneva (1010km) has been selected for the purposes of this calculation.

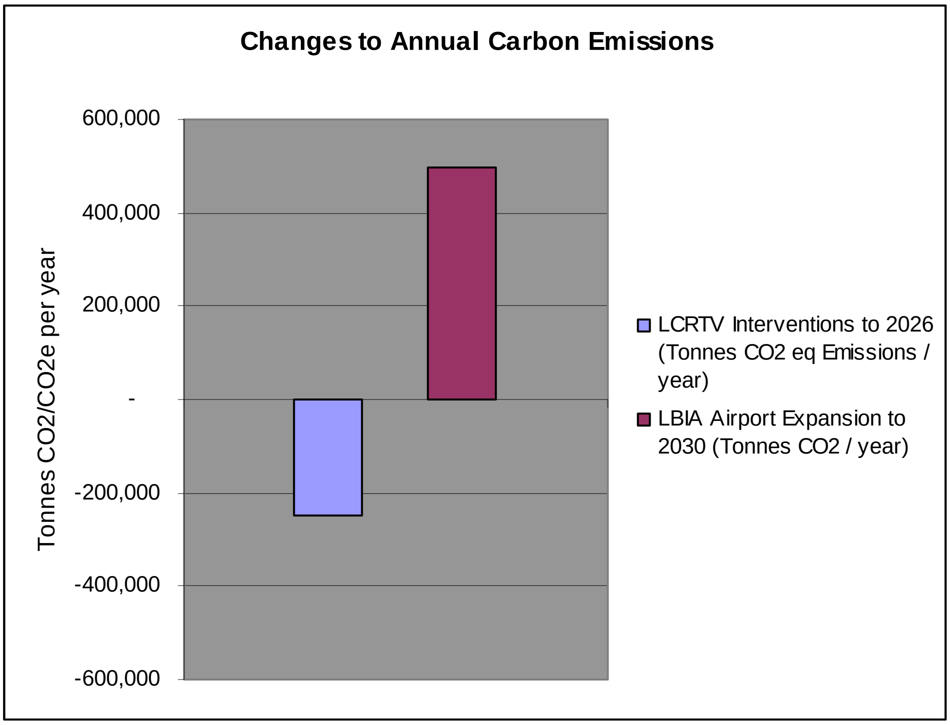
(c) Defra Emissions Factors (2008) – Average Short-haul international emissions factor

Emissions arising from air travel have not been included within the modelling of carbon emissions for the LCRTS. However, it is important to note that the scale of the potential increase in aviation emissions resulting from the expansion of the airport is double the reductions achieved by the LCRTS interventions over a similar time period. This comparison is shown in Figure 6.4 below.

[33] Leeds Bradford International Airport Expansion Masterplan (2005 - 2016), Available at: http://www.leedsbradfordairport.co.uk/airportcompany-airportmasterplan.php

[34] This calculation excludes the increased travel requirements of passengers to and from the airport. It also excludes any future emissions factor reductions achieved through improvements to aircraft fuel efficiency.

Figure 6.4 Potential Emissions arising from forecast airport expansion.



Source: REAP (2006)

6.6 LCRTS and Climate Change Adaptation

This study has focussed on the impact that transport is likely to have on climate change as a result of greenhouse gas emissions and the extent to which we can act now to reduce those emissions (climate change mitigation). Of equal importance to the long term functioning of the transport network in the region is its ability to adapt to a changing climate

As outlined in Section 2.2, the transport sector makes a significant contribution to the UK's carbon footprint. This report has sought to quantify this impact in the Leeds city region and identify the extent to which the interventions set out in the LCRTS would contribute to mitigating this impact.

However, Section 2.2.3 presented the likely implications for the UK and the region of future climate change impacts. These impacts are likely to be experienced even if we act now to reduce our GHG emissions.

The ability of the region and indeed the UK to adapt to these changes will determine the degree to which we prosper, socially, environmentally and economically over the coming decades.

Transport infrastructure plays a vital role in our social and economic wellbeing and, moving forward, we must ensure that we are able to adapt our transport systems to a changing climate. This can be achieved by addressing the following adaptation challenges:

- Better land use planning to minimise reliance on transport networks;
- Robust infrastructure designs to deal with changing environmental parameters;
- Operational response plans for dealing with extreme weather events;
- Better traveller information; and
- Decreased reliance on fossil fuels.

More specifically, the Yorkshire and Humber Climate Change Adaptation Study suggests that the West Yorkshire sub-region should undertake the following actions, with specific relevance to the transport sector.[35]

- Plan for the future increase in tourist numbers, including the infrastructure to support this;
- Address existing causes of deprivation in rural and urban areas, including transport accessibility; and
- Review the sub-region's critical infrastructure to identify vulnerabilities to the changing climate.

[35] Yorkshire and Humber Climate Change Adaptation Study (2008) – Sub-regional adaptation. Available at: http://www.adaptyh.co.uk/Adaptation/adaptationOverview.htm#WestYorkshire

7 Conclusion and Next Steps

7.1 Findings of the Study

This report has considered the contribution that personal transport within the LCR is making to climate change through the emission of greenhouse gasses. The report presents the results of a carbon emissions study that has been undertaken in conjunction with the refresh of the LCRTS.

Modelling has indicated that carbon dioxide emissions could be reduced by 7.5% if the range of interventions presented within the LCRTS were to be implemented. A significant proportion of this saving arises from the forecast uptake of low carbon vehicles in the UK over the next 20 years.

The second greatest saving arose from demand management; an intervention which focuses on controlling the demand for private vehicle use through parking control measures.

It is clear that these interventions alone fall short of achieving the levels of carbon emissions reduction that will be required to meet the UK government's legally binding objective of 80% reduction by 2050 and 42% by 2020.

More must be done to focus the development of transport interventions around measures that will deliver significant and lasting reductions in carbon emissions. To achieve this, a reduction in carbon emissions must lie at the heart of a transport strategy. LCR must respond to this challenge by, during the implementation of the Strategy, being mindful of the opportunities to reduce emissions and take the steps required to do so.

7.2 Next Steps

Understanding the Climate Change Agenda

In order to ensure that stakeholders in the LCRTS have a clear understanding of the challenges that climate change will pose to the transport sector, a programme of awareness raising should be developed. This should seek to empower stakeholders of the LCRTS to identify opportunities within their respective spheres of influence.

Objective and Target Setting

The LCRTS should establish an objective and target for the reduction of carbon dioxide emissions. The target should be specific, measurable, and achievable and have a timescale. The objective and target should set the context for the way that the transport vision is delivered across the region. All stakeholders need to buy into the scale and scope of the targets set.

Action Plan

Interventions should be developed and implemented with a specific focus on achieving reductions in carbon emissions. Different stakeholder groups should have responsibility for delivering against the climate change targets.

Monitoring

During this study, a number of assumptions were made regarding the effectiveness of transport interventions and the resultant reduction change in travel patterns that could be attributed to their implementation. This was due to an absence of available data. There should be a greater focus on monitoring the progress of the interventions in changing transport behaviours across the LCR.

Reporting

In order to drive improved transparency and accountability, the LCR should undertake to report on the successes and emissions savings arising from the LCRTS. This process will require the actions above to be implemented and due attention paid to the roles played by each stakeholder to the LCRTS and the achievements made.

Appendix A

Summary of Interventions Modelled

A1 Summary of Interventions Modelled

A1.1 Generic Interventions – Regional Application

A1.1.1 Smarter Choices

'Smarter Choices' is a marketing initiative that provides information to people to make them aware of alternative, more sustainable, modes of transport available to them.

Assumptions used in this study:

- The TravelSmart scheme introduced in Sheffield, Bristol and Nottingham produced, on average, a 4% modal shift away from private car use[36]. This study has assumed a similar rate of uptake.
- This shift would only apply to people living less than 15km from the urban centres, as beyond this, public transport coverage is less extensive meaning that alternative travel options for residents are limited.
- This will not require any increase in public transport facilities as there is sufficient existing capacity on the public transport network.

A1.1.2 Low Emission Vehicles

A recent report for BERR and DfT[37] details the potential switch to low emissions vehicles in the UK market between now and 2030. The report details four scenarios: business as usual, mid-range scenario, high-range scenario, and an extreme scenario.

Assumptions used in this study:

- For this analysis data from the mid-range scenario has been used in the modelling. This scenario is based on the current trend for environmental measures being maintained, which results in 2.5% of all cars being able to connect to the grid in 2020 and 11.7% by 2030.
- The LCRTS considers a timeline up to 2026 and therefore this year has been used for the calculations. In 2026 it is estimated that 8.02% of the UK fleet will consist of electric vehicles.
- To calculate the carbon impact of this proposed electric vehicle fleet, a conservative electricity consumption per kilometer value has been applied of 0.069kWh/km[38]. Carbon emissions have been calculated using the Defra rolling average carbon impact per kwh.[39]
- To achieve these levels, appropriate infrastructure provision and technical innovations will be required. This is assumed to have occurred.

A1.1.3 Demand Management

Demand management represents interventions that manage private transport demand such as through placing controls on the number of available parking spaces. There is evidence that demand management can achieve a 15-30% reduction in private car use when introduced in conjunction with other measures[40] (including cycling improvements, car sharing schemes, reduction in public transport fares and promotion). However, it is

[36] http://www.dft.gov.uk/pgr/sustainable/travelplans/ptp/personalisedtravelplanningev5774?page=6
[37] Arup (2008) Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug in Hybrid vehicles
[38] Arup internal communication
[39] Defra (2008) Guidelines Greenhouse gas emissions conversion factors
[40] Demand management was introduced in Manchester as part of a package of measures (including workplace travel planning). http://www.manchester.gov.uk/downloads/report02_100_.pdf

understood that this is achieved by specifically targeting employers rather than by using a 'blanket' approach to demand management.

Assumptions used in this study:

- A conservative estimate of a 7.5% mode shift has been assumed, though this would need to be accompanied by public transport improvements also.
- As with the Smarter Choices intervention, this measure would only achieve modal shift for trips to the urban centres less than 15km in length.

A1.1.4 Bus Priority and Quality Enhancements

The Manchester QBC network has contributed to modal shift on the major radial routes into the city centre[41]. Beyond this threshold it is considered that general traffic congestion does not cause significant journey time reliability problems for bus travel.

Assumptions used in this study:

- It has been assumed that modal shift of 5% could be achieved across the network stemming from large scale bus enhancements aimed at improving quality and journey time reliability.
- Bus priority and quality enhancements would encourage modal shift for those living within 10km of urban centres.
- It has been assumed that this intervention will not require any additional bus services to be added to the bus network. This is because most buses in West Yorkshire are only 50% full, meaning there is capacity in the network.

NOTE: It is likely that further emission reductions could be achieved through the updating of buses under the quality enhancements intervention as newer buses have reduced carbon emissions. This contribution has not been calculated as part of this study.

A1.1.5 Cycling

This intervention involves encouraging increased rates of cycling through investment in cycling infrastructure and cyclist training.

Little evidence exists in the UK on the effects of large scale investment in cycling. Whilst cities like York and Cambridge show high cycling mode shares, these are atypical in the UK and have characteristics not found across the Leeds City Region (in terms of the historic layout and flat topography).

Assumptions used in this study:

- A conservative estimate has been made that investment in cycling could lead to a 1% mode shift away from private car use, for journeys to the urban centres of less than 10km.
- It is considered that the 10km threshold is a realistic representation of the distance cyclists on average are prepared to travel to work.

A1.1.6 Expansion of the Bus Network and Affordability of Bus Fares

Assumptions used in this study:

This intervention is primarily intending to expand the bus network to areas currently less well served by this mode, including areas suffering from high levels of multiple deprivation. Accompanying this will be a reduction in bus fares for socially excluded residents. As car ownership is lower in these areas and residents travel less, it is not envisaged that car vehicle kilometres would be significantly reduced as a result of this scheme.

[41] http://212.100.233.98/embedded_object.asp?docid=2075&doclib

In addition, it has been assumed that this intervention will not require any additional bus services to be added to the bus network as the expansion will be achieved through more efficient management of routes.

A1.1.7 Home to School

The 'My Bus' scheme in West Yorkshire transports children from home to school and achieves an annual reduction of 2 million vehicle km by operating 150 dedicated school buses to transport pupils between home and school[42].

Assumptions used in this study:

It has been assumed that a similar degree of saving could be achieved again if the size of the fleet was doubled. In addition to car vehicle kilometre savings there will be a negative carbon impact arising from the increased bus fleet on the roads. This has been included in the carbon emission calculations.

To understand the impact of reduce car use the carbon calculations have been based on the carbon impact of an average car of unknown fuel type on an average trip in the UK[43]. To calculate the increased carbon impact through new buses added to the existing fleet the average carbon emissions from an average local bus has been used[44].

A1.2 Location or Corridor Specific Interventions

A1.2.1 Rail Electrification

The electrification of railway typically generates a modal shift from car to train use.

Assumptions used in this study:

Using data from the Regional Funding Allocation (RFA) business case submitted to the Regional Transport Board in November 2008, Arup has estimated the modal shift from the electrification of rail services between Halifax-Leeds-York/Selby. A similar application has been assumed for electrification of other routes: between Leeds and Manchester, Sheffield and Hull.

In addition carbon savings will be made by shifting from diesel to electric trains.

Assumptions used in this study:

These reductions have been assessed by considering the total train travel of LCR residents (REAP data) and combining this with data on the total percentage of the existing train network that is electrified and the proposed future increase in electrification.

A1.2.2 Active Traffic Management

Active Traffic Management is the controlled management of traffic on roads to reduce congestion. The only existing Active Traffic Management scheme in the UK is on the M42. Results from this indicate that both emissions and fuel consumption have fallen by 10% and 4% respectively[45].

Assumptions used in this study:

Using data from the DfT Average Annual Daily Traffic (AADT) resource, Arup has estimated AM peak vehicle flows on the motorway network in the Leeds City Region. This information was combined with ITIS AM peak average speed data and information presented in Figure A1.1 to determine the daily CO_2 emission currently produced on the strategic highway network. Arup then assumed a 10% increase in average speed as a result of traffic

[42] http://www.kirklees.gov.uk/community/education-learning/mybus.shtml
[43] Defra (2008) Guidelines to Defras Greenhouse gas emissions conversion factors
[44] Defra (2008) Guidelines to Defras Greenhouse gas emissions conversion factors for average impact per pkm combined with Defra (2008) Guidelines to Defras GHG Conversion Factors: Methodology paper for transport emissions factors for the average occupancy figure
[45] http://www.highways.gov.uk/knowledge/1359.aspx

management and calculated a revised CO_2 figure based on the carbon emissions released at this revised speed (see Figure A1.1 below).

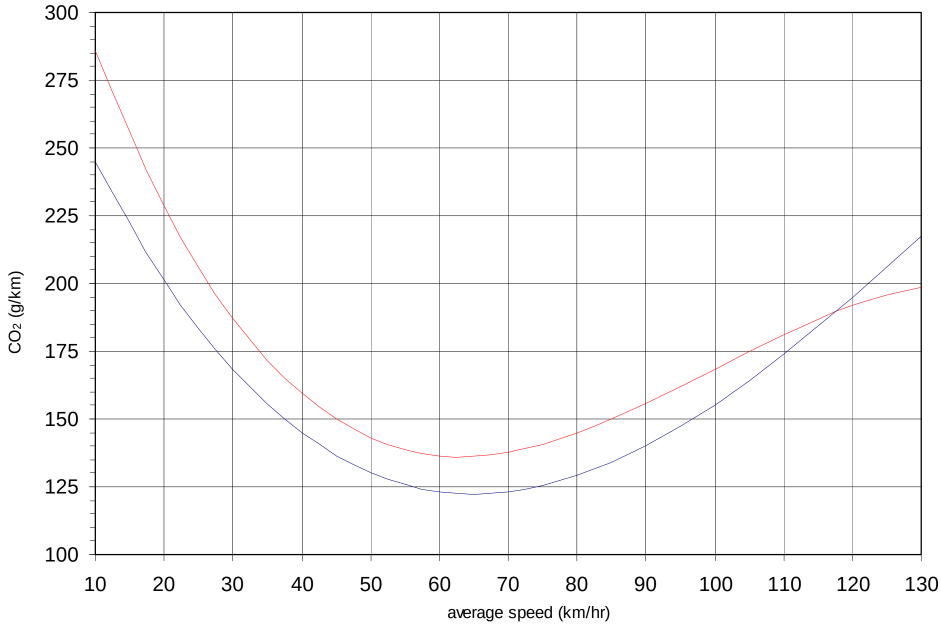


Figure A1.1: Petrol (red) and diesel (blue) Car CO2 emissions (gCO_2/km)

Source: Arup using the DMRB Environmental Assessment procedure

A1.2.3 Rapid Transit Network

As part of the ongoing work on Leeds trolleybus 'New Generation Transport' (NGT), Metro provided Arup with TUBA (Transport Users Benefits Appraisal) outputs presenting the carbon emission reduction generated by the scheme. These outputs were used for the REAP analysis.

A1.2.4 Targeted Highway Improvements

Arup has assumed that a series of projects across the City Region will result in a 0.5% increase in car vehicle km. In the absence of firm details on the potential scale of highway improvements such as length of route and number of lanes and an appropriate network model it is complex to estimate the potential increase in vehicle km as a result of road widening or new road building.

This could be offset slightly by higher average speeds on some routes, leading to reduced carbon emissions. The effects of this have not been quantified in this study.

A1.2.5 Alternative Rail Technologies

The estimate of modal shift away from private car use to tram-train for the LCR is based on studies undertaken by Arup for the Harrogate Line tram-train proposal. Included in this work was an assessment into modal shift away from private car use and the number of vehicle kilometres which would be saved as a result of the scheme. As the tram-train proposal also included delivery of new stations, the modal shift impact for those elements is included in this analysis rather than in the 'new rail stations' assessment. This ensures no double counting of scheme benefits.

Additionally, for the calculation of carbon impact of this scheme, the benefits of a shift away from diesel rail vehicles have been included, assuming that electrification of the line would also occur. It has also been assumed that the new tram/train network will be more frequent than the existing train network running at 4 trains per hour rather than 2 trains.

The impacts of the shift from diesel to tram train have been assessed base on the emissions from an average light rail/tram and an average train on the national rail network with a combined diesel/electric factor for the year 2005[46].

A1.2.6 Park and Ride

Vehicle kilometres removed by expansion of park and ride facilities has been calculated by determining the number of car parking spaces available at each site and the distance from the site to the urban centre. Included in this, was a calculation of the number of new bus kilometres operated as a result of the scheme.

A1.2.7 New Railway Stations

Figures for the reduction in vehicle kilometres as a result of new railway stations have been provided from outline business cases produced for RFA submissions in November 2008. For stations where no outline business case evidence is available, Arup has applied a series of assumptions based on the park and ride offer of the station.

Arup has therefore assumed that all new stations within the city region can be delivered within the existing timetables, thereby not increasing the number of rail kilometres operated on the network.

A1.2.8 Express Bus Coach Network

The limitations of the journey to work database result in an underestimation of longer-distance inter-urban bus movements. In the absence of a suitable source of trip patterns for journeys of this nature, Arup has applied a number of assumptions to estimate the number of vehicle kilometres removed from the network as a result of an express bus network.

Arup has assumed a frequency increase to existing services. For longer distances services, Arup has assumed a vehicle capacity of 50 seats (standard single-deck or coach), for more ‘local’ services, a vehicle capacity of 90 has been assumed (standard double-decker). Based on average bus occupancy in the Leeds City Region, it is estimated that services will have load factors of approximately 50%. It has also been assumed that services would operate for 14 hours each day. This provided a figure for the total daily market of the express bus network.

WebTAG estimate that, on average, 26% of rail journeys on a new service are made by people who previously travelled by car[47]. This figure, when applied to the estimated express bus market, provides the total vehicle kilometres removed from the road network as a result of the scheme although the benefits of this are slightly offset by the increase in bus kilometres on the network.

[46] Defra (2008) Guidelines to Defra’s Greenhouse gas emissions conversion factors
[47] http://www.dft.gov.uk/webtag/webdocuments/3_Expert/13_Rail/3.13.2.htm