Sheffield Air Quality Modelling

Low Emission Zone (LEZ) Feasibility Study

Phase 1 - Initial Assessment of Transport Emissions

Report for Sheffield City Council

In Association With South Yorkshire Passenger Transport Executive, South Yorkshire Local Transport Plan Partnership, First Group, Stagecoach, TM Travel, Freight Transport Association.

Funded by the Department for Environment, Food and Rural Affairs

November 2012

Document Control

Project Title:	Sheffield Air Quality Modelling – Low Emission Zone (LEZ) Feasibility Study - Phase 1, Initial Assessment of Transport Emissions
MVA Project Number:	100134
Document Type:	Final Report
Directory & File Name:	C:\Documents And Settings\Jblythe\My Documents\Sheffield\AQ\20120913 Sheffield Air Quality Modelling Final Report V1.0.Doc

Document Approval

Primary Author:	James Blythe
Other Author(s):	Sophie O'Connor
Reviewer(s):	David Connolly
Formatted by:	

Distribution

Issue	Date	Distribution	Comments
1	12/10/2012	David Connolly, Julie Meese, Andy McKie, Ogo Osammor	First Draft for Review
2	15/10/2012	Steering Group	Draft for Review
3	24/10/2012	David Connolly, Julie Meese	Amended version taking into account Steering Group Comments for final review
4	9/11/2012	Steering Group	Final Version

Contents

mvaconsultancy

Tables

Figures

Appendices

mvaconsultancy

Executive Summary

Sheffield Air Quality Modelling - Low Emission Zone Feasibility Study

Phase 1 – Initial Assessment of Transport Emissions

Sheffield aspires to be a city where health inequalities are reduced and air is healthy for all to breathe. Air pollution impacts negatively on people's health and the economy as well as contributing to climate change. Poor air quality has recently been estimated to account for up to 500 premature deaths per year in Sheffield, with health costs of around £160 million per year. The cause of air pollution in the city is largely due to both road transport and industry.

Locally and nationally air quality has generally been improving. However, in the most polluted areas, near motorways and within busy urban centres, it has not improved (or has even worsened). Sheffield, like many other major cities in the UK, currently breaches UK and European Union thresholds for air quality. Sheffield City Council declared an Air Quality Management Area across the whole of the urban area of the city for nitrogen dioxide (NO_2) and fine particles (PM_{10}) in March 2010. As a consequence a new Air Quality Action Plan (AQAP) for Sheffield 2015 was approved at Cabinet on 11 July 2012, which aims to reduce pollution in Sheffield in order to achieve health-based national air quality objectives and EU limit values by 2015.

There is the potential for the UK government to be fined if the EU limits are exceeded beyond 2015, and the fines imposed could be significant. Consequently this is a recognised risk for the Council. The UK government's application to delay compliance with EU objectives has recently been turned down, further compounding the risk to the Council.

A feasibility study into a Low Emission Zone (LEZ) is a key action within the AQAP. This work represents the first phase of the feasibility into a Low Emission Zone and looks at an initial assessment of transport emissions only, and the main contributors to these emissions, including the likely impact of improvements to the vehicle fleet by 2015.

This project has been funded by the Department for Environment, Food and Rural Affairs (DEFRA).

The project has been lead by Sheffield City Council, with the work to estimate and forecast transport emissions being undertaken by MVA Consultancy.

A Steering Group was appointed to oversee the project.

Study Overview

The key objective of this study was to use forecasts from the Sheffield and Rotherham Transport Model (SRTM3) to provide a robust evidence base upon which to develop an Air Quality Strategy.

The aim of the Air Quality Strategy is to help Sheffield to move towards compliance with European Air Quality Standards for NO_2 by tackling the main traffic-related emissions which are contributing to the current air quality problems in the Sheffield area, as set out in the AQAP for Sheffield 2015.

mvaconsultancy

Summary

The tasks undertaken during the project are outlined below:

- use of MVA's ENEVAL software and outputs from the Sheffield and Rotherham Transport Model (SRTM3) to estimate transport related emissions, based on assumptions about the vehicle fleet in Sheffield;

- examination of the impact of changes in vehicle fleet assumptions on estimated emissions;

- comparison of modelled base year emissions (2008) with observed air quality data;

- identification of areas with high levels of transport emissions that may be contributing to poor air quality; and

- identification of the subsets of traffic which are contributing most to current and future air quality problems and hence identifying where further work on developing emissions strategies should be focussed.

Modelling Tools

The Sheffield & Rotherham Transport Model (SRTM3) combines a bespoke demand model with SATURN highway and VOYAGER public transport assignment models. These models have been developed with a base year of 2008 in line with the guidance provided in the Department for Transport's Transport Analysis Guidance (TAG). These models have been validated in accordance with the requirements for TAG, and agreed by DfT to be fit for the purpose of supporting the Major Scheme Business Case (MSBC) submission for the Bus Rapid Transit (BRT) North scheme.

An existing future year SRTM3 forecast has been used as the basis for the calculation of estimated transport-related emissions in 2015. The chosen forecast is the local low growth scenario produced to support the Best and Final Funding Bid (BAFFB) for the BRT North scheme. The key characteristics of this forecast are:

- inclusion of all transport interventions that are considered to be 'near certain' or 'more than likely' to happen by 2015, including the BRT North scheme;

- the inclusion of all developments that are considered to be 'near certain' by 2015; and

- overall growth in travel demand that is consistent with the National Trip End Model (NTEM) version 6.2 forecasts.

Although SRTM3 has been constructed in line with the guidance in TAG, no funding has been made available to update the model over the last couple of years. The oldest data used to construct the model was collected in 2005, and DfT prefer data used in models to be at most five or six years old. Despite the age of some of the data, the model is the best tool available to provide an evidence base for this work, and the model has been constructed in line with DfT guidance and accepted by them for the appraisal of major schemes.

Note that, taxis are not included explicitly in the model but as they are included in the counts of cars they will be represented in the car matrices and therefore in traffic levels.

The traffic flows and speeds from the SRTM3 highway assignments have been fed into MVA's ENEVAL software in order to estimate the current and forecast transport emissions. ENEVAL

mvaconsultancy

only considers the emissions from vehicles, and does not consider emissions from other sources or dispersion.

Industry, and some other sources, will also contribute to emissions and hence to air quality. How well the emissions disperse will influence the impact of emissions on actual air quality, and the location of air quality problems which will not necessarily be by the roadside. Neither of these factors is considered in this report, which simply deals with the source of transport-related emissions.

Fleet Composition Assumptions

ENEVAL's default fleet assumptions are based on those in the DEFRA Toolkit for Vehicle Emissions. These represent the national average for each year (excluding London), with assumptions as to how the fleet composition will change over time. In order to improve the emissions calculations for Sheffield, local fleet compositions have been estimated for cars, freight vehicles and buses.

The bus fleet composition has been based on information collected from operators on the make up of their fleet and likely vehicle replacement strategies. Local car and freight compositions have been estimated from ANPR data based on the year of construction of the vehicles. The key characteristics of the Sheffield fleet compared with the national assumptions are:

- the proportion of single deck buses in the Sheffield fleet is higher than the national average; and

- the bus, car and freight fleets in Sheffield are all generally older than the national average.

Emissions Factors Assumptions

The default emissions factors contained within ENEVAL are taken from the Department for Transport (DfT) website and are based on TRL Report PPR353 – Emissions Factors 2009. However, it has become widely recognised that these formulae significantly underestimate NO_X emissions from the most recent Euro engine categories, particularly for diesel vehicles. An alternative calculation has recently been made available for the calculation of NO_X emissions in the form of the COPERT NO_X function. An updated version of the ENEVAL software has therefore, been created for the purposes of this study which includes an approximation of the COPERT NO_X function, in order to better represent NO_X emissions.

Impact of Assumptions

The assumptions made about the vehicle fleet and the calculation of NO_X emissions, have a significant impact on the model outputs. A variety of tests have been undertaken in order to understand the impact of these assumptions, with a summary of the impact outlined below:

mvaconsultancy

- the local bus fleet composition results in a 7% reduction in emissions, due to the higher than average proportion of single deck vehicles in the Sheffield bus fleet;

- the local fleet composition for cars and freight increases predicted emissions, particularly for cars, as a result of the older than average vehicle fleet - emissions levels are estimated to be 4% higher as a result of including the local fleet composition for all vehicle types;

- the use of the COPERT NO_X functions and the local fleet compositions results in 11% higher emissions levels in 2008; and

- inclusion of all of the updated assumptions increases the 2015 forecast emissions by 65% and reduces the forecast reduction from 2008 values from 50% to 30%.

Comparison of Observed Air Quality and Modelled Emissions

Observed Air Quality data (recorded NO_2 levels) has been obtained from Sheffield City Council for 2008 and has been plotted to show elevated NO_2 level areas. The plotting of the estimated transport emissions for the base year alongside the observed elevated NO_2 levels has shown that there is a good degree of correlation between those areas with elevated NO_2 levels and areas with high levels of transport related emissions. The plotted transport emissions are primarily NOx, a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2), the observed data is monitored NO_2.

The analysis of the observed air quality (monitored NO_2) and modelled transport emissions (NO_X) highlighted a number of areas where poor air quality exists, and is likely to be a result of transport-related emissions. The following key areas with observed poor air quality have been identified:

- Sheffield City Centre;

- the University/Broomhill Corridor;

- the Abbeydale Road/London Road Corridor; and

- close to the M1 Motorway at Meadowhall.

In addition, air quality (in the form of NO_2) is not monitored everywhere and the analysis of the modelled transport emissions (NO_X) has also highlighted a number of areas that are not monitored where there are high levels of transport emissions. The key areas identified are:

- Penistone Road corridor;

- Sheffield Parkway; and

- Attercliffe Road.

2015 Forecast Emissions

The forecast emissions for 2015 show that, despite increasing traffic levels in the city, there is expected to be a reduction in NO_X emissions as a result of the increasing proportions of the fleet which have engines in the higher (i.e. lower emission) Euro categories. Although the levels of transport-related NO_X emissions are forecast to reduce, there are still a number of areas where the levels of emissions are likely to be contributing towards local air quality (monitored NO_2) issues:

mvaconsultancy

- Sheffield City Centre;

- close to the M1 Motorway at Meadowhall;

- Penistone Road corridor; and

- Attercliffe Road.

There has been a clear drop in the forecast emissions in some of the areas identified as having high levels of emissions in 2008. While this is likely to lead to improvements in air quality (subject to emissions from other sources), the work undertaken within this study cannot quantify whether the improvement will be sufficient to meet air quality objectives or limit values. In addition, it is important to remember that the reduction in emissions is dependent on the assumed improvements in vehicle fleets being realised. Therefore, the following areas should still be considered:

- the University/Broomhill Corridor;

- Sheffield Parkway; and

- the Abbeydale Road/London Road Corridor.

Contributors to Emissions

The modelled NO_X emissions by vehicle type for the Sheffield area (excluding the Motorway) show that there is forecast to be a significant drop in NO_X emissions in the area. Emissions from cars were greater than from the other vehicle types in 2008 and are forecast to continue to be greater than the other vehicle types in 2015.

Light Goods vehicles are only responsible for a small proportion of emissions, which is a result of the number of light goods vehicles on the road compared to car. The emissions from light goods vehicles change by only a small amount between 2008 and 2015, due to the combination of the assumed 16% growth in light goods vehicle trips over this period, offset by the impact of the newer vehicles.

The emissions from other goods vehicles and buses are forecast to reduce between 2008 and 2015, but not by the same extent as car emissions. It is clear that both of these vehicle types are contributing a significant amount to city wide emissions and are forecast to continue to do so.

The analysis of contributors to emissions in the key problem areas has identified the following:

- on some links, such as West Street and Langsett Road, bus is responsible for almost all of the NO_X emissions.

- radial routes into the City typically have car and bus as the main contributors to emissions, though on some of these routes (e.g. Penistone Road and Meadowhall Road) other goods vehicles also are significant contributors to emissions; and

- other goods vehicles are the main contributor to emissions on the M1 Motorway, particularly in 2015.

mvaconsultancy

Conclusions

The study has highlighted the importance of the assumptions used to estimate the transport related emissions using outputs from transport models. In particular, the assumptions about the age, engine category and fuel type of the vehicle fleet has a significant impact on the forecast levels of emissions:

- The use of local data on the composition of the bus fleet results in lower levels of calculated NO_X emissions as a result of the higher proportion of single deck buses in the Sheffield fleet compared to the national average. This is despite the fact that the bus fleet in Sheffield is older than the national fleet on average.

- The use of local data on the composition of the car and freight fleets results in increased calculated NO_X emissions. This increase in emissions is a result of the older vehicle fleet in Sheffield compared to the national average.

- The TRL NO_X calculations are understood to underestimate emissions from the later Euro engine categories, particularly for diesel engines. Therefore, the use of the COPERT function for calculating NO_X emissions results in higher calculated levels of emissions.

- The split of cars between petrol and diesel also has a significant impact on emissions levels, with higher proportions of diesel vehicles leading to higher levels of NO_X emissions. Other studies have highlighted the impact that increasing diesel car proportions have on emissions.

The main contributor to city wide emissions in 2008 was car but with notable contributions from both bus and other goods vehicles. However, car emissions across the city are forecast to reduce significantly by 2015. The contributors to the emissions in the areas identified as having high levels of transport emissions potentially leading to poor air quality shows that the contributors to emissions vary by area. The key points arising from the contributors to emissions in these areas are:

- LGV is not contributing significant amounts in any area, so any policy aimed at LGVs will only have a limited impact on air quality in Sheffield.

- Buses are contributing significant amounts to emissions in the City Centre, through Hillsborough and on the A57/Broomhill corridor.

- Other goods vehicles are contributing significant amounts towards emissions on the M1, on Meadowhall Road and on Penistone Road.

- Car contributes significant amounts in all areas, except areas which are largely dedicated to bus flows.

It is clear from this analysis that any potential interventions that are aimed at one vehicle type are unlikely to remove all of the air quality problems resulting from transport emissions. It is important to remember that although buses contribute significant amounts to emissions each bus is moving a large number of people and could be taking a number of cars off the road.

mvaconsultancy

Recommendations for Further Work

The development of a strategy for improving air quality would benefit greatly from more accurate information on the current vehicle fleet in Sheffield. This includes the taxi fleet, which has not been considered explicitly in this work as taxi flows are not included in the transport model as a separate category (i.e. Car within the model includes all cars and taxis).

It is also worth considering any studies into the actual level of emissions from each of the Euro engine categories. In particular, having confidence in the actual performance of engines (in congested urban conditions) compared to their claimed performance would add a lot to the confidence in the model results.

Having developed a reasonable level of confidence in the assumptions being used to calculate emissions, and forecasting the likely emissions in 2015, then the model can be used to test some high level strategies aimed at reducing emissions, with a particular focus on the key areas identified.

This work has only considered the transport related emissions and not emissions from other sources or indeed the actual impact on air quality in the key areas. The use of the Airviro model to examine the impact on air quality of forecast changes in transport emissions would be beneficial. However, it is important in doing this to ensure that transport emissions in Airviro are modelled as accurately as possible and therefore that the assumptions used in Airviro reflect the work that has been reported on in this study.

The recommendations for further work listed above relate to improving the understanding of the current transport related emissions in Sheffield, and also their impact on Air Quality. Once the evidence base has been developed to an accepted level of confidence, the modelling tools can then be used to assess the impact of interventions that are designed to improve air quality through further reductions in transport-related emissions. The modelling tools can then be used to forecast the impact of interventions on emissions, and air quality, which may include the following:

- the development of a Low Emission Zone;
- fleet improvements, and further improvements in engine technology;
- switch away from diesel vehicles; and
- alternative fuels.

The Department for Environment, Food and Rural Affairs has now approved funding for Phase 2 of this project. The next stage of the project will therefore, be the detailed scoping out of further work to be undertaken, for which an LEZ Phase 2 Scoping Report will be produced.

mvaconsultancy

1   Introduction

1.1   Background

1.1.1   Sheffield aspires to be a city where health inequalities are reduced and air is healthy for all to breathe.

1.1.2   A modern, vibrant city needs to have a high-quality local environment, including cleaner air and cleaner transport, for the benefit of local people, and in order to attract people to the city for work and leisure.

1.1.3   Traffic-related emissions impact negatively on people's health through increased air pollution and contribute to greenhouse gas emissions and climate change.

1.1.4   Poor air quality adversely affects human health, and has recently been estimated to account for up to **500 premature deaths** per year in Sheffield, with health costs of around **£160 million** per year[1]. It has short and long-term health impacts, particularly for respiratory and cardiovascular health, including increased admissions to hospital.

1.1.5   A key message from leading respiratory and cardio-vascular physicians and environmental health experts is that modest reductions in pollution would lead to significant health gains[2].

1.1.6   Overall, the adverse effects of poor air quality are such that it has a bigger impact on life expectancy than road traffic accidents or passive smoking[3].

1.1.7   Locally and nationally air quality has generally been improving. However, in the most polluted areas, near motorways and within busy urban centres, it has not improved (or has even worsened).

1.1.8   Sheffield, like many other major cities in the UK, currently breaches UK and European Union thresholds for air quality, particularly for NO_2 and PM_{10}.

1.1.9   Sheffield City Council declared[4] an Air Quality Management Area across the whole of the urban area of the city for nitrogen dioxide (NO_2) and fine particles (PM_{10}) in March 2010.

1.1.10   This means that the Council has to produce an Air Quality Action Plan to cover the period (up) to 2015, with the aim of improving nitrogen dioxide (NO_2) and PM_{10} levels, such that the annual limit of $40\mu g.m^{-3}$ for NO_2 and the daily limit of $50\mu g.m^{-3}$ for PM_{10} (which is not to be exceeded more than 35 times a year) do not continue to be breached.

1.1.11   There is the potential for the UK government to be fined if the EU limits are exceeded beyond 2015, and the fines imposed could be significant. Consequently this is a recognised risk for the Council.

---

[1] Sheffield City Council's interpretation of the Evidence of Robert Vaughn from DEFRA to Environment Select Committee 2010 accessed at http://www.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/inquiries/parliament-2010/air-quality-a-follow-up-report/

[2] Environmental Audit Committee - Ninth Report Air quality: A follow up report

[3] Environmental Audit Committee - Ninth Report Air quality: A follow up report

[4] Air Quality Management in Sheffield, Sheffield City Council Cabinet Report 13 January 2010

mvaconsultancy

1.1.12   The UK government's application to delay compliance with EU objectives has recently been turned down, further compounding the risk to the Council.

1.1.13   The cause of air pollution in the City is largely due to both road transport and industry, and to a lesser extent, other processes that burn fossil fuels, such as commercial or domestic heating systems (e.g. gas boilers).

1.1.14   A new Air Quality Action Plan (AQAP) for Sheffield 2015 was approved at Cabinet on 11 July 2012 – please see Appendix A. The AQAP describes the actions that have been taken since 2010 to improve air quality and what more needs to be done.

1.1.15   The AQAP aims to reduce pollution in Sheffield in order to achieve health-based national air quality objective and EU limit values by 2015.

1.1.16   An ambitious set of local measures have been outlined in the AQAP, which when fully implemented should lead to a significant reduction in levels of nitrogen dioxide (NO_2), and fine particles (PM_{10}) in the air.

1.1.17   A feasibility study into a Low Emission Zone (LEZ) is a key action within the AQAP. This work represents the first phase of the feasibility into a Low Emission Zone and looks at an initial assessment of transport emissions only, and the main contributors to these emissions, including the likely impact of improvements to the vehicle fleet by 2015. The Department for Environment, Food and Rural Affairs has now approved funding for Phase 2 of this project. The next stage of work will be the scoping out of further work to be undertaken, for which a Scoping Report will be produced.

1.2   Project Funding

1.2.1   This project has been funded by the Department for Environment, Food and Rural Affairs (DEFRA).

1.3   Project Governance

1.3.1   The project has been lead by Sheffield City Council, with the work to estimate and forecast transport emissions being undertaken by MVA Consultancy. A Steering Group was appointed to oversee the project, comprising of representatives from the following organisations:

- Sheffield City Council;
- South Yorkshire Passenger Transport Executive;
- South Yorkshire Local Transport Plan Partnership;
- First Group;
- Stagecoach;
- TM Travel; and
- Freight Transport Association.

mvaconsultancy

1.4   Study Overview

1.4.1   The key objective of this study was to use forecasts from the Sheffield and Rotherham Transport Model (SRTM3) to provide a robust evidence base upon which to develop an Air Quality Strategy.

1.4.2   The aim of the Air Quality Strategy is to help Sheffield to move towards compliance with European Air Quality Standards for NO_2 by tackling the main traffic-related emissions which are contributing to the current air quality problems in the Sheffield area, as set out in the AQAP for Sheffield 2015[5].

1.4.3   The original scope of the project was as follows:

■   use of the Saturn highway assignment model within SRTM3 and MVA's ENEVAL software to undertake an initial analysis of base year (2008) transport related emissions using UK default fleet composition assumptions;

■   comparison of the modelled base year emissions with observed air quality data, followed by the identification of 'problem areas' where future air quality is most-likely to fail to reach required EU standards;

■   identification of the subsets of traffic which are contributing most to current and future air quality problems;

■   develop a costed programme of additional data collection which can be used to calibrate the relevant fleet proportions;

■   update the ENEVAL analysis using locally-calibrated fleet mix proportions;

■   use of the analysis of the current and future emissions to identify and appraise a range of potential cost-effective measures which are likely to help improve air quality in the relevant problem areas;

■   recommendation of an Emissions Strategy which will set out the steps required to enable SCC to move towards compliance with EU Air Quality standards; and

■   SCC's environmental team incorporating the outputs from the Preferred Strategy into their Airviro model, to confirm the corresponding impacts on (predicted) air quality across the city.

1.4.4   The approach to this project was intended to be flexible in order to respond to the findings from the analysis of the model forecasts as the project progressed. The analysis of the model forecasts led to the following changes to the scope of work undertaken within the original timescales, as agreed with the project Steering Group:

■   increased focus on the assumptions that were included in the model analysis, in particular on the vehicle fleet assumptions and the calculation of NO_X emissions;

■   use of the best available information on the vehicle fleet make up instead of the collection of new data; and

■   no consideration of the range of cost-effective measures that are likely to help improve air quality in the relevant problem areas at this stage of the project.

---

[5] Air Quality Action Plan 2015, Sheffield City Council Cabinet Report 11 July 2012

mvaconsultancy

1.5   AIRVIRO Modelling

1.5.1   Sheffield City Council have an Airviro system for modelling air quality, which takes into account emissions from all sources and also dispersal. Outputs from the highway assignment model are clearly an input to this model, although not as much detail on the vehicle fleet on the roads is input to Airviro as can be modelled with MVA's ENEVAL software.

1.5.2   As traffic is the main source of emissions within Sheffield, this work has concentrated on transport-related emissions and the ability of ENEVAL to use information on the vehicle fleet to calculate emissions. Industry, and some other sources, will also contribute to emissions and hence to air quality. How well the emissions disperse will influence the impact on actual air quality, and the location of air quality problems which will not necessarily be by the roadside. Neither of these factors is considered in this report, which simply deals with the source of transport-related emissions.

1.5.3   In order to understand the impact of policies to reduce transport emissions on air quality, it is recommended that the resulting strategy is tested in the Airviro model, and that the actual calculated emissions are transferred to Airviro, rather than recalculating emissions based on traffic levels.

1.6   Structure of this Report

1.6.1   Following this introductory section, the remainder of the report is set out as follows:

- Section 2 describes the modelling tools that have been used throughout this project;

- Section 3 outlines the assumptions made in the emissions modelling;

- Section 4 presents a comparison of the observed air quality and modelled transport emissions for the 2008 base year;

- Section 5 presents the results from the forecasts of transport related emissions in 2015;

- Section 6 outlines the findings from our analysis of the contributors to emissions in the key problem areas; and

- Section 7 summarises the conclusions from the work undertaken so far.

mvaconsultancy

2 Modelling Transport Emissions

2.1 Introduction

2.1.1 The purpose of this Chapter is to provide an introduction to the modelling tools that have been employed in the modelling of transport-related emissions, and to give details of the existing model forecasts which have been used in this work. This Chapter contains sections outlining each of the following:

- an introduction to the Sheffield and Rotherham Transport Model, and the SATURN highway assignment model;

- information on validation of the base year SATURN highway assignment model;

- details of the inputs to the 2015 model forecast, and the resulting forecast growth in traffic; and

- a description of MVA's ENEVAL software which has been used to estimate transport related emissions.

2.2 Sheffield and Rotherham Transport Model (SRTM3)

2.2.1 The Sheffield & Rotherham Transport Model (SRTM3) combines a bespoke demand model (SRDM3) with SATURN highway (SRHM3) and VOYAGER public transport (SRPTM3) assignment models. This system of models has been configured to provide the opportunity for the following transport interventions to be addressed:

- the generation of a core scenario (or alternative scenarios) that fully reflects the interactions of changes in incomes, car ownership, household structures, development patterns and travel costs (time and money) for future years;

- the modelling and appraisal of road traffic demand management measures targeted at improving the economic performance and the environment of Sheffield & Rotherham;

- the modelling and appraisal of public transport schemes including bus service and heavy rail enhancement options and Supertram extension proposals;

- the transport impacts of variations to land-use policy and economic growth assumptions, with the former to be considered at a relatively detailed spatial level; and

- the measurement of socio-economic impacts of transport interventions.

2.2.2 The modelling system is designed to address a comprehensive range of potential transport interventions, in particular bus priority measures, provision of new highway capacity, parking policies and traffic management initiatives. Broad brush representation of measures targeted at improved conditions for walking and cycling can also be addressed using this model.

mvaconsultancy

2.2.3   The outputs from SRTM3 include:

- levels of travel demand by time of day, mode of travel, geographic distribution, reason for travel, income group and the availability of a car;

- time and money costs of travel; and

- levels of traffic on roads within the modelled area, and patronage of public transport services.

2.2.4   These outputs can be used to analyse:

- traffic-related noise and emissions;

- road traffic accidents;

- road speeds and congestion;

- revenues derived from parking, public transport provision and road pricing;

- the accessibility of workplaces for employees, and conversely the available supply of labour for employers;

- transport economic impacts of proposals, accounting for changes in travel time and cost; and

- wider economic benefits resulting from the transport strategy proposals.

2.2.5   SRTM3 has been designed to focus on a study area that coincides with the districts of Sheffield and Rotherham. The model extends, albeit with decreasing levels of detail, across Yorkshire, Humberside and the East Midlands. The remainder of Great Britain is represented at a very coarse level of detail.

2.2.6   SRTM3 has been constructed following the Department for Transport's (DfT) guidance on transport modelling which is contained within the Transport Analysis Guidance (TAG). This guidance can be found at www.dft.gov.uk/webtag. Units 3.10, 3.11 and 3.12 are most relevant to the development of SRTM3.

2.2.7   Although SRTM3 has been constructed in line with the guidance in TAG, no funding has been made available to update the model over the last couple of years. The oldest data used to construct the model was collected in 2005, and DfT prefer data used in models to be at most five or six years old. Despite the age of some of the data, the model is the best tool available to provide an evidence base for this work, and the model has been constructed in line with DfT guidance and accepted by them for the appraisal of major schemes.

2.2.8   The Sheffield & Rotherham Demand Model (SRDM3), which is at the heart of SRTM3, has been tailored to reflect the current travel patterns and likely future travel choices of people within the districts of Sheffield & Rotherham. SRDM3 represents the main choices that face travellers including how often to travel, where to travel, which mode to use and what time of day to travel. Each of these choices is influenced by factors such as the reasons for the journey, the availability of a car and the income of the traveller. For this reason the representation of travel demand in SRDM3 is highly segmented. Journeys from and to home are linked in SRDM3 so that the cost of an out-and-return home based tour can be considered in its entirety.

mvaconsultancy

2.2.9   Goods vehicle demand is not subject to the demand modelling processes but the routeing of these vehicles through the network is modelled in the highway assignment model. Future year growth in goods vehicles is therefore applied directly to the assignment matrices so that the routeing impact of these vehicles is considered.

2.2.10   Nine time periods across the weekday have been included in the demand model, allowing the impacts of peak spreading to be assessed for different policy scenarios. These are:

- Pre-AM Peak   0700-0800   1.0 hrs
- AM Peak   0800-0900   1.0 hrs
- Post-AM Peak   0900-1000   1.0 hrs
- Inter-peak 1   1000-1300   3.0 hrs
- Inter-peak 2   1300-1600   3.0 hrs
- Pre-PM Peak   1600-1700   1.0 hrs
- PM Peak   1700-1800   1.0 hrs
- Post-PM Peak   1800-1900   1.0 hrs
- Off-peak   1900-2300   4.0hrs
- Total   16.0 hrs

2.2.11   Further detail on the development of the demand model is provided in "Sheffield & Rotherham Demand Model (SRDM3) Model Development Report", MVA Consultancy, July 2009.

SATURN Highway Assignment Model (SRHM3)

2.2.12   The SATURN highway assignment model has been developed in line with the guidance provided within TAG and has been accepted by the Department for Transport as being fit for the purpose of undertaking highway assignment to support Major Scheme Business Cases. The model is run within the main demand model and exists for each of the time periods contained within SRTM3.   However, the highway assignment model was initially built, calibrated and validated to the following three time periods:

- weekday morning peak hour : 0800-0900;
- weekday average inter-peak hour : 1000-1200 and 1400-1600; and
- weekday evening peak hour : 1700-1800.

2.2.13   The models for each of the shoulder peak periods were developed from the validated peak period models, using the same networks and with demand created from the same source as the peak period models. Therefore, these shoulder peak assignment models reflect the likely level of traffic within these time periods, as well as differences in the make up of the demand that exists in these periods.   The shoulder peak models have not undergone the same calibration and validation process as the peak period models.

2.2.14   The networks contained within the SATURN model include detailed junction coding on the Motorways, A roads, B roads and C roads plus all minor roads served by bus routes within Sheffield and Rotherham.

mvaconsultancy

2.2.15   The model is calibrated at a three user class level, as manual classified counts are only available for cars, Light Goods Vehicles (LGVs) and Other Goods Vehicles (OGVs). Note that, taxis are not included explicitly in the model but as they are included in the counts of cars they will be represented in the car matrices and therefore in traffic levels. The final validated model is then segmented into six user classes:

- cars – employer's business;
- cars – commute and other - low income;
- cars – commute and other - medium income;
- cars – commute and other - high income;
- Light Goods Vehicles (LGVs) – less than 3.5 tonnes; and
- Other Goods Vehicles (OGVs) – greater than 3.5 tonnes.

2.2.16   Bus flows are also included within the model, to ensure that the impact of buses on vehicle flow is taken into account. The bus flows are taken directly from the public transport assignment model.

2.2.17   Further detail on the development, calibration and validation of the SATURN highway assignment model is contained within the report: "SATURN Highway Local Model Calibration and Validation Report", MVA Consultancy, September 2009.

2.3   2008 Base Year Model

2.3.1   The base year for SRTM3 is 2008, with each of the models developed, calibrated and validated for this base year. Detail of the calibration and validation of the base year demand, highway assignment and public transport assignment models are contained within the individual reports for these models. A brief summary of the development of the SATURN highway assignment model is contained within this section, as this is the main tool utilised in estimating transport-related emissions for this project.

2.3.2   The following data was included in the model building and validation:

- traffic signal data from the Urban Traffic Control (UTC) teams of Sheffield City Council and Rotherham Metropolitan Borough Council;
- bus service patterns;
- journey time survey data from surveys between 2006 and 2008;
- roadside interview surveys undertaken between 2005 and 2008; and
- manual classified vehicle counts undertaken between 2006 and 2008.

mvaconsultancy

2.3.3   The calibration and validation of the model involved the following key tasks:

■   comparison of modelled flows with observed counts;

■   comparison of modelled and observed journey times on key routes;

■   comparison of model link lengths with crow fly distances;

■   comparison of junction coding compared against aerial photographs and site visits; and

■   modelled routes checked by inspection for plausibility.

2.3.4   The validation of the model flows against observed counts is undertaken in line with the guidance contained within TAG, which also refers to earlier guidance provided in the Design Manual for Roads and Bridges (DMRB) Volume 12, Section 2, Part 1, Chapter 4.

2.3.5   The following key validation statistics for the base year assignment models are presented in Table 2.1:

■   **the R squared value** – a measure of the goodness of fit between modelled flows and observed counts, based on a model of the form Y = X;

■   **GEH statistic** – the percentage of all links with a GEH value less than 5 (the GEH statistic is defined in TAG Unit 3.19);

■   **DMRB guideline** – the percentage of links that pass the 'DMRB Vehicle Flow Comparison', as detailed in section 2.3.6; and

■   **Modelled / Observed** – the ratio of total modelled flows to total observed counts across the whole modelled area.

2.3.6   A link passes the DMRB guidelines if:

■   where observed flow is less than 700 vehicles per hour, the modelled flow should be within 100 vehicles of the observed flow;

■   where observed flow is between 700 and 2700 vehicles per hour, the modelled flow should be within 15% of observed flow; and

■   where observed flow is greater than 2700 vehicles per hour, the modelled flow should be within 400 vehicles of the observed flow.

2.3.7   The recommendation within TAG is that 85% of all links should achieve the targets of a GEH statistic less than 5, and also pass the DMRB criteria. It can be seen that, although 85% of links pass the DMRB criteria, this is not the case for the GEH statistic. The size and complexity of the model makes it difficult to achieve these criteria, particularly given the variability that can exist in traffic flows. Work on improving the validation of the model has been concentrated on the areas around the major schemes that the models have been used to appraise.

mvaconsultancy

Table 2.1 Validation of Modelled Flows Against All Calibration Counts after Matrix Estimation

	R^2	Links with GEH <5	Links passing DMRB criteria	Ratio of Modelled to Counted Flow
Morning Peak				
Car	0.98	82%	90%	0.98
LGV	0.95	95%	100%	0.96
OGV	0.90	95%	99%	1.02
Total	0.98	79%	88%	0.98
Inter-peak				
Car	0.98	86%	94%	0.99
LGV	0.93	95%	99%	0.97
OGV	0.92	95%	100%	1.04
Total	0.98	82%	91%	0.99
Evening Peak				
Car	0.98	81%	91%	0.98
LGV	0.95	96%	100%	0.95
OGV	0.92	99%	99%	1.01
Total	0.98	79%	89%	0.97

2.4   Future Year Forecasts 2015

2.4.1   As noted earlier in the report, an existing forecast was to be used for the estimation of future year emissions. The recent work on the Best and Final Funding Bid (BAFFB) for the Bus Rapid Transit (BRT) North scheme had utilised a forecast year of 2015, as this was the proposed opening year for the scheme. Therefore, it was decided that this work provided the most suitable basis for the estimation of future year transport emissions. The local low growth scenario that was reported for this work was chosen as the most appropriate forecast as it reflected in some way the lower levels of development that will have come forward as a result of the recession.

2.4.2   The development of the future year scenario used for this work is described in more detail in the Report: "South Yorkshire Bus Rapid Transit (North) Forecasting Report", MVA

mvaconsultancy

Consultancy, September 2011. A summary of the key inputs to this forecast, as well as summary results from this forecast, is provided within this section.

2.4.3   The SRTM3 model uses a number of parameters that change over time, such as car occupancy levels, values of time and vehicle operating costs. For each modelled year, these parameters have all been estimated using the methodology set out in TAG Unit 3.5.6.

2.4.4   To establish the most likely development of land use and transport interventions to include in the core scenario, we developed an uncertainty log in line with the DfT's latest guidance (WebTAG Unit 3.15.5). The uncertainty log places each land use or transport intervention into one of four categories:

- 'near certain';
- 'more than likely to happen';
- 'reasonably foreseeable'; and
- 'hypothetical'.

2.4.5   Those that were placed in the 'near certain' or 'more than likely to happen' categories were included in the core scenario for the BRT North appraisal. The local low growth scenario, which has been used for this work, includes only those developments that are classified as near certain, but includes all transport interventions that are classified as 'near certain' or 'more than likely to happen'.

Transport Interventions

2.4.6   The uncertainty log for transport interventions is provided at Appendix B. A summary of the key schemes included is provided below:

- Improvements to the A630/Poplar Way/Europa Way in Rotherham;
- MOVA control at M1 Junction 33 (A630 Parkway);
- Ecclesall Road and A6109 Meadowhall Road Congestion Target Route package;
- Parking permit schemes in Upperthorpe and Highfield;
- Managed motorway scheme on M1 between junctions 28 and 31, and 32 to 35a;
- Improvements to M1 junction 34 North;
- Extra lane between junctions 31 and 32 on the M1;
- MOVA control at M1 Junction 34 South; and
- Bus Rapid Transit North.

2.4.7   The scenario that has been used for this work does not include the proposed Supertram Additional Vehicles (SAV) project or the Tram-Train (TT) Trial, both of which have received funding approval from DfT.

Demand Assumptions

2.4.8   The reference matrices are the matrices input to the demand model in the future year. They reflect changes from the base demand attributable to demographic changes such as changes

mvaconsultancy

in the number of jobs in an area and the number of residents and the number of cars they own. They represent the travel demand that would arise if there were no changes in costs from the base year model. The reference matrices for 2015 were created through the following process:

- growth in personal travel - the application of factors taken from the National Trip End Model (NTEM) version 6.2 to the base year highway and public transport demand matrices;

- treatment of individual developments – the process of accounting for individual developments whilst respecting the overall growth forecast by NTEM; and

- growth in commercial vehicle travel - National Transport Model factors applied to goods vehicles matrices. These assumptions result in a growth of 16% in light goods vehicles and 3% in other goods vehicles between 2008 and 2015.

2.4.9   The uncertainty log for land-use developments is provided at Appendix C. All developments listed as being Near Certain at 2015 are included in the demand assumptions for the model runs used in this work.

2.4.10   The forecast trip matrices were controlled to match NTEM growth by mode (car, PT, walk/cycle) by car availability level (car owning, non-car owning) by journey purpose (commute, employer's business, other), as set out in TAG Unit 3.15.2. Overall, this results in, increases in car trips of around about 0.77% a year and increases in public transport trips of around 0.23%, but with significant variation by area. The growth across the study area is shown in Table 2.2.

Table 2.2 Reference Matrices - Percentage Growth in Trip Origins from 2008 to 2015

Location	Car	PT	Walk / Cycle
Sheffield City Centre	14%	8%	181%
Rotherham Town Centre	-8%	-6%	1%
Rest of Sheffield	4%	1%	1%
Rest of Rotherham	7%	6%	6%
External	5%	2%	5%
Total	**5%**	**3%**	**5%**

2.4.11   Growth in Sheffield City Centre trips is higher than average for all three modes and to compensate for this growth in the rest of Sheffield is lower than the average growth for each mode. The very large growth in walking and cycling in Sheffield City Centre is linked to a corresponding increase in the number of dwellings there.

mvaconsultancy

2.4.12   The demand model makes changes to the demand in response to changes in the cost of travel through time, and also the impact of congestion levels and transport interventions. A summary of the forecast traffic growth from the demand model is provided in Table 2.3.

Table 2.3 Forecast Growth in Car Demand between 2008 and 2015

	Sheffield City Centre	Rotherham Town Centre	Rest of Sheffield	Rest of Rotherham	Outside Study Area	Total
Sheffield City Centre	23%	-6%	5%	8%	8%	**7%**
Rotherham Town Centre	-7%	-8%	5%	-8%	-3%	**-7%**
Rest of Sheffield	5%	4%	4%	15%	7%	**5%**
Rest of Rotherham	11%	-9%	15%	7%	9%	**7%**
Outside Study Area	7%	-6%	7%	9%	11%	**9%**
Total	**7%**	**-8%**	**5%**	**8%**	**9%**	**6%**

2.4.13   The demand model has reduced car growth in congested areas and increased it in less congested areas. A number of factors serve to reduce the perceived cost of motoring such as increases in the value of time (resulting from increased income) that cause travellers to perceive prices to be falling and increases in the fuel efficiency of cars. Where the decline in the perceived cost of motoring outweighs the impact of rising congestion the model forecasts increases in both car demand and trip lengths.

2.5   Emissions Modelling - ENEVAL

2.5.1   ENEVAL (ENvironmental EVALuation Tool) has been developed by MVA to use detailed outputs from transport models to estimate both current and forecast emissions of NO_X, PM_{10}, total hydrocarbons and CO_2. The key characteristics of ENEVAL are:

■   consistent with the TRL's (Transport Research Laboratory) 2009 Road Traffic Emissions factors, as recommended for use in TAG at the time of the preparation of the Best and Final Funding bid for BRT North;

■   use of traffic speeds on a link-by-link basis in emissions calculations;

■   input of the traffic composition by vehicle type, fuel type and euro class;

■   ability to model emissions from traffic queuing at junctions separately;

mvaconsultancy

- calculation of particulates from tail-pipe emissions and 'other' sources (e.g., brakes and tyres) separately.

- fast run times compared to other emissions models; and

- ability to handle very large networks.

2.5.2   It is important to note that ENEVAL only considers the emissions from vehicles, and does not consider emissions from other sources and dispersion. Air Quality problems will exist as a result of emissions from various sources, transport being one of them, and how well the emissions disperse will influence the impact of emissions on actual air quality and the location of air quality problems. The use of transport models can only deal with the emissions from vehicles and the location at which these emissions originate. In order to consider these other impacts an air quality modelling tool, such as Sheffield City Council's Airviro model, will need to be used.

mvaconsultancy

3 Emissions Modelling Assumptions

3.1 Introduction

3.1.1 The inputs from the transport model to ENEVAL are the traffic flows by vehicle type and the speeds of traffic on the links in the model, taking account of delays encountered at junctions. In order to calculate the emissions the following assumptions are also required:

- details of the composition of the vehicle fleet, including the proportion of each vehicle type that have petrol and diesel engines, and the proportion of each vehicle type in each of the Euro emission classes; and

- factors to calculate the emissions from each vehicle by type and engine category as a function of the speed at which vehicles are moving at.

3.2 Fleet Composition

3.2.1 The ENEVAL software is set up to have a default fleet composition, which are taken from the DEFRA Toolkit for Vehicle Emissions. These represent the national average for each year (excluding London), with assumptions as to how the fleet composition will change over time.

3.2.2 However, as part of this Study, these default fleet proportions were replaced by values calibrated to match the observed characteristics of the various vehicle fleets in the Sheffield area, as described below.
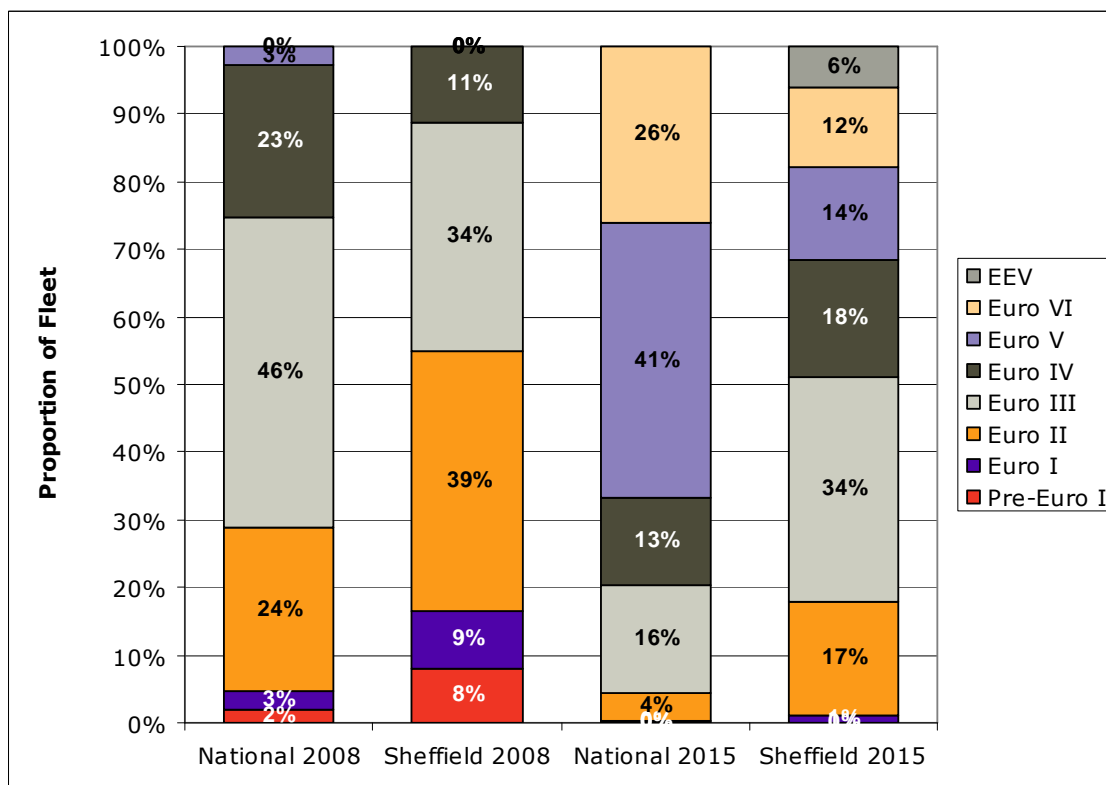
Bus Fleet Composition

3.2.3 In order to improve the representation of the bus fleet within the modelling the following steps have been taken:

- data have been collected from the bus operators on split of their fleet by Euro Class as it was in 2008 and as it was in July 2012;

- the likely fleet composition has been estimated for 2015 using assumed vehicle replacement strategies;

- the assumptions have been circulated to the operators for review;

- different compositions have been included by operator (with First's Sheffield and Rotherham fleets separated); and

- bus routes currently-operated, and due to be operated, by hybrid-technology buses have been modelled as a separate bus operator.

3.2.4 A comparison of the bus fleet compositions in the national assumptions and in the local data is presented in Figure 3.1 and Figure 3.2. The proportion of the fleet that are single deck and double deck buses is presented in Figure 3.1, and it is important to note that the national fleet assumptions assumes that this split does not change over time. As can be seen, there is a much higher proportion of single deck buses in the Sheffield fleet, with 75% being single deck in 2008. However, the Sheffield fleet data suggests that the single deck proportion is falling over time.

mvaconsultancy
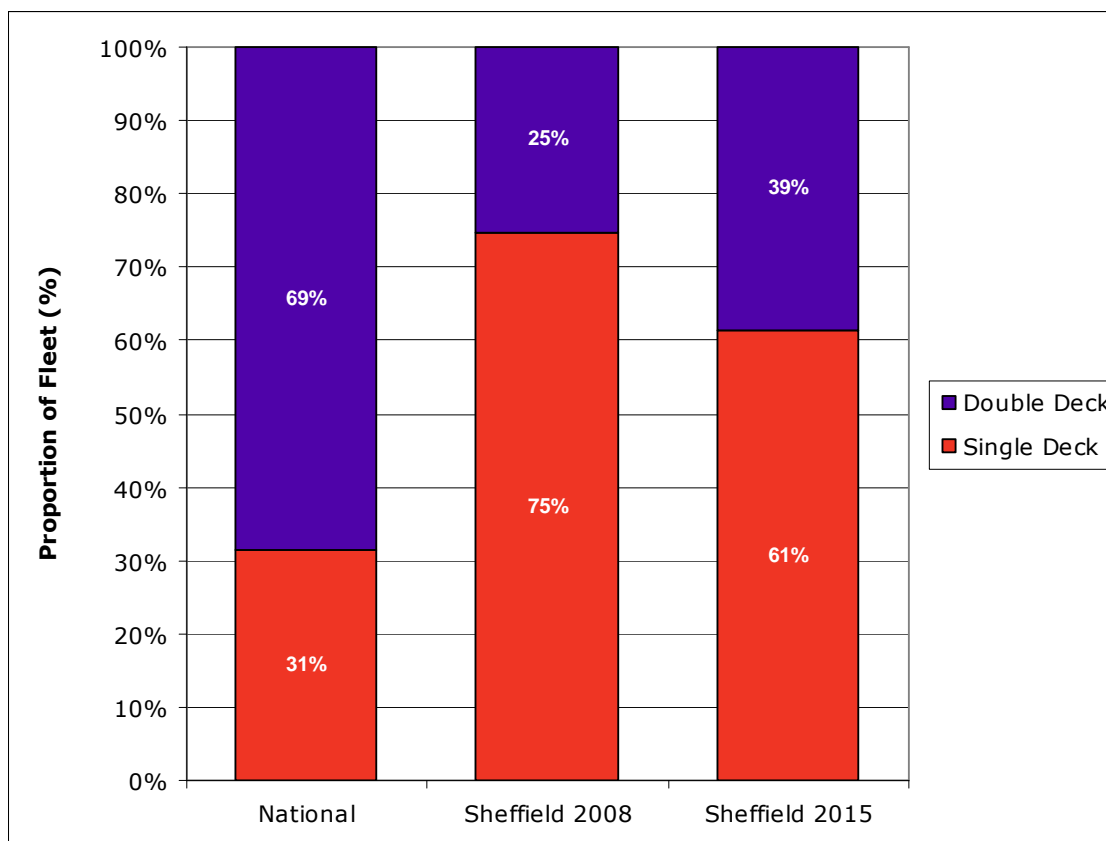
Figure 3.1   Comparison of National Bus Fleet Split and Sheffield Bus Fleet Split Assumptions

3.2.5   The split of the bus fleet into each of the Euro categories is presented in Figure 3.2, and this shows the much older fleet composition that exists in Sheffield compared with the national fleet average. There are much lower proportions of Euro IV, V and VI in Sheffield compared with the national fleet average. In 2008 almost 90% of the fleet was of Euro III standard or earlier in Sheffield, compared with the national fleet average of 75%. In 2015 it is projected that still over half of the Sheffield fleet is Euro III or earlier, when the national average is forecast to be only 20%.

3.2.6   One key point to note is that the national assumptions show an estimate of 25% of buses in the Euro VI category, despite the fact that there are currently no vehicles of this type one the street. The level of vehicle replacement required to reach this level of Euro VI buses is not though to be realistic as it would require the replacement of 25% of the fleet in a two to three year period. There would also be some EEV vehicles in the national fleet, although this proportion is expected to be small.

mvaconsultancy

Figure 3.2   Comparison of National Bus Fleet and Sheffield Bus Fleet Engine Category Assumptions

Car and Freight Fleet Composition

3.2.7   In order to estimate local fleet proportions for cars and goods vehicles, the following steps have been taken:

■   Sheffield City Council have provided summarised ANPR data for 2007, including Euro engine splits by vehicle type;

■   a sample set of ANPR data for 2012 has been used to estimate proportions by Euro engine category based on year of first registration; and

■   fleet composition for 2015 has been estimated by interpolation, based on the trend between the 2007 and 2012 data.

3.2.8   The petrol and diesel splits within the national and Sheffield assumptions for car are shown in Figure 3.3.   The national assumptions used are those for urban roads, and show a decrease in the petrol split from just over 70% in 2008 to just over 60% in 2015.   The national assumptions have been used in all cases for 2008, with Sheffield specific proportions calculated for 2015.   These Sheffield proportions show a significantly higher diesel proportion in 2015 than the national data, with 45% of the car fleet being diesel vehicles.

mvaconsultancy
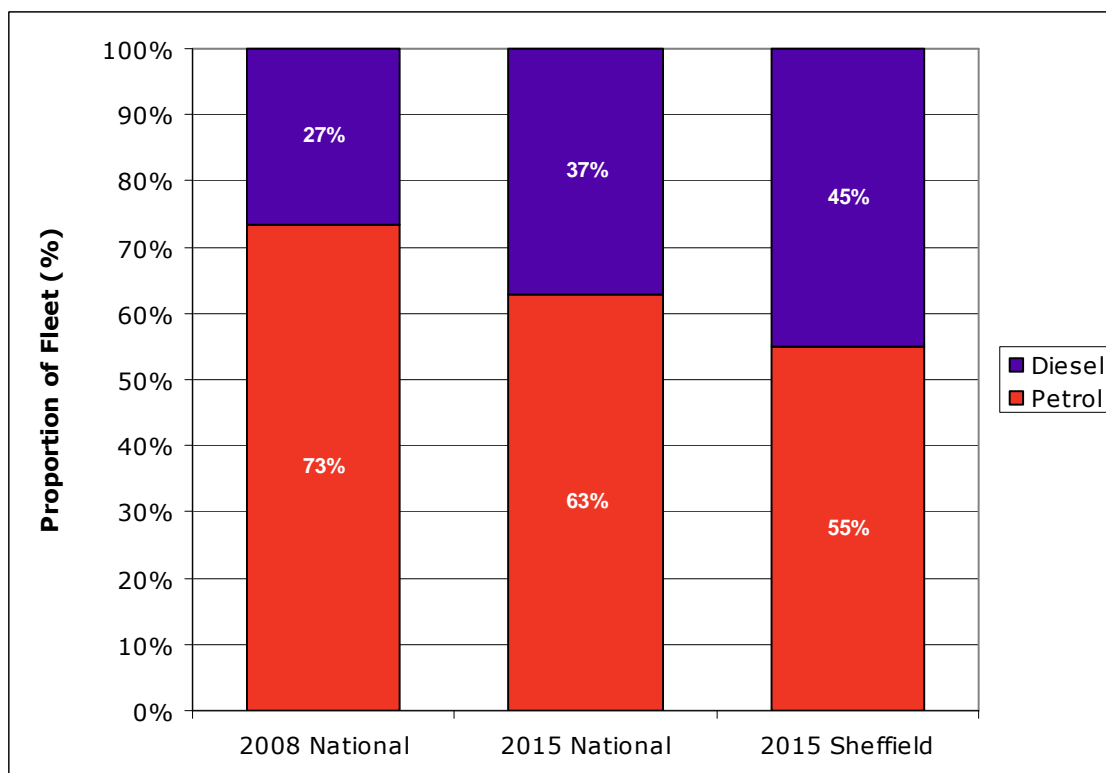
Figure 3.3 Car Fleet Petrol and Diesel Split Assumptions for 2008 and 2015

3.2.9   The proportion of the car fleet that falls within each Euro engine category are shown for both the national and Sheffield assumptions for 2008 and 2015, in Figure 3.4. In common with the bus data, these once again show an older car fleet for Sheffield than shown in the national average. In 2008 just less that half of the national fleet is shown to be Euro III or earlier, whereas in the Sheffield fleet over 80% of the fleet falls into these engine categories. In 2015, 90% of the vehicle fleet is newer than the Euro III category, with the corresponding proportion for the Sheffield fleet being 56%.

3.2.10   The data therefore suggest that the Sheffield car fleet is significantly older than the UK national average, and so adopting the local age profile will have a noticeable impact on the forecast emissions.

mvaconsultancy
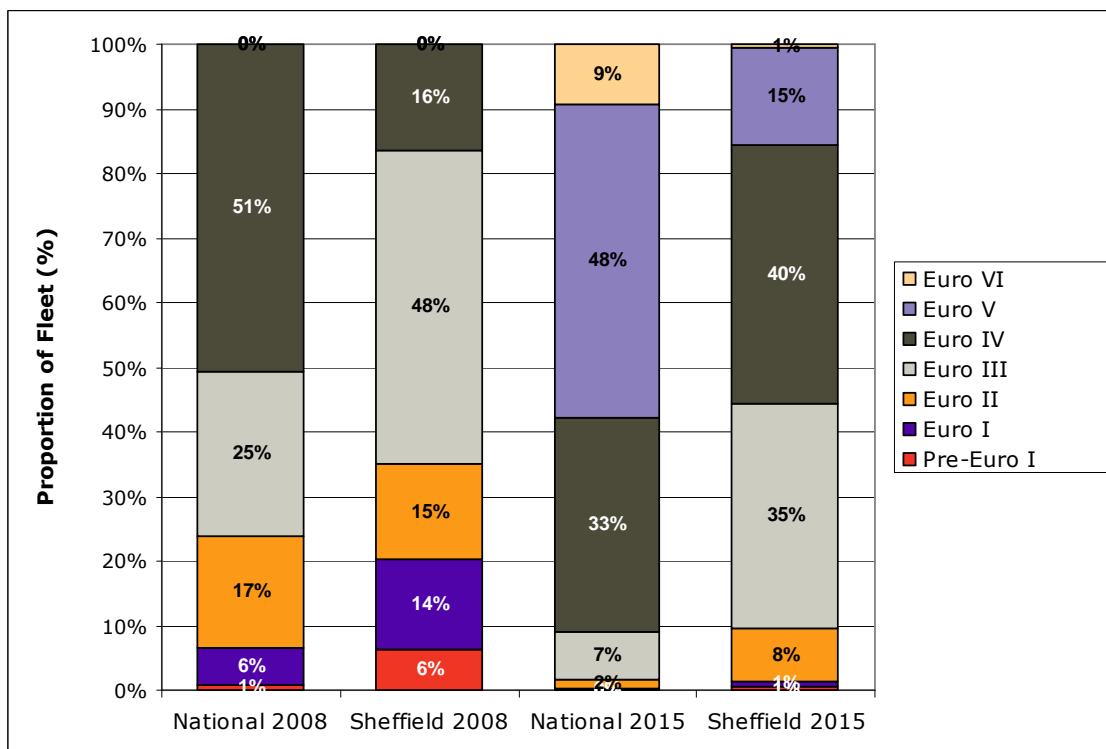
Figure 3.4 Car Fleet Engine Category Assumptions for 2008 and 2015

3.2.11   The national assumptions used for goods vehicles take into account the assumed urban splits of light goods vehicles between petrol and diesel, and also the urban splits of other goods vehicles between articulated and rigid.   The latter will have an impact on estimated motorway emissions, as the proportions of articulated heavy goods vehicles on motorways is significantly higher than on urban roads. This will mean that the emissions for other goods vehicles on motorways will be underestimated in this work, a point that is important to remember when considering motorway emissions.

3.2.12   The engine category assumptions for the light goods vehicle fleet are shown in Figure 3.5, which compares the national fleet assumptions and those calculated for Sheffield. In 2008, the national and Sheffield assumptions have very similar proportions of the fleet that are pre-Euro III. However, the Sheffield fleet assumption has a much higher proportion of Euro III engines in the fleet than in the national average. The older fleet make up in Sheffield is still evident in the assumptions made in 2015 with almost half of the national fleet expected to be Euro V engines. Approaching 40% of the Sheffield fleet is expected to be Euro III or earlier in 2015, when the figure is less than 15% in the national fleet assumptions.

mvaconsultancy
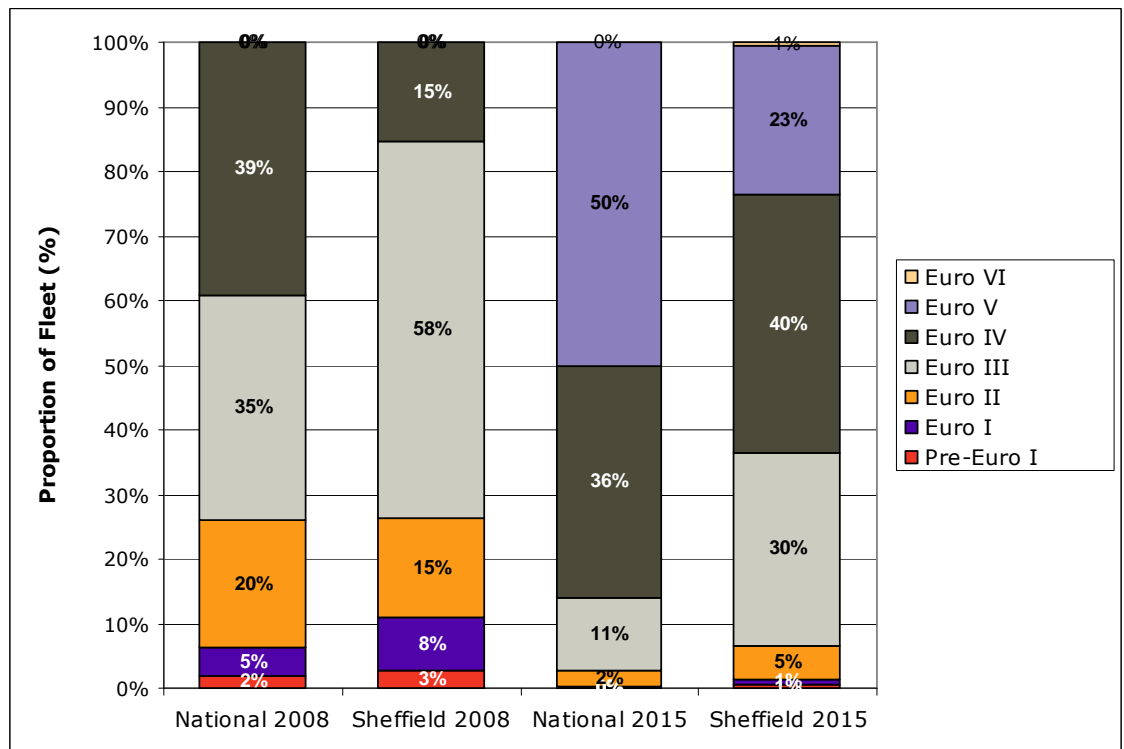
Figure 3.5 LGV Fleet Engine Category Assumptions for 2008 and 2015

3.2.13   In common with the other vehicle types, the Sheffield fleet assumptions clearly show an older fleet than the national fleet assumptions. The pre-Euro III proportions are very similar in 2008, but by 2015 almost half of the Sheffield fleet is estimated to still be Euro III or earlier, whereas the UK national fleet assumption is that less than 15% of the fleet will be pre-Euro III.
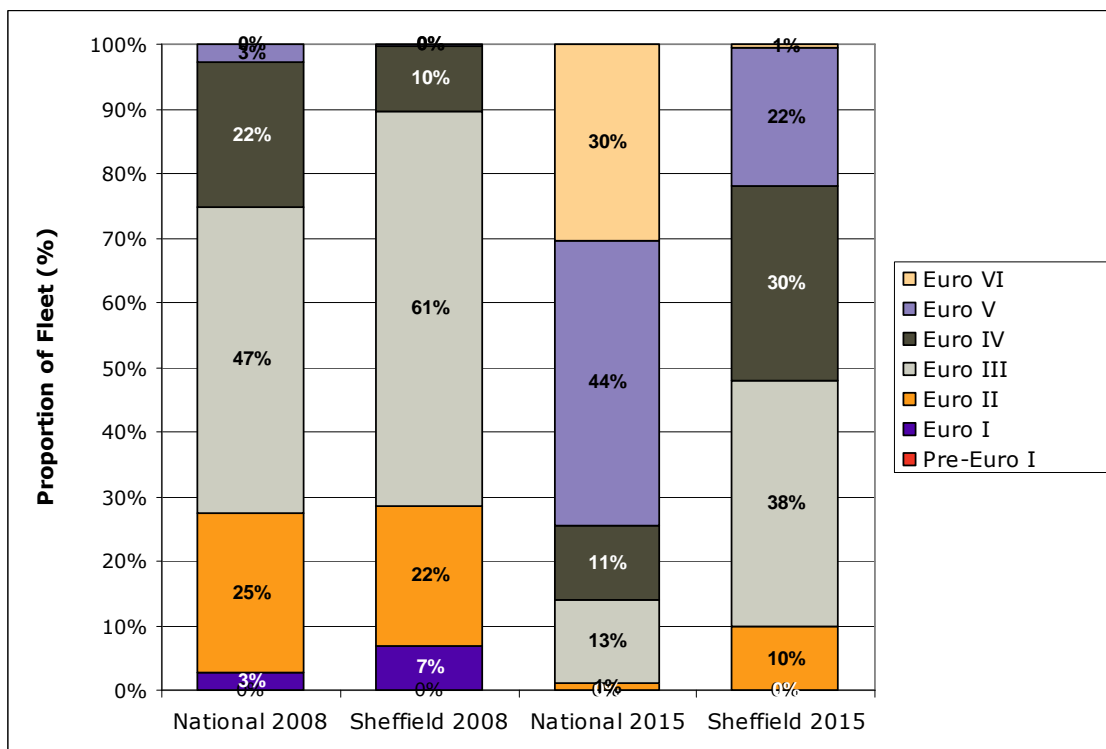
Figure 3.6 OGV Fleet Engine Category Assumptions for 2008 and 2015

3.3   Emissions Factors

3.3.1   The Emissions Factors contained within ENEVAL are taken from the Department for Transport (DfT) website and are based on TRL Report PPR353 – Emissions Factors 2009.   These emissions factors are those recommended for use in TAG at the time of the preparation of the Best and Final Funding bid for BRT North.

3.3.2   However, it has become widely recognised that these formulae significantly underestimate NO_X emissions from the most recent Euro engine categories, particularly for diesel vehicles. An alternative calculation has recently been made available for the calculation of NO_X emissions in the form of the COPERT NO_X function.   An alternative version of the ENEVAL software which uses an approximation of the COPERT NO_X function to represent NO_X emissions was therefore created for the purposes of this study.

3.4   Impact of Assumptions

3.4.1   The assumptions outlined in this Chapter are key to the calculation of emissions, and so it is important to understand the impact that they have on the results from the model. A variety of tests have been undertaken in order to understand the impact of these assumptions. The impact of these tests on NO_X emissions is shown in Table 3.1 and the key findings from testing these assumptions in the base year can be summarised as follows:

mvaconsultancy

- The inclusion of data on the local bus fleet composition reduces calculated emissions by 7%, as a result of the lower proportion of double deck vehicles in the Sheffield fleet compared to the national average. The emissions factor calculations employed assume that emissions from single deck vehicles, based on an average load, are lower than double deck vehicles.

- The use of local data on the composition of the whole vehicle fleet increases calculated emissions by 4% compared to the national fleet composition, as a result of the older Euro composition than the national average.

- The use of the COPERT NO_X function as well as the local fleet composition results in calculated emissions levels 11% higher than using the national fleet composition and the TRL NO_X function.

Table 3.1 Impact of Assumptions on Estimated Annual NO_X Emissions in 2008 (Sheffield, Excluding Motorway)

	NO_X Emissions (tonnes/ annum)	Difference from UK National Fleet Assumptions
National Fleet Composition, TRL NO_X function	1,218	
Sheffield Bus Fleet Composition, National Car and Freight Fleet Compositions, TRL NO_X function	1,135	-7%
Sheffield Bus, Car and Freight Fleet Compositions, TRL NO_X function	1,261	4%
Sheffield Bus, Car and Freight Fleet Compositions, COPERT NO_X Calculation	1,357	11%

3.4.2   A similar test of the assumptions for the 2015 forecast year shows that the fleet composition assumptions have a significant impact on the estimated emissions for 2015. The national fleet composition results in a forecast reduction in NO_X emissions of over 50% using the TRL NO_X function. However, when the Sheffield fleet composition assumptions are used, along with the COPERT NO_X function and the revised petrol and diesel proportions, a reduction of only 30% is forecast. The total NO_X emissions for the Sheffield area are 65% higher with all of the updated assumptions included, than with the original assumptions, highlighting the importance of the assumptions on the modelled results.

mvaconsultancy

Table 3.2 Impact of Assumptions on Estimated Annual NO$_X$ Emissions in 2015 (Sheffield, Excluding Motorway)

|	2008 NO$_X$ Emissions (tonnes/ annum)	2015 NO$_X$ Emissions (tonnes/ annum)	Change 2008 to 2015	Difference from UK National Fleet Assumptions at 2015
National Fleet Composition, TRL NO$_X$ function	1,218	575	-53%	
Sheffield Fleet Compositions and COPERT NO$_X$ function	1,357	845	-38%	47%
Sheffield Fleet Compositions and COPERT NO$_X$ with New Diesel/ Petrol Split	1,357	945	-30%	65%

Impact on the Contributors to Emissions

3.4.3   The impact of the fleet and emissions assumptions on the emissions by each vehicle type in 2008 are shown in Figure 3.7. The following key conclusions can be drawn from this analysis:

■   the inclusion of the Sheffield bus fleet composition results in a reduction in the estimated bus emissions as a result of the proportion of single deck buses in Sheffield being higher than the national average;

■   the inclusion of the Sheffield car and freight vehicle compositions results in a noticeable increase in estimated car emissions as a result of the older average fleet that is assumed in the Sheffield data; and

■   the use of the COPERT NO$_X$ calculation leads to a further notable increase in car emissions.

3.4.4   Figure 3.8 shows the impact of the changes in assumptions on emissions in 2015, with the following key impacts being noted:

■   the inclusion of the Sheffield fleet data results in notable increases in car and other goods vehicle emissions due to the older fleet mix that is assumed in the Sheffield data; and

■   the use of the COPERT NO$_X$ calculation again results in a further increase in emissions.

mvaconsultancy
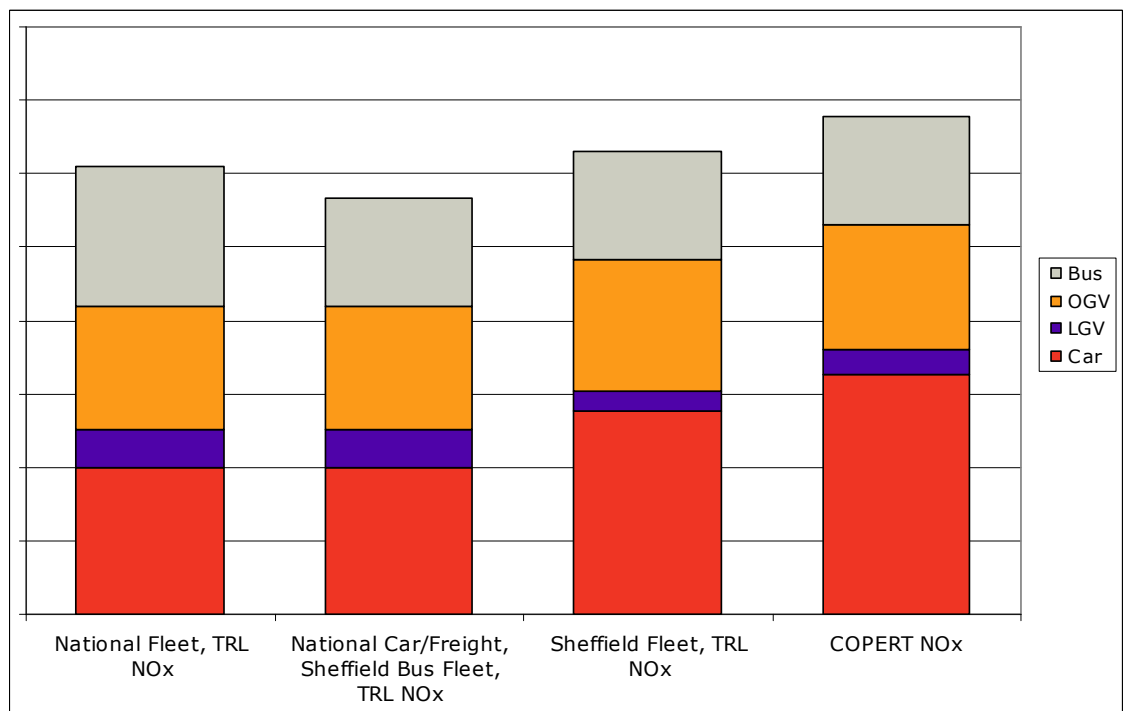
Figure 3.7 Emissions by Vehicle Type, 2008 (Sheffield, Excluding Motorway)
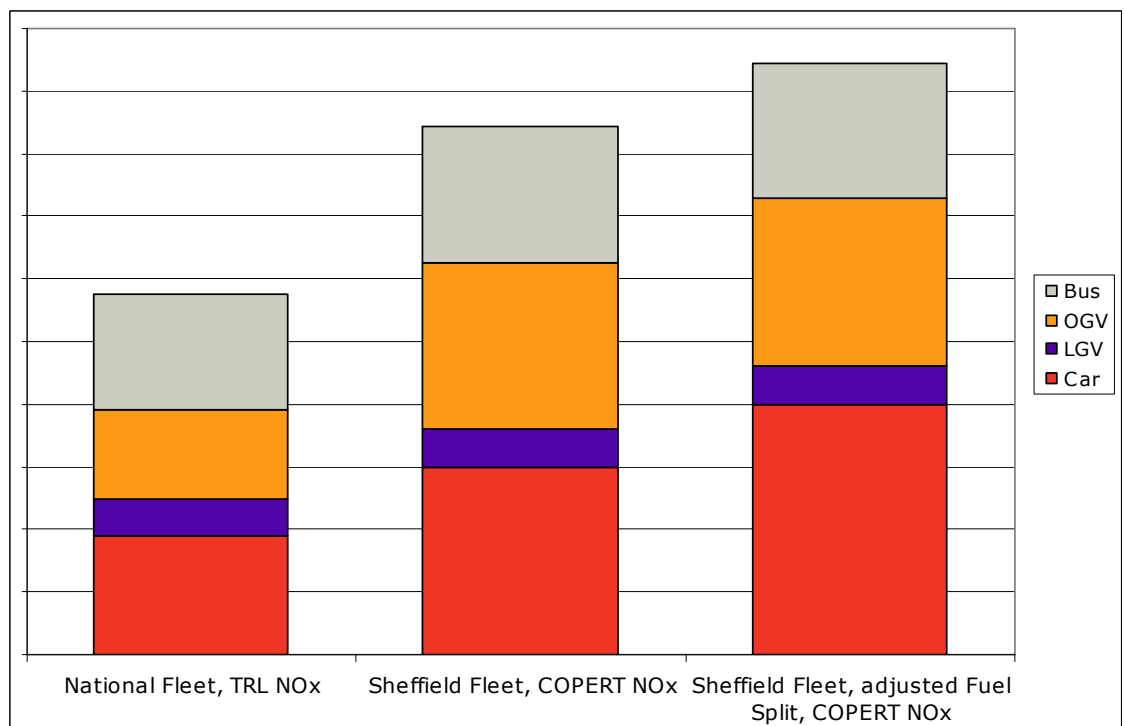
Figure 3.8 Emissions by Vehicle Type, 2015 (Sheffield, Excluding Motorway)

mvaconsultancy

4 Observed and Modelled 2008 Base Year Emissions

4.1 Introduction

4.1.1 This Chapter reports on the analysis of observed air quality (monitored NO_2) taken from Sheffield City Council's monitoring of air quality, and comparison of this observed air quality with transport-related emissions of NO_X. The analysis of the observed air quality and estimated transport emissions has led to the identification of key areas which have poor air quality, for which further analysis of emissions is included later in this report. It is important to consider the following points when looking at the analysis reported in this Chapter:

- the observed air quality is recorded air quality and includes background emissions as well as transport related emissions, and includes the effect of pollutant dispersal;

- the modelled emissions are tailpipe emissions of NO_X and do not include background emissions or the dispersal of emissions; and

- the colour coding of modelled emissions in the figures referred to in this report is merely to highlight the level of emissions, and does not necessarily identify areas that will exceed the EU limits.

4.1.2 The assumptions included in the calculation of modelled transport emissions reported in this chapter are:

- Sheffield bus fleet composition;

- Sheffield car and freight fleet composition;

- Adjusted petrol and diesel split for cars; and

- COPERT NO_X calculation.

4.2 Comparison of Observed Air Quality and Modelled Emissions

4.2.1 The observed air quality within Sheffield is shown in Figure F1 of Appendix F. In this figure the size of the circles representing air quality observations is relative to the level of emissions, with those sites that exceed the EU limits coloured in red, and those approaching the EU limits in orange.

4.2.2 The modelled transport-related emissions are shown in Figure F3 of Appendix F, with the emissions for each 200m x 200m grid shown. The grids have been coloured based on the level of emissions in such a way as to show a correlation with the areas which have observed poor air quality. The observed air quality is also shown on this figure, and as can be seen there is a good degree of correlation between those areas with poor air quality and high levels of transport-related emissions.

4.2.3 In interpreting these figures it is important to remember that there is more than transport emissions contributing to air quality, and that this study is only considering the link between transport-related emissions and air quality. Further detailed modelling, using Airviro, would

mvaconsultancy

be required to more accurately predict the impact of the transport-related emissions on the concentration of air quality pollutants at different locations.

4.3   Key Areas with Poor Air Quality and High Emissions Levels

4.3.1   The analysis of the observed air quality and modelled transport emissions has highlighted a number of areas where poor air quality exists, or may exist, as a result of transport emissions. The following key areas with observed poor air quality have been identified:

- Sheffield City Centre;

- the University/Broomhill Corridor;

- the Abbeydale Road/London Road Corridor; and

- close to the M1 Motorway at Meadowhall.

4.3.2   Considering the areas listed above, the only one of these that does not show a strong correlation with the areas where transport emissions are at their highest is Chesterfield Road/London Road (north of Broadfield Road) on the Abbeydale Road/London Road Corridor. This indicates that there could be some other contributor to the recorded poor air quality, and that traffic-related emissions may not be the main issue to address. In particular it is worth noting that the railway line, which is diesel operated, runs parallel to the road in this area which is also on an incline.

4.3.3 NO_2 is currently not monitored in all areas across the city. However, the analysis of the modelled transport emissions has highlighted a number of areas where there are likely to be high levels of transport emissions which may be creating local air quality issues. These potential air quality problem areas include:

- Penistone Road corridor;

- Sheffield Parkway; and

- Attercliffe Road.

mvaconsultancy

5   2015 Forecast Emissions

5.1   Introduction

5.1.1   This Chapter reports on the forecast transport emissions for 2015, using traffic flows and speeds taken from the 2015 Local Low Growth Scenario transport model forecasts from the Best and Final Funding Bid (BAFFB) work on the Bus Rapid Transit (BRT) North. These traffic forecasts were described in detail in Section 2.4. This section concentrates on the key points arising from the forecast emissions at 2015.

5.1.2   The assumptions included in the calculation of modelled transport emissions reported in this chapter are:

- Sheffield bus fleet composition;

- Sheffield car and freight fleet composition;

- adjusted petrol and diesel split for cars; and

- COPERT NO_X calculation.

5.2   2015 Forecast Emissions

5.2.1   The forecast emissions for 2015 are shown in Appendix G, using the same colour scale as presented in the figure for 2008 in Figure F2 of Appendix F. This allows the impact of changes in traffic levels and the impact of changes in the vehicle fleet over the period to be analysed.

5.2.2   These results show that there is a reduction in NO_X emissions that is expected to take place in the Sheffield area, despite the increasing traffic levels. It was noted earlier that the 2015 forecasts include an average 6% increase in car journeys, which are of an increasing journey length, and increases in goods vehicle traffic. A reduction in future emissions is predicted because the rate of improvement in the emissions performance of the fleet over time more than offsets this traffic growth.

5.2.3   Although the levels of transport-related NO_X emissions are forecast to reduce, there are still a number of areas where the levels of emissions are likely to be contributing towards air quality issues. The key areas experiencing the high levels of emissions are:

- Sheffield City Centre;

- close to the M1 Motorway at Meadowhall;

- Penistone Road corridor; and

- Attercliffe Road.

5.2.4   The modelling predicts a significant drop in the traffic emissions in some of the areas identified as having high levels of emissions in 2008. While this is likely to lead to improvements in air quality (subject to emissions from other sources), the work undertaken within this study cannot quantify whether the improvement will be sufficient to meet current and future air quality objectives and limit values. In addition, it is important to remember

mvaconsultancy

that the reduction in emissions is dependent on the assumed improvements in vehicle fleets being achieved in practice. The following areas are still worthy of detailed analysis:

- the University/Broomhill Corridor;

- Sheffield Parkway; and

- the Abbeydale Road/London Road Corridor.

mvaconsultancy

6 Contributors to Emissions

6.1 Introduction

6.1.1 The purpose of this Chapter is to analyse the main contributors to the emissions in Sheffield, and to identify the vehicle types that would need to be targeted in order to reduce emissions in areas with poor air quality. This Chapter first looks at the city wide emissions, covering the whole Sheffield area, excluding the M1 Motorway. The contributors to emissions on certain links in the areas identified as having, or potentially having, poor air quality, are then considered.

6.2 City Wide Emissions

6.2.1 The modelled NO_X emissions by vehicle type are shown in Figure 6.1 for both the 2008 base year and the forecast year of 2015. As can be seen from this figure, there is forecast to be a significant drop in NO_X emissions in the area. City wide it is clear that emissions from car were greater than the other vehicle types in 2008, and continue to be greater than the other vehicle types in 2015.

6.2.2 Light Goods vehicles are only responsible for a small proportion of emissions, which is a result of the number of light goods vehicles on the road compared to car. It is worth noting, that the validation of the base year model has shown that the modelled light goods vehicle flows in Sheffield are slightly lower than the observed count data is suggesting. However, given that light goods vehicles only represent a small proportion of the total emissions, it is extremely unlikely that this will have a material impact on the results. The emissions from light goods vehicles change by only a small amount between 2008 and 2015, which is a result of the assumed 16% growth in light goods vehicle trips over this period.

6.2.3 The emissions from other goods vehicles and buses are forecast to reduce between 2008 and 2015, but not by the same extent that car emissions are forecast to reduce. It is clear that both of these vehicle types are contributing a significant amount to city wide emissions, and are forecast to continue to do so.

mvaconsultancy
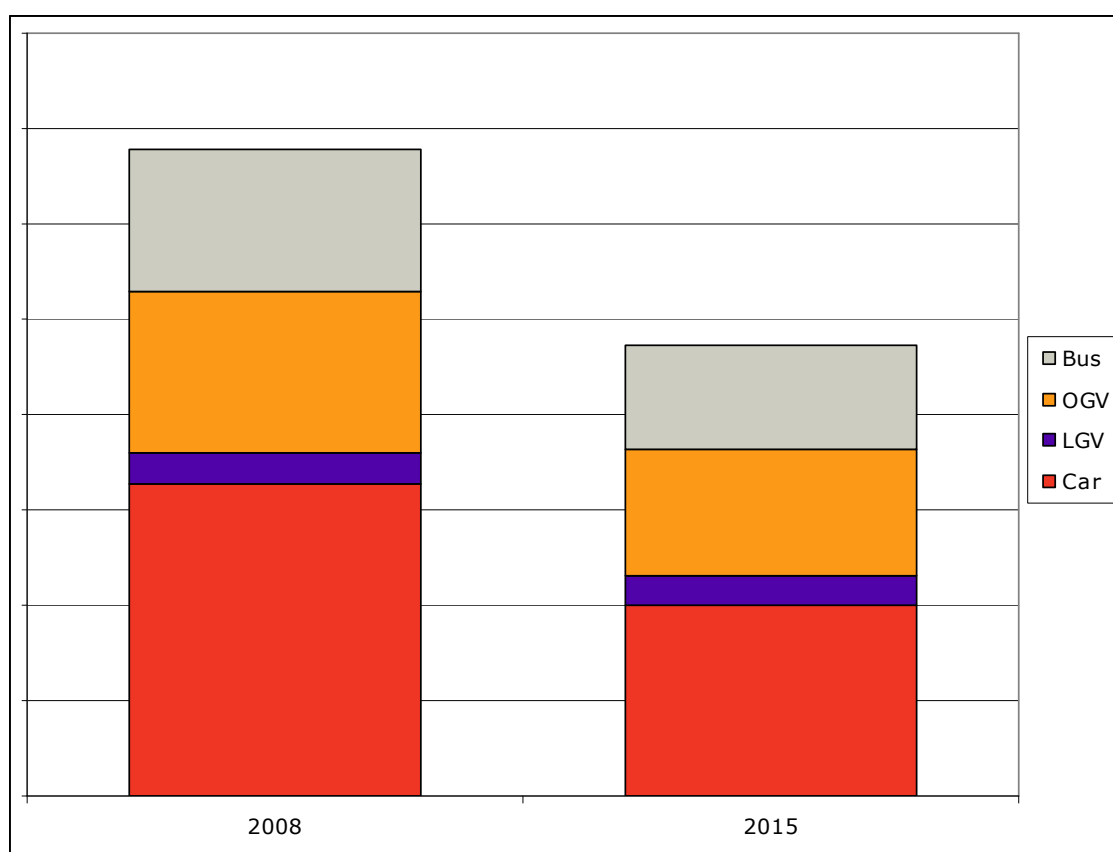
Figure 6.1   Modelled NO$_X$ Emissions by Vehicle Type in Sheffield (excluding Motorway) in 2008 and 2015

6.3   Key Area Emissions

6.3.1   This section analyses the emissions in a number of the areas identified earlier in this report as either having an observed air quality problem, or having high levels of transport-related emissions that could well be resulting in poor air quality. The analyses of each area is presented in Appendix H including figures showing the model links within the area that have the higher levels of emissions (shown in red) and figures showing the emissions from each vehicle type on key links within the areas.

City Centre

6.3.2   The total NO$_X$ emissions by vehicle type for the City Centre area are shown in Figure 6.2, which shows that the significant contributors to emissions in this area are car and bus. These two vehicle types are contributing roughly the same amount towards the total emissions, and reduce by a similar amount between 2008 and 2015.

6.3.3   The figures showing the links with the higher levels of emissions for both years, show that the key radial routes and the main bus routes through the city centre have the higher levels of emissions. The number of links in the higher emissions category reduces significantly, but some routes retain their high levels of emissions, such as the A61 from the North and West Street.

mvaconsultancy

6.3.4   The analysis of the contributors to emissions on these two routes shows a contrasting story:

■   on West Street almost all of the modelled emissions are resulting from buses, with only a very small proportion from cars and other goods vehicles; and

■   on the A61 approach to the Inner Ring Road, car is the most significant contributor to emissions, but bus is also contributing a significant amount.
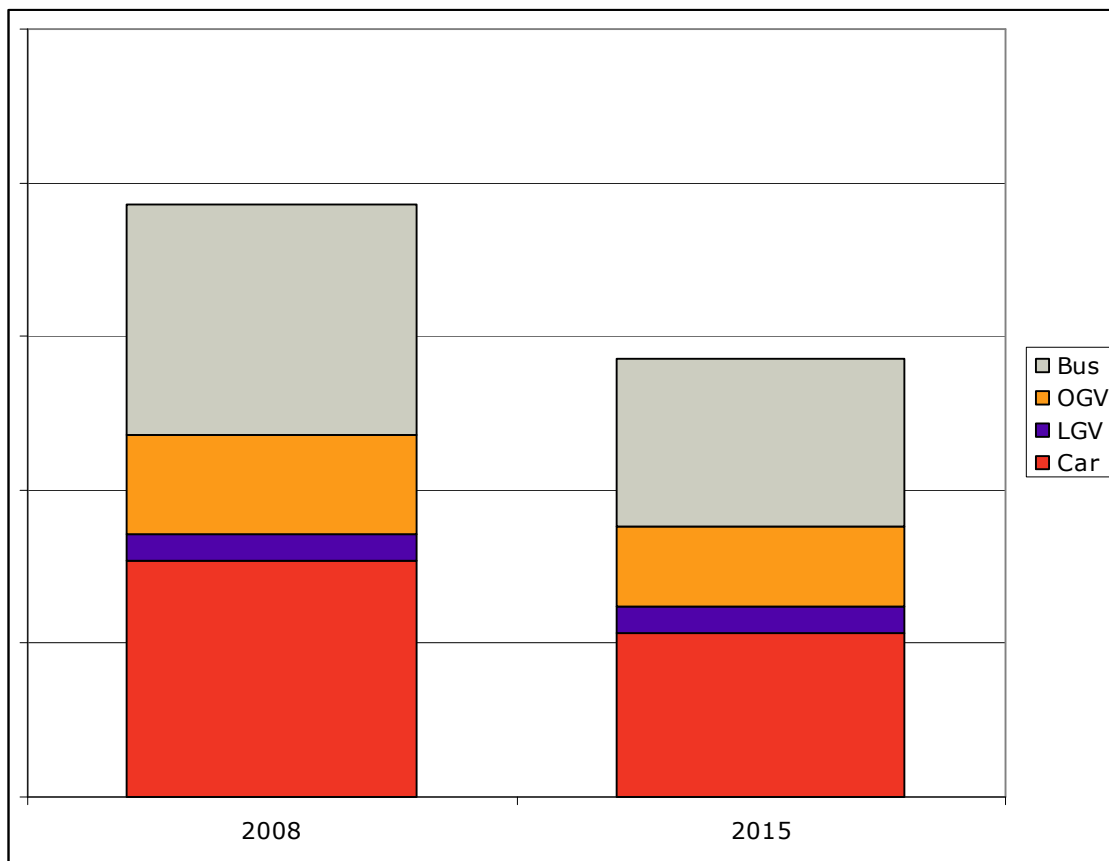
Figure 6.2 Modelled Emissions by Vehicle Type in Sheffield City Centre in 2008 and 2015

University/Broomhill Corridor

6.3.5   The figures showing the emissions on links in this corridor show that in 2008 the A57 has high levels of emissions from Broomhill to the University, as do parts of Fulwood Road and Glossop Road. There is a notable reduction in emissions on these links forecast by 2015, the key link with high levels of emissions being the A57 between Fulwood Road and Glossop Road.

6.3.6   The analysis of the contributors to emissions on two key links show:

■   significant contributions to emissions from both buses and cars; and

■   reducing emissions from cars, other goods vehicles and buses but very little change in emissions from light goods vehicles, the latter being driven by the growth assumptions.

mvaconsultancy

Abbeydale Road/London Road Corridor

6.3.7   On both of these corridors there are links showing as having high levels of emissions in 2008, particularly on London Road. There are clear reductions in the emission on each link forecast between 2008 and 2015, but a section of Abbeydale Road remains in the high level band of emissions. The analysis of the contributors to these emissions show:

- car is the most significant contributor to emissions on both corridors;

- in common with the other corridors, bus is also a significant contributor to emissions;

- the contribution for other goods vehicles is more significant than on the A57/Broomhill corridor; and

- emissions from each of these key contributors are forecast to reduce between 2008 and 2015.

Penistone Road Corridor

6.3.8   On this corridor, the links on the two main radial routes (Penistone Road and Langsett Road) have high levels of emissions in 2008, and also in 2015. Holme Lane and Herries Road also fall into the high emissions level category in both years. The differing nature of the traffic on Penistone Road and Langsett Road is highlighted by the contributors to the emissions, which show the following:

- cars are the most significant contributor to emissions on Penistone Road, but other goods vehicles are also significant contributors;

- while there is a significant reduction in car emissions on Penistone Road between 2008 and 2015, the reduction from other goods vehicles is not as significant; and

- on Langsett Road the emissions are almost wholly a result of the bus traffic on this route, with a reduction in these emissions noticeable between 2008 and 2015.

Close to M1

6.3.9   The three key routes close to the M1 and Meadowhall, Sheffield Road, Meadowhall Road and the M1 itself, all show high levels of emissions on links in 2008. Links on the M1 and Meadowhall Road remain in the higher category of emissions in 2015. The analysis of the contributors to emissions on these links, show that:

- other goods vehicles are the main contributor to emissions on the M1 Motorway, particularly in 2015;

- cars are also a significant contributor to emissions on the M1 in 2008, but there is a significant reduction in car emissions between 2008 and 2015;

- on Meadowhall Road, car and other goods vehicles are contributing roughly equal amounts to emissions in 2008; and

- the significant reduction in car emission on Meadowhall Road between 2008 and 2015 results in other goods vehicles contributing the most to emissions on this link in 2015.

mvaconsultancy

7   Conclusions

7.1   Introduction

7.1.1   This Chapter presents the main conclusions arising from the analysis of calculated transport emissions, and the contributors to emissions in areas with poor air quality. These key findings are considered in two separate sections:

- the impact of vehicle composition and NO_X emissions functions on the level of calculated emissions;

- the contributors to emissions across the city and in some of the key identified problem areas; and

- recommendations for subsequent phases of the LEX feasibility Study.

7.2   Impact of Assumptions

7.2.1   The study has highlighted the importance of the assumptions used to estimate the transport-related emissions using outputs from transport models. In particular, the assumptions about the age, engine category and fuel type of the vehicle fleet has a significant impact on the forecast levels of emissions:

- the use of local data on the composition of the bus fleet results in lower levels of calculated NO_X emissions as a result of the higher proportion of single deck buses in the Sheffield fleet compared to the national average, despite the fact that the bus fleet in Sheffield is older than the national fleet on average;

- the use of local data on the composition of the car and freight fleets results in increased calculated NO_X emissions as a result of the older vehicle fleet in Sheffield compared to the UK national average;

- the TRL NO_X calculations are understood to underestimate emissions from the later Euro engine categories, particularly for diesel engines and the use of the COPERT function for calculating NO_X emissions results in higher calculated levels of emissions; and

- the split of cars between petrol and diesel also has a significant impact on emissions levels, with higher proportions of diesel vehicles leading to higher levels of NO_X emissions.

7.2.2   The combination of the impact of each of these factors on calculated transport-related NO_X emissions in 2015 is a 65% increase in the total emissions across Sheffield, excluding the Motorway, compared with the emissions forecast using the default parameters.

7.3   Contributors to Emissions

7.3.1   The main contributor to city wide emissions in 2008 was car but with notable contributions from both bus and other goods vehicles. However, car emissions across the city are forecast to reduce significantly by 2015.

mvaconsultancy

7.3.2   The contributors to the emissions in the areas identified as having high levels of transport emissions potentially leading to poor air quality shows that the contributors to emissions vary by area. The key points arising from the contributors to emissions in these areas are:

- LGV is not contributing significant amounts in any area, so any policy aimed at LGVs will only have a limited impact on air quality in Sheffield;

- other goods vehicles are contributing significant amounts towards emissions on the M1, on Meadowhall Road and on Penistone Road;

- buses are contributing significant amounts to emissions in the City Centre, through Hillsborough and on the A57/Broomhill corridor; and

- cars contribute significant amounts to the emissions in all areas, except areas which are largely dedicated to bus flows.

7.3.3   It is clear from this analysis that any potential interventions that are aimed at one vehicle type are unlikely to remove all of the air quality problems resulting from transport emissions. It is important to remember that although buses contribute significant amounts to emissions each bus is moving a large number of people and could be taking a number of cars off the road.

7.4   Recommendations for Further Phases of this Study

7.4.1   The development of a strategy for improving air quality would benefit greatly from more accurate information on the current vehicle fleet in Sheffield. This includes the taxi fleet, which has not been considered explicitly in this work as taxi flows are not included in the transport model as a separate category (i.e. Car within the model includes all cars and taxis).

7.4.2   It is also worth considering any studies into the actual level of emissions from each of the Euro emission categories. In particular, having confidence in the actual performance of engines (in congested urban conditions) compared to their claimed performance would add a lot to the confidence in the model results.

7.4.3   Having developed a reasonable level of confidence in the assumptions being used to calculate emissions and forecasting the likely emissions in 2015, then the model can be used to test some high level strategies aimed at reducing emissions, with a particular focus on the key areas identified.

7.4.4   This work has only considered the transport-related emissions and not emissions from other sources or indeed the actual impact on air quality in the key areas. The use of the Airviro model to examine the impact on air quality of forecast changes in transport emissions would be beneficial. However, it is important in doing this to ensure that transport emissions in Airviro are modelled as accurately as possible and therefore that the assumptions used in Airviro reflect the work that has been reported on in this study. It is therefore recommended that Airviro take the forecast emissions from ENEVAL rather than recalculating them from the traffic flows.

7.4.5   The recommendations for further work listed above relate to improving the understanding of the current transport-related emissions in Sheffield, and also their impact on Air Quality.

mvaconsultancy

Once the evidence base has been developed to an accepted level of confidence, the modelling tools can then be used to assess the impact of interventions that are designed to improve air quality through further reductions in transport-related emissions. The modelling tools can then be used to forecast the impact of interventions on emissions, and air quality, which may include the following:

■   the development of a Low Emission Zone;

■   fleet improvements, and further improvements in engine technology;

■   switch away from diesel vehicles; and

■   alternative fuels.

7.4.6   The Department for Environment, Food and Rural Affairs has now approved funding for Phase 2 of this project. The next stage of the project will therefore, be the detailed scoping out of further work to be undertaken, for which an LEZ Phase 2 Scoping Report will be produced.

mvaconsultancy

MVA Consultancy provides advice on transport, to central, regional and local government, agencies, developers, operators and financiers.
A diverse group of results-oriented people, we are part of a strong team of professionals worldwide. Through client business planning, customer research and strategy development we create solutions that work for real people in the real world.

For more information visit www.mvaconsultancy.com

Abu Dhabi

AS Business Centre, Suite 201, Al Ain Road, Umm al Nar, P.O. Box 129865, Abu Dhabi, UAE
T: +971 2 510 2402   F: +971 2 510 2403

Birmingham

Second Floor, 37a Waterloo Street
Birmingham B2 5TJ United Kingdom
T: +44 (0)121 233 7680 F: +44 (0)121 233 7681

Dublin

First Floor, 12/13 Exchange Place
Custom House Docks, IFSC, Dublin 1, Ireland
T: +353 (0)1 542 6000 F: +353 (0)1 542 6001

Edinburgh

Second Floor, Prospect House, 5 Thistle Street,
Edinburgh EH2 1DF United Kingdom
T: +44 (0)131 220 6966 F: +44 (0)131 220 6087

Glasgow

Seventh Floor, 78 St Vincent Street
Glasgow G2 5UB United Kingdom
T: +44 (0)141 225 4400 F: +44 (0)141 225 4401

London

Seventh Floor, 15 Old Bailey
London EC4M 7EF United Kingdom
T: +44 (0)20 7529 6500 F: +44 (0)20 7529 6556

Lyon

11, rue de la République, 69001 Lyon, France
T: +33 (0)4 72 10 29 29 F: +33 (0)4 72 10 29 28

Manchester

25th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 236 0282 F: +44 (0)161 236 0095

Marseille

76, rue de la République, 13002 Marseille, France
T: +33 (0)4 91 37 35 15 F: +33 (0)4 91 91 90 14

Paris

12-14, rue Jules César, 75012 Paris, France
T: +33 (0)1 53 17 36 00 F: +33 (0)1 53 17 36 01

Woking

Dukes Court, Duke Street, Woking
Surrey GU21 5BH United Kingdom
T: +44 (0)1483 728051 F: +44 (0)1483 755207

Email: info@mvaconsultancy.com

Offices also in

Bangkok, Beijing, Hong Kong, Shenzhen and Singapore

mvaconsultancy