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LOW EMISSION ZONE (LEZ) FEASIBILITY STUDY
Phase 2 – Final Report

SHEFFIELD AIR QUALITY MODELLING

LOW EMISSION ZONE (LEZ) FEASIBILITY STUDY

Phase 2 – Final Report

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Sheffield Air Quality Modelling

Low Emission Zone (LEZ) Feasibility Study
Phase 2 – Final Report

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EXECUTIVE SUMMARY

Background

This report describes Phase 2 of a Low Emission Zone Feasibility Study, which was identified as a key action within the Council's Air Quality Action Plan for Sheffield 2015.

Phase 1 of this Study was completed in November 2012 and concluded that further work needed to be done in order to better understand how vehicles currently travelling around Sheffield contribute to poor air quality, before starting to identify solutions.

The scope of the Phase 2 Study was to:

- better understand current traffic emissions in Sheffield, by identifying which types of traffic are contributing most to current and likely future air quality problems;
- use this information to identify a range of potential cost-effective measures which are likely to help improve Sheffield's air quality; and
- agree a Low Emission Zone Strategy which will enable Sheffield to move towards compliance with health based European Air Quality limit values by 2015.

Current Air Quality Issues in Sheffield

Local authorities are required by law to monitor and assess air quality in their areas against national and European air quality limit values. Road traffic contributes to poor air quality by emitting two key pollutants (Nitrogen dioxide gas (NO_2) and fine dust particles (PM)) amongst others, which are damaging to human health and the environment. The European Union has defined maximum concentrations (annual average levels and the number of days exceeding a specified level) for these pollutants which need to be achieved by 2015, with the threat of fines if the UK fails to meet these air quality standards.

The Council has been continuously monitoring air quality over the past decade, collecting data at hundreds of sites across Sheffield. This data shows that there are 51 locations where the European Unions' annual average limit value for NO_2 (40 $\mu g/m^3$) has not been met in one or more of the last 3 years for which Air Quality data is available (2010-2012), and that NO_2 emissions would need to reduce by up to 30% in order to comply with the limit value. Analysis has confirmed that road transport is the most-significant overall single contributor to Sheffield's NO_2 emissions at these locations. However, the results also suggest that traffic's share of the NO_2 emissions range from around 10% to 90% at different locations, which means that reducing traffic emissions in isolation, without also tackling emissions from other sources such as industrial, commercial and domestic heating, is unlikely to achieve the required overall improvements in air quality.

As a result of this, the Low Emission Zone Strategy has been developed on the basis that local road transport must deliver its 'fair share' of the emissions reductions needed to achieve the air quality limit values at each location and that other actions identified within Sheffield's Air Quality Action Plan will be used to reduce the emissions from the other sectors similarly. The strategy has not

considered the measures which are required to reduce emissions from traffic using the M1 Motorway itself, or from the rail network, as these are not within the Council's direct control. However, both of these are known to contribute to Sheffield's local air quality problems and will therefore need to be addressed.

Approach to Low Emission Zone Strategy Development

A number of information sources and tools have been used to ensure that the Low Emission Zone Strategy could target the key vehicle fleets which contribute most to transport emissions. The data and tools used by the Study included:

- observed 'real-time' emissions rates taken from vehicles travelling around Sheffield;
- information about Sheffield's current traffic fleets, taken from Automatic Number Plate Recognition (ANPR) data and other data provided by Sheffield City Council and local bus operators;
- traffic models of the Sheffield area; and
- Sheffield City Council's local air quality model.

These were then used to help understand current and likely future traffic emission levels within Sheffield.

The analysis showed that, while emissions of fine dust particles (PM) are falling through the use of newer engine / exhaust technology, NO_X (nitric oxide (NO) + nitrogen dioxide (NO_2)) emissions are likely to reduce more slowly, which means that the required reduction in NO_2 concentrations from traffic will be difficult to achieve in the short term. One reason for this is the poor NO_X performance of newer (Euro 5/V) vehicles in Sheffield, which was observed in the emissions data collected for this study, but also supported by similar evidence from other recent research studies.

Simply waiting for vehicle fleets to renew naturally over time and use better technology in order to reduce NO_X emissions from road traffic in Sheffield will therefore take too long, 2020 at the very earliest.

A more-proactive Low Emission Zone Strategy is therefore required, which reduces NO_X emissions from road traffic.

A formal controlled 'London' Style Low Emission Zone, which is currently focused upon reducing emissions of fine dust particles (PM) from Buses and Goods Vehicles, and will apply only to Buses for NO_X in 2015, is unlikely to solve the NO_X problem in Sheffield.

The Sheffield Low Emission Zone Strategy would therefore, need to be:

- effective, by targeting those vehicles which contribute significantly to current and future emissions of NO_X;
- focused on vehicles with high NO_X emissions rates, which operate regularly within Sheffield
- efficient and cost-effective;

- deliverable (including public /political acceptability);
- technically feasible;
- enforceable; and
- affordable, in terms of the size of fleet affected.

It has been estimated that while being approximately 80% of the fleet in Sheffield, private cars will contribute just over 50% of NO_x emissions in 2015, with 35% being emitted by diesel cars. The difference between petrol and diesel car emissions is growing over time, as the latest modern EURO emissions standards continually reduce the NO_x emissions from petrol engines.

Other Goods Vehicles (OGVs > 3.5T) only comprise 2% of the vehicle fleet in Sheffield but are estimated to be responsible for around 12% of the NO_X emissions in 2015, while Buses and Taxis (2% and 5% of the fleet respectively) are each forecast to contribute around 10% of NO_x emissions.

The key fleets to be targeted in the Low Emission Zone Strategy were therefore identified as:

- Buses;
- Taxis;
- Light Goods Vehicles (LGVs < 3.5T);
- Other Goods Vehicles (OGVs > 3.5T); and
- Private Diesel Cars.

A range of options were considered and the Preferred Low Emission Zone strategy was then developed by combining the most efficient and effective components.

The Preferred Low Emission Zone Strategy 2015

The main focus of the preferred Low Emission Zone Strategy is tackling NO_x emissions from Buses and the most polluting Taxis, both of which have fleets operating regularly within Sheffield and over which the Council has some regulatory control, together with the most polluting Goods Vehicles:

- Minimum NO_X emission standard (EURO VI) for Buses; and
- Maximum NO_X emissions rate levels for:

  - Taxis – affecting the 'worst polluting' 50% of the current fleet
  - Light Goods Vehicles (LGV < 3.5T) – affecting the 'worst polluting' 15% of the current fleet
  - Other Goods Vehicles (OGV > 3.5T) - affecting the 'worst polluting' 10% of the current fleet

A number of additional supplementary "softer behavioural change" measures, are also recommended to strengthen the impact of the overall Low Emission Zone strategy, as follows:

- measures to encourage 10% private car users to switch from diesel back to petrol;

- 5% reduction in emissions from both petrol and diesel private cars, by reducing car use, encouraging more-efficient driving styles and promoting travelling at different times; and
- 5% reduction in emissions from Other Goods Vehicles (OGVs > 3.5T) by more-efficient routing and more efficient driving styles.'

Some of these "softer" measures are already on-going but need a stronger focus in order to deliver the required benefits. These measures particularly need to be focussed on key air quality corridors and 'hot-spots' and implemented by targeting large employers and commercial organisations with large vehicle fleets, including Sheffield City Council, the National Health Service, Sheffield's Universities, Meadowhall, other large retailers etc.

Some localised transport measures, such as active traffic management may also be required to help further reduce transport emissions at sites with very high transport emissions. Similar action is also required by other sectors to ensure the European air quality limit values are met for NO_2 by 2015.

Implementing the Sheffield Low Emission Zone Strategy will require:

a) significant on-going commitment by Sheffield City Council and its Partners;
b) the UK Government to take the lead on key national policies such as reducing the use of diesel vehicles in urban areas and tackling emissions from the M1 Motorway;
c) significant investment in 'green technology' and alternative transport fuels such as Compressed Natural Gas and petrol-hybrid or electric vehicle technologies;
d) a strong public awareness campaign, focussing on the health impacts of poor local air quality in Sheffield; and
e) continued local Air Quality Monitoring in order to demonstrate compliance by 2015

There are a number of potential UK Government funding sources available to help deliver the Sheffield Low Emission Zone Strategy, such as the Local Sustainable Transport Fund, Local Transport Plan and Green Bus Fund etc, but further funding is likely to be required to deliver the full strategy, particularly the aspects which require upgrading the various Bus and Goods Vehicle commercial fleets.

A summary of the main recommendations from the Study is provided below.

RECOMMENDATIONS

Support for the Low Emission Zone Strategy and Its Delivery

1 Sheffield City Council approve the full package of measures identified in this report.

2 Appropriate central, regional and local government departments working with their Partners, co-ordinate and produce a clear policy steer and ensure that the necessary funds are made available to deliver the relevant measures within appropriate timescales. Further research and action is required regarding the performance of EURO 5/V vehicles, in particular heavy duty vehicles, as recent investment in these vehicles by the Bus and Freight industries may actually be worsening the air quality in urban areas. Evidence that EURO 6/VI actual performance is in-line with the required standards will also be required.

3 Necessary staff resources are made available to deliver the strategy.

Planning Controls

4 Sheffield and neighbouring Council Planning Departments should be made aware of the details of the emerging Emissions Strategy and do as much as possible to support it.

5 New developments which are likely to generate significant amounts of traffic should be required and given support to ensure that emissions of NO_x and particulate matter are minimised.

Public Awareness and the Communications Strategy

6 Effective media and marketing campaigns are needed to raise public awareness of the health impacts of poor air quality.

7 The car-buying public should be made fully aware of the differences in the level of emissions between petrol, diesel and 'new technology' cars and the importance of the Euro-rating system.

8 UK Government should take the lead in a UK-wide campaign and supporting policy measures to reduce the proportion of diesel cars (and older petrol cars) used in urban environments.

9 The health benefits of a) the additional active travel and b) the improved air quality if 'everyone plays their part' should be emphasised, as should the 'carbon-footprint reductions' of these behaviour changes.

Measures to Promote Reduced Car Use

10 Cost-effective measures which help deliver reduced private car use should be funded and supported by all stakeholders.

11 Sheffield City Council (with support from its neighbouring Local Authorities) should take all of the actions required to reduce the number of high-emission-rate Hackney Taxis and Private Hire Vehicles operating within Sheffield.

12 Sheffield City Council should consider introducing 'green taxi ranks' at the train station or other priority locations and / or offer discounts on Taxi License fees for petrol hybrid, electric or

Compressed Natural Gas / Bio-methane vehicles. This may require the setting up of suitable central government funding e.g. a 'Green Taxi Fund'.

13 Sheffield City Council and South Yorkshire Passenger Transport Executive should support the local bus operators, by submitting bids for appropriate funding sources etc), in order to upgrade the bus fleet operating within Sheffield.

Reducing Emissions from the Existing Fleet

14 We recommend that the Public Awareness and Communications Strategy should join with other existing campaigns and include a campaign to pass on the main 'more-efficient driving' tips to the general public, organisations with large fleets and individuals who 'drive for a living'.

15.1 The Eco Stars Fleet Recognition Scheme should be the 'weapon of choice' for promoting fleet efficiency in freight vehicles as a means to delivering emissions reductions within Sheffield.

15.2 The marketing campaign for the Eco Stars scheme should focus on the economic benefits (fuel cost savings) of participation, with potential secondary messages regarding the health and customer-relations benefits.

15.3 The message regarding fuel cost savings should be backed up by robust Case Study evidence.

16 Sheffield City Council should promote the fuel cost-saving benefits of a) eco-driving and the Eco Stars Fleet Recognition Scheme and b) replacing older and poorly-maintained goods vehicles with newer/cleaner/more-efficient alternatives. This promotion should focus on organisations which are responsible for generating large amounts of goods vehicle traffic within Sheffield.

17 Sheffield City Council should continue to work to identify ways to reduce 'unnecessary' goods vehicle traffic travelling through Sheffield, and particularly in air quality problem areas.

18.1 The existing Council heavy goods vehicle (HGV) Routing Strategy could be widened to include a more ambitious real-time information strategy targeted at all drivers.

18.2 Any signing strategy should take account of the issues identified as part of the Council's HGV Routing Strategy.

19 The Public Awareness and Communications Strategy should consider whether it would be possible to persuade motorists to avoid driving at the peak congested times.

20 Sheffield City Council should evaluate the benefits and dis-benefits from undertaking increased night-time deliveries of goods.

21 The scoping phase of the Public Awareness and Communications Strategy should consider whether there are any locations or organisations where vehicle idling is currently an issue worthy of a targeted approach.

Monitoring Progress

22 Sheffield City Council and Defra should ensure that sufficient resources are available to continue to robustly monitor local air quality across the city, in order to demonstrate compliance by 2015.

Wider Emissions Strategy

23 The Low Emissions Zone Strategy should be part of a wider Emissions Strategy aimed at fairly tackling emissions from all relevant sources and sectors in the Sheffield area. The strategy has not considered the measures which are required to reduce emissions from traffic using the M1 Motorway itself, or from the rail network, as these are not within the Council's direct regulatory control. However, both of these are known to contribute to Sheffield's local air quality problems and will therefore need to be addressed.

1.   INTRODUCTION

1.1   Overview and Context

1.1.1   Sheffield aspires to be a city where health inequalities are reduced and air is healthy for all to breathe. 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. However, traffic-related emissions impact negatively on people's health through increased air pollution and include greenhouse gases which are contributing to global climate change.

1.1.2   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. Overall, the adverse effects of poor air quality are likely to be having a bigger negative impact on SCC's residents' life expectancy than road traffic accidents or passive smoking[2].

1.1.3   Analysis of Sheffield's hospital admissions for 'Circulatory diseases' and for coronary heart disease both show a strong correlation with the annual average concentration of small particulate matter in the various Sheffield neighbourhoods – see Appendix B for details.

1.1.4   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[3].

1.1.5   Locally and nationally air quality has generally been improving. However, in the most polluted areas, near busy roads and within congested urban centres, it has not improved (or has even worsened). These areas are often located in poorer parts of the city, so the poor local air quality will tend to compound other health-related problems in these areas.

1.1.6   Sheffield, like many other major cities in the UK, currently breaches UK and European Union thresholds for air quality, particularly for NO_2. Sheffield City Council declared[4] an

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[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

Air Quality Management Area (AQMA) across the whole of the urban area of the city for nitrogen dioxide (NO_2) and fine particles (PM_{10}) in January 2010.

1.1.7 This declaration of an AQMA requires the Council to produce an Air Quality Action Plan, with the aim of achieving the relevant UK and EU air quality standards as soon as possible, ideally before the EU limit values become mandatory in 2015.

1.1.8 A recent application by the UK Government to delay the deadline for compliance with the EU limits in London and across the UK was turned down by the EU, raising the likelihood of the UK government being fined if it continues to breach the limits beyond 2015, with the possibility that these fines would be passed on to the relevant Local Authorities.

1.1.9 The fines imposed could be significant and so represent a significant risk for the Council, adding to the main health-based arguments for tackling Sheffield's current air quality problems.

1.1.10 The main causes of air pollution in the city are road transport and industry, and to a lesser extent, other processes that involve combustion, including commercial and domestic heating systems (e.g. gas boilers).

1.1.11 In July 2012, Sheffield City Council (SCC) approved an Air Quality Action Plan (AQAP)[5] which aims to reduce pollution in Sheffield and help to achieve health-based national air quality objective and EU limit values by 2015.

1.1.12 A set of local measures was 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. A key element of this Action Plan was a Low Emission Zone (LEZ) Feasibility Study.

1.2 Study Overview

1.2.1 In July 2012 Sheffield City Council (SCC) approved an Air Quality Action Plan (AQAP) which aims to reduce pollution in Sheffield and help to achieve health-based national air quality objective and EU limit values by 2015.

1.2.2 A set of local measures was 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.

1.2.3 A key element of this Action Plan was a Low Emission Zone (LEZ) Feasibility Study, which involved two distinct phases.

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

1.2.4   Phase 1 of the Study was completed in November 2012[6] and included the tasks outlined below:

- MVA's ENEVAL software and outputs from the Sheffield and Rotherham Transport Model (SRTM3) were used to estimate transport related emissions, based on assumptions about the vehicle fleet in Sheffield;
- the impact of changes in vehicle fleet assumptions on emissions were estimated;
- 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 were shown to be contributing most to current and future air quality problems and hence identifying where further work on developing emissions strategies should be focussed.

1.2.5   A number of recommendations for further analysis were made in the Phase 1 Study:

- utilise more accurate information on the current vehicle fleet in Sheffield, including the taxi fleet, which was not considered explicitly in Phase 1;
- obtain data showing 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;
- test high level strategies aimed at reducing emissions;
- use Sheffield City Council's Airviro model to examine the impact on air quality of forecast changes in transport emissions; and
- use of the modelling tools 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
    - take up of alternative fuels.

1.2.6   This report describes the subsequent Phase 2 of the LEZ Study.

1.2.7   The scope of the Phase 2 Study was as follows:

- update the Sheffield and Rotherham Highway Transport to a base year of 2012, utilising updated observed growth and recommended assumptions to establish a robust base for the emissions modelling;
- update MVA's ENEVAL software to use the latest DEFRA accepted emissions factors (COPERT 4, Version 10) which provide a better representation of actual engine technology performance;

- use Automatic Number Plate Recognition data to allow locally calibrated fleet mix proportions to be used in the analysis, including better representation of taxi activity;
- use observed emissions data for different fleet and engine technologies;
- confirm the subsets of traffic which are contributing most to current and future air quality problems;
- analyse 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 Sheffield;
- identify an Emissions Strategy which will set out the steps required to enable SCC to move towards compliance with EU Air Quality standards; and
- use South Yorkshire's existing Airviro Air Quality model to predict the impacts of the Preferred Strategy on air quality across the city.

1.3 Project Funding

1.3.1 This project has been funded by the Department for Environment, Food and Rural Affairs (DEFRA) and Sheffield City Council (using South Yorkshire Local Transport Plan funds).

1.4 Project Governance

1.4.1 The project has been led by Sheffield City Council, with the work to estimate and forecast transport emissions being undertaken by MVA Consultancy. A Steering Group[7] was appointed to oversee the project, comprising of representatives from the following organisations[8]:

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

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[7] A consolidated set of slides presented at the Steering Group meetings is provided in Appendix L

[8] Appendix A contains a full list of Steering Group members

1.5   Structure of this report

1.5.1   The remaining chapters of this report are as follows:

- Chapter 2 summarises the current air quality in Sheffield, describing the known air quality issues and how transport contributes to the air quality problems;
- Chapter 3 describes the methodology used to develop the Low Emission Zone strategy, the tools used and the options considered;
- Chapter 4 describes the Preferred Low Emission Zone Strategy and how it may be achieved; and
- Chapter 5 summarises the Recommendations and Next Steps for development of the Preferred Low Emission Zone Strategy.

2. CURRENT AIR QUALITY IN SHEFFIELD

2.1 Background

2.1.1 Local authorities are statutorily bound to monitor and assess air quality in their areas against national air quality objectives. The objectives pertain to seven key pollutants due to their impacts on human health:

- Benzene;
- 1-3 butadiene;
- Carbon monoxide;
- Lead;
- Nitrogen dioxide (NO_2);
- Ozone; and
- Particulate matter (PM_{10}).

2.1.2 Nitrogen dioxide (NO_2) and PM_{10} are key concerns because their objectives are breached in most urban areas. Table 1 contain the English national air quality objectives for these pollutants.

Table 1. National air quality objectives for NO_2 and PM_{10}[9]

POLLUTANT	CONCENTRATION	MEASUREMENT
Nitrogen dioxide	200 µg/m^3	Not to be exceeded more than 18 times per year - 1 Hour Mean
	40 µg/m^3	Annual Mean
Particulate Matter ($PM_{10)}$	50 µg/m^3	Not to be exceeded more than 35 times per year – 24 hour mean
	40 µg/m^3	Annual Mean
Fine Particles ($PM_{2.5}$)	25 µg/m^3	Annual Mean
	15% reduction in concentrations at urban background (2010-2020)	Annual Mean

2.1.3 Nitrogen oxides (predominantly nitric oxide NO and nitrogen dioxide NO_2), are produced as a by-product of combustion. The main sources are power generation, industrial combustion and road traffic.

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[9] UK National Air Quality Archive http://uk-air.defra.gov.uk/documents/National_air_quality_objectives.pdf

2.1.4   Emission of these oxides of nitrogen leads to a number of local air quality issues, including:

- short-term exposure to high concentrations (>200 µg/m^3) can cause inflammation of the airways and high levels of NO_2 can increase susceptibility to respiratory infections and to allergens[10];
- while it is difficult to separate the health impacts of NO_2 concentrations from those of other pollutants (notably particulate matter) which tend to be emitted from the same sources and therefore tend to be highly correlated, there is growing evidence from studies that have attempted to correct for these PM effects that NO_2 may be contributing directly to the observed respiratory-related health outcomes – the recent WHO Review of Evidence on Health Aspects of air pollution (REVIHAAP 2013)[11] concludes that 'the weight of evidence on short-term associations [between NO_2 concentrations and health outcomes] is 'suggestive of a causal relationship'
- in sunlight, the various oxides of nitrogen react with volatile organic compounds (VOC) to produce various photochemical pollutants including ground-level ozone which causes inflammation and irritation to the eyes, nose & throat, exacerbates asthma and damages many types of plant, resulting in reduced crop yields and damage to the natural habitat, often at significant distances from the original source of the NO_X and VOC pollution;
- NO_X contributes to **hypertrophication** (e.g. algae blooms and other responses to raised nitrate levels) of the natural environment, with adverse effects on both flora and fauna within the affected habitats; and
- they combine with atmospheric moisture to form nitric acid, leading to damaging **acidification** of natural habitats ('acid rain') and damage to buildings.

2.1.5   Transport, electricity supply and industrial and commercial processes account for the production of most nitrogen oxides. Of these, road transport contributes most to the long-term ground level concentration of NO_X in urban areas. Industrial emissions are normally released at an elevated level and are therefore distributed in lower concentrations over a wider area.

2.1.6   Particulate matter (PM) is a mixture of solid particles and liquid droplets found in the air. These particles are usually described according to their size e.g. PM_{10} (diameter of 10 µm or less) or $PM_{2.5}$ (diameter of 2.5 µm or less). These small particles (usually invisible to the naked eye) can be breathed in and carried deep in to the lungs, where they

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[10] *Air Pollution in the UK 2012'* September 2013
 http://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2012_issue_1

[11] WHO Review of Evidence on Health Impacts of Air Pollution (REVIHAAP) 2013
http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

contribute to a variety heart and lung-related health problems. In general, the smaller particles can penetrate deeper into the cardio-vascular system where they create greater damage to health, so that the damage from a given weight of $PM_{2.5}$ is much worse that the corresponding weight of PM_{10}.

2.1.7   The health effects of these very small particles are clearly described in Section A of the WHO's recent Review of Evidence on Health Impacts of Air Pollution (REVIHAAP)[12]. In particular, the evidence suggests that the health benefits of reducing $PM_{2.5}$ concentrations continue to be observed at all concentration levels, suggesting that air quality strategies should focus on reducing $PM_{2.5}$ concentrations, rather than achieving any particular threshold value.

2.1.8   Traffic contributes to local PM concentrations through emissions of particles through the vehicles' exhaust systems and from non-tail-pipe sources of 'wear-and-tear', including the vehicles' tyres and brake pads and the road surface itself. The tail-pipe emissions of PMs from diesel engines tend to be much higher than from a petrol engine of a similar age and size, particularly for older vehicles, where diesel emissions are typically up to 4 times higher for diesel than for petrol cars.

2.1.9   Road transport is a significant contributor to overall PM air quality concentrations, particularly at the 'small' end of the range of particle sizes.

2.2   European Vehicle Emissions Standards

2.2.1   Euro Emission Standards apply to tail-pipe emissions of all new vehicles sold within the European Union and define the acceptable limit for exhaust emissions for a number of emission types, include NO_x and PM. The Euro classifications for private cars and light duty goods vehicles are referred to as EURO 1 to EURO 6, while the corresponding standards for heavy duty vehicles are referred to as EURO I to EURO VI (i.e. using Roman numerals).

2.2.2   The EURO 1/I standard came into force in the early 1990s, and increasingly stringent standards have been introduced since then, with the EURO 6/VI standard coming into force from 31 December 2013. Appendix C provides further details about the introduction date of the various Euro Emission Standards. It should be noted that vehicle manufacturers often produce vehicles compliant with an upcoming standard – for example, EURO 6/VI vehicles could be purchased well ahead of the relevant end-of-December 2013 deadline.

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[12] WHO Review of Evidence on Health Impacts of Air Pollution (REVIHAAP) 2013

http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

2.3   Sheffield's Current Air Quality

2.3.1   As noted in the Sheffield Air Quality Action Plan (AQAP), the air quality problems in Sheffield are similar to those in other areas in the UK. In general, over recent years, air quality has been improving. However, in some places - notably near motorways and busy urban centres - there has been little improvement, and sometimes worsening of air quality. Current and predicted levels for 2015, indicate that Sheffield breaches the air quality objectives shown in Table 1 which could potentially lead to EU fines.

2.3.2   While the M1 and diesel trains add considerably to the air quality problems in Sheffield, these sources are outside of the direct control of Sheffield City Council and therefore are not included in the analysis and modelling undertaken for this study, nor does the LEZ strategy attempt to address their emissions.

2.3.3   Figure 1 displays the NO_2 concentrations from Automatic Urban and Rural Networks (AURN) and non-automatic monitoring sites in South Yorkshire[13], which illustrates the magnitude of the air quality problems in the Sheffield area.
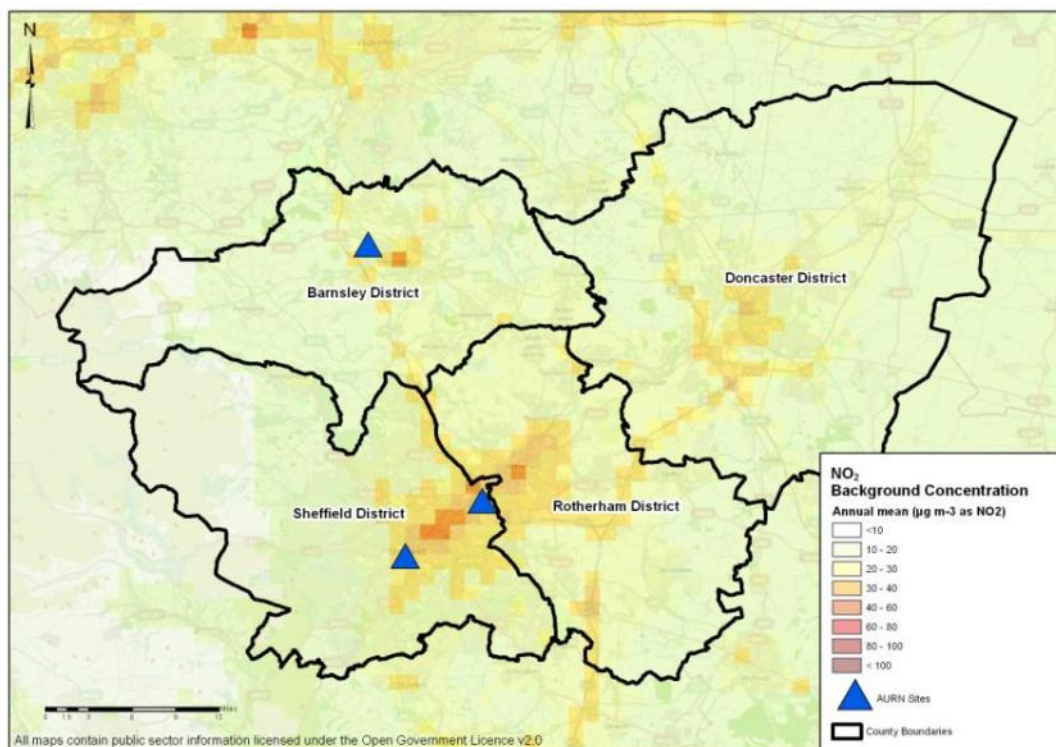
Figure 1. NO$_2$ Air Quality Concentrations with AURN sites

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[13] UK-AIR last accessed 09 September 2013

2.3.4 Information from continuous monitoring and modelling by Sheffield City Council led to the declaration of the Air Quality Management Area (AQMA) indicated as the blue region in Figure 2. The aim of Sheffield's AQAP is therefore to reduce the concentrations of the main pollutants below the UK air quality objectives as quickly as possible across the AQMA area.
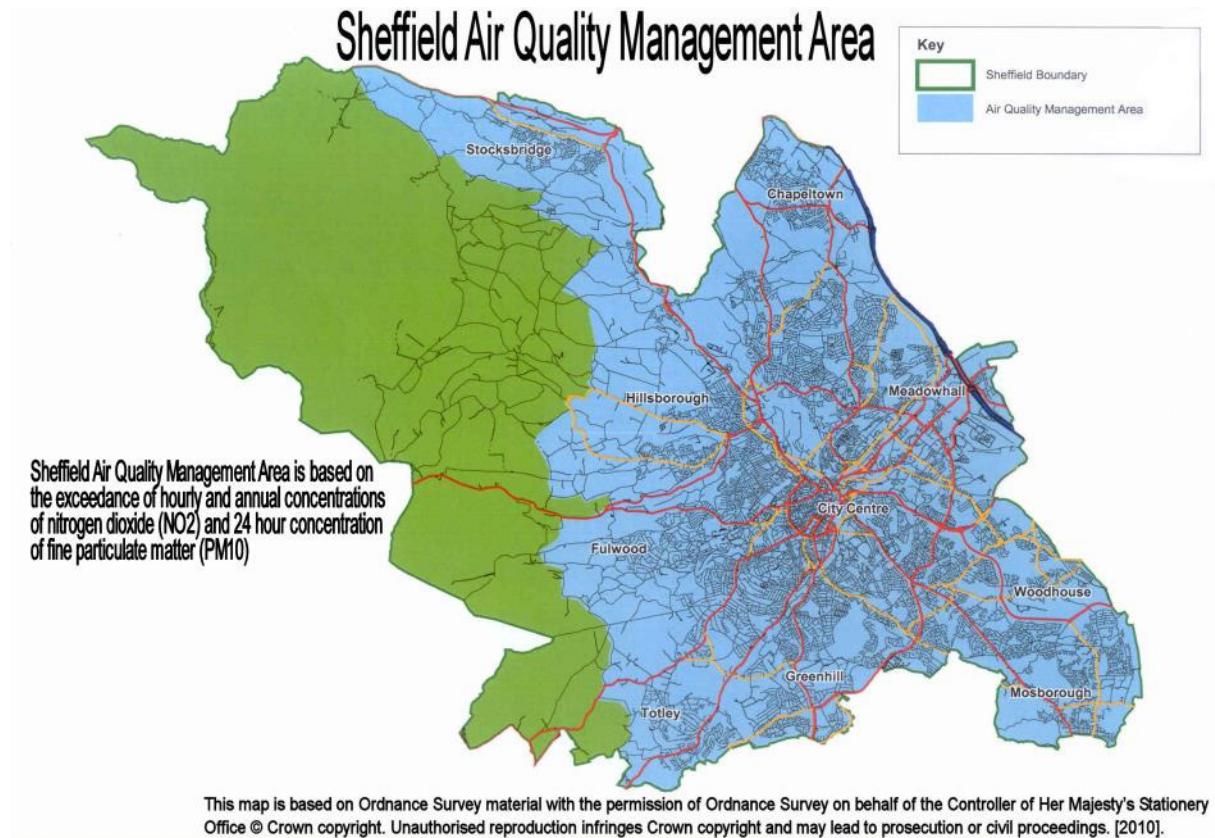
Figure 2. Sheffield Air Quality Management Area

2.3.5 Sheffield City Council has been continuously monitoring air quality over the past decade, collecting data at hundreds of sites across the Sheffield area. Analysis of the data from these sites identified 51 locations where the 40 $\mu g/m^3$ annual average limit for NO_2 was breached in one or more of the last 3 years for which AQ data is available (2010-2012).

2.3.6 The AQ data for these 51 'NO_2 problem' sites suggested that average NO_2 concentrations are currently falling by around 1% per annum, though with some variation in this trend between different sites.

2.3.7 Applying this 1% per annum reduction to the latest 2012 NO_2 annual average concentrations at the 51 'NO_2 Problem' sites provided an estimate of how much these sites are likely to exceed the 40 $\mu g/m^3$ in the current year (2013). The results are

summarised in Table 2 and illustrated in Figure 3. The location and recent NO_2 concentration data for these 'NO$_2$ Problem sites' are provided in Appendix D.

Table 2. Number of sites exceeding NO$_2$ limit values (Based on Predicted 2013 levels)

PERCENT REDUCTION REQUIRED	NUMBER OF SITES
0%	10
0-5%	8
5-10%	12
10-20%	13
20-30%	8
Total	51
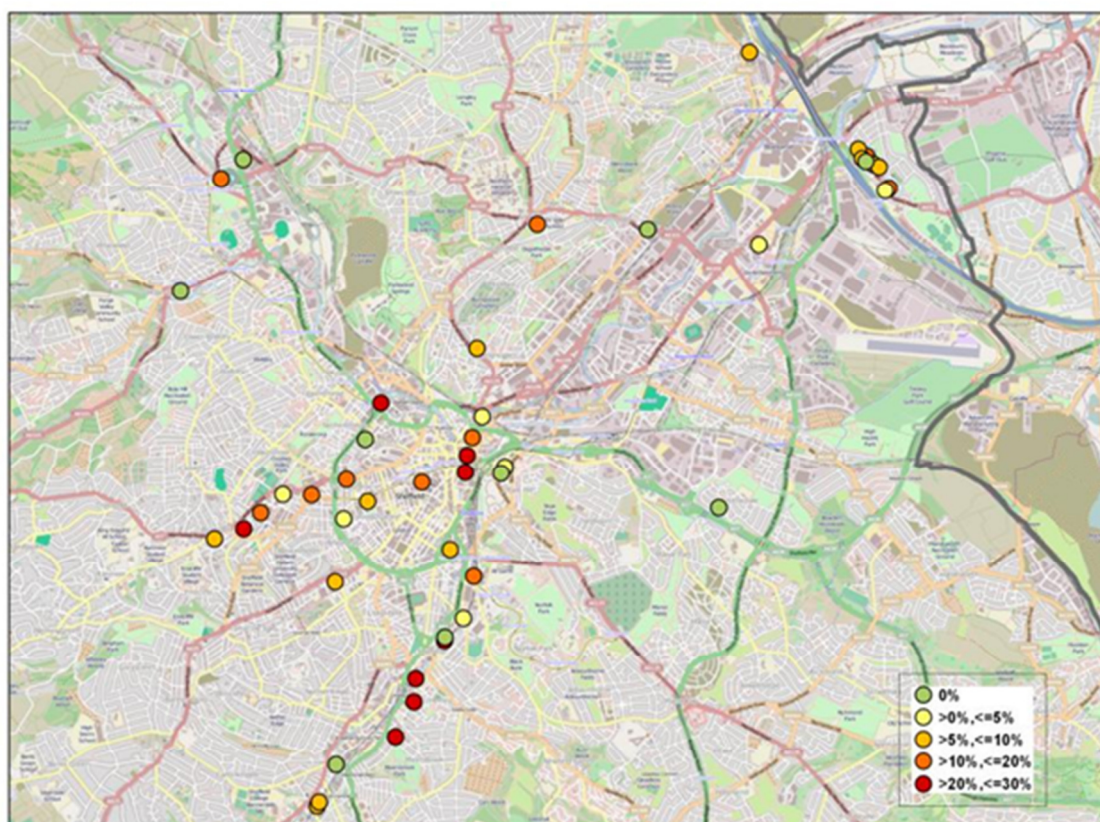
Figure 3. Percentage Reduction in NO$_2$ Concentrations Required (from predicted 2013 values)

2.3.8   Analysis of Sheffield's hospital admissions for 'Circulatory diseases' and for coronary heart disease also both show a strong correlation with the annual average concentration of small particulate matter in the relevant neighbourhoods – see Appendix B for details.

2.4   Transport's contribution to Sheffield's Air Quality Issues

2.4.1   The key emissions sources in Sheffield are road traffic and industry, with domestic and commercial sources such as heating also contributing to the problems. Emissions modelling by Sheffield City Council suggests that road transport accounts for around 50% of NO_x and about 40% of total PM_{10} emissions.[14]

2.4.2   However, these proportions vary by location. Data from Defra's NAEI web-site[15] shows the estimated contributions from different sources within 1km x 1km grid squares. A GIS was used to overlay the resulting proportions onto the 51 'NO_2 problem' locations discussed in the previous section, to provide an approximate estimate of the contribution of road traffic to the NO_x emissions at these locations, assuming the data represents ground-level air quality. The results are summarised in Appendix D.

2.4.3   Road traffic's current share of the 'NO_X as NO_2' emissions for the 41 sites whose annual average NO_2 is expected to exceeded 40μg/m^3 in 2013 are illustrated in Figure 4.
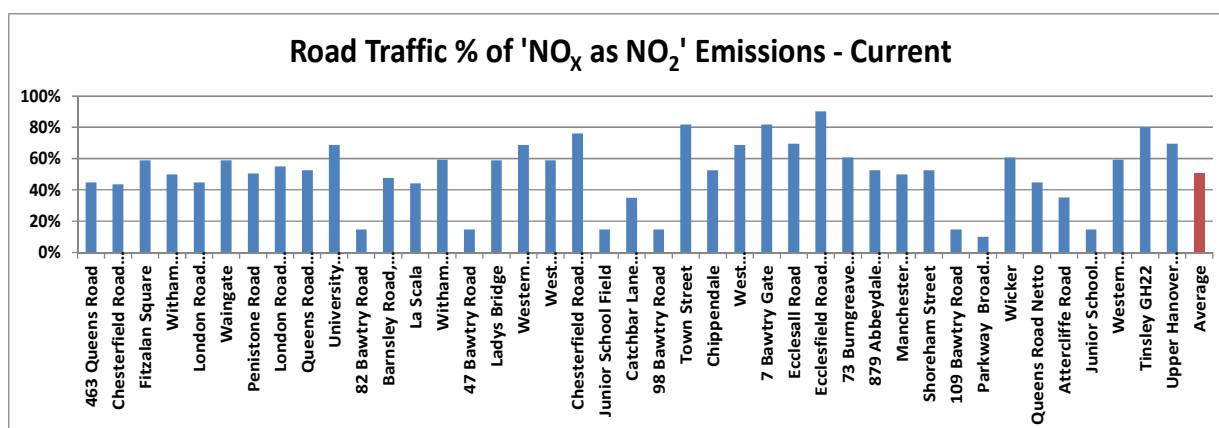
Figure 4. Road Traffic % of NO_X as NO_2 Emissions (2012): Source: NAEI

2.4.4   The results suggest that traffic's share of the NO_X emissions range from around 10% (in the NAEI 1km grid square containing Parkway Broad Lane), up to around 90% of emissions in the 1km grid square containing the Ecclesfield Road AQ monitoring site. The corresponding mean and median values both lie close to 50%, confirming that road transport is the most-significant overall single contributor to Sheffield's 'NO_X as NO_2' emissions at the 'NO_2 problem' locations.

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[14] Air Quality Action Plan 2015, Sheffield City Council

[15] http://naei.defra.gov.uk/data/

2.4.5 However, the wide range of road traffic's %share of the total NO_X/NO_2 emissions means that reducing traffic emission in isolation (i.e. without also tackling NO_X emissions from other sources) is unlikely to achieve the required improvements in air quality. Indeed, as shown by the data in Appendix D, at NO_2 problem locations which are in areas where road traffic represents only a relatively small share of the relevant NO_X emissions, large %reductions in road traffic emissions of NO_X would be required to 'unilaterally' reduce local air quality down below the required 40 μg/m^3 NO_2 annual average limit.

2.4.6 The LEZ strategy development has therefore been developed on the basis that road transport will endeavour to deliver its 'fair share' of the emissions reductions needed to achieve compliance with the target air quality limits at each location and that other initiatives within Sheffield's overall emissions strategy will be used to tackle the emissions from the other sectors.

2.4.7 The following chapter contains further information from the modelling undertaken for this study about the contribution of different transport modes to the air quality issues in Sheffield, and the process used to develop the LEZ Strategy.

3. LEZ DEVELOPMENT PROCESS

3.1 Overview

3.1.1 The Phase 1 Study produced a number of recommendations for improving the representation of the traffic emissions in Sheffield to underpin the LEZ development process. These data are discussed in the following section, which summarises the 'real-world' data and models used to develop the LEZ Strategy. The models used range from high-level strategy appraisal tools to detailed emissions modelling.

3.1.2 A number of high level 'strategy components' were appraised and discussed with key members of the Steering Group, in order to develop an understanding of the likely achievements and limitations of different potential policies. The data from these strategy component assessments were used to define and agree the preferred LEZ strategy, which is described and discussed in the Chapter 4.

3.2 Data and Tools Used for LEZ Development

3.2.1 As well as the data from UK-AIR and NAEI outlined in the previous chapter, a number of other data sources and modelling tools were used in the development of the LEZ:

- observed 'real-time' Sheffield traffic emissions rates;
- characteristics of Sheffield's current traffic fleets, derived from Automatic Number Plate Recognition (ANPR) data and other fleet data provided by Sheffield City Council and local bus operators;
- traffic models of the Sheffield area; and
- emissions models.

Observed 'real-time' Sheffield traffic emissions

3.2.2 One of the recommendations from the Phase 1 study was to obtain data showing the actual 'on-street' emissions performance of Sheffield traffic, to check and understand the performance of different Euro categories of vehicles operating in the traffic conditions currently found within Sheffield's AQMA, rather than the 'expected' performance based on current default emissions modelling assumptions.

3.2.3 To obtain these 'real-time' emissions data, remote sensing of vehicle emissions at five sites in Sheffield was undertaken by ITS Leeds during 2013. The locations of the five sensing sites are shown in Figure 5.

Figure 5. Location of Remote Emissions Sensing Sites

3.2.4   The monitoring at each site included:

- vehicle detectors to capture speed and acceleration data;
- a camera to capture number plate data, allowing vehicle information to be obtained, including the Euro classification and vehicle type; and
- detection boxes to obtain emissions data.

A summary of the results from the observed emissions data collection is provided in Appendix E.

3.2.5   A key finding from the observed emissions data was the poor NO_x performance of EURO 5/V vehicles. This finding is in-line with current understanding of the NO_x performance of both light- and heavy-duty diesel vehicles in urban driving conditions[16] and is also backed up by results from other European studies[17]. The PM_{10} emissions from EURO 5/V vehicles were lower than emissions from earlier EURO classified vehicles. This finding helps explain why despite the recent investment in newer

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[16] http://uk-air.defra.gov.uk/reports/cat05/1108251149_110718_AQ0724_Final_report.pdf (page 47, last accessed 26 November 2013)

[17] http://www.tno.nl/downloads/real_world_nox_emissions_euro_v_vi_heavy_duty_vehicles.pdf last accessed 26 November 2013

technology in the Bus and OGV (>3.5T) fleets, NO_X emissions in urban areas have not been reducing as anticipated.

3.2.6   The resulting observed emissions distributions were used within the various appraisal tools described below, with the exception of Euro 6/VI, where there were generally insufficient observations to produce robust estimates of the relevant distributions.

3.2.7   These observed distributions predict significantly higher NO_X emissions from Sheffield's taxis than predicted by the default COPERT 4 V10 relationships, and generally lower-than-COPERT-based predictions of NO_X emissions from Sheffield's buses and goods vehicles. Further details of these differences are provided in slides 37 and 38 of Appendix L.

Vehicle Characteristics

3.2.8   One of the objectives for the Phase 2 Study was to use more accurate information on the current vehicle fleet in Sheffield, including Automatic Number Plate Recognition (ANPR) data. These data allow locally-calibrated fleet mix proportions to be used in the analysis, including a disaggregation by age, engine size and fuel type and separate identification of taxis within the traffic flow at different locations across the AQMA.

3.2.9   ANPR data for three weekdays - 12th, 13th and 20th March 2013 were provided for 19 locations across Sheffield, containing over 1.6 million observations. These were processed by Sheffield City Council and the Department for Transport, and completely anonymised in accordance with strict data protection protocols.

3.2.10   The data provided included vehicle characteristics including:

- vehicle type e.g. Car, Bus;
- vehicle make/model;
- propulsion type e.g. Petrol, Diesel, Hybrid electric; and
- date of first registration – used to allocate vehicles to the Euro Class in force in that year[18].

3.2.11   Separate summary ANPR data were provided for weekend observations, to allow the impact of increased taxi flows on Friday evenings to be included in the LEZ strategy development. These data were used to adjust the main ANPR data to achieve an 'average' 24-hour weekday (i.e. including Friday evening to reflect increased taxi usage) within the modelling and analysis.

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[18] This approach will mis-classify any vehicles which achieved a Euro standard earlier than required - the effect of this is likely to cancel out for the earlier EURO categories (1/I to 4/IV) but will lead to an underestimate of Euro 5/V and 6/VI categories

3.2.12   Fleet information from the bus companies was provided, specifying the propulsion type and Euro classification of their vehicles, including some route specific data. Additional detailed data regarding the vehicle characteristics of a) the various fleets owned and operated by Sheffield City Council and b) Sheffield's registered taxis was also provided and used to support additional detailed analysis of the on-street emissions monitoring information.

3.2.13   The summary fleet split data from the ANPR data is illustrated in the figure below. Additional details of the fleet-mix observed at the various ANPR survey sites, including fuel type and Euro classification proportions etc, are provided in Appendix F.

3.2.14   The key points emerging from the ANPR data were:

●   the increasing proportion through time of diesel cars in relation to petrol cars;
●   that 40% of the private cars are diesel; and
●   35% of OGVs (>3.5T) are EURO V, highlighting the significant investment this industry has made in acquiring new technology.
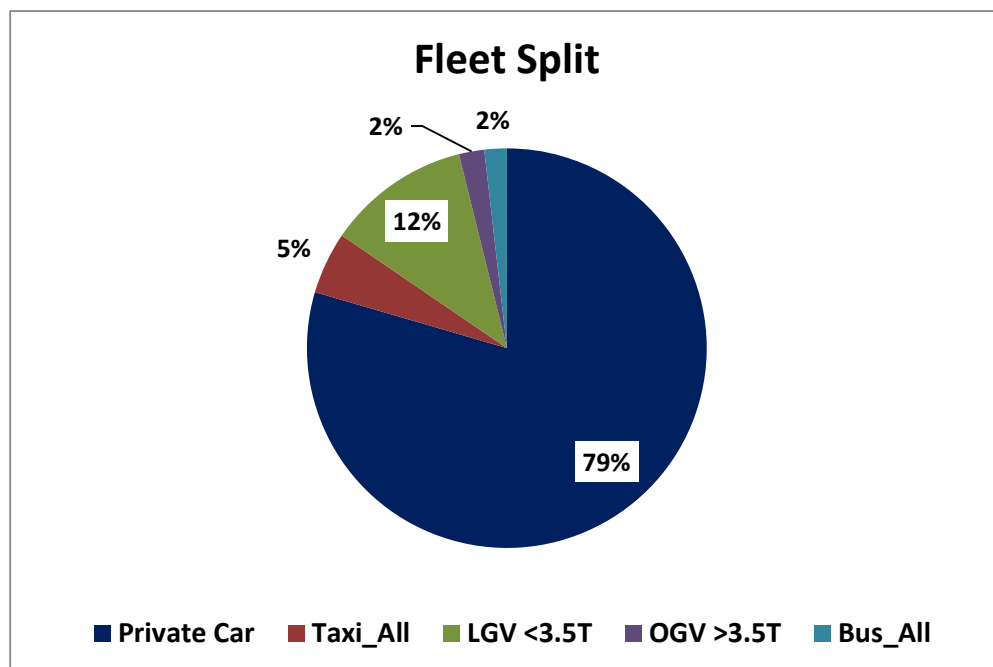
Figure 6. ANPR Fleet Summary

Traffic Representation

3.2.15   For the Phase 2 analysis, Sheffield City Council's transport model (SRTM3) was updated to reflect current traffic conditions. The base year was updated to represent 2012, using updated observed growth from traffic surveys and recommended assumptions, to establish a robust base for the emissions modelling. The assumptions regarding land-use and transport infrastructure changes are provided on slide 13 of Appendix L.

3.2.16   Sheffield City Council provided traffic count information which was used to adjust the highway traffic volumes in line with changes between 2008 (the base year of the transport model) and 2012. The way in which travellers value their time changes through time, and these assumptions were also modified in line with DfT guidance to reflect 2012 values. The growth factors and values of time used in the modelling are provided in Appendix F.

3.2.17   The bus service routes and frequencies in the transport model were also updated in line with current service patterns.

3.2.18   In a related study, a detailed traffic (microsimulation) model using AIMSUN modelling software was updated using data from the updated SRTM3 transport model. This detailed model was used in a separate research project for Defra to assess appropriate tools for modelling transport emissions, but was not used directly in the LEZ strategy development.

Emissions modelling

3.2.19   A number of tools were used for the appraisal and modelling of emissions.

3.2.20   As noted earlier, one of the key items for the Phase 2 study was the high level appraisal of different strategy types. **LESAT** is a low emissions strategy development tool developed by MVA, used for quick, high level appraisal of different transport strategies. The fleet summary data from the ANPR surveys and the observed emissions data collected in Sheffield's AQMA by Leeds ITS were input to the spreadsheet tool.

3.2.21   For vehicle types with few or no observed emissions for EURO 6/VI vehicles, the emissions data for all EURO 6/VI vehicles is based on the relevant published emissions standards and hence any degradation over time or issues in the emissions performance of these vehicles has not been included. This assumption is reasonable for the short timescales assumed here for the implementation and appraisal of the LEZ Strategy, but are likely to lead to an increasing under-estimate of more-distant future emissions. This is particularly relevant when we consider the impacts of the 'Wait and See' Do Minimum strategy.

3.2.22   LESAT identifies the contribution which each subset of the vehicle fleet will make to the emissions of the two main pollutants (NO_X and PM_{10})in any given future year, taking account of natural fleet renewal over time and the impacts of user-defined LEZ measures, which can be based on either a minimum EURO category or a maximum emission rate applied to the various input emissions distributions for each vehicle type and EURO category.

3.2.23   LESAT was used to identify the subsets of traffic which contribute most to current and future emissions within Sheffield's AQMA and to estimate the effectiveness, efficiency and cost-effectiveness of the various components of an emerging LEZ strategy.

3.2.24   For more detailed assessment of the transport emissions, **ENEVAL,** MVA's emissions modelling tool, was used. ENEVAL takes inputs directly from transport models, in this case the Sheffield City Council SRTM3 transport model, and produces transport-related emissions data. For this study, the focus was on NO_X and PM_{10} emissions. ENEVAL was updated to use the latest Defra accepted emissions factors (COPERT 4, Version 10).

3.2.25   Output emissions data from ENEVAL was passed to Sheffield City Council for detailed modelling in South Yorkshire's AIRVIRO model. This is a sophisticated air pollution dispersal model which applies the impacts of atmospheric chemistry, the effects of prevailing wind and relevant topographic details to the emissions from a range of sources, including transport, industry, commercial and residential heating, to predict local air quality across a wide area of South Yorkshire.

3.3   Approach to LEZ Development

3.3.1   The tools summarised in the previous section were used in combination to inform Steering Group meetings and derive the LEZ strategy.

3.3.2   The LESAT was first used to determine the reduction in NO_x emissions (as a proxy for future NO_2 concentrations), that would occur through 'Do Minimum' natural fleet renewal, with all new vehicles (post-2014) assumed to achieve EURO 6/VI emissions standards. This assumption accounts for the achievement of at least 50% of buses being EURO V or better by October 2017, which is currently in the Sheffield Bus Partnership Agreement between Sheffield City Council and local bus operators.

3.3.3   The following figure shows the output from the strategy tool, illustrating the contribution to NO_x and PM_{10} reductions by the different fleet types, resulting in a predicted 7% reduction in total road traffic NO_x emissions within Sheffield's AQMA, relative to current (early 2013) levels.

Table 3. Reduction in Emissions Through Natural Fleet Renewal 2015

Strategy Year	2015	Description	Do Min 2015	Accounts for fleet renewal from 2013 to Strategy Year	
Impact of Strategy		**Do Minimum**		**Do Minimum**	
Main Vehicle Type	**Vehicle Subclass**	**% Change in NO_x**	**% Contribution to Total Change in NO_x**	**% Change in PM_{10}**	**% Contribution to Total Change in PM_{10}**
Car	Private Car - Petrol	-18.3%	-3.3%	-10.9%	-2.0%
	Private Car - Diesel	-4.3%	-1.6%	-23.0%	-8.1%
	Private Car - Other	0.1%	0.0%	0.1%	0.0%
	Taxi_Hackney	2.6%	0.2%	-9.8%	-0.8%
	Taxi_Other	6.3%	0.2%	-15.9%	-0.5%
LGV <3.5T	LGV <3.5T	0.8%	0.1%	-19.7%	-3.9%
OGV >3.5T	OGV >3.5T	-13.3%	-1.4%	-13.0%	-0.9%
	Bus_SingleD	4.2%	0.2%	3.1%	0.1%
Bus	Bus_DoubleD	-18.1%	-1.2%	-0.7%	0.0%
Total		-6.8%	-6.8%	-16.1%	-16.1%

3.3.4   However, the analysis of Sheffield's current air quality monitoring data (as summarised earlier in Figure 3 of this report) suggests that up to 30% reduction in current NO_2 concentrations will be needed if the required 40μg/m^3 annual average concentration of NO_2 is to be achieved at all of the current air quality monitoring locations within Sheffield's AQMA.

3.3.5   Analysis with LESAT (presented in Table 4) showed that, as a best-case scenario it would be 2020 before emissions from road traffic delivered their 'fair share' of a 30% reduction in NO_2 concentrations at all of Sheffield's current AQ monitoring sites, as a result of natural fleet renewal through time. This best-case analysis of the Do Minimum 'Wait and See' policy includes a number of important 'optimistic' assumptions, including:

- no degradation in EURO 6/VI technology performance over time;
- no growth in current traffic levels;
- an X% reduction in NO_x emissions will deliver an X% reduction in annual average NO_2 concentrations; and
- all other sources of NO_x emissions will also deliver their 'fair share' of the required reductions.

Table 4. Reduction in Emissions Through Natural Fleet Renewal 2020

Strategy Year		2020	Description	Do Min 2020	Illustrates the year in which reduction in NOx of 30% would occur through fleet renewal alone
.					
Impact of Strategy		**Do Minimum**		**Do Minimum**	
Main Vehicle Type	**Vehicle Subclass**	**% Change in NO$_x$**	**% Contribution to Total Change in NO$_x$**	**% Change in PM$_{10}$**	**% Contribution to Total Change in PM$_{10}$**
Car	Private Car - Petrol	-44.8%	-8.1%	-30.2%	-5.4%
	Private Car - Diesel	-33.1%	-11.9%	-61.9%	-21.9%
	Private Car - Other	0.1%	0.0%	0.1%	0.0%
	Taxi_Hackney	-25.6%	-1.5%	-56.5%	-4.7%
	Taxi_Other	-14.8%	-0.5%	-73.9%	-2.3%
LGV <3.5T	LGV <3.5T	-31.0%	-4.8%	-48.4%	-9.5%
OGV >3.5T	OGV >3.5T	-51.5%	-5.5%	-37.5%	-2.6%
	Bus_SingleD	-14.3%	-0.5%	-39.3%	-1.3%
Bus	Bus_DoubleD	-30.7%	-2.0%	-44.2%	-2.3%
Total		-34.9%	-34.8%	-50.0%	-50.0%

3.3.6   This best-case analysis confirmed that simply waiting for 'Do Minimum' fleet renewal to reduce NO$_x$ emissions from road traffic to occur 'naturally' through time will take too long to reduce annual average concentration of NO$_2$ if the air quality objectives of a 40µg/m^3 is to be achieved at all of Sheffield's current AQ monitoring locations in anything close to the 2015 compliance timescale required by the EU.

3.3.7   A more-proactive LEZ strategy is therefore required for Sheffield's AQMA.

3.3.8   This strategy should:

○   be effective, by targeting subsets of the traffic which contribute significantly to current and future emissions of the two main pollutants;
○   focus on vehicles with high emissions rates;
○   be efficient – assessed through the %reduction in emission achieved divided by the number of vehicles which need to be upgraded to comply with the assumed LEZ strategy, taking account of the different amounts of time different fleets spend driving within Sheffield's AQMA; and

○ be cost-effective – taking into consideration the approximate cost of making the 'bad' vehicles compliant with the LEZ constraints[19].

3.3.9 All the above criteria were appraised using the modelling and tools employed in this study, ensuring a consistent appraisal of the different LEZ strategies.

3.3.10 Other key criteria for the LEZ strategy include:

○ non vehicle compliance costs associated with the delivery of the LEZ strategy;
○ deliverability (including public /political acceptability);
○ technical feasibility;
○ enforceability; and
○ affordability.

3.4 Description and Summary of Results of 'Components Testing'

3.4.1 To ensure compliance with the criteria listed in paragraph 3.3.6 above, analysis was undertaken to predict the key contributors to traffic emissions within the Sheffield AQMA area in 2015. Figure 7 shows that private cars will contribute just over 50% of NO_x emissions in 2015. The detailed breakdown of private car shows that diesel cars will contribute far more to these NO_x emissions than petrol cars, especially at the newer (i.e. post-EURO 3/III) end of the age range. Other Goods Vehicles (OGVs (>3.5T)) only comprise 2% of the fleet, but will be responsible for around 12% of the NO_x emissions in 2015.

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[19] Defined by a combination of the vehicle type and the scale of the upgrade implied by the LEZ constraints being appraised
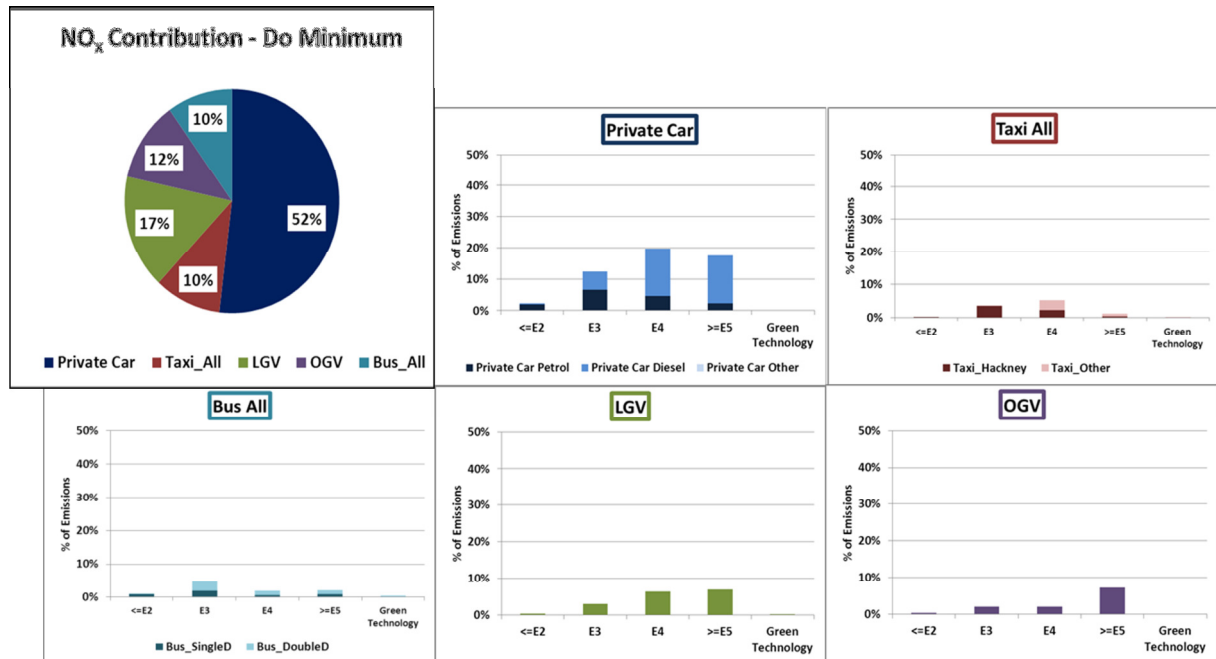
Figure 7. Contributors to NOₓ emissions (2015)[20]

3.4.2   Similar results for the contributors to PM_{10} are shown in Figure 8.

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[20] The E number refers to the EURO classification and represents both small and heavy duty vehicle types eg E5 represents EURO 5 for cars and LGVs <3.5T and EURO V for OGV (>3.5T) and Bus.
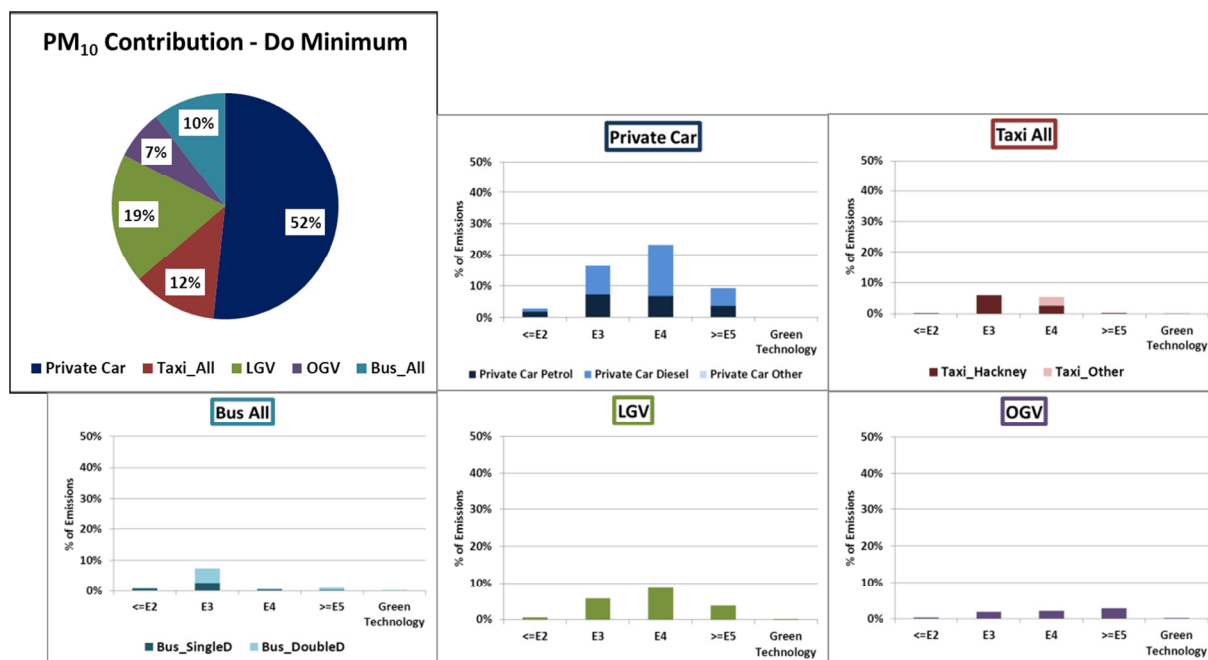
Figure 8. Contributors to PM$_{10}$ emissions (2015)

3.4.3   A 'pack' of example strategy components was developed using LESAT, showing different options of targeting different fleets (Table 5) with different levels of 'enthusiasm' (Table 6).

Table 5. Description of Strategy Component Options

OPTION	TARGETING
1	Bus & Taxi
2	Bus & Taxi & Goods Vehicles
3	Switching Diesel to Petrol (all feasible vehicle types)
4	Tackling Diesel Car (Private Car only)

Table 6. Description of Strategy Achievement

STRATEGY ACHIEVEMENT	ACHIEVEMENT DESCRIPTION
Very Low	0-5% NO$_x$ emission reduction
Low	5-10% NO$_x$ emission reduction
Medium	10-20% NO$_x$ emission reduction
High	20-30% NO$_x$ emission reduction
Excessive	30%+ NO$_x$ emission reduction

3.4.4   Summary results from the LEZ strategy component analysis are provided in the following sections. More-detailed results for each LEZ strategy option are provided in Appendix H.

3.4.5   The cost metrics were purely used as a broad, consistent comparator between the different options appraised. The cost reflects only an approximation of the cost to upgrade vehicles to make them comply with the measure, and in the case of bus upgrades it has been assumed that 50% would be achieved through retrofitting and the remaining 50% through the purchase of compliant vehicles[21]. The costs do not take into account the natural fleet renewal through time or additional costs such as required infrastructure, on-going costs required with Selective Catalytic Reduction technology etc. The costs of switching diesel vehicles to petrol have not been included as diesel costs are commonly more expensive than their petrol counterparts and the main costs involved with such a measure would be 'nuisance costs' and running costs, which are more expensive for petrol vehicles.

3.4.6   The 'cost per 1000 vehicles' metric takes into account the relative size of the various fleets and the costs of upgrading different vehicle types – for example, if a scenario consists of just upgrading 50% of the taxi fleet and taxis comprise 5% of the total fleet of vehicles using Sheffield's streets, then 25 out of 1000 fleet vehicles would be affected and the cost per vehicle would be the difference between the values of the current and upgraded taxis.

3.4.7   The following bands have been used in the classification of this 'Cost per 1000 vehicles' indicator.

Table 7. Description of Cost Per Fleet of 1000 Vehicles (£m)

DESCRIPTION	COST PER 1000 VEHICLES (£M)
Very Low	<1
Low	1-5
Medium	5-10
High	10+

3.4.8   In the summary results, 'High' Efficiency and Cost-Effectiveness metrics are desirable attributes, while a 'High' Cost Per 1000 Vehicles is an undesirable attribute.

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[21] Compliant vehicles are not necessarily newly manufactured vehicles as for some option components, existing technology eg EURO 5/V are specified. In the measures in which a maximum emissions rate is specified, EURO 2/II vehicles could still be utilised as long as they comply with the specified emissions rate.

Option 1 – Targeting Bus and Taxi

3.4.9 A series of Bus and Taxi measures were assessed:

- Minimum of EURO 5/V compliance;
- Minimum of EURO 6/VI compliance;
- Maximum emission rate with very low, low and medium strategy achievement[22] - in these tests the observed emissions profile was adjusted so that the stated maximum value was not exceeded; and
- For the medium achievement strategy, the bus and taxi contributions were assessed separately to show the individual 'NO$_x$ reduction efficiency' of each fleet.

3.4.10 The results from these strategy component tests are presented in the following table, showing the effectiveness in reducing NO$_x$, the percentage of the total fleet affected and the relative 'efficiency' of the strategy. The %reduction in emissions includes the reduction achieved through natural fleet renewal. Higher values for the efficiency measure indicate more efficient strategies (i.e. more emission reduction per vehicle affected) than those with lower values.

3.4.11 The results show that specifying a minimum EURO 5/V-based standard would only have a low achievement in reducing NO$_x$, whereas only allowing EURO 6/VI within the Sheffield AQMA would be reasonably effective – reducing NO$_x$ emissions by almost 20% by 2015. The three emissions rate targeting sub-options showed medium achievement, even when targeting large proportions of the fleet (75-85% of both bus and taxi fleets). Splitting out the contributions for bus and taxi separately shows that the bus element is a more efficient strategy measure than the taxi portion.

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[22] A bus and taxi strategy alone could not result in a 'high' strategy achievement

Table 8.   Option 1 – Targeting Bus and Taxi results

Option	Strategy Component Description	Effectiveness (Total NO$_x$ Reduction)	% Total Fleet Affected	Efficiency (NO$_x$) higher = more efficient	Cost per fleet of 1000 vehicles (in total fleet) £m	Cost Effectiveness (% NO$_x$ reduction per £m for fleet upgrade)
Option 1a - Bus Taxi EuroA	Bus and Taxi Euroclass strategy (low achievement) - Taxi E5+ - Bus E5+	8%	5%	Very Low	Low	Very Low
Option 1b - Bus Taxi EuroB	Bus and Taxi Euroclass strategy (medium achievement) - Taxi E6 - Bus E6	19%	6%	High	Low	Low
Option 1c - Bus Taxi ERA	Bus and Taxi Emission rate (medium achievement) - proportion of each fleet type affected - 30-40%	12%	2%	High	Very Low	High
Option 1d - Bus Taxi ERB	Bus and Taxi Emission rate (medium achievement) - proportion of each fleet type affected - 60-70%	16%	4%	High	Low	Medium
Option 1e - Bus Taxi ERC	Bus and Taxi Emission rate (medium achievement) - proportion of each fleet type affected - 75-85%	18%	5%	High	Low	Low
Option 1f - Bus ERCb	Bus Emission rate (medium achievement separated) - proportion of fleet type affected - 75-85%	12%	1%	High	Low	Low
Option 1g - Taxi ERCt	Taxi Emission rate (medium achievement separated) - proportion of fleet type affected - 75-85%	13%	4%	High	Very Low	Medium

Option 2 – Targeting Bus, Taxi and Goods Vehicles

3.4.12 The second option assessed LEZ strategy components targeting Bus, Taxi and Goods vehicle fleets. The types of options tested were similar to those in Options 1:

- Minimum of EURO 5/V compliance;
- Minimum of EURO 6/VI compliance; and
- Maximum emission rate with low, medium and high strategy achievement.

3.4.13 The results of the Option 2 LEZ strategy components assessed are presented in Table 9. Setting a minimum EURO 5/V standard would have a very low achievement, due to the poor performance of all fleet types, in particular OGVs (>3.5T) (the reduction in NO$_x$ for this sub-option is actually *lower* than that achieved through fleet renewal alone to 2015). However, specifying a minimum EURO 6/VI standard would achieve a greater than 40% ('excessive') reduction in NO$_x$. The component options in which a maximum emission rate was specified for each fleet type all have similar efficiency measures.

Setting maximum emission rates that would affect 50-65% of the bus, taxi and goods vehicle fleets would achieve around 27% reduction in total NO_x emissions in 2015.

Table 9. Option 2 – Targeting Bus, Taxi and Goods Vehicle Results

Option	Strategy Component Description	Effectiveness (Total NO$_x$ Reduction)	% Total Fleet Affected	Efficiency (NO$_x$) higher = more efficient	Cost per fleet of 1000 vehicles (in total fleet) £m	Cost Effectiveness (% NO$_x$ reduction per £m for fleet upgrade)
Option 2a - Bus Taxi GVs EuroA	Bus, Taxi, Goods Vehicles Euroclass strategy (very low achievement) - Taxi E5+ - Bus E5+ - Goods E5+	5%	13%	Very Low	Medium	
Option 2b - Bus Taxi GVs EuroB	Bus, Taxi, Goods Vehicles Euroclass strategy (excessive achievement) - Taxi E6 - Bus E6 - Goods E6	40%	19%	Low	High	Low
Option 2c - Bus Taxi GVs ERA	Bus, Taxi, Goods Vehicles Emission rate (medium achievement) - proportion of each fleet type affected - 10-25%	14%	4%	Medium	Very Low	High
Option 2d - Bus Taxi GVs ERB	Bus, Taxi, Goods Vehicles Emission rate (high achievement) - proportion of each fleet type affected - 35-45%	22%	8%	Medium	Low	Medium
Option 2e - Bus Taxi GVs ERC	Bus, Taxi, Goods Vehicles Emission rate (high achievement) - proportion of each fleet type affected - 50-65%	27%	11%	Medium	Medium	Low

Option 3 – Tackling Diesel Vehicles (all applicable Vehicle Types)

3.4.14   In the third option, all diesel vehicles were targeted. The sub-options tested were:

- Light vehicles (private car, LGV (<3.5T), private hire taxis) switching from diesel to petrol; and
- All diesel vehicles switch to an appropriate lower emission fuel/technology (i.e. petrol-based for light vehicles and 'green technology' such as Compressed Natural Gas (CNG) /Biomethane or hybrid electric for Heavy Duty vehicles (buses, hackney taxis and OGVs (>3.5T).

These options assumed that 100% of the relevant diesel vehicles switched to the new fuel. However, the results for lower proportions of the fleet switching can be estimated *pro rata* from the 100% results shown in Table 10.

3.4.15   Due to the poor performance (in NO_x and PM_{10} terms) of diesel cars, switching to other fuel types has a significant impact on emissions. The results show that a 100% shift away from diesel would deliver a 66% reduction in NO_X emissions from road traffic in 2015, much more than would be required if traffic is only aiming to deliver its 'fair share'

of the 30% reduction in current NO_2 concentrations implied by the current air quality monitoring data. The relative efficiency of these two sub-options are not particularly high due to the large number of vehicles that would need to be replaced in such a strategy.

3.4.16 However, persuading a portion of the diesel fleet to switch to lower emissions alternatives, in conjunction with specific other technology measures targeted at vehicles which spend large amounts of time driving within the AQMA, is likely to increase the overall effectiveness of the strategy, particularly if this 'switch from diesel' policy can be targeted at the high end of the emissions rate (g/Km) distribution.

Table 10. Option 3 – Tackling Diesel Vehicles Results

Option	Strategy Component Description	Effectiveness (Total NO_x Reduction)	% Total Fleet Affected	Efficiency (NO_x) higher = more efficient	Cost per fleet of 1000 vehicles (in total fleet) £m	Cost Effectiveness (% NO_x reduction per £m for fleet upgrade)
Option 3a - Dies-Pet only	100% Diesel Vehicles Switch to Petrol - affecting Car, LGV, Taxi PHV	45%	46%	Very Low		
Option 3b - Dies-Pet_CNG	100% Diesel Vehicles Switch to Petrol or CNG/equivalent - Petrol for Car, LGV, Taxi PHV - CNG for Taxi Hackney, OGV, Bus	63%	52%	Low	High	Low

Option 4 – Tackling Diesel Cars (Private Car only)

3.4.17 Two sub-options were assessed when considering the option of tacking diesel private cars. These were:

- Switching diesel cars to petrol;
- Removing diesel cars (i.e. not replacing them).

3.4.18 The results of these sub-options are provided in Table 11. Again, 100% of the diesel cars have been assumed to be switched or removed and the results can be pro-rated for lower proportions of the fleet affected. As with the Option 3 results, both sub-options have low relative efficiency measures, due to the large number of vehicles they affect. The results for the 'Removing Diesel' option (Option 4b) exclude both the beneficial secondary impacts of the traffic reduction (in terms of reduced congestion possibly leading to more-efficient driving conditions for the remaining traffic) and the potential economic and political disbenefits of 'driving away the motorist' from Sheffield City Centre. No indicative vehicle upgrade cost related metrics have been calculated for this Option.

Table 11. Option 4 – Tackling Diesel Private Cars Results

Option	Strategy Component Description	Effectiveness (Total NO$_x$ Reduction)	% Total Fleet Affected	Efficiency (NO$_x$) higher = more efficient
Option 4a - Diesel Car switch	100% Diesel Cars Switch to Petrol	33%	32%	**Very Low**
Option 4b - Diesel Car remove	100% Diesel cars removed and not replaced	41%	32%	**Low**

3.5 Description and Summary of 'Softer Measures' Considered

3.5.1 In addition to formal LEZ measures which affect the mix of traffic using the streets within Sheffield's AQMA, we have considered a wide range of 'non-technology-based' measures which might be encouraged to reduce emissions from the existing vehicle fleet. A number of these are summarised and discussed in this section. Additional 'Case Study' summaries and other relevant details are provided in Appendix I.

More-efficient Driving

3.5.2 Few existing drivers drive as efficiently as possible and experience has shown that a combination of the correct 'message' (i.e. focussing on fuel savings which benefit the individual, rather than emissions reduction, which are often perceived as only benefitting 'others' outside the vehicle) can encourage changes in driving style which result in fuel savings and, by implication, emissions reductions.

3.5.3 The key features include:

- driving smoothly in a high gear (to reduce engine revs but avoiding 'engine labouring');
- smooth and early gear changes during acceleration (again to avoid high engine revving);
- observing and anticipating traffic conditions ahead (to try to maintain a steady speed and avoid the need for hard braking and re-acceleration);
- avoiding extra drag caused by roof-racks, trailers etc
- minimising the use of air conditioning; and
- regular checks of tyre pressure (and knowing the correct tyre pressure for the vehicle and its load) etc.

3.5.4   The UK's Energy Savings Trust[23] estimate that '*by driving smarter the average UK driver could save between £300 and £350 each year*', so that, in theory, this 'average driver' would quickly save more than the cost of a typical 'eco-driving' training course.

3.5.5   However, it is likely to be more efficient to pass on as many of the these tips as possible to the general public through appropriate communications campaigns and focus any expenditure on driver training on those who 'drive for a living' (taxi drivers, freight operators, 'white van man' etc), ideally within a wider 'fleet efficiency' programme – see below

More-efficient Fleet/Logistics Operations

3.5.6   There are a number of schemes designed to encourage organisations that own and/or operate fleets of vehicles to operate these fleets more-efficiently (and safely). Many of the measures which these schemes promote are designed to save fuel and these measures will generally, reduce emissions of both greenhouse gases and air pollutants.

3.5.7   The two most-prominent schemes within the UK are the Fleet Operators Recognition Scheme (FORS)[24] operated by Transport for London and the Eco Stars scheme[25] operated by Transport and Travel Research Ltd. (TTR) on behalf of South Yorkshire and other UK schemes..

HGV Routing

3.5.8   In 2012 Sheffield City Council approved a report seeking approval for '*an HGV Route Network for journeys through Sheffield and into the city, a process and criteria for assessing HGV problems and a hierarchy of measures to deal with them*' and '*continuing work to develop proposals to dealing with some HGV spots and getting information to the SAT NAV companies and Freight Industry*'.

3.5.9   The follow-on work is on-going and has the potential to reduce the amount of HGV traffic through the AQMA area, particularly through traffic from Derbyshire to the M1.

Improved Signing and Real-time Information

3.5.10   Improved signing, including real-time information could help direct traffic away from congested areas within the city centre leading to more efficient traffic flows and reduced emissions, especially in areas with air quality problems. It may also reduce emissions from 'lost-driver' traffic. This real-time information could be provided from a purely congestion-minimisation/avoidance perspective, or as part of a wider air quality

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[23] http://www.energysavingtrust.org.uk/Travel/Driving

[24] http://www.fors-online.org.uk/

[25] http://www.ecostars-europe.eu/en/

management process (i.e. in response to observed or predicted episodes of poor air quality in particular locations or areas).

Measures to Promote Reduced Car Use

3.5.11   It probably goes without saying that any measures which succeed in reducing car use will help to reduce emissions from road traffic. The possibilities here include:

- 'Hearts and minds' campaigns highlighting the disbenefits of car use, encouraging active travel and increased use of (low-emission)public transport modes;
- investment in walking and cycling infrastructure;
- maintaining or improving the quality of the public transport alternatives to car use;
- personalised travel planning to increase awareness of the alternatives to car use;
- travel Plans within large organisations; and
- use of Planning Controls.

3.5.12   Any increase in active modes will provide additional health benefit from the additional exercise) and any reduction in traffic will have the potential to create additional 'secondary' emissions benefits, if the traffic which remains can operate an more-efficient speeds (e.g. avoiding stop-start congested driving conditions).

Peak-Spreading (including Night-time deliveries)

3.5.13   Any measures which shift traffic from congested stop/start driving conditions to periods with more-efficient traffic conditions are likely to generate emissions benefits, both for the vehicles which switch to the less-congested time period and for those who benefit from the resulting reduction in the peak-hour congestion.

3.5.14   This measure could be incorporated within a communications strategy (encouraging car users to avoid the peaks, ideally including an estimate of the potential time savings to those who are being encouraged to switch) and/or within a real-time information strategy.

3.5.15   This measure could also include a move towards more night-time deliveries of goods. However, care is needed to ensure that the other impacts of such a move (increased night-time noise and the additional costs to the freight operator and those receiving the goods) do not offset the (probably-fairly-small) emissions benefits which would result.

Eliminating Vehicle Idling

3.5.16   There may be the potential for further reduction/elimination of unnecessary vehicle idling, particularly at taxi ranks and in bus stations / at bus stops or termini.

Planning Controls

3.5.17   Many of the LEZ measures (in terms of the emissions performance of vehicles allowed to operate to/from and through given locations) could initially be enforced via planning controls on new developments (and will therefore be considered as part of the delivery mechanism for the harder engine-technology-based measures discussed earlier).

3.5.18   However, the Planning System can also be used to deliver softer measures, by encouraging more-sustainable travel (through the requirement for (and monitoring of) effective Travel Plans for new developments and large existing organisations), the creation of urban environments which are conducive to active travel and public transport use, etc.

3.6   Consideration of Delivery Mechanisms

3.6.1   The consideration of how the various 'hard' engine-technology and 'softer' behavioural change measures were combined to derive the preferred LEZ Strategy is described in the next chapter (where we consider the costs and barriers within our appraisal of the preferred strategy) and in the final chapter (where we recommend a series of 'Next Steps').

4. PREFERRED LEZ

4.1 Description of Preferred LEZ Strategy

4.1.1 For the preferred LEZ strategy, it was considered that a geographically-defined enforced LEZ for Sheffield was not necessarily the best solution. Research has shown that introducing an LEZ of this type in regional cities with a lower population density is not as successful as in large cities like London. It would be expensive and likely to push problems into neighbouring areas and could be detrimental to Sheffield's economy. It should be noted that the London LEZ only targets PM_{10} currently from Buses and Goods Vehicles. From 2015, NO_x standards will apply for buses only. To achieve these objectives, Transport for London (TfL) have funded mass retro-fit programmes to make vehicles comply with the relevant standards. TfL have also subsidised on-going costs such as the Diesel Exhaust Fluid (AdBlue) consumed by the Selective Catalytic Reducers (SCRs) used to reduce NO_x emissions.

4.1.2 A similar LEZ feasibility study undertaken for Newcastle/Gateshead (which is more similar an urban area to Sheffield) concluded that the economic costs of introducing a formal enforced LEZ outweighed the potential benefits[26].

4.1.3 Table 1 contains examples of existing LEZs in Europe with current, and future standards. As can be seen by looking at the results in Section 3.4, the Euro classes specified in Appendix C and the emissions data collected in Sheffield in Appendix E, the specification of many of these existing LEZs are not particularly stringent, and would be insufficient in addressing the air quality problems caused by traffic in Sheffield.

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[26] Newcastle/Gateshead Low Emission Zone Feasibility Study, September 2013

Table 12. Low Emissions Zones in Europe[27]

VEHICLE TYPE	LEZ	EMISSIONS STANDARD 2012	FUTURE EMISSIONS STANDARD
Lorries only	Netherlands	EURO 4 (PM)	EURO 4 (1/7/13)
	Motorway A12, Austria	EURO 2/3	
	Steiermark Province & Graz, Austria	EURO 2	EURO 3 (1/1/14)
	Mont Blanc Tunnel, FR/IT	EURO 3	
	Prague, CZ	EURO 2	
	Budapest, Hungary	Differential parking charges	
Heavy duty vehicles	London, UK	EURO 4 (PM)	
	Denmark	Fit Filter if less than EURO 4	
	Sweden	8 years old / EURO3	
Vehicles with 4+ wheels	Germany	EURO 2-4 (PM) & EURO 1 Petrol	EURO 3-4 (PM) & EURO 1 Petrol
	Lisbon, Portugal	EURO 1 or EURO 2	Planned: EURO 3 all (Jan 2014)
	Greece, Athens	EURO 1/EURO 4	
All vehicles	Italy	EURO 1-4 / no 2-stroke motorcycles	EURO 2-4 / no 2-stroke motorcycles
Local buses under agreements	Norwich, UK	EURO 3 (NO_X)	
	Oxford, UK	None	EURO V (1/1/14)
Vans	London, UK	EURO 3(PM)	
	Germany	EURO 2-4 (PM) & EURO 1 Petrol	EURO 3-4 (PM) & EURO 1 Petrol
	Italy	EURO 1-4 / no 2-stroke motorcycles	EURO 2-4 / no 2-stroke motorcycle
	Under consideration in some Dutch cities		EURO 4 from July 2013; EURO 4 with particle filter from January 2015.

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[27] http://www.lowemissionzones.eu/overview-of-lezs?showall=&limitstart= last accessed 20 November 2013

4.1.4   An LEZ strategy was defined which aimed to reduce the air quality impacts by all vehicle fleets driving in the Sheffield area, through a range of 'technology' and 'softer' behavioural measures. Rather than aim to reduce all sites below the specified air quality objective levels, which would be overly excessive for the majority of sites, an achievable LEZ strategy was defined that ameliorates the traffic emissions at most sites. Further action (through localised transport measures, or other industries reducing their emissions more than needed) will be required to address the remaining problem sites.

Technological Measures in the Preferred LEZ Strategy

4.1.5   The preferred LEZ strategy contains the following technological measures:

- Minimum EURO 6/VI for buses;
- Maximum emissions rate targets for:

  - OGV (>3.5T) - affecting the 'worst' 10% of the fleet
  - LGV (<3.5T) – affecting the 'worst' 15% of the fleet
  - Taxis – affecting the 'worst' 50% of the fleet

Softer Measures in the Preferred LEZ Strategy

4.1.6   Based on the types of softer measures discussed in Section 3.5, it is considered that the following further features could be achieved as part of the LEZ strategy:

- 10% private cars switching from diesel to petrol; and
- 5% removal in petrol and diesel private cars and OGVs (>3.5T), such as through re-routing, peak spreading, more efficient operations.

4.2   Impacts of the Preferred LEZ

4.2.1   The impacts of the preferred LEZ strategy were assessed in the LESAT in two steps. The first assessed the impacts of the emissions rate and Euroclass targets while the second included the additional changes to the fleet through softer measures such as 'Hearts and Minds' and eco-driving. The summary results of the LESAT analyses are contained in Table 13, and the detailed LESAT results are provided in Appendix J. The efficiency metric has not been calculated when considering the inclusion of the softer measures. The LESAT results show that the preferred strategy would result in approximately a 25% reduction in NO_x emissions across the Sheffield area, 7% of which is the natural fleet renewal aspect by 2015. The reduction in emissions at different sites within the city would be different dependent on the proportion of the different fleet types travelling through the sites.

**Table 13. Preferred LEZ Strategy Effectiveness and Efficiency**

Option	Strategy Component Description	Effectiveness (Total NO_x Reduction)	% Total Fleet Affected	Efficiency (NO_x) higher = more efficient	Cost per fleet of 1000 vehicles (in total fleet) £m	Cost Effectiveness (% NO_x reduction per £m for fleet upgrade)
PreferredStratA - Targets	Preferred Strategy A - Setting Emission Rate and Euroclass Targets	20%	6%	Medium	Low	Medium
PreferredStratB-Targets&Fleet	Preferred Strategy B - Setting Emission Rate and Euroclass Targets and Fleet Changes	25%	12%		Low	

4.2.2 Modelling was undertaken in ENEVAL to show how the strategy performs at a more detailed level across the city. Figure 9 presents the detailed transport NO_x emissions for the Do Minimum (fleet renewal) element at 2015, while Figure 10 shows the Do Something scenario, which also contains the other strategy measures. Yellow, orange and red indicate increasing emissions levels in these figures.

Figure 9. ENEVAL Transport NO_x Emissions – 2015 Do Minimum (Fleet Renewal)
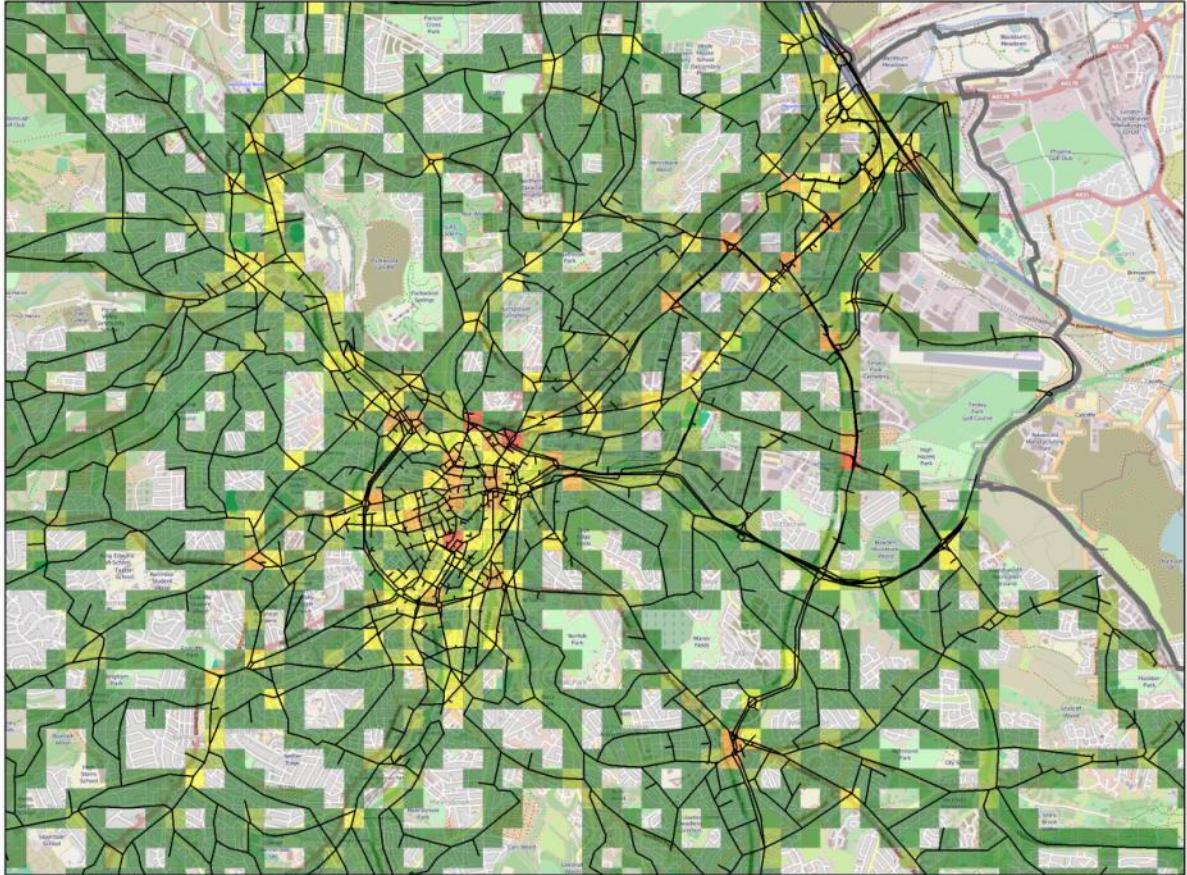
Figure 10. **ENEVAL Transport NO$_x$ Emissions – 2015 Do Something (LEZ Strategy)**

4.2.3   To illustrate the contribution of the non-fleet renewal aspects of the LEZ to the reduction in emissions, Figure 11 presents the differences in NO$_x$ emissions between the Do Something and Do Minimum. This figure illustrates the significant reduction in NO$_x$ through the preferred LEZ strategy.
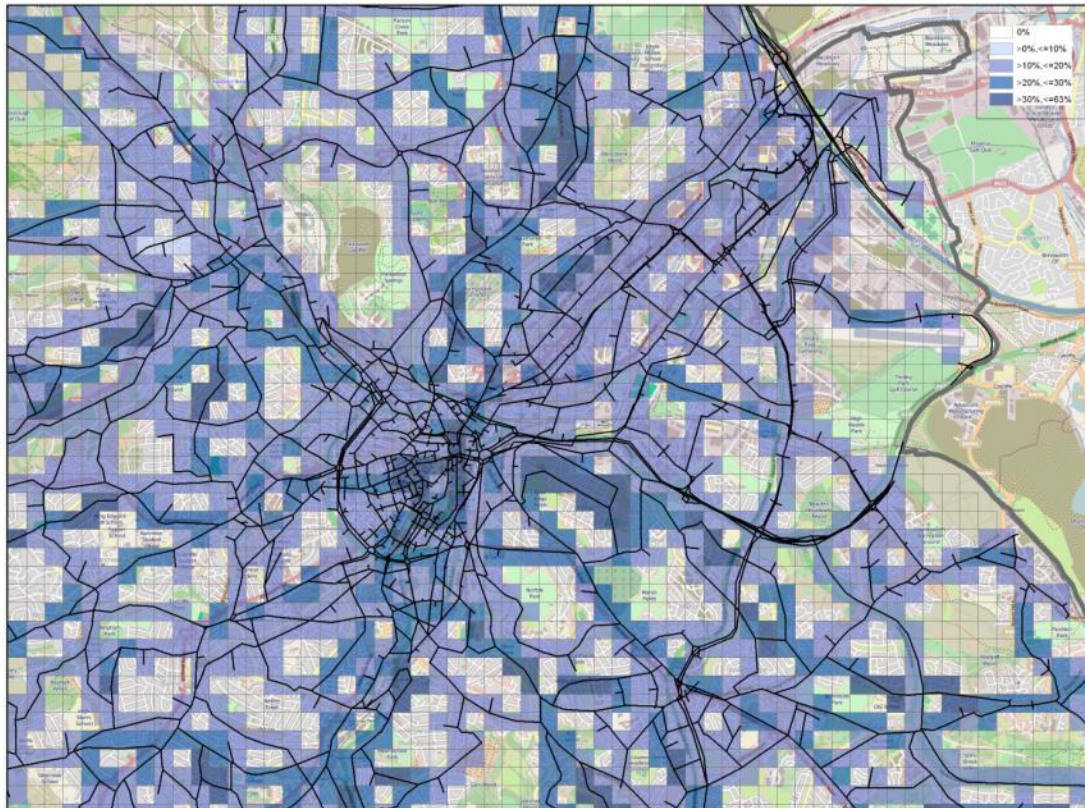
Figure 11.   **Transport NO$_x$ Emissions – LEZ Strategy Impacts (2015 Do Something - 2015 Do Min)**

4.2.4   Figure 12 shows the %reduction still required at the identified problem sites, post implementation of the preferred LEZ strategy. The figure shows that most of the sites require no further reduction in NO$_2$, indicated in green, on the simplifying (and optimistic) assumption that an X% reduction in NO$_X$ emissions will lead to an X% reduction in annual average NO$_2$ concentrations.

4.2.5   At these sites, the proposed transport strategy has successfully tackled it's 'fair share' of NO$_X$ emissions, and if other sectors were to reduce their emissions at these sites , it is likely that the NO$_2$ annual average exceedance will have been addressed. There are a number of sites that require further reductions, where the transport LEZ strategy has not sufficiently tackled the air quality problems. At these sites, the other sectors must reduce their emissions a little further, or additional localised transport measures such as active traffic management, may be required, in order to reduce NO$_X$ emissions by the required amount.

4.2.6   Table 14 provides a breakdown of the number of sites within each 'percentage reduction band' before and after the implementation of the LEZ. This breakdown shows that the LEZ has been effective in 33 out of the 51 sites and the remaining 18 will require further measures.
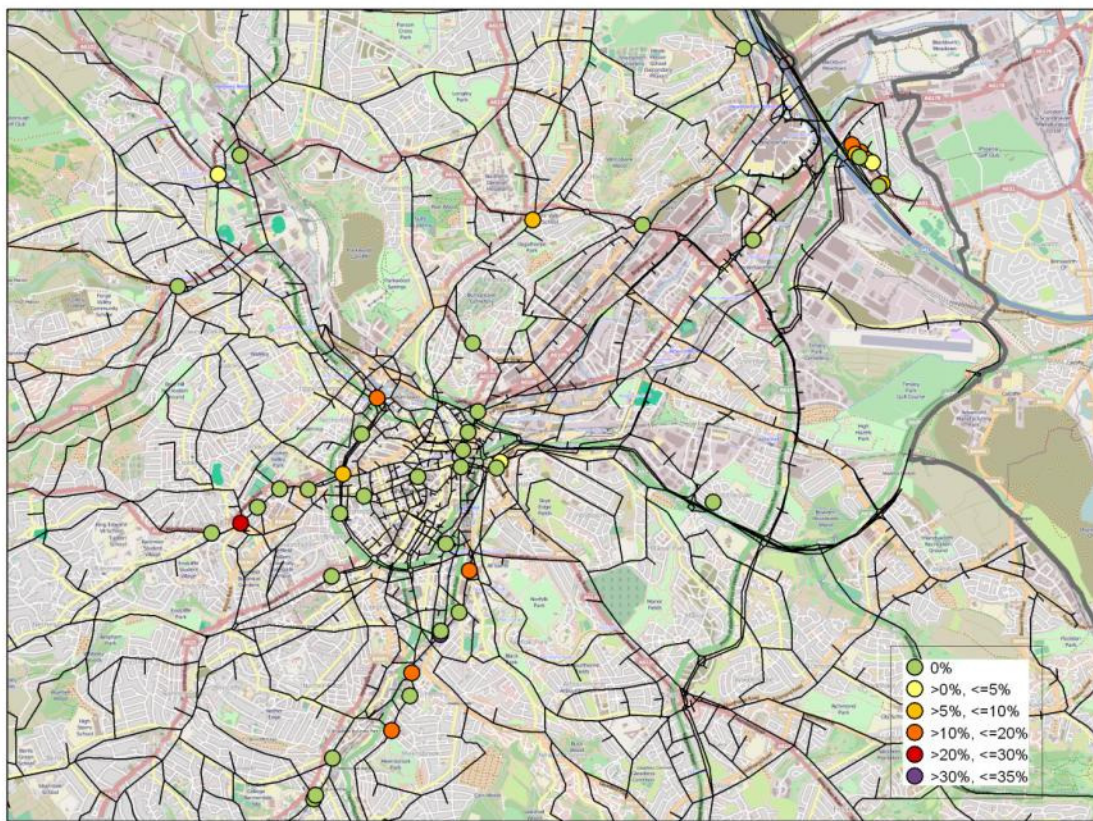
Figure 12.   **%Reduction in NO$_2$ Concentrations Required Post LEZ Strategy**

Table 14. Predicted number of sites exceeding NO$_2$ limit Pre and Post LEZ Strategy

PERCENT REDUCTION REQUIRED	NUMBER OF SITES (PRE-LEZ STRATEGY)	NUMBER OF SITES (POST-LEZ STRATEGY)
0%	10	33
0-5%	8	2
5-10%	12	6
10-20%	13	8
20-30%	8	1
30%+	0	1
Total	**51**	**51**

4.2.7   A detailed breakdown of the strategy impacts at each of the sites is provided in Appendix K, and shows that transport has more than tackled its 'fair share' at 44 of the 51 sites.

4.2.8   Figure 13 shows the sector breakdown of the predicted remaining emissions at sites exceeding the NO_2 limit in 2015, post implementation of the preferred LEZ strategy. This figure illustrates that specific localised measures by the relevant sectors might be advised in order to control the emissions at the different sites. Road traffic remains a contributor to the emissions at all the sites, and at some sites local traffic measures could be used to manage traffic more effectively.
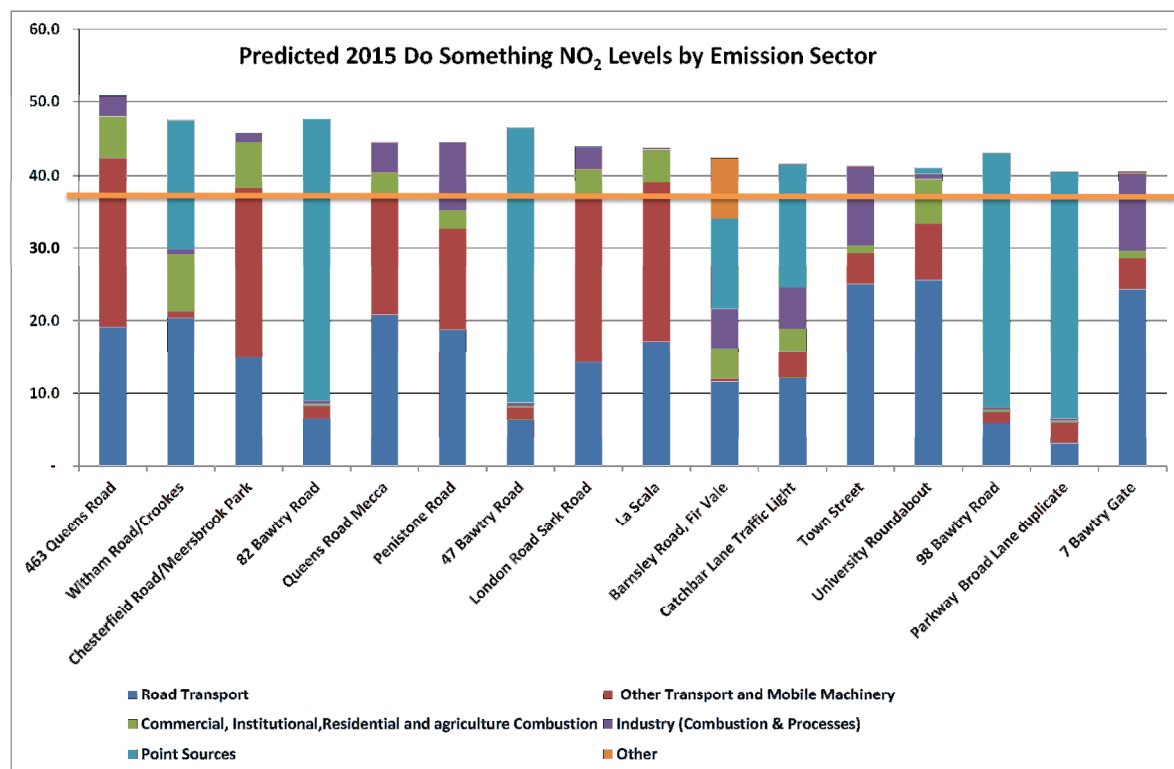
Figure 13.   Predicted Apportionment of Remaining Emissions Post LEZ Strategy

4.2.9   The reductions in PM_{10} from ENEVAL are shown in Figure 14. These result from the EURO VI standard from buses and the softer measures considered in the LEZ strategy, as no maximum PM_{10} emissions rates were specified for the other fleets. The figure shows a noticeable reductions in PM_{10} across the Sheffield AQMA, with significant reductions in the city centre.
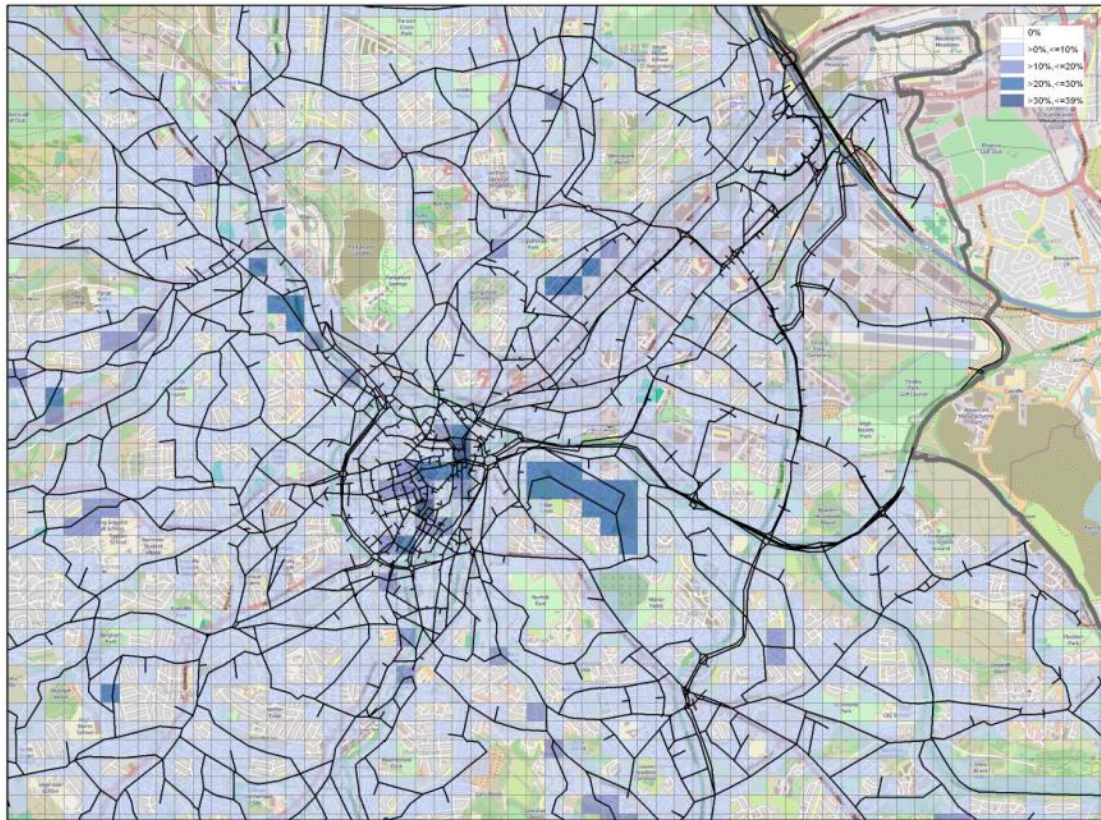
Figure 14. Transport PM$_{10}$ Emissions – LEZ Strategy Impacts (2015 Do Something - 2015 Do Min)

4.2.10 The ENEVAL transport emissions were passed to the Sheffield City Council AIRVIRO model for detailed emissions modelling. Table 15 presents the predicted number of sites exceeding the NO$_2$ limit value before and after the LEZ strategy. The number of sites within each band pre LEZ strategy is similar to those shown in Table 14, with slightly higher numbers in the higher bands. The AIRVIRO results post LEZ strategy again show the strategy has been effective in improving the predicted air quality at many of the sites, although the results are more conservative than in the more simplistic modelling used in the LEZ strategy development. This is due to the more sophisticated dispersal modelling undertaken by AIRVIRO which includes the effects of wind, buildings and canyons etc.

Table 15. Predicted number of sites exceeding NO$_2$ limit Pre and Post LEZ Strategy in AIRVIRO

PERCENT REDUCTION REQUIRED	NUMBER OF SITES (PRE-LEZ STRATEGY)	NUMBER OF SITES (POST-LEZ STRATEGY)
0%	9	21
0-5%	7	8
5-10%	12	6
10-20%	10	9
20-30%	6	6
30%+	7	1
Total	**51**	**51**

4.2.11   Figure 15 presents a comparison between the AIRVIRO and ENEVAL sites predicted to exceed the NO$_2$ objective level values after the implementation of the LEZ strategy. The figure shows a similar level of exceedance at many of the sites, while others show greater variation. Sheffield City Council should use the detailed results from AIVIRO, including the breakdown of emissions by sector, to determine the localised measures needed to reduce the residual measures within the air quality limit values. PM$_{10}$ results from AIRVIRO could also be reviewed to confirm the levels are reducing as predicted.
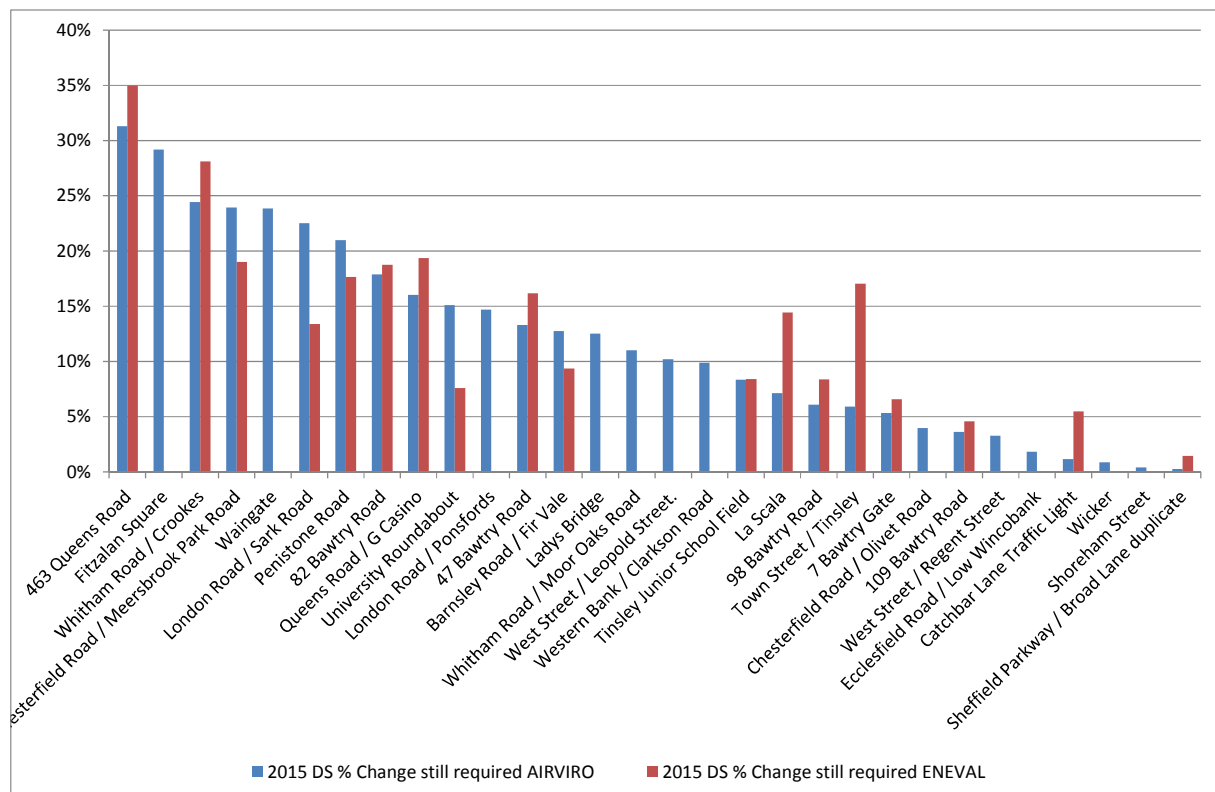
Figure 15. **Comparison of Sites Exceeding NO$_2$ limit Post Strategy AIRVIRO and ENEVAL**

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5. RECOMMENDATIONS AND NEXT STEPS

5.1 Recommendations

5.1.1 The preceding chapters have described the development of an efficient and cost-effective LEZ Strategy for tackling road traffic's 'fair share' of Sheffield's current air quality issues.

5.1.2 Once this report and its implications have been agreed by Sheffield City Council, there will be a need for all stakeholders, including Sheffield City Council and its neighbours, Defra, the Department for Transport, South Yorkshire PTE, the relevant Health Boards, Local Enterprise Partnership, Sheffield's bus and taxi operators, freight organisations and the operators of large local vehicle fleets to actively support the delivery of the various policies and measures identified in this report.

5.1.3 There is also an urgent need for a marketing and communications campaign to raise public awareness of the need to tackle local air quality and increase support for the LEZ Strategy, as part of a wider AQMA-wide emissions strategy.

5.1.4 In this chapter we list a number of recommendations and identify a number of key 'Next Steps' which will facilitate this Strategy Delivery process.

5.2 Support for the LEZ Strategy and Its Delivery

5.2.1 **Recommendation 1** We recommend that Sheffield City Council approve the full package of measures identified in this report

5.2.2 **Recommendation 2** We recommend that the central, regional and local government departments responsible for environment, public health and transport, working with their Partners, co-ordinate and produce a clear policy steer and ensure that the necessary funds are made available to deliver the relevant measures within appropriate timescales. Further research and action is required regarding the performance of EURO 5/V vehicles, in particular heavy duty vehicles, as recent investment in these vehicles by the Bus and Freight industries may actually be worsening the air quality in urban areas. Evidence that EURO 6/VI actual performance is in-line with the required standards will also be required.

5.2.3 **Recommendation 3** In particular, we recommend that the necessary staff resources are made available to deliver the strategy within Sheffield.

5.3 Planning Controls

5.3.1 Many of the LEZ measures (in terms of the emissions performance of vehicles allowed to operate to/from and through given locations could initially be enforced via planning

controls on new developments (and will therefore be considered as part of the delivery mechanism for the harder engine-technology-based measures discussed earlier.

5.3.2   However, the Planning System can also be used to deliver softer measures, by encouraging more-sustainable travel (through the requirement for (and monitoring of) effective Travel Plans for new developments and large existing organisations), the creation of urban environments which are conducive to active travel and public transport use, etc.

5.3.3   **Recommendation 4** The Planning Departments of Sheffield City Council and its neighbours should be made aware of the details of the emerging Emissions Strategy (including this LEZ-related component) and do as much as possible to support it.

5.3.4   **Recommendation 5** In particular, new developments which are likely to generate significant amounts of traffic within the AQMA should be required to ensure that the emissions of NO_X and particulate matter from this traffic is minimised, using a combination of minimum emissions standards for fleets under the control of the relevant organisation and support for measures which help promote low emission modes to/from the site, including those trips made by goods vehicles. This could include CNG refuelling infrastructure, charging points for electric vehicles, financial support for low emission buses and a permit scheme to restrict taxis which fail to meet SCC's emissions standards.

5.4   Public Awareness and the Communications Strategy

5.4.1   **Recommendation 6** Sheffield City Council (and possibly some of its neighbours) should design and deliver an effective media and marketing campaign to raise awareness of the health impacts of poor air quality, the need for relevant organisations to devote resources to tackling the problem and the need for individuals to change their behaviour, including reducing their use of private car for trips which can be made by less-polluting modes and to consider the emissions performance of the car they use for trips which cannot easily be made by other modes.

5.4.2   **Recommendation 7** In particular, potentially as part of a central Government strategy, the car-buying public should be made fully aware of the differences in the level of emissions between petrol, diesel and 'new technology' cars and the importance of the Euro-rating system when considering their purchase of cars and light goods vehicles (<3.5T). Incentives, such as reduced vehicle tax, could be used to increase take-up of cleaner vehicles.

5.4.3   **Recommendation 8** - The UK Government should take the lead in a UK-wide campaign and introduction of supporting policy measures to reduce the proportion of diesel cars (and older petrol cars) used in urban environments.

5.4.4   **Recommendation 9** The health benefits of a) the additional active travel and b) the improved air quality if 'everyone plays their part' should be emphasised, as should the

'carbon-footprint reductions' of these behaviour changes. Over the longer term, the adverse health impacts of climate change, due to greenhouse gas emissions, could potentially be greater than the current adverse effects of particulate air pollution.

5.5   Measures to Promote Reduced Car Use

5.5.1   **Recommendation 10** Cost-effective measures which help deliver reduced car use should be funded and supported by all stakeholders. These include:

- O   'Hearts and minds' campaigns highlighting the disbenefits of car use, encouraging active travel and increased use of (low-emission)public transport modes;
- O   investment in walking and cycling infrastructure;
- O   maintaining or improving the quality of the public transport alternatives to car use;
- O   personalised travel planning to increase awareness of the alternatives to car use;
- O   travel Plans within large organisations; and
- O   use of Planning Controls.

Sheffield's Taxi and Private Hire Fleet

5.5.2   **Recommendation 11** Sheffield City Council (with support from its neighbours) should take all of the actions required to reduce the number of high-emission-rate taxis and private hire vehicles operating with Sheffield's AQMA area, starting with the most-polluting vehicles and continuing until all vehicles achieve an emission rate of 1.6g/km (Hackney) and 1.1g/km (private hire vehicles) in congested urban driving condition. Licences would only be provided for vehicles meeting the required emissions rate levels.

5.5.3   **Recommendation 12** Sheffield City Council should introduce 'green taxi ranks' at the train station or other priority locations, or offering a discount on license fees for petrol hybrid taxi vehicles.[28] This could be subsidised through a central government 'Green Taxi Fund', and/or other existing funding mechanisms such as the Local Sustainable Transport Fund (LSTF).

Sheffield's Bus Fleet

5.5.4   **Recommendation 13** - Sheffield City Council and South Yorkshire PTE should adopt a policy and provide support (including submitting bids to the appropriate funding sources) to upgrade the bus fleet operating within Sheffield's AQMA to achieve a minimum of EURO VI performance for NO_X and PM emissions, using an appropriate combination of EURO VI diesel, CNG, hybrid, pure electric and fuel cell technology. This will need to take into consideration that diesel hybrid buses are expensive and pure electric Buses may not suit Sheffield topography. This recommendation would build on

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[28] Vehicle Emission Measurement and Analysis - Sheffield City Council, Dr J Tate

the existing work funded by the Local Transport Plan & Local Sustainable Transport Fund for developing refuelling infrastructure for these alternative fuels.

5.6   Reducing Emissions from the Existing Fleet

General Public

5.6.1   **Recommendation 14** We recommend that a communications strategy should include a campaign to pass on the main 'more-efficient driving' tips to the general public (focussing on the fuel cost savings), plus a campaign targeted at organisations with large fleets and individuals who 'drive for a living' (taxi drivers, freight operators, 'white van man' etc), again highlighting the costs savings, ideally within a wider 'fleet efficiency' programme.

More-efficient Fleet/Logistics Operations

5.6.2   **Recommendation 15.1** Since South Yorkshire Local Transport Plan Partnership are already partners of the Eco Stars Fleet Recognition Scheme[29], this approach to fleet optimisation should be the 'weapon of choice' for promoting fleet efficiency as a means to delivering emissions reductions within the Sheffield AQMA.

5.6.3   **Recommendation 15.2** The marketing campaign for the Eco Stars scheme should focus on the message that the cost of an organisation's participation in the Eco Stars scheme will save them more (in fuel and other logistics-related costs) than the cost and overhead of participation in the scheme, with potential secondary messages regarding the health and customer-relations benefits which their reduced emissions and Eco Star rating will deliver.

5.6.4   **Recommendation 15.3** The message regarding net cost savings should, if possible, be backed up by robust Case Study evidence.

5.6.5   **Recommendation 16** Sheffield City Council should promote the cost-saving merits of a) eco-driving and the Eco Stars Fleet Recognition Scheme and b) replacing older and poorly-maintained goods vehicles with newer/cleaner/more-efficient alternatives. This promotion should focus on organisations which are responsible for running or procuring services which generate large amounts of goods vehicle traffic within Sheffield's AQMA.

Heavy Goods Vehicle (HGV) Routing

5.6.6   **Recommendation 17** Sheffield City Council should continue to work to identify ways to reduce 'unnecessary' goods vehicle traffic travelling through the AQMA in general and the known air quality problem areas in particular.

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[29] ECO Stars Fleet Recognition Scheme Handbook

Improved Signing and Real-time Information

5.6.7 **Recommendation 18.1** The HGV Routing Strategy could be widened to a more ambitious real-time information strategy targeted at all drivers. Improved signing, including real-time information could help direct traffic away from congested areas within the city centre leading to more-efficient traffic flows and reduced emissions, especially in areas with air quality problems. It may also reduce emissions from 'lost-driver' traffic.

5.6.8 This real-time information could be provided from a purely congestion-minimisation/avoidance perspective, or as part of a wider air quality management process (i.e. in response to observed or predicted episodes of poor air quality in particular locations or areas).

5.6.9 **Recommendation 18.2** Any signing strategy should take account of the issues identified as part of the HGV Routing work described above.

Peak-Spreading (including Night-time deliveries)

5.6.10 **Recommendation 19** The communications strategy (described above) should consider whether it would be possible to persuade motorists to avoid driving at the peak congested times, highlighting the potential time and fuel savings from changing the time of the journey.

5.6.11 **Recommendation 20** Regarding increased night-time deliveries of goods, we suspect that other impacts of such a move (increased night-time noise and the additional costs to the freight operator and those receiving the goods) might offset the (probably fairly small) emissions benefits which would result. However, SCC should liaise with those delivering and receiving the goods to confirm that this is the case (i.e. the disbenefits of this potential policy outweigh its emissions benefits).

Eliminating Vehicle Idling

5.6.12 We suspect there is scope for further reduction/elimination of unnecessary vehicle idling, particularly at taxi ranks and in bus stations / at bus stops or termini. While this could be included within a more-general publicity campaign, it might be more-efficiently targeted at fleets using locations where vehicle idling vehicles is known to be an issue. This targeting would therefore benefit from an initial inspection of likely/potential problem areas.

5.6.13 **Recommendation 21** The scoping phase of the communications strategy should consider whether there are any locations or organisations where vehicle idling is currently an issue worthy of a targeted approach.

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5.7 Monitoring Progress

5.7.1   **Recommendation 22** Sheffield City Council and Defra should work together to ensure that sufficient resources are available to robustly monitor local air quality across the city, to ensure that progress is being made at the existing air quality monitoring sites to achieve the relevant improvements to local air quality and to identify any new 'hot-spots' which might appear.

5.8 Wider Emissions Strategy

5.8.1   **Recommendation 23** The LEZ Strategy should be part of a wider Emissions strategy aimed at tackling emissions from all relevant sources and sectors in the Sheffield area, which could include lobbying central government to tackle road traffic emissions originating from the M1.

5.8.2   The M1 emissions have not been reduced as part of the Preferred Strategy, as traffic using the M1 is largely beyond Sheffield City Council's regulatory control. However, the emissions from the motorway traffic have a significant impact on the local air quality in Sheffield and these emissions therefore require urgent effective action from central government.

5.9 Costs of the Preferred LEZ Strategy

5.9.1   The preferred LEZ strategy would enforce changes across all fleet types. In total, 12% of the vehicles travelling through and around Sheffield would be affected, with the breakdown across different fleet types as presented in Table 16. The most affected fleet types are buses and taxis.

Table 16. Percentage of Fleet Affected

FLEET TYPE	% FLEET AFFECTED
Private Car – Petrol	5
Private Car – Diesel	10
Taxi (Hackney)	52%
Taxi (Private Hire)	53%
LGV (<3.5T)	17%
OGV (>3.5T)	8%
Bus (Single Deck)	97%
Bus (Double Deck)	85%
Total	**12%**

5.9.2   Only when the implementation approach of the Preferred Strategy has been agreed, can a full cost benefit analysis be undertaken. However, some indicative costs of required measures are provided below.

5.9.3   For most fleet types, either minimum Euro class or maximum emissions rates have been specified. This will require purchase of newer technology vehicles, or retro-fitting older vehicles to comply with the stated target. Costs are dependent on the vehicle type and technology selected, however some current indicative costs are:

- ⭕ retrofitting buses with Selective Catalytic Reduction (SCR) units - £15k;
- ⭕ conversion to dual fuel (CNG/Diesel) for OGVs (>3.5T) costs between £15-30k, with a payback period of 1 to 2 years and CNG alternatives are available for most vehicles types, costing approximately £5k (LGV (<3.5T)) to £30k (OGV (>3.5T)) higher than the conventional fuel vehicles [30]
- ⭕ while hybrid electric vehicles are more expensive than diesel, a recent study found that hybrid electric taxis became more economic than average diesel taxis within 5,000 miles of use with 37% lower fuel related costs[31]. Hybrid vehicles may also have lower maintenance costs as regenerative braking reduces the load on the engines and brakes[32].

5.9.4   Other costs associated with implementing the LEZ strategy would include:

- ⭕ development of CNG refuelling network to service bus, taxi and other fleets - £2m[30];
- ⭕ additional signage and real-time information systems for revised routing;
- ⭕ implementation and enforcement of system for compliance of vehicles with emissions standards;
- ⭕ establishment of 'green-taxi ranks' at train stations and other priority locations[32];
- ⭕ campaigns to generate public and political support and generate behavioural change;
- ⭕ assistance for development of travel plans;
- ⭕ on-going investment in walking and cycling initiatives; and
- ⭕ necessary staff resources to deliver the strategy.

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[30] Investment in CNG / Biomethane Stations to Improve Sheffield Air Quality whilst delivering Low Carbon, Joule Vert Ltd

[31] Developing the evidence base and business case for hybrid taxis, S Rogerson, ITS Leeds

[32] Vehicle Emission Measurement and Analysis - Sheffield City Council, Dr J Tate

5.10 Funding Sources for LEZ

5.10.1 Significant funding will be required to deliver the Preferred LEZ Strategy.

5.10.2 A number of potential funding sources are available to assist with the implementation and achievement of the LEZ strategy, for example:

- **Local Sustainable Transport Fund (LSTF)** – a comprehensive refuelling infrastructure for Sheffield may be pursued through this fund. The aim would be to have two stations that would serve bus operators, taxis, council services, emergency services and freight, in place before March 2015;

- **Clean Bus Technology Fund (CBTF)** – a DfT fund available to local authorities to reduce NO_x emissions from buses, Stagecoach submitted a bid in partnership with Sheffield City Council recently and were successful in their bid for a grant from this fund to retrofit 5 EURO IV Optare Solo Buses with dedicated CNG Engines (with 3 way catalysts) and Gas Storage, to run on Bio-Methane;

- **Green Bus Fund** – support from the DfT to local authorities and bus companies to purchase low carbon buses. Stagecoach Yorkshire have already received a grant for Hybrid buses in Sheffield, currently for 40 vehicles in total;

- **Local Transport Plan** – grants from DfT to local authorities to improve and maintain local transport services, aimed at promoting sustainable transport measures. Initiatives can cover a range of schemes, including buses, taxis, cycling, reducing the need to travel or 'smarter choices' ;

- **Sheffield City Region Investment Fund (SCRIF)** – different funding streams are brought together and allocated through local governance procedures to schemes offering economic benefits and achieving strategic priorities;

- **Defra Air Quality grant** – capital project support to local authorities to deliver projects aimed at improving air quality, in particular those addressing exceedances of NO_2 objectives; this grant has been used to support the LEZ Phase 2 Study and further funding has recently awarded to Sheffield City Council for a comprehensive communications campaign related to the AQAP / LEZ Study; and

- **Public Health Grant** – Department of Health grants for local authorities to spend on public health related services to improve the health of the local population.

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