Low Emission Topic Note 3
Review of Low Emission Zone / Low Emission Strategy Feasibility Studies

Prepared by Green Sphere on behalf of the Low Emission Partnership

Authors: Liz Bates and Rob Pilling
Reviewer: Katherine Stanger

During 2011-2013 DEFRA awarded over £1.6 million to local authorities to help investigate the potential emission and concentration impact of a variety of low emission air quality improvement measures. This review examines progress of these projects to Mar 2014. It provides a snapshot of status, scope and outputs at that time; and identifies common themes and learning.

The review required development of a comparison approach, which has potential for wider application, not least, a follow up to examine the further progress of the study projects from Mar 2014 to the present.

Topic notes provide communication of outputs from review and development work undertaken by the Low Emission Partnership. For more information and publication time table please contact info@lowemissionstrategies.org. The Partnership would welcome feedback and questions relating to any aspect of this topic note and on wider related issues.

Contents

Please note that the report provides a snapshot as of end March 2014 (i.e. all work/progress Apr 14 onwards is referred to in the future tense)

1 Introduction

1.1 Purpose

Since 2011 DEFRA have allocated in excess of £1.6 million to local authorities to help them investigate the potential emission and concentration impact of a variety of low emission air quality improvement measures. The funding has been used to support a wide range of studies including; detailed analysis of London style LEZ controls (e.g. *York, Newcastle*), scoping studies to identify preferred LES options *(e.g. Sheffield, Waverley, Horsham)* and detailed analysis of specific traffic management solutions (e.g. *Maidstone*). Studies are found to be at a various stages, with many still ongoing. Of particular future interest will be the outputs from the large regional LES/ LEZ projects in West Yorkshire and the West Midlands that are still to report. The aim of this review is to provide an update on the current status, scope and outputs from the DEFRA funded LES /LEZ projects and to identify any common themes and learning points arising from them.

1.2 Scope of Review

Tables 1a to 1d provide an overview of the DEFRA funded LES /LEZ projects considered as part of this review. These are all DEFRA funded projects unless stated otherwise. The studies have been grouped into categories:

- Low Emission Zone only studies
- Assessment of various LES / LEZ options
- Assessment of traffic management measures only
- Other LES studies

Where appropriate the studies have also classified as ***'detailed'*** or ***'screening'*** assessments:

- A ***'screening'*** study (**S**) is typically based on daily traffic flow data and more readily accessible emission tools such as DEFRA's emission factor toolkit. They are generally undertaken by commercial consultants or in-house by LAs.
- A ***'detailed'*** study (**D**) typically employs dedicated traffic models linked to specialist emission and dispersion models and/or actual pollution monitoring data.

Table 1a: Low Emission Zone only feasibility projects

Local Authority	Funding received	Funding year	Context	Type	Status
Oxford City Council and Oxfordshire County	£15,000[1]	06/07	LEZ in a historic city centre with CBA	D	complete
City of York Council CBA (LEZ feasibility study)	£40,000	11/12	City centre LEZ bus corridor in a historic city	D	complete
Newcastle and Gateshead	£60,000	11/12	LEZ covering a large city, large town centre and surrounding sub-urban districts	D	complete
Aylesbury Vale	£28,000	11/12	Impact of Euro V bus controls on a town centre and other AQMAs along a major road	S	complete
Warwick	£20,000	11/12	Entry options for a LEZ in centre of a large historic town	S	complete
Bath & NE Somerset	£46,500	11/12	Entry options for LEZ in a historic city centre	D	ongoing
Reading Borough Council	£40,000	11/12	Entry options for a HGV based LEZ in town centre (including testing of enforcement methods)	D	complete
Southampton	£40,000	11/12	LEZ feasibility study for city centre near a large port	S	complete

Table 1b: Assessment of various LES/LEZ options

Local Authority	Funding received	Funding year	Context	Type	Status
Bradford	£103,000 *	11/12	LES/LEZ options for variety of city centre, motorway and major route locations across Bradford and Leeds (joint project)	D	ongoing
Leeds City Council	£50,000	11/12	As for Bradford	D	ongoing
West Yorkshire	£150,000*	12/13	Extrapolation of Bradford / Leeds study to cover West Yorkshire region	D	ongoing
Warrington	£40,000	11/12	LES/LEZ options for town centre	D	ongoing
Sheffield City Council	£40,000	11/12	Development of recommended LES options for a large city and surrounding area	D	complete
Exeter	£60,000	12/13	LES/LEZ options for a historic city centre	D	ongoing
Birmingham City Council (as part of West Midlands Group)	£120,000 and £150,000*	11/12 12/13	LES / LEZ options for variety of city centre, motorway and major route locations across the West Midlands	D	ongoing
Horsham District Council	£15,000	11/12	LES options for a small village with major road running through it	S	complete
Waverley Council	£21,500	11/12	LES options for a small town	S	complete
St Alban's and District Council	£14,000	11/12	LES options for a town centre	S	?
Maidstone District Council	£40,000	11/12	LES options for a town and impact of reversing flow on an inclined one way system	S	complete
Lewes Council (on behalf of wider Sussex authorities)	£120,000	12/13	Assessment of LES and LEZ options for Sussex AQMA's	D	ongoing
Stockport MBC – Greater Manchester bid	£190,000	11/12	Impacts of traffic control and low emission vehicles across a city region	unknown	unknown

*Total funding includes wider low emission strategy development of which LES/LEZ feasibility study is a part

Table 1c: Traffic Management Measures only

Local Authority	Funding received	Funding year	Context	Study type	Status
Portsmouth	£60,000	12/13	Traffic management options for city centre	D	ongoing
Reigate & Banstead Borough Council	£53,236	11/12	Optimisation of traffic signal timings to minimise pollutant concentrations in a town centre	unknown	unknown
Stoke on Trent	£60,000	11/12	Impact of traffic management measures along a road corridor	unknown	unknown

Table 1d: Other LES component studies

Local Authority	Funding received	Funding year	Context	Study type	Status
City of York Council (Anti-idling study)	£	11/12	Review of idling emissions in city centre and other key locations. Emission impact / cost benefit study of potential anti-idling measures.	D	complete
City of York Council Low Emission Bus study)	Not DEFRA funded	n/a	Feasibility / cost benefit of introducing low emission buses into York	D	complete

Table 1e: Unclassified projects

Local Authority	Funding received	Funding year	Project title	Status
Northampton	£65,000	12/13	LEZ feasibility	Not pursued
Cheshire East	£30,000	11/12	LES development	Some quantitative work planned in the future

2 Harm - Main Drivers and Metrics

Local authorities have a direct responsibility to review and assess air quality in their territory and to declare AQMAs where the health based national air quality objectives are not met. They have further powers and responsibility to take action to protect and improve public health. Recent inclusion of an air pollution indicator of mortality in the Public Health Outcomes Framework for England[1] adds emphasis to the significant impacts of long term exposure to $PM_{2.5}$. All councils have CO_2 reduction targets and there is general recognition that in most cases local air quality improvement and carbon reduction can work hand in hand.

In the UK most AQMA declarations are due to breaches of the annual average objective for nitrogen dioxide (NO_2). Elevated concentrations of NO_2 are generally attributable to local traffic conditions, hence reducing NO_x emissions from traffic in pollutant 'hotspots' has been and continues to be the predominant focus of AQAPs. Some councils are beginning to recognise the importance of other pollutants within these plans, and others have or are developing parallel approaches to address wider health and/or climate impacts.

Tables 2a and 2b identify the primary (i.e. 'driving metrics') for the two study-sets, they also note where supplementary metrics are assessed/reported (i.e. supporting metrics)

Table 2a identifies main and supporting 'harm' metrics for the LEZ study-set

Council	Driving Metric(s)	Supporting Metric(s)
Oxford City Council and Oxfordshire County Council	Compliance with NO_2 objective levels in AQMAs.	Impact on PM_{10} concentrations
York	Compliance with NO_2 objective levels in AQMAs.	Impact on PM_{10} concentrations
Newcastle and Gateshead	Compliance with NO_2 objective levels in AQMAs.	Impact on CO_2, PM_{10} and $PM_{2.5}$
Aylesbury Vale	Compliance with NO_2 objective levels in AQMAs.	none
Warwick	Compliance with NO_2 objective levels in AQMAs.	Damage costs for PM, reduction in life years lost, hospital admissions saved
Bath & NE Somerset	Compliance with NO_2 objective levels in AQMAs.	Impact on PM_{10} concentrations
Sheffield	Compliance with NO_2 objective in AQMAs.	PM10 concentration maps
Horsham	Compliance with NO_2 objective levels in AQMAs.	none
Waverley	Compliance with NO_2 objective levels in AQMAs.	None in this study – though impact on PM recommended for inclusion in follow up
Maidstone	Compliance with NO_2 objective levels in AQMAs.	Change in PM and CO_2 emissions, Damage costs for NOx and PM_{10}
Reading	Compliance with NO_2 objective levels in AQMAs.	none
Southampton	Compliance with NO_2 objective levels in AQMAs.	Impact on PM_{10} concentrations

[1] http://www.phoutcomes.info/

Table 2b identifies main and supporting 'harm' metrics for the LES study-set

Council	Driving Metric(s)	Supporting Metric(s)
Bradford	Total NOx, NO2 and PM2.5 reduction across whole network (health driven)	Change in CO_2 across network
Leeds	Total NOx, NO2 and PM2.5 reduction across whole network (health driven)	Change in CO_2across netwrok
West Yorkshire	Total NOx, NO2 and PM2.5 reduction across whole network (health driven)	Change in CO_2across network
Warrington	Report not yet available for review.	unknown
Sheffield	Compliance with NO_2 objective in AQMAs.	PM10 concentration maps
Exeter	Report not yet available for review.	unknown
Birmingham City Council (as part of West Midlands Group)	Regional Low Emission Strategy in development. Aims/metrics not yet available for review.	unknown
Horsham District Council	Compliance with NO_2 objective levels in AQMAs.	none
Waverley Council	Compliance with NO_2 objective levels in AQMAs.	none
St Alban's and District Council	Compliance with NO_2 objective levels in AQMAs.	unknown
Maidstone District Council	Compliance with NO_2 objective levels in AQMAs.	Change in PM and CO_2 emissions Damage costs for NOx and PM_{10}
Lewes	Compliance with NO2 objective levels in AQMAs.	(also assessing health impacts in AQMA's)

Table 2d: Identifies main and supporting 'harm' metrics for component LES study-set

Council	Driving Metric(s)	Supporting Metric(s)
City of York (anti-idling study)	NO_x, PM_{10} (total emission reduction)	CO_2
City of York (low emission bus feasibility study)	NO_x, PM_{10} (total emission reduction)	CO_2

All studies in table 2a are driven primarily in pursuit of AQO compliance. Some of the studies consider and assess PM_{10} (incl. York, Maidstone, Newcastle, Sheffield and Oxford), the Newcastle study also provides data for $PM_{2.5.}$ Outputs for PM are not main drivers for scoping, optimising and selecting preferred options. Newcastle and Maidstone studies provide quantitative data on CO_2 emissions, again these are presented as supplementary metrics.

The picture is generally similar to table 2b, with notable exceptions in West Yorkshire. Results of these studies, which are understood to be driven by broader metrics were not available at point of review. An update review once these studies have published would therefore be informative. Study metrics for the West Midlands work have not been verified but it is anticipated that like the West Yorkshire study it will have a strong emphasis on public health outcomes.

On CO_2, a number of local authorities (e.g. *York, Oxford, Bradford*) have produced Low Emission Strategies (LES) that seek to minimise both local and global air pollutants across their whole area. The West Yorkshire LES has close links to LTP carbon reduction targets and CO_2 outputs are being generated as a supporting metric in the LES / LEZ option study.

In summary, the existing LEZ study set is tightly focussed on AQO compliance. Where broader AQ factors are considered these are presented as supplementary metrics. AQO compliance also holds strong influence on the LES study set. However, there is emerging evidence of a greater focus on public health and carbon related metrics within the ongoing regional studies (e.g. West Yorkshire, West Midlands, Sussex). As these projects move forwards, they are starting to establish alternative driving metrics (e.g $PM_{2.5}$) as well as or (where appropriate) in place of AQO compliance.

3 Action – Scope of Measures

3.1 Timescales

Both costs and benefits of measures are highly sensitive to timescale assumptions. The baseline and do-something years considered by each of the councils differ. Most of the studies provide outputs for 2015 but the baseline against which they are compared vary from 2010 through to 2015. Some councils (e.g. Newcastle, Maidstone and Reading) have modelled actions against two different baseline years, which provide useful sensitivity cases.

3.2 General Scope

Seven LEZ studies consider blanket 'London' style entry controls to different types of vehicles over specific geographical locations. In addition, a further six of the LES option studies include LEZ options that would introduce emission controls for some vehicle types over whole boroughs or other defined areas (tables 3a-b) The LES option studies also consider wider measures, which fall into two categories: 'diesel controls' and 'traffic management and suppression' (tables 3c-d)

Table 3a LEZ scenarios involving HDVs

Different LEZ emission entry controls considered within the various studies. Each column in the tables represents a different modelled scenario in terms of vehicle types affected. Where there is multiple Euro standard entries within a cell this indicates that the scenario was modelled multiple times applying a different Euro entry standard each time. For each study the year of the baseline modelling (base) and the assumed LEZ introduction (do-something (DS) have also been provided.

Local Authority	Base / Do Something	Bus only	Bus and coach only	All HDV (buses, coaches and HGV)	Buses and HGVs only	HGVs only (artic and rigid)	All goods vehicles (artic, rigid and LGV)	Buses and taxis only	Buses, HGVs and LGVs	Buses, taxis and HGVs
City of York	13 / 13		III, IV, V							
Newcastle and Gateshead	10 & 21 / 21	VI					V, VI			
Aylesbury Vale	10 / 15	V								
Warwick	15 / 15	V, VI			VI	V, VI				
Bath & NE Somerset*	15 / 15			IV, V, VI		IV, V, VI				
Sheffield	13 / 15							5 (V), 6(VI)		5 (V), 6(VI)
Horsham District Council	15 / 15				V					
Waverley District Council	15 / 15				V					
Maidstone**	11 & 15 / 15	IV III/IV/V IV/ V								
Reading	12 & 15/17					IV,V,VI				
Southampton	10 & 16/18								6(VI)	

*This study is still ongoing and outputs have not yet been reported

** mixed standard scenarios: III/IV/V (30% Euro III, 60% Euro IV) IV/V (10% Euro V. 80% Euro IV, 20% Euro V)

Table 3b Other LEZ scenarios considered

Local Authority	Base / Do Something	All vehicles types	Diesel LGVs	All LGVs	All LDVs (cars and LGVs)	All cars	All diesel cars removed /converted to petrol	All diesel vehicles removed	Other scenarios
City of York	13 / 13								[1]
Newcastle	10 & 21 / 21	5(V),6 (VI)				6			
Warwick	15 / 15		5	5	5	5	X		[2]
Sheffield	13 /15						X	X	[3]
Waverley	15/ 15						X		

[1] Electric Park & Ride buses [2] All pre-Euro 5 diesel cars converted to petrol [3] All LDVs converted to petrol

Table 3c: Diesel measures

Council	Lorry re-routing / lorry ban	Removal of all light duty diesel vehicles	Conversion of all cars to petrol	Removal of all diesel vehicles	Parking / access restrictions for diesel cars
Sheffield		x	x	x	
Maidstone	x			x	
Waverley	x				x
Horsham	x				

Table 3d: Traffic management/suppression

Council	20mph zone	Anti-idling measures	Revised traffic circulation scheme	Congestion reduction scheme	Traffic gating	Controlled motorway	Mixed measure preferred option LES scenario
York		x					
Sheffield							x
Waverley	x		x	x			
Maidstone			x	x		x	
Horsham	x		x	x	x		

3.3 LEZ entry Standards

A variety of LEZ entry standards have been considered both in terms of the types of vehicles affected and performance criteria. Overall, a greater emphasis has been placed on reducing emissions from HDVs than LDVs, with buses and HGVs the main focus of attention. The bulk of the work concentrates on Euro standard based schemes. The impact of introducing Euro 5(V) standards is the most frequently studied scenario closely followed by Euro 6 (VI). Less attention has been given to Euro 3 (III) and Euro 4 (IV) entry standards. Other scenarios consider removal of some or all diesel vehicles specifically.

York has moved away from the uncertainties associated with future diesel emission control technology and instead plans to promote the replacement of diesel vehicles with full electric, hybrid and CNG alternatives.

3.4 Other LES options (assessed within study sets)

Modelled alternatives for reducing HDV emissions include re-routing strategies / access restrictions for HGVs *(Maidstone, Waverley, Horsham)* and *use of* alternative fuels for buses *(York).* The significant impact of diesel cars / LGVs on air quality is recognised in many of the studies with a number including scenarios that prevent access to diesel vehicles *(Waverley*) or assume complete / partial replacement of the LDV fleet with petrol alternatives *(Sheffield, Warwick, Maidstone).*

The LES feasibility studies indicate a continued interest in a variety of congestion reduction measures (including revised traffic circulation schemes, traffic gating and managed motorway scenarios) and look at the impact of other options such as 20mph schemes *(Waverley, Horsham*) and anti-idling scenarios (*York*).

The Sheffield LES report provides a 'mixed measure' preferred option that covers a range of LES measures for a wide range of vehicles.

3.5 Further possible interventions (not assessed within study sets)

There remains a significant range of possible LES action not considered within the study sets, for example as described the LEP National Assessment - building the case for action (2011) and also in the low emission hub (www.low emissionhub.org). This includes the broad categories of low emission planning policies, procurement, retro-fitting, fleet recognition/accreditation schemes, ultralow emission vehicles/infrastructure investment, car rental/sharing and active travel.

Some of these broader measures would (or could) contribute to achieving the *traffic affects* modelled under the studies. So depending on the proposed implementation pathways they may to some extent be implicit within the assessments.

3.6 Direct Implementation of measures

Not all local authorities have undertaken quantitative emission / concentration impact assessments prior to implementation of LEZ measures. Norfolk County Council and Norwich City Council introduced a Euro III based LEZ in July 2008 for local bus services as part of the European CIVITAS project co-financed by the European Union. This project is particularly significant as it pioneered the use of a Traffic Regulation Condition (TRC) as a means of enforcing an LEZ. Whilst the TRC approach has been successful and is being replicated in other areas *(Oxford, Brighton)* the Euro III entry standard in Norwich is reported to have provided little (if any) reduction in local NO_2 concentration and is currently under review. The proposed LEZ for Brighton (due to be implemented in January 2015) will adopt a Euro V standard for all public service vehicles (some exemptions for vehicles with infrequent entries) and an anti-idling policy to be controlled via a TRC.

3.7 Outlook for strategic action

Overall, a variety of LES measures aimed at a range of different vehicles is likely to be a long term goal for most authorities but the cost and time taken to develop and test optimal strategic LES measures is currently beyond the capacity of most. Without provision and greater coordination of further time and resources to undertake strategic development and dissemination of current understanding and practice, the approach to development of Low Emission Strategies is likely to become/remain piecemeal and reactive rather than strategic and focussed (this mirrors ongoing concerns with many current AQAPS).

4 Review Methodology – Method Comparison and Benefit indicators

4.1 Approach

Input data and output data varied widely between the studies. A particular challenge was the format of reported outputs which could be in the form of area wide contour plots, graphs (of various type) or single averaged values for whole study areas. In some cases only qualitative statements about the likely impact on emission / concentration change were provided for some LES measures. Achieving meaningful comparison between study outputs was a difficult.

To enable inter-study comparison of concentration and emission benefits a series of summary tables were produced. These identified study inputs and outputs and also the main harm, action and benefits arising. Where possible, data was taken directly from completed feasibility reports but where this was not possible other sources were consulted such as DEFRA air quality grant applications, action plans, local authority progress reports and direct communication with local authority officers/air quality consultants.

4.2 Input Parameters

Table 4a summarises assessment parameters and assumptions, these included:

- Source of traffic data (national / local), type of transport model (strategic / micro-sim)
- Fleet composition (incl vehicle type/age and petrol to diesel ratio)
- Emission factors and type of emission model
- Dispersion model type and inputs (e.g met data and background concentrations)
- Geo-range of LEZ/ LES scenarios and geo-area of study (e.g. district or action area)
- Timescales (base year / scenarios) and assumptions on business as usual trends

4.3 Output Variables

Table 4b summarises study outputs. Variables were found to include:

- Reporting of predicted emission changes (incl. % change or absolute values)
- Reporting of predicted concentration changes (incl. % change or absolute values)
- Use of qualitative descriptors about AQO compliance or magnitude of change
- Area for which outputs were reported (e.g. district or action area only)

4.4 Benefit Indicators

The input and output data summary tables were used as the basis for developing a series of benefit and significance indicators against which an easier inter-comparison of the study outputs could be made (see section 5).

Table 4a: Main study inputs

Study	Extent of modelling	Area of action	Models	Traffic Data	Notes
York LEZ study (13 / 13)	York city centre road network (approx 20km$^{2)}$	Low emission bus corridor covering approx 3km of roads in centre	**Traffic:** Paramics **Emissions:** PHEM **Concentration:** ADMS - Roads	Local ANPR count data including vehicle age and type (all vehicle types) Local bus operator vehicle data matched to bus routes Modelling work based on changes across total fleet	Scenario outputs reported here are for the LEZ corridor and are compared with baseline outputs for LEZ corridor (for same year). Further outputs for whole area covered by the transport model can be found in the York report. Results reported are change due to LEZ measure only and do not consider traffic growth or natural fleet renewal (base and scenario years are the same)
N & GH (10 / 21)	Newcastle and Gateshead area plus 1km buffer (approx 255km^2)	Low emission zone covering the whole of the Newcastle and Gateshead area	**Traffic:** Tyne & Wear strategic transport model **Emissions:** PITHEM **Concentration** ADMS-Urban	Local automatic traffic count data and classified count data (all vehicles) Local bus model outputs Local traffic speed data Modelling work based on changes across total fleet	The Newcastle modelling network can be broken down into a number of different domains allowing model outputs to be obtained for individual areas of interest. For the purpose of this review average outputs from 3 AQMAs have been reported against baseline outputs for the same AQMAs in 2010 and 2021. Outputs for other areas are available in the N&GH report..
Aylesbury Vale (10/15)	Main vehicle network around town of Aylesbury	Buses throughout Aylesbury to meet Euro V standard by 2015	Unknown – but outputs include concentrations derived from dispersion modelling	Unknown	A summary of concentration impacts only is included in the n Aylesbury Vale Progress Report 2013. The full report was not obtained for the purpose of this review.
Warwick (15/15)	Main vehicle network around Warwick including the two AQMAs	Town centre LEZ incorporating both AQMAs. (Area LEZ cordons ~1.5 km X 1km)	Not specified	Unknown	Baseline model for 2011 used to produce 2015 business as usual model for Warwick which is then used for comparison with 2015 LES/LEZ scenarios. The 2015 BAU incorporates factor for traffic growth between 2011 and 2015. Reported changes are due to LES/LEZ measures only (not technology improvements or traffic growth changes LEZ report only covers concentration impacts at key receptors within AQMAs for do-something 2015 compared with base 2015 and do-something 2018 compared with base 2015.
Sheffield (13/15)	Sheffield and surrounding area	Whole modelled area	**Traffic:** Sheffield and Rotherham Transport Model (SRTM3) **Emissions:** LESAT and ENEVAL **Concentration** AirViro	Local ANPR count data including vehicle age and type (all vehicle types) Local bus operator vehicle data matched to bus routes Modelling work based on changes across total fleet	The Sheffield 2015 scenarios include estimates of traffic growth based on known development plans and include planned highway improvements. This growth may offset some of the LEZ / LES scenario improvements such that the emission and concentration outputs for the Sheffield LES / LEZ scenario may be lower than those suggested by other studies where traffic growth is not accounted for. The NOx reductions between 2013 and 2015 will include some natural vehicle replacement emission savings.

Horsham (15/15)	the linear village of Storrington (~5 x 1.5 km rectangular)	Storrington village	**Traffic:** Not used **Emissions:** NAEI (Copert4) **Concentration** ADMS roads	Local ANPR traffic count flow and vehicle classification data inserted straight into ADMS-Urban as individual link data (AADT)	Baseline model for 2011 used to produce 2015 Business as usual model. The 2015 BAU model used for comparison with LES/LEZ scenario options for 2015. The 2015 BAU incorporates factor for traffic growth between 2011 and 2015. Reported changes are due to LES/LEZ measures only (not technology improvements or traffic growth changes)
Waverley (15/15)	All roads within the Farnham town centre AQMA (~ 1km x 1km)	Farnham town centre AQMA	**Traffic:** Outputs from Farnham Micro-simulation transport model used to provide AADT flows for dispersion model **Emissions:** Not specified **Concentration** ADMS roads	Detail not provided	Baseline year for study is 2010. Using this baseline a Business as usual case for 2015 was produced (taking into expected traffic growth due to development). This BAU 2015 scenario then used for comparison with 2015 LES /LEZ scenarios Reported changes are due to LES/LEZ measures only (not technology improvements or traffic growth changes).
Maidstone Revised circulation study (12/12)	Small circular one way system in the centre of Maidstone (~400m x 700m).	Reverse flow of the one way system	**Traffic:** Not used **Emissions:** DEFRA EFT **Concentration:** ADMS Roads Extra	AADT flows and vehicle classification from DfT national surveys	The study assumes that flow is simply reversed such that change in emissions is due to impact of reduced gradient on highest flow links. Does not account for any change in traffic flow patterns likely to arise from reversed flow situation either withn the one-way system or on surrounding roads. Study compares 2012 base with 2012 do-something.
LES options study (15/15)	8 individual areas modelled based around AQMAs. (Each a few km^2) These areas are combination of city centre, suburban and motorway locations	In and around the individually modelled AQMA areas.	**Traffic:** Not used **Emissions:** DEFRA EFT **Concentration:** ADMS Roads	AADT flows obtained from Maidstone transport model	Not all the modelled LES/LEZ options were tested in all the modelled areas. Results reported are for the areas in which any particular LES /LEZ option was tested. Where this involved more than one area an average of results and / or the 'general picture' has been reported. Baseline results for 2015 / 2026 (do-nothing scenarios) include a factor for traffic growth based on 2011 baseline. As some other studies do not include traffic growth estimates the impact of the LES / LEZ studies in Maidstone may be generally lower than for similar measures in other studies without traffic growth built in.

Table 4b: Main study outputs

LA	Reported outputs (Emission)	Output format (Emissions)	Reported outputs (Concentration)	Output format (Concentrations)
York LEZ study (13/13)	Change in emissions within LEZ corridor For individual scenarios in 2013 compared with LEZ base 2013	Bar chart showing total LEZ area emissions per scenario	Average concentration across all modelled receptors in LEZ for each scenario (NO_2 /PM_{10}) Significance in concentration change at individual receptor locations based on EPUK planning guidance values (NO_2 only)	Line chart of average receptor concentration across LEZ and statements of average change value within report text Chart showing number of receptors experiencing different categories of change (based on EPUK significance categories). Text commentary on number of exceedances of AQOs arising under different scenarios.
N & GH [5] (21/21) (10/21)	Total change in emissions within 3 AQMA areas with different LEZ entry requirements in place. Outputs for 2010 base and 2021 with and without LEZ options in place.	Table of percentage NOx and PM_{10} emission changes associated with the LEZ scenarios, based on sum of total emissions within the three AQMA areas. Outputs for 20121LEZ scenarios vs 2021 base and 2021 scenarios vs 2010 base.	Change in NO2 concentration within each of the AQMAs for each of the LEZ scenarios (compared to 2010 and 2012 baselines) Text commentary on occurance of AQO exceedances in 2021 for different LEZ scenarios	Table of average concentration change in ug/m3 relative to 2010 and 2021 baselines for each of three AQMAs Concentration contour plots s (allowing AQO exceedance areas to be identified for each scenario)
Aylesbury Vale (10/15)	Not reported	Not reported	Average reduction in NO2 concentration within Aylesbury AQMAs (single figure)	Single average reduction value reported in ug/m3 and text based comments / table on ability to achieve compliance with AQOs in 2015 with bus LEZ in place
Warwick (15/15)	Not reported	Not reported	Reduction in NO2 concentration for specific AQMA receptors for do-nothing 2015 and do-something 2015	Table of data
Sheffield	Total % NOx reduction across whole study area for each LEZ/LES scenario considered	Data tables (2013 baseline emissions v 2015 with LES / LEZ scenarios in place)	Number of sites exceeding AQO for NO2 with and without the prefered'LEZ' option in place. Concentration changes for individual LES / LEZ options not reported	Table showing number of exceedances of NO2 objective across modelled area with and without preferred LEZ option in place

Horsham	Not reported	Not reported	NO2 concentrations at various receptors in study are for 2015 BAU and different LES/LEZ scenarios	Data tables and contour plots of concentrations showing hotspot areas
Waverley	Not reported	Not reported	Concentrations at various receptors within AQMA with different LES/LEZ measures in place for comparison against 2015 BAU.	Data tables
Maidstone Revised circulation study (12/12)	Reduction in NOx emission rate across the whole of the study area	Single value provided in report	Concentrations at various receptors within the one way system provided for 2012 do-nothing and 2012 reversed flow.	Data tables
Maidstone LES options study 15/15	Not reported	Not reported	Concentration changes within AQMA modelled areas where specific options applied.	Data tables & descriptive text

5 Benefits – Concentrations and Emissions

5.1 Benefit Indicators

Where reported quantitatively, NO2 benefits were usually presented in terms of either:
- Changes in NO_2 concentration (ug/m^3 and /or % change against a specified baseline or
- Changes in emissions (tonnes of pollutants and/or % change wrt specified baseline).

Further information was also often provided in terms of change with reference to '*number of sites meeting the 40ug/m^3 objective level*'.

PM benefits, where reported, were usually presented in terms of bulk emissions.

Table 4a and 4b shows how information was drawn from individual studies in order to develop indicators relating to AQO compliance and bulk emissions respectively.

Table 4a: Development of significance indicators – NO_2 compliance based

Council	*Data taken direct from report*	*Calculations /assumptions*
York (LEZ) **13/13**	Change in average NO_2 concentration across receptors located within the LEZ corridor Number of receptors where 40ug/m^3 NO_2 objective exceeded (within LEZ corridor) Qualitative commentary on significance of concentration change at individual receptors within the LEZ.	Average change in NO_2 concentration within the LEZ for each modelled scenario taken from a line chart in report. Percentage change against LEZ base scenario then calculated. Method applied does not consider changes in NO2 concentrations that arise on the wider network as a result of improvements to bus fleet to comply with LEZ entry. Method does not consider concentration changes at individual receptor points or outside LEZ which can vary widely from those used for reporting
N & GH **(10/21/21)**	Change in average NO_2 concentration across three AQMAs. AQO exceedances from contour plots	Absolute change figures (ug/m3) taken direct from tables in report and then average % change in concentration calculated for the AQMAs. Method does not consider concentration changes at individual receptor points or those outside the AQMAs which can vary widely from those used for reporting. Not all the AQMAs had exceedances of NO2 objective in 2021 – the concentration impact changes therefore represent most positive outcome that could occur in any of the three AQMAs considered for 2021 scenarios.
Aylesbury Vale (10/15)	Average reduction in NO_2 across the AQMAs (2.3ug/m3). Impact of scenario on AQO exceedance in existing AQMAs (from table and report commentary)	Reported outputs assume all NO_2 reduction is due to Euro V bus standard. Progress report indicates that some scenarios included changes to road network as part of future development plans but unclear if this was the case for the Euro V bus scenario. The magnitude of the predicted NO_2 reduction from the bus based LEZ may include some impact from future development.
Warwick (15/15)	Reduction in NO2 at key receptor points in AQMAs for 2015 do-something against do-nothing 2015.	Concentration impact varies at each individual receptor in the two AQMAs. When reporting concentration significance for the different LEZ scenarios in 2015 the 'general picture' has been reported in terms of whether concentrations went up or down as a result of the LEZ measure and whether AQO exceedances remained. The overall rating may not be applicable to individual receptor results.

Sheffield (13/15)	Change in number of NO2 exceedances with preferred' LEZ'option in place.	Concentration based output only available for the Sheffield 'preferred' LES option which is a combination of individual LES / LEZ type measures
Horsham (15/15)	Concentrations at various receptors for 2015 BAU and 2015 with LES/LEZ scenarios	Concentration impact varies at each individual receptor . When reporting concentration significance for the different LEZ scenarios in 2015 the 'general picture' has been reported in terms of whether concentrations at reported receptors tended to go up or down as a result of the LEZ measure and whether AQO exceedances remained. The overall rating may not be applicable to individual receptor results.
Waverley (15/15)	Concentrations at various receptors for 2015 BAU and 2015 with LES/LEZ scenarios	Concentration impact varies at each individual receptor . When reporting concentration significance for the different LEZ scenarios in 2015 the 'general picture' has been reported in terms of whether concentrations at reported receptors tended to go up or down as a result of the LEZ measure and whether AQO exceedances remained. The overall rating may not be applicable to individual receptor results.
Maidstone (12/12) Revised circulation study	Concentrations at various receptors for 2012 do nothing and 2012 with reversed flow	Outputs assume traffic flows remain the same but are simply reversed in direction to reduce number of vehicles climbing gradient. In practice flows are likely to change significantly.
Maidstone (15/15) LES options study	Concentration changes within AQMA modelled areas where specific options applied. Summary text information on change in AQO compliance.	Concentration impact varies at each individual receptor . Where LEZ / LES measure is applied to a number of modelled areas the 'general picture' has been reported in terms of whether concentrations at reported receptors tended to go up or down as a result of the measure and whether AQO exceedances remained. The overall rating may not be applicable to individual receptor results or other AQMAs considered within the report.

Table 4b: Development of significance indicators – emission based (NO_2 and PM_{10})

Council	Data taken direct from report	Additional calculations /assumptions made
York (LEZ)	% change in NOx and PM10 emission against baseline (baseline and scenario outputs based on traffic data for LEZ area only)	Total NOx and PM10 emissions read from bar charts within report and % change against baseline then calculated.
N&GH	Total NO_2 emission in tonnes for each scenario (from bar chart) % change in PM10 emissions within 3 AQMA areas	% change in total NO_2 emission against baseline for each scenario for whole study area PM_{10} emission change data only for AQMA areas – not whole study area
Aylesbury	Emissions not reported	Emissions not reported
Warwick	Emissions not reported	Emissions not reported
Sheffield (13/15)	Change in total NOx emissions across whole study area for individual LES/ LEZ options No PM10 emission outputs available in the report	Sheffield outputs based on impact across a whole region rather than in particular air quality hotspot areas. At a more local level the impact of some measures may differ from those suggested by this general overview, particularly where there are higher than average number of certain types of vehicles e.g. buses based measures may be more effective than figures suggest in city centre areas with high bus flows. As no PM emission outputs are reported the measures in the Sheffield LEZ/LES study can only achieve a maximum of a light green rating in the significance colour coding, in practice they may be equivalent to measures given a dark green rating in other studies for which PM10 data is provided.
Horsham	Emissions not reported	Emissions not reported
Waverley	Emissions not reported	Emissions not reported

5.2 Uncertainty

When interpreting study results, sources of varying uncertainty included:
- type and detail of study (eg. scoping versus detailed assessment)
- type and origin of metrics (eg. emission estimate versus modelled concentrations)
- confidence in measure technical effectiveness (eg. real world Euro 6 performance)
- confidence as to whether (and when) the measure could/would be implemented.

In particular, there is increasing evidence that real world performance of new Euro standards does not always deliver legislated reductions in emissions. LEZ scenarios beyond 2014 and those which consider introduction of Euro 6(VI) emission standards are clearly very sensitive to this.

5.3 Inter study comparison

Direct comparison of results between studies is hampered by a number of factors, including differences in the: (i) choice of baseline and do-something year, (ii) choice and presentation of metrics, and (iii) detailed scope and design of the broad options

For technology acceleration measures (eg. those based on Euro standards) the choice of reference year is particularly important since the further into the future scenario modelling is undertaken, the lesser the emission benefit will be. While comparisons have generally been made on single points in time, it should also be noted that technology acceleration measures are only effective for a relatively short period, while other types of measures (e.g. infrastructure, systemic and behavioural changes) may provide longer periods of benefit.

5.4 Significance

Two descriptive scales were adopted to enable a simple inter-study comparison of projected benefits for hot spot reduction and bulk emission reduction respectively
(tables 4a and 4b below).

Table 4a: Hotspot Reduction

Resulting impact of measure	Description
All exceedances eliminated	major positive
Some areas of exceedance eliminated	small positive
Concentrations reduced at most locations, no change in exceedances	slight positive
No significant changes in concentrations	no impact
Increase in concentration at most locations, air quality objectives still met	slight negative
Increase in concentration at most locations, no change in exceedances	small negative
Increased concentration at most locations, areas of exceedance increases	major negative

Table 4b: Emission Reduction

% emission reduction	Impact
Reduction against baseline of > 15%	major positive
Reduction against baseline of 10-15%	large positive
Reduction against baseline of 5-10%	small positive
Reduction against baseline < 5%	slight positive
No change	no change
Increase against baseline <5%	slight negative
Increase against baseline >5%	small negative

And Colour coding provides a sense of the overall strength of an option *in relation to the specific indicators* shown below. Where multiple results apply, colour rating is determined by the 'best result':

	Dark Green	Light Green	Orange
NO2 compliance	Major Positive	Small Positive	Slight positive or worse
Emission Reductions	Major Positive (PM)	Large Positive (PM)	Small positive or worse
		Major/Large Positive (NOx)	Small positive or worse

5.5 Presentation of Results

Tables 4c-4d present an overview of the impact on current NO_2 hotspots as a result of the LEZ scenarios modelled by different councils. It provides an indication of which councils might obtain the most NO_2 reduction benefit from the introduction of LEZ controls and the type of entry standard needed to achieve this. When viewing these tables it must be remembered that the modelled intervention year significantly influences the likely concentration benefit (It is evident from these tables that early intervention offers the greatest opportunity to accelerate compliance with NO_2 air quality objectives).

Table 4e-4f presents a summary of the corresponding emission reductions.

5.6 Summary Benefits Tables

Table 4c Impact of LEZ action scenarios on NO_2 compliance

+++ (major positive), ++ (small positive), + (slight positive), = (no impact), - (slight negative), - - (small negative), - - - (major negative)

Local Authority (Base Year / Action Year)	Bus only [7}	Bus and coach only	All HDV [1]	Buses and HGVs only	HGVs only [2]	All goods vehicles	Buses and taxis only	Buses, taxis and HGVs	All vehicle types	All LGVs	All LDVs [4]	All diesel LGV	All cars
York (13/13) (change in LEZ only)		=(III) + (IV) ++ (V)											
N & GH [5] (21/21) (change in AQMAs only)	++ (VI)					=(V) ++(VI)			++ (V) +++ (VI				+++ (VI)
Aylesbury Vale (10/15) (average change in AQMAs only)	+ (V)												
Warwick (15/15) (general impact in AQMAs only)	= (V) ++(VI)		++(VI)		= (V) +(VI)					= (V)	++ (V)	= (V)	++ (V)
Horsham (15/15)				+++ (V)									
Waverley (15/15)				+ (V)									
Maidstone (15/15)	++ (IV) ++ (III/IV/V) ++ (IV/V)												

[1] Buses, coaches and HGV, [2] artic and rigid, [3] (artic, rigid and LGV), [4] LGVS and cars, [5] Newcastle & Gateshead [6] Sheffield report does not provide concentration data for individual scenarios but 'preferred' LEZ options modelling for a combination of proposed LES based measures indicates that a number of exceedance sites would remain in 2015 even after application of the proposed traffic based measures [7] mixed standard scenarios: III/IV/V (30% Euro III, 60% Euro IV) IV/V (10% Euro V. 80% Euro IV, 20% Euro V)

Table 4d Impact of other LES measures on NO_2 compliance

+++ (major positive), ++ (small positive), + (slight positive), = (no impact), - (slight negative), - - (small negative), - - - (major negative)

Local Authority	Lorry re-routing / lorry ban [1]	Removal of all light duty diesel vehicles	Conversion of all cars to petrol	Removal of all diesel vehicles	Parking / access restrictions for diesel cars	20mph zone	Anti-idling measures	Revised traffic circulation scheme [2]	Congestion reduction / UTMC/VMS scheme [3]	Traffic gating [4]	Controlled motorway	Mixed measure preferred option LES scenario
Sheffield (13/15)												++
Maidstone (15/15)	++ (ban in peak periods only)							++	+(10%) ++(20%)		24/7 ++++ Peak only +	
Waverley (15/15)	=				+ + +	-		+ (10%), ++ (50%)				
Horsham (15/15)	++ (25%, 50%) +++ (75%)								+ (10%) ++ (25%) ++ (50%)	++ (25%) +++ (50%)		

[1] percentages indicate levels of lorry flow removed, [2] **reduction** in total traffic flow [3] reduction in total traffic flow [4] reduction in congestion

Table 4e Impact of LEZ action scenarios on emissions

++++ (major positive), +++ (large positive), ++ (small positive), + (slight positive), = (no impact), - (slight negative), - - (small negative)

Local Authority [1]	Bus only	Bus and coach only	All goods vehicles (artic, rigid and LGV)	Buses and taxis only	Buses, taxis and HGVs	All cars	All vehicle types
York (13/13, III) Change in LEZ only		++++ (PM10) ++ (NOx)					
York (13/13, IV) Change in LEZ only		++++ (PM10) +++ (NOx)					
York (13/13, V) Change in LEZ only		++++(PM10) ++++ (NOx)					
Newcastle (10/21, V)			++++ (NOx) ++++ (PM10))				++++ (NOx,) ++++ (PM10))
Newcastle (10/21, VI)		++++ (NOx,) ++++ (PM10)	++++ (NOx,) ++++ (PM10)			++++ (NOx,) ++++ (PM10))	++++ (NOx,) ++++ (PM10))
Newcastle (21/21, V)			= (NOx,) = (PM10)				+ (NOx) + (PM10))
Newcastle (21/21, VI)		++++(NOx) +(PM10)	++ (NOx) + (PM10)			+++ (NOx) + (PM10)	++++(NOx) +(PM10)
Maidstone (15/15)	VI + NOx, + PM10 (III/IV/V) ++ NOx +PM10 (IV/V) ++ NOx + PM10						
Sheffield (13/15, V)				++ (NOx)	++ (NOx)		
Sheffield (13/15, VI)				++++ (NOx)	++++ (NOx)		
N &GH (10/21, VI)	++++ (NOX, NO2) ++++ (PM10/2.5)		++++ (NOX, NO2, ++++ (PM10/2.5)			++++ (NOX, NO2, ++++ (PM10/2.5)	++++ (NOX, NO2) ++++ (PM10/2.5)
N &GH (21/21, VI)	++++ (NOx) + (PM10/2.5)		++ (NOx) + (PM10/2.5)			++ (NOx), ++++ (NO2) + (PM10/2.5)	++++ (NOx, NO2) ++ (PM10), +++ (PM2.5)

Note: The Aylesbury Vale, Warwick, Horsham and Waverley reports do not contain any emission reduction data – only concentration impacts

Table 4f Impact of other LES measures on emissions

++++ (major positive), +++ (large positive), ++ (small positive), + (slight positive), = (no impact), - (slight negative), - - (small negative)

Local Authority	Lorry re-routing / lorry ban	Removal of all light duty diesel vehicles	Conversion of all cars to petrol	Removal of all diesel vehicles	Parking / access restrictions for diesel cars	Anti-idling measures	Revised traffic circulation scheme	Congestion reduction / UTMC scheme	Traffic gating	Controlled motorway	Mixed measure preferred option LES scenario
Sheffield (13/15)		+ + + + (NOx)	+ + + + (NOx)	+ + + + (NOx)							+ + + + (NOx)
Maidstone (15/15)	++++ (NOx) + (PM10)						+ + (NOx)	10% ++ NO2 +PM10 20% ++ NO2 +PM10		24/7 ++++NO2 ++PM10 Peak only +NO2 +PM10	

Note: The Waverley and Horsham LES feasibility reports do not provide emission reduction data.
The York anti-idling study considered emission changes in areas currently prone to idling, data not included in table above.

6 Discussion

6.1 Euro based LEZs

The greatest NO_2 gains are likely to be made by applying a Euro 6/VI entry standard to both HDVs and LDVs (particularly diesel LDVs) and at the earliest opportunity. Even so, Euro VI standards struggle to deliver full compliance for NO_2. Conversely standards based on Euro IV or V offer little benefit on compliance, unless potentially in cases where implementation is already in chain.

Uncertainties noted in section 4.3 regarding the on-road performance of Euro 6/VI vehicles generate a catch-22 since by the time performance is proven, potential gains from early introduction of associated controls will have been largely lost through natural fleet renewal.

Beyond the technical uncertainties, it is also not clear whether the level of investment needed to implement an early Euro 6/VI standard is financially, politically or publically acceptable. For example, in the cases of Newcastle and Reading, the proposal was considered too expensive and risked impact on the local economy.

In assessing and presenting the benefits case for a Euro 6/VI (or other) LEZ scheme, significant (and potentially the biggest) benefit in public health and social cost terms is likely to come from co-reduction of bulk PM emissions. However, there is a risk that these benefits are not given due consideration where there is an overly tight focus on NO2 compliance as the driving metric.

6.2 Alternatives to Euro Standard based LEZs

If Euro IV and Euro V based LEZs offer little or no opportunity for air quality improvement and Euro VI based schemes are deemed too expensive and risky (at the exact point in time where they offer maximum benefit potential) then an alternative longer term and more reliable emission reduction solution may be sought. During the course of this review only one example of LEZ controls being potentially applied to Ultra Low Emission Vehicles (ULEVs) was identified.

6.3 Broader based Low Emission Strategies

There remains a significant range of possible action beyond traditional cordon based Low Emission Zones (Euro based or ULEV). Some are considered within the study sets, but many are not.

A more comprehensive scope of measures is described in the LEP National Assessment - building the case for action (2011) and also in the low emission hub (www.low emissionhub.org). These include, for example, work on low emission planning policies, procurement, retro-fitting, fleet recognition/accreditation schemes, ultralow emission vehicles/infrastructure investment, car rental/sharing and active travel.

As with traditional LEZ's it is unlikely that any one of these individual measures will deliver all or even the majority of air quality management requirements. However, delivered intelligently as part of a combined package they have potential to provide the building blocks for a balanced and sustained programme of change and improvement.

6.4 Implications for Air Quality Assessment

The choice of metrics for scoping and optimisation of measures plays an important role in determining the shape of subsequent action. While it is tempting to simplify assessment processes by driving optimisation largely by a single metric, this approach risks missing opportunities for the most cost effective and beneficial action overall. It is a major concern that option scoping, and optimisation for local action on air quality overall is being distorted by an overly tight focus on NO2 compliance at the expense of other pollutants/types of metric, especially bulk reduction of PM (and CO2).

Conceptualisation of air quality action as discrete stand-alone interventions targeted primarily at eliminating NO2 exceedence, leads almost inevitably to traditional Euro-based low emission zones. Conceptualisation of air quality action as a managed programme of change taking into account multiple performance indicators and multiple intervention mechanisms provides a broader scope of opportunity and the possibility of greater (cost-)benefit. The management and information needs of these approaches are very different as is the approach towards optimal underpinning assessment.

6.5 Implications for Knowledge Management

The work reviewed has been driven by a significant investment of public funds arising largely from a single source. The projects themselves have largely similar aims and a largely similar scope and approach. However cross comparison was hampered by disparate methods and reporting.

While it is desirable for work to be tailored to local needs, greater effort on standardisation and coordination would help to extract greater value from the work and also help to direct future investment into the most useful and beneficial activities. Standardisation of performance indicators and reporting formats would provide an important step in the right direction. As would a national database of project proposals, grant awards and final reports.

6.6 Supporting Notes to Discussion

[1] Euro IV standards (AQO): Only two studies considered Euro IV scenarios. These are councils that are already actively pursuing a wider LES approach to air quality improvement and would probably be looking for a relatively quick adoption of LEZ style controls if they are considered suitable. On this basis they would be looking to introduce LEZ controls within a time frame where Euro IV buses would otherwise still make up a large proportion of the local bus fleet and hence the advantage of going beyond a Euro IV standard will need to be demonstrated locally. Maidstone has looked at the impact of introducing Euro IV buses against a 2011 baseline and a 2015 baseline. This shows that the level of accelerated emission reduction achievable due to local bus measures rapidly deteriorates with time for Euro IV buses, demonstrating that the longer it takes to implement bus emission controls the more stringent the emission standard has to be to achieve a measurable impact on NO_2 concentrations. Both the York and Maidstone studies suggest that beyond 2013 a Euro IV emission standard for buses is unlikely to achieve any significant improvement in NO_2 concentration over and above that which will occur naturally through general fleet replacement. Although a Euro IV bus standard would be unlikely to deliver NO_2 air quality objectives in York, it has been shown to have the potential to have a 'major positive' impact on PM_{10} emissions that could have wider public health benefits.

[2] EU 6/VI LEZ standards (AQO): As expected the Euro 6/VI scenarios modelled suggest that setting a Euro VI entry standard for one or more vehicle types offers greater NO_2 concentration reduction potential than either a Euro IV or Euro V standard. The Newcastle study suggests that accelerated NO_2 concentration improvements with a Euro 6/VI standard may still be possible in 2021. This suggests that the introduction of Euro 6/VI emission controls within the next 5 years still has the potential to offer accelerated NO_2 concentration reduction in some towns and cities. The greatest gains are likely to be made by applying a Euro 6/VI entry standard to both HDVs and LDVs (particularly diesel LDVs). Whether the level of investment needed to attain this standard is considered to be cost-effective will need to be examined on a case by case basis. In the case of Newcastle, the introduction of a Euro 6/VI standard has not been progressed because it is considered to be too expensive and poses too great a risk to the local economy

[3] Euro IV and V standards (emissions): Although the NO_x impact of a Euro IV bus standard was found to be 'large' or 'major' positive for both York and Maidstone respectively this does not translate to a 'major' improvement in NO_2 concentrations and compliance with air quality objectives. The extent of NO_2 exceedance is reduced at some receptors the majority in both cases remain above the national air quality objective levels. A Euro 4/IV standard therefore appears to offer little advantage in terms of meeting the NO_2 objectives, but as the emission reduction data shows there is potential for a significant reduction in particle emissions which could have significant local health benefits. On the whole the introduction of a Euro 5/V emission standard has been found to be slightly more effective than a Euro 4/IV standard in most cases for NO_2 reduction but is still unlikely to deliver the annual average air quality objective for NO_2 at all locations by 2015. On this basis there appears to be little to be gained from moving to a predominately Euro 4/IV fleet to a Euro 5/V fleet in terms of compliance with air quality objectives for NO_2. However, as with the Euro 4/IV standard a Euro 5/V entry requirement has the potential to significantly reduce particulate emissions and deliver significant health benefits. Under the current air quality management system the particulate reduction potential of LEZ style controls are often dismissed due to the strong emphasis on NO_2 compliance.

[4] Euro IV and V standards (emissions):
The York LEZ feasibility study considered a standalone scenario that would see all Park & Ride buses in York converted to electric vehicles. This would remove all tailpipe emissions from buses within the LEZ study area and guarantee a reduction in emissions of NO_x, PM_{10}, and $PM_{2.5}$ within the city centre area. Unlike the Euro 6 emission standard there is no uncertainty surrounding the removal of emissions but potentially a greater risk associated with the use of relatively new technology on such a frequent and high profile bus service.

Despite the operational risks the outputs from the York LEZ study and a further Low Emission Bus Feasibility study (developing a roadmap for low emission bus technology in York) has resulted in City of York Council working together with First Group to deliver electric buses on the New Poppleton Bar Park & Ride site opened June 2014. Electric buses have also been introduced at a second Park & Ride site. York is now working towards ensuring 80% of all bus movements in the city are electric by 2018. Consideration is currently being given to the development of a Traffic Reguilation Condition (TRC) that would make this mandatory for some services, effectively creating a ULEV based LEZ for local buses in York