ANNEX D

Planning and Environmental Policy Group

Local Air Quality Management

Practice Guidance 2

Practice Guidance to Local Authorities on Low Emissions Zones

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Department of the Environment
Calvert House
23 Castle Place
Belfast BT1 1FY
Telephone 028 90254887
Website: www.doeni.gov.uk

Information about this publication and further copies are available from:

Department of the Environment
Calvert House
23 Castle Place
Belfast BT1 1FY
Telephone 028 90254887

Email: Stephen.kerr@doeni.gov.uk

This document is available on the Northern Ireland Air Quality website:

www.airqualityni.co.uk

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Executive summary

i. This guidance may be used by local authorities in Northern Ireland in regard to carrying out their local air quality management duties under Part III of the Environment (Northern Ireland) Order 2002. This guidance is intended to enable local authorities to improve on the service they already provide in tackling poor air quality by providing relevant policy and technical guidance on a specific transport measure – the **Low Emission Zone.** The guidance provides information on selecting methods for implementing this measure, practical issues that have arisen in implementing previous examples of this measure and advice on appraising potential costs and air quality benefits of the measure in cost-effectiveness and cost-benefit analyses.

ii. A Low Emission Zone is a geographically defined area where the most polluting of vehicles are restricted, deterred or discouraged from access and use. The aim is to reduce the number of more polluting vehicles being used in a particular area by setting particular emission standards or criteria, with the aim of improving the air quality.

iii. Low Emission Zone schemes are operating in several cities such as London and cities in Sweden and Germany. The most significant existing scheme in the UK is the London Low Emission Zone scheme.

iv. The two main legal options for implementing Low Emission Zones in the UK are Traffic Regulation Orders under the Road Traffic Regulations Act 1984 (commonly introduced to manage traffic flow at specific locations, to define on-street parking conditions, or as part of a broader traffic management scheme) and Section 106 agreements as planning obligations for site usage (see guidance contained in Planning Policy Statement 23: Planning and Pollution Control (2004)).

v. Schemes should be developed via appraisal and the guidance provides information on assessing emissions, air quality and costs assessments. It also provides information on using these data in cost-effectiveness and cost-benefit analyses that are consistent with a generic guidance note on appraising the cost-effectiveness of local air quality action plan measures. Local authorities are strongly encouraged to refer to this guidance note too.

vi. Low Emission Zones tend to be focussed on city and town centres, where land-use is dense, traffic is heavy and population exposure is high. There is the highest value in such areas from restricting, discouraging or deterring the use of more polluting vehicles. Previous studies have demonstrated that the most common vehicles to target in a scheme with enforceable restrictions are diesel powered Heavy Duty Vehicles due to their cost-effectiveness relative to schemes that would restrict other vehicle types.

vii. Schemes should aim to regulate emissions to a sufficiently high standard and early enough to produce benefits over and above the business as usual case. Between now and 2010-2012 a Euro III standard should be considered as the minimum standard for Low Emission Zone schemes. From 2010-2012, higher standards should be considered. Following this recommendation is

predicted to produce three to four years of benefits, albeit diminishing. However, local source apportionment and analysis should be used to determine which vehicles and which pollutants are the most relevant to target. This should be considered as part of the scheme design, to determine the cost-effectiveness of various options.

viii. The most effective methods of managing permitted vehicles (for traffic, parking or development control schemes) will be to use existing systems and sources of information as far as possible. A significant number of Low Emission Zones are now in place or under development in Europe. Examples of Low Emission Zones from mainland Europe include manual and low-tech enforcement methods as well as camera based systems. Given constraints on revenue budgets, a scheme which has low operating costs will tend to be more attractive from a whole-life cost viewpoint. However, this needs to be carefully balanced against the resulting level of compliance by users with the scheme emission standards, or the purpose and value of the scheme is undermined.

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1 Introduction

1.1 Purpose of this Guidance Document

1.1. This guidance may be used by local authorities in Northern Ireland in regard to carrying out their local air quality management duties under Part III of the Environment (Northern Ireland) Order 2002. This guidance is intended to enable local authorities to improve on the service they already provide in tackling poor air quality by specifically providing relevant policy and technical guidance on a specific transport measure – **Low Emission Zone (LEZ).**

1.2. The guidance provides information on selecting methods for implementing this measure, practical issues that have arisen in implementing previous examples of this measure and advice on appraising potential costs and air quality benefits of the measure in cost-effectiveness and cost-benefit analyses. It also provides detail on existing or planned examples of these schemes.

1.2 Background to the Guidance

1.3. The guidance has been developed to be consistent with key government guidance on appraising new policy and road transport policies in particular.

1.4. The Government Green Book requires that there should be an economic assessment of the social costs and benefits of all new policies projects and programmes. Within the Green Book and related HM Treasury guidance on assessment of the Business Case (5 Case Model), policies are considered under five components and this guidance is consistent with the Green Book as follows.

- Applicability: LEZs potentially contribute towards strategic objectives in the areas of environment (air quality and climate change) and economy (reduce congestion if linked to a congestion charging scheme).
- Appropriateness: Guidance is given in this document to help develop policies for which costs and benefits are either balanced or overall beneficial in economic terms.
- Attractive: Guidance is given in this document to help authorities to prepare their commercial case for LEZ by considering scheme costs including those falling on vehicle operators.
- Affordable: Guidance is given in this document to help authorities to prepare budgets for LEZ scheme costs.
- Achievable: Guidance is given in this document on existing examples of LEZ schemes and key implementation issues including enforcement powers and other practical considerations.

1.5. As far as possible this guidance is also consistent with the government's New Approach to Transport Appraisal (NATA). In practical terms NATA guidance is delivered via the web-based Transport Analysis Guidance (webTAG). In particular this includes guidance on how to conduct a transport policy or scheme appraisal that meets the Department for Transport (DfT) guidelines.

If as guidance changes inconsistencies arise primacy should be given to webTAG guidance except for the evaluation of air pollutants.

1.6. These sources of guidance have been consulted during the development of this guidance document so that a high degree of consistency with overarching governmental guidance on economic appraisal and road transport appraisal in particular have been achieved.

1.3 How should the guidance be used?

1.7. The guidance is advisory not mandatory. Local authorities that have declared Air Quality Management Areas (AQMAs) must have regard to the guidance when developing their Air Quality Action Plans. However, the guidance is also suitable and recommended for those other local authorities that are considering implementing measures to improve local air quality.

1.8. Local authorities should have regard to this guidance in conjunction with other relevant guidance with regard to LAQM duties. These guidance documents are as follows.

- Local Air Quality Management Technical Guidance 2009.
- Local Air Quality Management Policy Guidance 2009 including:
  - Practice Guidance on the Economic Principles for the assessment of local measures to improve air quality,
  - Practice Guidance relating to measures to encourage the uptake of Low Emission Vehicles (LEV),
  - Practice Guidance relating to measures to encourage the uptake of retrofit abatement equipment in existing vehicles.

1.9. It is advised that local authorities give regard to all Practice Guidance documents on local air quality measures rather than just this one. Each one contains important information, some of the guidance overlaps between documents and local authorities are also strongly recommended to follow the general guidance on the economic principles of local air quality assessments regardless of the measure being considered.

1.10. It is highlighted that the specific measures in the guidance are not the only measures that local authorities should examine when considering how to improve local air quality. The relevant Policy Guidance is clear that local authorities should be prepared to consider all possible measures if relevant. However, there is now an increasing amount of experience in implementing these particular measures in the UK and in other countries.

1.11. Further help on the guidance can be obtained from Defra (air.quality@defra.gsi.gov.uk), or by contacting the Local Authority Air Quality Action Plan Helpdesk (Telephone:0870 190 6050 Email: lasupport@aeat.co.uk).

1.4 Definitions of Low Emission Zones

1.12. A LEZ is a geographically defined area where the most polluting of vehicles are restricted, deterred or discouraged from access and use. The aim is to

reduce the use and number of more polluting vehicles being used in a particular area by setting particular emission standards or criteria, with the aim of improving the air quality.

1.13. Low Emission Zones have been successfully implemented and run for a number of years in Sweden and the Greater Tokyo Area, and more recently in London and cities in the Netherlands. The impact can be similar to an acceleration of fleet turnover or the fitting of abatement devices, thereby reducing emissions sooner than would otherwise have happened.

1.14. This note will focus on enforceable restrictions of traffic and parking on the public highway and planning conditions to control vehicle use and parking at private development sites, as a basis for setting up a LEZ.

1.15. It should be noted that reducing the number of more polluting vehicles might be achieved by a range of other methods. For example, incentivisation mechanisms, partnerships or regulations that focus on specific sectors of road transport might be used to encourage lower emission vehicles or take-up of emission abatement technologies. Information about these potential approaches to reducing vehicle emissions can be found in the accompanying guidance notes. It would also be possible to combine different schemes as part of an overall emissions reduction strategy.

1.5 Economic rationale for Low Emission Zone Schemes

1.16. The economic rationale for schemes such as these is linked to the external costs of operating polluting vehicles. Those undertaking polluting activity are placing costs on society as a whole through adverse health impacts and damage to ecosystems and the wider environment. The separation of private transport benefits and public impacts means that individuals are likely to consume goods or services in a way that is not socially optimal, unless there is an intervention. To place a limit on this, in relation to air quality for example, there are specific concentration limit values that have been defined and implemented to prevent unacceptable societal damages. Schemes described in this guidance document seek to provide additional incentive in order to make progress towards the limit values by reducing the external costs of transport.

1.17. Low Emission Zone schemes in this guidance are focussed on encouraging the replacement or use of existing vehicles with ones with lower emissions[1]. The main impacts of such schemes are likely to be:

- reduced emissions and improved air quality, hence contributing to UK environmental, health and economic objectives;
- higher vehicle replacement costs but improved fuel efficiency in many cases.

1.18. The ex ante appraisal of a London LEZ scheme suggested that progress towards air quality objectives would be made cost-effectively. As a result

[1] Although LEZ could be defined for industrial or commercial zones such that emissions from stationary sources are regulated, this type of scheme is not addressed in this guidance.

three LEZ policy scenarios were studied during the revision of the UK Air Quality Strategy (Defra, 2007) to appraise the wider application of such schemes. One scenario assumed that LEZ schemes were implemented in seven large urban areas in the UK. The details of the scenario assumed the implementation of a minimum Euro III standard for PM_{10} introduced in 2010 in the central areas of Glasgow, Manchester, Liverpool, Sheffield, Newcastle, Birmingham, and Leeds.

1.19. Benefits were estimated for the period 2010-2017. Emissions saved in 2010 were estimated at 150 tonnes particulate matter (PM_{10}) and 461 tonnes nitrogen oxides (NO_x) diminishing to zero by 2017. This is calculated to produce modest health benefits with a present value of £5-7 million. The calculation did not take account of benefits that may accrue outside of the LEZ zones, i.e. from the activity that vehicles undertake outside of urban centres, which are assumed to be non-negligible. Scheme costs were estimated as a present value of £9 million and costs to operators at £10 million with high uncertainty attached to this estimate. It should be noted that the schemes were assumed to be enforced via fixed and mobile camera techniques. This guidance provides information on lower cost options for implementing LEZ schemes.

1.20. In the Air Quality Strategy analysis the costs outweigh the benefits. However, apart from the scheme cost issue addressed above the analysis only considered a ‘weak’ option for emission standard. A Euro III standard would produce more benefits, say, if it had been implemented in 2008 as in the London scheme. This is an important reason why the London scheme has been appraised as being cost-effective with benefits balancing costs. For schemes implemented from 2010 onwards, local authorities should be thinking of schemes in terms of higher Euro standards. The London scheme does precisely this in a second phase in order to achieve air quality benefits in future years. In such cases the benefits are more likely to match the costs.

2 Options for Low Emission Zone schemes

2.1. The purpose of this chapter is to provide practical guidance on available options for LEZ schemes. Options include the different legal bases under which local authorities are empowered to introduce schemes and the various aspects of scheme design such as boundaries, emissions criteria, management and enforcement. The chapter structures these options and the headings are introduced in the left hand column of the table below. The table also summarises key aspects associated with the headings and options whereas the relevant text following the table expands on this to provide more detail in each case.

Table 1: Structured options and key aspects for introducing Low Emission Zone schemes

Scheme options	**Vehicle restrictions**	**Parking restrictions**	**Using the planning system**
Legal basis	Traffic Regulation Order (TRO) under Road Traffic Regulations Act 1984 (RTRA 1984). Enables access by permitted vehicles, which can be based on environmental criteria.	Traffic Regulation Order under RTRA 1984. Enables differential charging, which can be based on environmental criteria.	S106 agreement. Enables obligations based on environmental objectives.
Scheme design			
Vehicle emission standards and type	Can be based on one or more of: • Euro standards; • Vehicle age; • Emission abatement retrofit technology; • Fuel type/engine technology; • Carbon dioxide (CO_2) rating; • Engine size. Vehicle classification should also be specified: • Type(s) of vehicle (for example bus, car, van); • Weight; • Other specifications (are ambulances or specialist vehicles included?)	As per vehicle restrictions. NB most common approach (in UK) is to base on CO_2 ratings/engine size. This would not improve air quality unless combined with a minimum Euro standard requirement.	As per vehicle restrictions.

Scheme options	Vehicle restrictions	Parking restrictions	Using the planning system
	Is the scheme to be targeted at specific users, or exclude particular users (emergency vehicles, those with a disability, etc.)?		
Management of permitted vehicles	Scheme rules must be accessible to all vehicle owners, including non-UK owners. Allowing/providing certification routes for compliance by retrofit can be useful.	UK schemes have tended to focus on residents parking or season ticket holders, which provides a management system to build upon.	See Government policy on planning obligations www.communities.gov.uk/publications/planningandbuilding/circularplanningobligations
Enforcement powers and penalties	Outside London the relevant moving vehicle offences are currently enforceable by Police. Powers under Traffic Management Act 2004 (TMA 2004) may provide civil enforcement powers to local authorities. These are necessary to effectively enforce a scheme.	Traffic Management Act 2004 now provides for the civil enforcement of most types of parking contraventions. Local authority appointed Civil Enforcement Officers can issue Penalty Charge Notices (PCN) for parking contraventions.	Following a breach of planning control the Planning Authority (Local Authority or Council) has the option to take enforcement action. This may take the form of enforcement notices, (temporary) stop notices, Breach of Condition Notices, planning contravention notices, or High Court or county court injunctions.
Vehicle detection	Various methods, which can be combined in one scheme: • manual observation; • Automatic Number Plate Recognition (ANPR) cameras (fixed sites or mobile units); • Tag and beacon or swipe-card technology.[2]	Generally done by manual observation, although camera (CCTV) systems have been used.	In principal the same methods as for Traffic Restrictions would be available.

[2] It must be noted that any new on board equipment will need to be consistent with the European Electronic Tolling Service (EETS).

2.1 Scheme design

2.2. The starting point for the design of any LEZ scheme should be the scheme objectives, i.e. targeting pollutants emitted by specific vehicle type(s). Having established the objectives and indications of the potential location(s) for the zone, there are further design considerations local authorities need to take into account. Key issues in the design of a zone where LEV are prioritised over the most polluting vehicles are organised in this section under the headings of:

- legal basis;
- enforcement powers and penalties;
- vehicle emission standards and vehicle type;
- management of permitted vehicles;
- vehicle detection

2.3. Wherever possible, common guidance is given on traffic controls, parking controls and planning obligations. Where it is appropriate, separate guidance is provided.

2.1.1 Legal basis for implementation

2.4. Based on this guidance note's scope of coverage the following section covers two main routes to setting up an area (or zone) with traffic or parking controls based on vehicle emission criteria:

- Traffic Regulation Orders for enforceable restrictions on the public highway; and
- Section 106 agreements as planning obligations for development sites and private land.

Traffic Regulation Orders - Traffic and parking orders

2.5. There are several types of enforceable restrictions that can be employed by highway authorities under current legislation. The general basis for these is the TRO. Traffic Regulation Orders are commonly introduced to manage traffic flow at specific locations, to define on-street parking conditions, or as part of a broader traffic management scheme. For example, TRO can be used to restrict access to a given area or to certain types or weight of vehicle or during specific time periods. Traffic management schemes are typically focused on historic or busy commercial centres, where the effects of traffic on safety, noise and pollution levels can be quite dramatic, and also in sensitive residential neighbourhoods.

2.6. Highway authorities are empowered under the RTRA 1984 to make TROs to regulate the speed, movement and parking of vehicles and to regulate pedestrian movement. Traffic Regulation Orders are required for any enforceable restriction on the highway. They may be made under the terms of the RTRA 1984 or, for "special events", the Town Police Clauses Act 1847. The RTRA 1984 specifies what restrictions a TRO may impose. The Local

Authorities Traffic Orders (Procedure) (England) Regulations 1996 lay down the legal requirements for making and implementing a TRO.

2.7. The main points relating to the making of Orders that may be used for enforceable restrictions are summarised as follows:

i The Highway Authority may restrict any/all classes of vehicle from using any road or from carrying out certain activities in any road either permanently or on certain days/dates /times, provided that it specifies a valid reason (as defined in the RTRA 1984) in the statement of reasons. They may do this by making restrictions, which prohibit, restrict or regulate the use of any road by vehicular traffic or specified classes of vehicle. Restrictions may require traffic to proceed in a certain direction, restrict waiting or loading or prohibit through traffic.

ii valid reasons for making an Order include:

a) for avoiding danger to persons or other traffic using the road or any other road or for preventing the likelihood of any such danger arising, or
b) for preventing damage to the road or to any building on or near to the road, or
c) for facilitating the passage on the road or any other road of any class of traffic (including pedestrians), or
d) for preventing the use of the road by vehicular traffic of a kind which, or its use by vehicular traffic in a manner which, is unsuitable having regard to the existing character of the road or adjoining property, or
e) (without prejudice to the generality of paragraph (d) above) for preserving the character of a road in a case where it is specially suitable for use by persons on horseback or on foot, or
f) for preserving or improving the amenities of the area through which the road runs, or
g) for any of the purposes specified in paragraphs (a) to (c) of subsection (1) of section 87 of the Environment Act 1995 (EA 1995).

2.8. As noted, under point g), the EA 1995 is relevant. This Act broadened the purposes for which a TRO might be made to include the pursuit of environmental objectives. The relevant parts from the EA 1995 are Section 36 of Schedule 22, which states that TRO can be used “with respect to the assessment or management of the quality of air”. This is relevant to a traffic or parking control scheme designed to maximise environmental benefits.

2.9. Orders can be made that apply to certain classes of vehicle, and to set up a permitting system to exempt certain vehicles from the controls. The criteria for a permission (or permit) is defined by the Authority making the TRO. Therefore, it can be based on an environmental/emission standard linked to local objectives and circumstances. This approach has been used in a priority access scheme in the city of Bath.

2.10. All local authorities need to develop a parking strategy covering on- and off-street parking. Many different types of on-street parking schemes can be created under the powers provided in Part IV of the RTRA 1984. Local authorities use TROs to put parking schemes in place and appropriate traffic signs and road markings so that the public know what the restrictions mean.

2.11. A highway authority has the power to set charges for parking permits pursuant to the RTRA 1984 (as amended) and in doing so may set differential charges for different types of vehicle. In exercising its duties under the 1984 Act, a highway authority is under a duty to secure the expeditious, convenient and safe movement of traffic (including pedestrians) and suitable and adequate parking on and off the road. In meeting these duties, the highway must have regard to;

- the effect on amenities of any locality;
- the strategy prepared under section.80 EA 1995.
- any other matters appearing to the local authority to be relevant.

2.12. These matters provide a legal basis for the differential charging based on CO_2 and other emissions.

2.13. The signing of a vehicle access control scheme should be one of the first elements to consider when designing a scheme, to ensure it can be legally signed. It is important that the design of all sign faces is considered when drawing up the TRO. All signs used for a scheme should be in accordance with the Traffic Signs Regulations and General Directions and used as described in the Traffic Signs Manual. Sometimes the objectives for vehicle access control schemes have led to designs for which no suitable sign is prescribed in Traffic Signs Regulations and General Directions. In such cases it is necessary to seek authorisation for a specific sign from the DfT, before any variation to the prescribed signing takes place. Considering all the available prescribed signing must be a first step.

2.14. Advertising the scheme orders is an essential part of the scheme set-up, and guidance is provided in the relevant regulations about this and the statutory consultees for any TRO. If a major LEZ is to be established then local authorities should seek their own legal advice on the matter of advertising the relevant emission standards to vehicle owners in other Members States. Some European cities have used their membership of the European LEZ Network (www.lowemissionzones.eu) to advertise their information on vehicle emission standards.

Planning conditions

2.15. Local planning authorities can impose conditions on planning permissions only where there is a clear land-use planning justification for doing so. Conditions should be used in a way which is clearly seen to be fair, reasonable and practicable. One key test of whether a particular condition is necessary is if planning permission would have to be refused if the condition were not imposed. Otherwise, such a condition would need special and precise justification. Unless otherwise specified, a planning permission runs with the land. Exceptionally, however, the personal circumstances of an occupier, personal hardship, or the difficulties of businesses which are of value to the welfare of the local community, may be material to the consideration of a planning application. In such circumstances, a permission may be made subject to a condition that it is personal to the applicant. Such arguments will seldom outweigh the more general planning considerations,

however. See The Planning System: General Principles www.communities.gov.uk/publications/planningandbuilding/planningsystem.

It should be noted that planning conditions cannot be used to require financial contributions. See Circular 11/95: Use of conditions in planning permission (www.communities.gov.uk/publications/planningandbuilding/circularuse).

2.16. Where it is not possible to include matters that are necessary for a development to proceed in a planning condition, developers may seek to negotiate a planning obligation under section 106 of the Town and Country Planning Act 1990 (as amended by the Planning and Compensation Act 1991). Planning obligations should meet the Secretary of State's policy tests set out in Circular 05/05 (www.communities.gov.uk/publications/planningandbuilding/circularplanningobligations); i.e. they should be:

- necessary;
- relevant to planning;
- directly related to the proposed development;
- fairly and reasonably related in scale and kind to the proposed development; and
- reasonable in all other respects.

The use of planning obligations must be governed by the fundamental principle that planning permission may not be bought or sold. It is therefore not legitimate for unacceptable development to be permitted because of benefits or inducements offered by a developer which are not necessary to make the development acceptable in planning terms. Planning obligations are only a material consideration to be taken into account when deciding whether to grant planning permission, and it is for local planning authorities to decide what weight should be attached to a particular material consideration.

2.17. In terms of air quality, the impact of a development on air quality should be considered with regard to Planning Policy Statement 23 (often referred to as PPS23), particularly Annex 1 www.communities.gov.uk/publications/planningandbuilding/pps23annex1.

2.18. Both environmental impacts of a development and location of a development (whether it is close to a source of pollution or contributing further to an existing problem) can be taken into account as material planning considerations.

2.19. A useful document on the subject of low emission strategies - using the planning system to reduce transport emissions - has been produced by the Beacons Low Emission Strategies Group (2008). Broader guidance, aimed at ensuring that air quality is properly accounted for in local development control processes, has been produced by the NSCA (now Environmental Protection UK) as ‘Development Control: Planning for Air Quality’ (updated in 2006).

2.2 Enforcement powers and penalties

Traffic and parking orders

Parking enforcement

2.20. Local authorities have long been responsible for managing all on-street and some off-street parking, whether directly or indirectly. The powers to control waiting and loading and to provide and charge for on-street parking are provided by the RTRA 1984, with various amendments since such as by the Road Traffic Regulation (Parking) Act 1986, and most recently the TMA 2004.

2.21. The Road Traffic Act 1991 significantly changed the way that on-street parking restrictions are enforced. Before 1991, the police and traffic wardens were responsible for enforcement and income from fixed penalty notices (FPNs) went to the Exchequer. However, the police service found itself increasingly unable to resource parking enforcement. The 1991 Act made it mandatory for London boroughs and optional for other local authorities to take on the civil enforcement of non-endorsable parking contraventions. When a local authority takes over this power from the police, staff employed directly or indirectly by them issue Penalty Charge Notices (PCNs) and the local authority keeps the income for operation of the scheme.

2.22. Part 6 of the TMA 2004 now provides for the civil enforcement of most types of parking contraventions. It replaces Part II and Schedule 3 of the Road Traffic Act 1991 and some local legislation covering London only. The TMA 2004 and the associated regulations have given to English authorities outside London many powers already available to authorities in London, giving greater consistency across the country while allowing for parking policies to suit local circumstances.

2.23. It is assumed that most Authorities interested in using variable parking charges to incentivise lower emission vehicles will also be interested in taking up the powers available to them under the TMA 2004. Therefore, this guidance note is written with these latest regulations in mind and the environment of Civil Parking Enforcement that they provide.

Traffic enforcement

2.24. The TMA 2004 provides a single framework to make regulations for civil enforcement by local authorities or parking and waiting restrictions, bus lanes and some moving traffic offences. It is therefore a very important piece of legislation for local traffic authorities that wish to better manage their road networks and take on aspects of enforcement that may not be a priority for the Police.

2.25. Regulations under Schedule 7 to the TMA 2004 would allow local traffic authority-appointed Civil Enforcement Officers the powers to monitor and penalise a range of moving traffic offences such as stopping in boxed junctions and making banned turns. This would complement civil enforcement powers already available for parking management. Powers for moving vehicle enforcement may be extended in the future for authorities in

England with regulations provided by DfT. Updates are available via http://www.dft.gov.uk/pgr/roads/tpm/tmaportal/.

2.26. Extending civil enforcements powers would enable Highway Authorities outside London to use camera evidence of traffic contraventions. This would provide such authorities parity with those in London where legislation has enabled the adoption of civil enforcement of moving vehicle contraventions.

2.27. If powers are extended by the Schedule 7 regulations then road traffic signs described by the TMA 2004 for civil enforcement might be used to sign an LEZ. For example ‘motor vehicles prohibited’ (sign 619) can include the supplementary text 'except for permitted vehicles’. This appears sufficient to sign an access control scheme such as a LEZ, but authorities should seek their own legal advice. This could be more effective if special authorisation was given to add the term ‘LEZ’ before 'permitted vehicles', or add supplementary plates for which a Highway Authority could apply to DfT.

2.28. Civil penalties for moving vehicle contraventions (under TMA 2004) may be the same as currently applied to bus lane, parking and other similar moving traffic offences. Parking penalty charges are set at different bands and levels, up to £70 outside London, with discount or further charge depending when paid. It would be appropriate for a Highway Authority to consider the level of penalty charge required for effective enforcement. A supplementary local authority circular or relevant guidance is a mechanism that would enable a variation of the PCN charge in certain circumstances.

Planning obligations

2.29. Section 106 of the Town and Country Planning Act 1990 introduced the concept of planning obligations, which comprises both planning agreements and unilateral undertakings. It enables a planning obligation to be entered into by means of a unilateral undertaking by a developer as well as by agreement between a developer and a local planning authority.

2.30. Section 106(1) provides that anyone with an interest in land may enter into a planning obligation enforceable by the local planning authority. Such obligations may restrict development or use of land; require operations or activities to be carried out in, on, under or over the land; require the land to be used in any specified way; or require payments to be made to the authority either in a single sum or periodically.

2.31. Section 106(5) provides for restrictions or requirements imposed under a planning obligation to be enforced by injunction.

2.32. ODPM Circular 05/2005 (issued by what was then the Office of the Deputy Prime Minister) provides current policy on planning obligations under the Town and Country Planning Act 1990 (www.communities.gov.uk/publications/planningandbuilding/circularplanningobligations).

2.33. In the case of the Greenwich Peninsula and Royal Arsenal developments, the obligation to develop the LEZ scheme in more detail falls on the

developer, and the obligation to comply is borne by the developer and the future occupiers.

2.3 Vehicle emission standards and vehicle type

2.34. The approach for defining vehicle standards and vehicle type on which to base enforceable restrictions (on the public highway or at development sites) could be determined in one or a combination of ways.

2.35. The following criteria are relevant to schemes which target toxic pollutants:

- Euro standards (the term for European type approval standards on the emission performance of new vehicles over a defined test cycle);
- age of vehicle/ Year of first registration (because older vehicles tend to be more polluting, largely because Euro standards have progressively raised performance in this area);
- a particular fuel/technology combination (if they are considered to have particular benefits, such as hybrid, gaseous or renewable fuels);
- a retrofit technology (which can be used on older vehicles to clean up exhaust emissions, generally PM or NO_x);
- vehicle type (cars, vans, heavy goods vehicles (HGVs), emergency vehicles etc.) that is to be included or excluded.

2.36. For schemes in which the CO_2 reduction is an objective then the following criteria are a relevant basis for defining permitted vehicles:

- engine size (as a crude proxy for fuel consumption, and hence CO_2 output); and/or
- CO_2 output.

2.37. While the choice between these options in relation to LEZs is a choice for local authorities, Defra and DfT are currently considering how to approach vehicle classification to ensure that there is a level of consistency between schemes. This work will also be relevant for those Authorities considering LEZ schemes as to increase efficiency across scheme types through added consistency.

2.38. Authorities should be aware that setting a carbon reduction objective only may be counter-productive in air quality terms since it may lead to increased uptake of diesel-engined vehicles (being in general more fuel efficient). Authorities should therefore consider whether a Euro-standard objective should be set at the same time.

2.39. Existing LEZ that target toxic pollutants most commonly use Euro standards as the basis for setting emission. In a great number of cases there exist supplementary criteria to allow some exemption (or time-extensions) for retrofitting emission abatement technology. Age as a proxy for Euro standard is also a common accompanying basis.

2.40. For UK based parking schemes CO_2 emissions are the most common focus, and some mainland European schemes include discounts for alternative

fuels, and Austria (Graz) for a combination of low CO_2 and high Euro standard (for toxic pollutants).

2.41. Whatever the criteria used, it is essential is that they are open to and operable by any normal user. This would rule out region or country specific standards that might not be available to vehicle owners across Europe.

2.42. Euro standards describe the emissions criteria that vehicle manufacturers must type approve their vehicles to in order to supply for general sale in the EU. Euro I vehicles began to be produced for a EC-specific type approval standard that came into force in 1993, with pre-Euro vehicles generally being those registered before this date.

2.43. The dates at which these standards came into force for various vehicle types are shown in Table 2.

2.44. It should be noted that there can be a time lag between when a vehicle is manufactured (to a particular Euro standard) in order to be Type Approved and when the vehicle is finally sold to the initial purchaser as new, and registered (with DVLA). However, it is also the case that some manufacturers can produce vehicles to a specification that will meet the next Euro standard (on emissions) before the mandatory deadline, so it is possible to purchase buses that considerably exceed Euro 4 standards before the standards for Euro 5 are fully in place.

Table 2: Introduction dates for European emission standards

Vehicle class	Euro 1/I	Euro 2/II	Euro 3 /III	Euro 4/IV	Euro 5/V	Euro 6/VI
Passenger cars (for example private hire taxi)	31/12/92 – 01/01/97	01/01/97 – 01/01/01	01/01/01 – 01/01/06	01/01/06 - 01/01/11	01/01/11 - 01/09/15	01/09/15 -
Light commercial Class I – up to 1.3 tonnes unladen weight	01/10/94 – 01/10/97	01/10/97 – 01/01/01	01/01/01 – 01/01/06	01/01/06 - 01/01/11	01/01/11 - 01/09/15	01/09/15 -
Light commercial Class II/III between 1.3 tonnes unladen and 3.5 tonnes maximum laden weight	01/10/94 – 01/10/97	01/10/98 – 01/01/02	01/01/02 – 01/01/07	01/01/07 - 01/01/12	01/01/12 - 01/09/16	01/09/16 -
Heavy duty - over 3.5 tonnes maximum laden weight (inc. N2 & N3 and PSV M2 & M3)	10/10/93 –01/10/96	01/10/96 – 01/10/01	01/10/01 – 01/10/06	01/10/06 - 01/10/09	01/10/09 -	01/01/14

2.45. The benefits of using Euro standards for a scheme design are that they describe the emission performance in a well defined way, based on an approved testing procedure that defines the manufacturing process. It is a criteria against which any vehicle in Europe can be judged, therefore it is interoperable across countries. One drawback is that information about an individual vehicle's Euro standard is not always easy to access by its owner or the scheme operator, particularly for older vehicles.

2.46. The benefits of using age-based standards are simplicity and smooth progression (on an annual basis) of vehicles that will not comply with the scheme rules. The latter may be advantageous for forward investment and planning. The drawback is a potentially arbitrary cut-off point for vehicle moving from compliant to non-compliant status. A vehicle could be the wrong side of the age-criteria but have been manufactured to the same Euro standard as a slightly younger vehicle.

2.47. In practice, if a Euro standard basis is chosen for the scheme, it is useful to provide for some age-based proxies for vehicles when necessary in order to simplify the registration/certification process for vehicles where Euro standard information is hard to find. The experience from London LEZ is that information on Euro standards is not always readily available. Therefore, while the London LEZ expresses its emission criteria in terms of emissions standard in many cases vehicles are assessed using an age-as-proxy-for Euro standard. For any large-scale LEZ it is suggested that similar systems would be applicable in England, based on lessons learned and processes developed by Government agencies from the London implementation.

2.48. The benefit of retrofit technologies is that they can provide a 'safety net' for those vehicle owners who do not want, or cannot afford, to buy a newer vehicle to comply with a scheme. Emission abatement technology can be retrofitted to a vehicle to make it meet more stringent emissions limits than those to which it was originally type approved. For vehicles with long lifetimes and high usage, such as buses, this can be more cost-effective than replacing the vehicle.

2.49. The drawback, from a scheme design and administration viewpoint, is that while PM abatement technology can be approved in the UK (via the VOSA Reduced Pollution Certificate (RPC) process) the only equivalent scheme for NO_x reduction equipment is Transport for London's (TfL) London Taxi Emissions Abatement scheme, the scope of which is limited to black cabs. While NO_x abatement equipment is available for retrofitting the lack of an approval and certification route makes it more difficult to design a UK scheme which has the option of NO_x abatement to reach a required emission standard, compared to PM abatement via the VOSA RPC scheme. Further discussion of retrofitting can be found in the Practice Guidance on measures to encourage the uptake of retrofitting abatement equipment on vehicles.

2.50. The level of a vehicle's local pollutant emissions are primarily influenced by the vehicle technology rather than the properties of the fuel. Alternative fuels do not necessarily offer air quality benefits. However, gaseous fuels generally emit less CO_2 than petrol and biofuels can offer lifecycle CO_2 emissions reductions. As a result there may be local and specific arguments for

including alternative fuels and technologies in the list of compliant vehicles, perhaps if carbon reduction is a stated focus of the scheme.

2.51. For CO_2 focussed schemes the most common criteria are engine size and CO_2 emissions, and can be found from vehicle registration records for passenger car models from the VCA website (http://www.vcacarfueldata.org.uk/index.asp). Carbon dioxide figures for specific vehicles from registration records is available from the Direct Gov website at www.taxdisc.direct.gov.uk/EvlPortalApp/index.jsp. From 1 March 2001, practically all new car registrations have a published CO_2 emission level in g/km recorded on the registration documents and DVLA database. Therefore all carbon-focussed scheme, even one that only includes passenger cars, will need to include two methods for participation to ensure the scheme is open and fair.

2.52. It should be noted that there is no reliable approach for basing a scheme on emissions performance 'in service' (for example via the annual testing regime) since annual emissions testing merely checks for major faults on vehicles and is not capable of distinguishing between correctly functioning vehicles of different emissions performance. However, this has not proved a barrier to the introduction of a LEZ in the UK (London) or other European countries, as they use age and/or Euro standards as a basis.

2.3.1 Management of permitted vehicles

2.53. The scheme operator maintains the definition of what is a permitted vehicle. Processes are required to verify the emission standard of a particular vehicle. Certification processes may be necessary, or useful to include in a scheme if they already exist, if there is likely to be a lack of information about potential users of the scheme or if the scheme design means retrofit emission abatement equipment is allowed.

2.54. Management of the permission to enter the zone requires information and identification of individual vehicles with administration systems to cross-check permissions. In a large scheme covering a number of types of vehicle this would probably require the creation of a database with links to the DVLA, as for the London LEZ.

2.55. If a scheme is small-scale, affecting relatively few vehicles or one focussed on local fleets, then a basic permit management and verification system might be sufficient. Access control schemes in Cambridge and Bath are examples of where transponders are provided to a relatively small number of exempted vehicles (taxis and buses).

2.56. Carbon dioxide based UK parking schemes are based on resident parking permits or season ticket holders, which provides an administrative basis for managing new users. Schemes such as Winchester discount on parking for A and B-band CO_2 rated cars was limited at launch to Season ticket holders at long stay car parks. At the end of the trial period, the concept was extended to residents parking schemes in and around the city centre. The discounts are not available for short-stay Pay and Display, Park and Ride, Pay on Foot or Pay on Exit car parks. Including these types of parking within

a scheme would involve more complex management systems, and therefore higher running costs.

2.57. Management of permitted vehicles in a scheme focussed on a development site should be more straightforward compared to the public highway. Through-traffic is not normal and all vehicles are destined for privately controlled parking. The costs of administering any scheme would be expected to be borne by the developer, or ongoing management company set up by the developer or development occupiers.

2.58. Once a vehicle owner has checked with the scheme rules whether their vehicle complies or not they must be able to prove the status of their vehicle against the scheme rules. The vehicle registration mark (VRM) shown on the number plate can be used if this information is linked with the data used to verify the emissions criteria. Alternatively, or as a supplement, a specific sticker or plate may be issued by the scheme operator following verification of a qualifying emission standard.

2.4 Vehicle detection

2.59. This section identifies the likely approaches for detecting vehicles and determining which do not comply with the criteria set for a traffic, parking or development control scheme aimed at reducing vehicle emissions. This section assumes powers under the TMA 2004 for civil enforcement of both parking and moving vehicle contraventions on the public highway are available and have been taken up. It does not aim to repeat operational guidance available on specific matters of parking enforcement.

2.60. Identification of a vehicle that complies with scheme criteria could be via a paper permit, windscreen sticker, by the VRM on the number plate. A scheme design could instead require the vehicle to self-identify itself, by use of a transponder or a proximity smart card.

2.61. Detection of a vehicle for subsequent identification of emission status could be carried out by a variety of methods, sometimes in combination.

- Manual methods, whereby enforcement personnel visually check vehicles travelling within or parked within the scheme area for identification marks (VRM and/or a permit/sticker). In the mainland Europe examples of LEZ the checks would tend to focus on older looking vehicles and might use a mixture of manual recording and possibly photography. Some post-checking against a database of compliant vehicles would then be necessary.
- Digital cameras and ANPR – all passing number plates are recorded and using Optical Character Recognition (OCR) for matching against a database of vehicle data. A network of cameras would be installed on the key routes into/out of the boundary of the scheme and possibly at key junctions within the zone if it is very large. As a supplementary, or alternative approach, mobile ANPR cameras could be used to monitor key junctions and/or ‘hot-spots’ of possible non-compliance.
- Dedicated Short Range Communication (DSRC) – tags and beacons, more suitable for schemes with relatively few and pre-determined users

which comply with the scheme criteria. Tags or proximity smartcards are commonly issued to vehicle owners for accessing private car parks, or can be scanned through a wind-screen, and can also be used to trigger bollards which control access on the public highway.

2.62. The benefits of manual detection methods are lower capital costs, and some flexibility over future operating costs if enforcement levels can be reduced. Manual enforcement is suitable for parking schemes, whether on-street parking on development sites. A drawback of manual enforcement is the limit on the number and speed of vehicles that can be checked by a person. However, existing schemes show this approach should not be ruled out.

2.63. The London Lorry Control Scheme (commonly referred to as 'The London Lorry Ban') is an example of a successful manually enforced scheme. A small team of five officers manage to cover the prescribed route network across London and actively investigate some 500-600 vehicles a month. Officers position themselves at junctions known to be attractive, but controlled, routes for HGV. In addition, they will respond to complaints from residents of vehicles 'off-route'. The main objective is deterrence and to assist HGV drivers with better route planning in order to raise compliance rates. This scheme, and those LEZ enforced manually in other European countries, indicate that manual detection could be a basis for enforcement. Detection of Heavy Duty Vehicles (HDVs) is likely to be more successful than Light Duty Vehicles (LDVs), as HDVs are larger and less numerous.

2.64. The TMA 2004 regulations currently give the power to authorities throughout England to issue PCNs for parking contraventions detected with a camera and associated recording equipment (approved device). Regulations from the Act may also be prepared for moving vehicle contraventions. Cameras can only be used by Highway Authorities in a civil enforcement environment. There is current experience of using camera enforcement within London for moving traffic enforcement, and outside London for bus lane enforcement. The Secretary of State must certify any type of device used solely to detect contraventions and once certified they may be called an 'approved device'.

2.65. The benefits of such automated enforcement systems are that high speed and volume flows of vehicles can be detected and recorded, and that every vehicle can be checked. Drawbacks can include the relative inflexibility of fixed camera systems once they are installed, and the up-front capital costs.

2.66. Automatic Number Plate Recognition cameras can provide one part of such an automated system. They are able to capture 90%+ of passing number plates. Automatic Number Plate Recognition cameras are used in the London Congestion Charge Scheme (CCS) and for the London LEZ. In the London CCS, images are kept for checking of vehicles whose details are not in a database of vehicles for which a charge has been paid (or registered as exempt). In order to cover 'hotspots' of non-permitted vehicles within the LEZ, mobile (van-based) enforcement units could be suitable.

2.67. There will be additional options for identification and detection of vehicles entering development sites, depending on the layout and approach for managing traffic and parking. Development sites generally have a limited

number of entry and exit points, and are able to use manual or automatic barriers at these and at entrances to car parks. The road network tends to discourage through-movement, and access by non-residents or visitors. These factors enable greater opportunity for checks on vehicles. Parking permit and management systems provide opportunities for further identification and detection, to verify against a permitted vehicle database.

2.68. It should be noted that it is not strictly necessary to achieve a 100% detection level for a scheme to be effective. The level of compliance, and impact non-compliance has on emission impacts, will impact on the value for money of any scheme. However, the aim should be to achieve a balance with sufficient enforcement to provide an effective deterrent, in order to achieve the scheme objectives.

3 Developing a Low Emission Zone

3.1. Schemes may be designed using the options introduced in the previous chapter. Local authorities will need to appraise these options to make decisions on the most appropriate and cost-effective for a scheme in their area. This chapter provides guidance on the most important aspects of appraisal in particular regarding appraising the cost-effectiveness and benefits of schemes in terms of air quality objectives.

3.2. The chapter is structured as follows.

- The overall or generic effects of schemes are defined.
- A staged approach to appraising emissions and air quality effects of scheme designs is introduced. Staging the appraisal may allow a number of designs to be scoped out of the appraisal at an early stage on grounds of negligible benefits.
- The important types of capital and operating costs are introduced to allow a realistic appraisal of scheme design costs and costs to operators to be drawn up during appraisal.
- Guidance on using emissions and costs data to complete cost-effectiveness and cost-benefit appraisals is then provided.

3.1 Generic Effects

3.3. It is likely that LEZ schemes will have significant impacts on environmental objectives. Indeed improving the environment is a key objective of such schemes. The nature of the impacts will be scheme specific and depend on the scheme location and the scheme's impact on traffic levels by location, time of day and the composition of traffic. The environmental impacts of a scheme will also depend on the extent to which the LEZ is combined with other measures.

3.4. Table 3 describes qualitatively the potential impacts of these schemes.

Table 3: Qualitative assessment of the potential impacts of a Low Emission Zone scheme

Impact	Qualitative assessment	Notes/assumptions
Inside scheme zone		
Pollutant emissions (NO_x, PM_{10})	✓	True for Euro-standard based schemes. Schemes may address NOx and PM_{10} either individually or not.
CO_2 emissions	✓	Assuming Vehicle Excise Duty (VED)-based schemes
	-	Most likely neutral or marginally negative impacts for Euro-standard based schemes
Noise	✓	Newer vehicles are typically quieter
Travel time	-	Assuming the same number of vehicles circulate either complying with the scheme or not
Regulatory costs	X	Wide range of potential costs. Could be partly offset by revenue raised by the scheme
Operator costs	X	Additional operating costs or vehicle replacement costs before end of commercially useful life.
Outside scheme zone		
Pollutant emissions (NO_x, PM_{10})	-	Older vehicles may be sold for use in areas outside the zone but compliant vehicles that use the zone are also active outside of the zone
CO_2 emissions	-	
	-	Assuming a Euro-standard based scheme
Noise	-	Older vehicles may be sold for use in areas outside the zone but compliant vehicles that use the zone are also active outside of the zone
Travel time	-	Assuming the same number of vehicles circulate either complying with the scheme or not
Regulatory costs	-	Potentially no regulatory costs outside of zone
Operator costs	-	Potentially neutral operator costs if travel time impacts are neutral

Notes:

1. Qualitative assessment: ✓ symbolises a beneficial impact, x symbolises a negative impact, - symbolises a neutral impact.
2. Low Emission Zone schemes may have potentially significant non-air quality impacts. Therefore local authorities are advised to have regard to the generic guidance on the economic principles that apply when assessing these schemes. This guidance provides more detail on actions to take to assess significant non-air quality impacts.

3.2 Emissions/Air Quality Impact Assessment

3.5. Local authorities are advised to proceed through a staged process to assess the potential emissions and air quality impacts. These stages are:

- a screening stage (to identify the potential of such schemes);
- intermediate stage (consistent with LAQM methods and duties such as action planning and progress reporting);
- detailed stage (using the webTAG from DfT on appraising road transport schemes).

3.2.1 Screening assessment

3.6. The purpose of a screening assessment is to quickly assess the potential benefits of a scheme. It is intended to be simple and to use a minimum of information that is available.

3.7. At a basic level LEZ schemes are intended to reduce the use of more polluting vehicles with ones with more stringent emissions standards, for example, a shift from Euro II or older vehicles to Euro IV vehicles. In these basic terms the potential benefit from a LEZ scheme is therefore associated with the reduction in unit emissions (or emission factors).

3.8. A broad assessment could proceed as follows:

1. Define a zone inside which a LEZ scheme might operate and identify those vehicle types that the scheme would seek to regulate.
2. Assemble from transport models or otherwise estimate the annual activity (veh km) of those vehicle types within the zone. One way of estimating activity is to multiply traffic volumes by link length and then to sum over all links in the zone.
3. Define a year in which the scheme may start.
4. Use the emissions factor toolkit for vehicle emissions (http://www.airquality.co.uk/archive/laqm/tools.php?tool=emission) to obtain the year and vehicle type specific emission factors for NO_x and PM_{10} (g/veh km).
5. Multiply activity by emission factor to estimate the basecase emissions.

3.9. The effect of scheme depends on the emission standard set. For example, the London LEZ scheme requires HDVs to achieve at least a Euro III standard for PM_{10} by 7 July 2008.

1. The effect is to change the weighted emission factors for HDV types (see worked example in later section).
2. Recalculate the product of the activity and the emission factors to estimate the annual emissions with the scheme in operation.
3. The difference from the basecase is the potential emissions benefit of the scheme.
4. In combination with screening assessments of other schemes the relative attractiveness of each scheme in emissions terms can be compared.

3.10. Note that this simple approach to assessing LEZ schemes does not address potentially important effects such as the re-distribution of traffic and the contribution to emissions from congested conditions. Intermediate or detailed assessments are advised to address these issues more fully.

3.2.2 Intermediate assessment guidance

3.11. For an intermediate assessment Local authorities are advised to have regard to the related guidance documents on generic economic principles for assessment local air quality schemes provided alongside this guidance. This guidance document provides background information on emissions and air quality impact assessments. In particular it sets out recommendations on:

- developing a detailed baseline emission inventory;
- potential sources of data for the inventory;
- available tools for estimating the emission impacts of transport measures;
- having regard to the technical guidance on further assessment of local air quality for assessing compliance against the air quality objectives.

Specific guidance on assessing Low Emission Zone schemes

3.12. These schemes aim to change the emission factors of vehicles that circulate in a zone. Therefore the emissions and air quality assessments should be designed to include the following parameters or indicators:

- annual average daily road transport activity (veh.km) disaggregated by vehicle type and road links;
- implementation year (so that future underlying changes in emission factors are accounted for);
- fleet inventories (number of vehicles, their breakdown by euro standard and retrofit abatement equipment if relevant) for vehicle types affected by the measure.

3.13. During the design phase of a LEZ scheme local authorities should assess the effect (or range of effects) of the scheme on these indicators. In particular the effects of requiring a minimum Euro standard by an implementation date for specific vehicle types will be the key impact. Applying these changes to the baseline emission inventory and air quality dispersion model will estimate the potential emissions and air quality benefits of the measure.

3.2.3 Detailed assessment guidance

3.14. If assessment of the scheme proceeds to the need for a formal road scheme appraisal consistent with the NATA then local authorities should have full regard for the detailed guidance on completing these appraisals.

3.15. The full Transport Analysis Guidance can be found online at http://www.webtag.org.uk/. Unit 3.3.3 contains the specific guidance on local air quality assessment.

3.3 Cost Assessment

3.16. For any scheme, in order to demonstrate value for money local authorities will need to analyse both set up costs and operational costs.

3.17. Traffic enforcement, parking enforcement and development control schemes will all deal with users (customers) and collect and store information about specific vehicles. Traffic and parking schemes will certainly involve some administration of financial matters, be it via a charge for permits and/or income from penalties.

3.18. The back office operation that underpins the operation of the scheme should be based on a sound business model. The choice and design of business model will be a key determinant in whole-life costs of a scheme. There is a strong argument to determine the business model immediately after choosing the scheme format, in order to understand the basis on which the various sub-systems that will deliver a working scheme will operate and be linked. Consideration also needs to be given to the procurement strategy.

3.19. The objective of the procurement process is to ensure that competition is used to obtain the lowest whole life costing while providing the most robust and technically proven. Some of the lessons from commercial sector organisations are that developing an effective procurement strategy at the outset is essential to getting value for money.

3.20. If a scheme uses any hardware or software components it is valuable to specify industry standards (not just sector or function specific) packages rather than bespoke software solutions. This will provide benefit by ensuring that ongoing support and maintenance as well as future upgrades can be carried out at a competitive rate.

3.21. A scheme may incorporate more than one solution in order to meet the needs and constraints of different users. Indeed, it is desirable that all but the smallest schemes do incorporate more than one solution in order to maximise cost-effectiveness and meet a range of user needs. An example would be a CO_2-based resident parking schemes where vehicles registered prior to 2001 have permits allocated against their engine size, because CO_2 emission ratings are not readily available.

3.22. If schemes are required to be interoperable, then this will need building into the design phase and both set-up and operational aspects could involve some aspect of additional cost.

3.23. Additional factors that will affect a consideration of cost and timescale for setting up and operating a traffic enforcement schemes are bound up in the scheme characteristics. This includes the basis of scheme (numbers and sub-types of vehicles that are to be included within the scope), the physical size of the scheme and the level of technology used for detection and enforcement. Together these factors contribute much to the level of complexity of a scheme design.

3.24. The greater the number of vehicle types within the scope of the scheme the greater the overall number of vehicles, and therefore costs. In broad terms, the size of the UK fleet rises in number from Bus/coach, HGV, Light Goods Vehicles (LGV) (vans) to passenger cars. Therefore, a scheme which includes only HDV will tend to cost the scheme operator less than one which only includes passenger cars, all other things being equal. This does not yet take into account operator costs.

3.25. A physically larger scheme will tend to cost more to set up and operate, if all other factors remain equal. Hence, a single strategic access point that effectively controls most of the cross-city traffic in a historic urban area could be very effective, but will not be an option for a modern city centre with urban dual carriageway through-routes. The size of a scheme design will be individual to the location and opportunities of the road network, as well as the extent of air quality problems.

3.26. A major factor is the level of technology used. Schemes that use technology in the vehicle identification, detect or enforcement functions (tags, smart cards or ANPR) will tend to have greater set-up costs than paper or sticker-based schemes, and operating design should be considered in the cost-benefit/effectiveness assessment. Considerable attention should be paid to what are the predicted minimum and maximum compliance rates. Compliance rates will markedly change the overall cost-effectiveness of different scheme options. However, if a windscreen sticker-based system works effectively in the UK context, it will tend to be more cost-effective than one closely monitored by camera systems.

3.27. With powers that may be available under the TMA 2004 PCN can be applied by local authority Civil Enforcement Officers. Penalty Charge Notice revenues may be retained and used to support the operation of a scheme. If a traffic enforcement scheme is running effectively the levels of PCN revenue should be low. However, scheme running costs will still continue, albeit ideally at lower levels. This means there are strong arguments for designing low-cost traffic enforcement schemes, particularly for the operation phase.

3.28. For parking schemes, then the revenue earned is dependant on the amount and demand for parking places. Authorities should never use parking charges just to raise revenue or as a local tax. However, where the demand for parking is high, the delivery of transport objectives with realistic demand management prices for parking may result in surplus income. In such cases local authorities must ensure that any on-street revenue not used for enforcement is used for legitimate purposes only and that its main use is to improve, by whatever means, transport provision in the area so that road users benefit. Carbon dioxide related parking schemes have generally been designed so that overall the scheme costs remain in line with the situation prior to the scheme, even if charges may now fall differentially across the users.

3.29. The costs of setting up and operating a scheme based on planning conditions would be expected to be borne by the developer. There would, however, be time and effort required from the Planning Authority in agreeing the scheme rules. A development based scheme aimed at reducing

emissions from traffic should take into account the types of costs and design impacts noted in this guidance.

3.30. Considering the various cost elements that might be relevant to a scheme, we can divide these into capital costs (i.e. set-up or investment costs) and operating costs. A list of generic cost categories is set out in Table 4 below.

Table 4: Cost items for Low Emission Zone scheme set-up and operation

Capital costs	Operating costs

• Scheme design and planning
• Legal support
• TRO review and update
• Consultation process
• Marketing and information campaign
• Traffic management / safety
• Roadside equipment (signing, detection, enforcement)
• Central administration and IT systems (back-office functions: vehicle record, certification, enquiry handling)
  o project management
  o systems design and configuration control
  o systems integration and implementation
  o systems testing and acceptance
	• Accommodation
	• Staff costs
	• Training
	• Registration and validation of vehicles
	• Any new vehicle identification method (for example windscreen stickers) and the issuing process for this
	• Equipment / software replacement and maintenance costs
	• Vehicle immobilisation and removals
	• PCN processing
	• Adjudication and appeal costs
	• Supplies, services and transport
	  o contingency plans for business continuity and disaster recovery;
	  o data retention and archiving;
	• Monitoring and evaluating the scheme impacts
	• Certification of retrofit devices, suppliers and vehicles fitted with retrofit devices

3.4 Cost-effectiveness and Cost-benefit Assessment

3.31. Cost-effectiveness analysis and Cost-Benefit Analysis are both methods for economic appraisal. Practice Guidance on Economic Principles provides more detailed information on these techniques and how to use them. This section summarises the key points.

3.32. Cost-effectiveness compares different ways of achieving the same objective. It is relevant for air quality when looking to achieve (or to make progress towards) the reduction of air quality exceedences, i.e. legally binding concentrations that must not be exceeded. However, such a cost-effectiveness analysis focuses only on one objective, and does not consider other Government environmental goals. The benefit of cost-effectiveness analysis is that it allows the relative attractiveness of different options or combinations of measures to be assessed, in order to achieve the overall objective (the removal of the exceedence) in the most cost-effective way, i.e. economically efficiently.

3.33. Cost-benefit analysis assesses whether the total benefits of a project or policy exceed the costs. It is therefore an absolute measure and can assess value for money. It quantifies costs and benefits in monetary terms, including values not captured by markets (i.e. the full costs and benefits to society). The UK Government, in its guidance for economic appraisal, favours the use of cost-benefit analysis. This is also the main part of the approach used in local transport appraisal – and has been the case for many years. Cost-benefit analysis is relevant for all air quality proposals, but especially those which are not specifically addressing an existing exceedence. The results of a cost-benefit analysis can then be used to update the cost-effectiveness analysis to consider all environmental goals, by working with 'net' cost-effectiveness, where the capital and scheme costs are expressed net of all environmental costs or benefits, before the cost-effectiveness ranking.

3.34. Note that these two techniques can be complementary. Cost-effectiveness is part of both techniques, but in cost-benefit analysis, the analysis is extended to compare directly to the benefits of the proposals.

3.35. In order to undertake either cost-effectiveness analysis or cost-benefit analysis, it is necessary to collate and assess information on costs for use in an economic framework. It is highlighted that practitioners often confuse financial and economic appraisal. An economic appraisal considers the costs in terms of society as a whole and the overall value for money. A financial appraisal looks at the affordability of a proposal, and is more likely to be more familiar as it will be similar to local budgetary framework, financial costs and accounts (an accountancy based perspective). For any scheme, both the economic and financial case for a proposal will be important, as it will be necessary to show the wider value for money of a proposal, but also ensure that from the local authority perspective, it is affordable. However, for cost-effectiveness analysis and cost-benefit analysis, the economic assessment should be used. The Practice Guidance on Economic Principles provides more details.

3.36. In economic appraisal, all historic and future cost estimates need to be expressed in equivalent terms, so they can be directly compared. The Practice Guidance on Economic Principles provides details of how to analyse cost information so it can be used in cost-effectiveness and cost-benefit analysis. This is likely to require some analysis of cost data (including future costs). It is also necessary to work within an economic framework in the assessment of costs, which requires analysis of all costs (not just those that occur to the local authority in the local authority area), and has to exclude all transfers, such as VAT, taxes or charges. The Practice Guidance on Economic Principles provides more details.

3.37. To undertake a scoping cost-effectiveness analysis, the annual emissions benefits of a measure, as estimated using the approach set out in the previous section, are combined with the cost data, where costs are expressed as an equivalent annual costs. The annual emission benefits are divided by the equivalent annual cost to give the cost (£) to reduce one tonne of emissions (cost per tonne). This gives the cost-effectiveness of a measure – and this allows different options to be compared – those with the lowest cost per tonne abated (the lower cost per tonne) are the most cost-effective.

Note that in the case of an AQMA, the relevant metric is likely to be the emissions abated in the area of the exceedence, though more accurately, it is the cost per level of air quality improvement (µg m^{-3}). However, such an analysis only considers one environmental goal, and it is also necessary to consider other environmental objectives in a 'net' cost-effectiveness analysis to correctly prioritise measures (see below).

3.38. It is also possible to use the cost-effectiveness ranking to build up an action plan towards the reduction of an exceedence. Those measures that are most cost-effective, i.e. that achieve greatest air quality improvements for least cost should be included first in the plan. Progressively less cost-effective options are then added until the target air quality improvement is achieved, or until proportional progress towards the target can be demonstrated. Undertaking analysis in this way will also provide a total cost of compliance. Note, however, that cost-effectiveness works only with a single pollutant. To address this, it is possible to work with the 'net cost-effectiveness' to consider other environmental objectives. Moreover, the cost-effectiveness of a measure is only one element of the options, and other factors will be important in determining the overall ranking of measures, including the wider assessment, legal and technical issues, practicality and acceptability.

3.39. To undertake a cost-benefit analysis, the same information on emissions and costs is used, though there are important differences. First, the emissions benefits are expressed in monetary terms. The valuation of emission benefits can be undertaken using the Defra damage costs, which give the benefits in (£) per tonne of pollutant reduced, using the Defra damage cost spreadsheet, available at (http://www.defra.gov.uk/environment/airquality/panels/igcb/guidance/index.htm. The benefits in each year over the scheme lifetime are used (rather than the benefits in one year), and the total monetary benefits of all pollution benefits (for multiple pollutants, such as NO_x and PM_{10}) are estimated, along with the monetary values for other environmental effects such as greenhouse gas emissions, using the Government damage cost (the Shadow Price for Carbon, SPC). This is used to generate the total present value of benefits, which can be compared against the total present value of costs of the options (note cost-benefit analysis works with the total stream of costs, i.e. the present value, not the annualised costs used in cost-effectiveness analysis above).

3.40. The cost-benefit analysis simply compares the present value of the stream of benefits divided by the present value of the stream of costs, to generate a net present value (NPV). The NPV is the primary criterion for deciding whether government action can be justified, i.e. whether a scheme has a positive net present value. A higher NPV indicates an option is preferable. However, other factors will be important in determining the overall ranking of measures, including any other benefits or costs, legal and technical issues, practicality and acceptability.

3.41. The cost-benefit analysis results can be used to provide a 'net' cost-effectiveness analysis. The 'net' cost effectiveness is equal to the present value of costs less present value of benefits / by reduction in tonnes pollutant, or in the above case where the cost-effectiveness analysis is

concerned with air quality targets in a given year, is equal to annualised costs less annualised benefits / by reduction in tonnes pollutant (or µg m^{-3}). The advantage of this 'net' cost-effectiveness assessment is it allows consideration of other environmental objectives, i.e. reductions of other air quality pollutants or changes in greenhouse gas emissions, and so provides a more holistic overall ranking method for planning.

3.42. Previous studies have looked at the cost-effectiveness and cost-benefit analysis of retrofit schemes. These include for example, the Interdepartmental Group on Costs and Benefits (IGCB) Economic Analysis to Inform the Review of the Air Quality Strategy (http://www.defra.gov.uk/environment/airquality/publications/stratreview-analysis/index.htm), the London LEZ (http://www.tfl.gov.uk/roadusers/lez/default.aspx). A worked example is included in the following section.

4 Worked example

4.1 Introduction

4.1. To illustrate how the guidance in chapter 3 may work in practice the following worked example provides guidance on assessing emissions effects, costs and cost-effectiveness and cost benefit assessment.

4.2. This worked example assumes a LEZ is implemented to regulate HGV emissions via replacement of existing vehicles with new vehicles. The example illustrates the effect of:

- varying the emission standard with which the HGVs must comply;
- varying the year by which HGVs must comply (ie the implementation year).

4.2 Emissions assessment

Do minimum or baseline case

4.3. This policy would affect HGVs only. If possible collate information on:

- number of vehicles potentially affected;
- their age (i.e. when first registered) and whether they already have abatement equipment fitted;
- planned replacement rates (ie, how long each is expected to remain in service).

4.4. However, HGVs and their activity are mainly unregulated by local authorities. Unlike bus operators there are potentially very many operators and many vehicles involved so that it is unlikely that accurate data of these types will be readily available. In these circumstances it is necessary to rely on the national predictions from the Air Quality Archive. Use the emissions factor toolkit for vehicle emissions (http://www.airquality.co.uk/archive/laqm/tools.php?tool=emission) or National Atmospheric Emissions Inventory (NAEI) webpages to obtain the year and vehicle type specific emission factors for NO_x and PM_{10} (g/veh km). These emission factors take account of the weighted contribution of different Euro standard vehicles to the average emission factor based on national data regarding vehicle replacement rates. Tables 5 and 6 illustrate this approach.

Table 5: Proportionate breakdown of national Heavy Goods Vehicle fleet by Euro standard

Vehicle	Standard	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rigid HGV	Pre-Euro I	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rigid HGV	Euro I	0.054	0.033	0.015	0.006	0.000	0.000	0.000	0.000	0.000
Rigid HGV	Euro II	0.294	0.237	0.187	0.138	0.098	0.066	0.035	0.016	0.006
Rigid HGV	Euro III	0.510	0.474	0.428	0.392	0.332	0.274	0.219	0.170	0.123
Rigid HGV	Euro IV	0.137	0.230	0.232	0.207	0.195	0.189	0.170	0.146	0.119
Rigid HGV	Euro V	0.000	0.027	0.137	0.257	0.375	0.471	0.575	0.667	0.751
Total		**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**
Artic HGV	Pre-Euro I	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Artic HGV	Euro I	0.027	0.018	0.009	0.003	0.000	0.000	0.000	0.000	0.000
Artic HGV	Euro II	0.210	0.149	0.101	0.069	0.051	0.035	0.021	0.010	0.003
Artic HGV	Euro III	0.587	0.518	0.441	0.360	0.274	0.201	0.143	0.098	0.067
Artic HGV	Euro IV	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.093
Artic HGV	Euro V	0.000	0.035	0.175	0.316	0.449	0.569	0.675	0.765	0.837
Total		**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**

Table 6: Baseline Heavy Goods Vehicle emission factors (g/km) at 30 kph based on national fleet trends

	2007	2008	2009	2010	2011	2012	2013	2014	2015
NO_x - Rigid HGV	5.388	5.000	4.527	4.097	3.702	3.386	3.073	2.821	2.612
NO_x - Artic HGV	11.77	10.79	9.55	8.47	7.57	6.80	6.16	5.62	5.23
PM_{10} - Rigid HGV	0.142	0.121	0.105	0.091	0.078	0.068	0.058	0.050	0.044
PM_{10} - Artic HGV	0.38	0.32	0.27	0.22	0.19	0.16	0.13	0.11	0.10

4.5. Note that this example takes a simple view that an average speed of 30 kph is representative of urban HGV activity. Detailed analysis should include consideration of emissions associated with congestion too if these are relevant to the case.

4.6. It is also necessary to collate estimates of the total annual vehicle kilometres travelled by these vehicles. These data are most likely to be held in local datasets such as local authority traffic models. Note that if the policy will only

be enforced in a specific zone that the total annual vehicle kilometres travelled by these vehicles in that zone should be estimated. This can be estimated by multiplying the total link length on the implicated routes by the annual traffic flow.

Table 7: Baseline Heavy Goods Vehicle activity data (million veh.km)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rigid HGV	44.13	43.69	43.25	42.81	43.01	43.20	43.40	43.60	43.79
Artic HGV	22.29	22.88	23.48	24.08	24.45	24.83	25.20	25.58	25.95

4.7. Emission rates and activity data are multiplied to estimate the baseline HGV emissions shown in Table 8.

Table 8: Estimated baseline Heavy Goods Vehicle emissions (tonnes) in the Low Emission Zone

	2007	2008	2009	2010	2011	2012	2013	2014	2015
NO_x - Rigid HGV	255.2	233.6	209.0	186.7	168.1	153.4	138.6	126.7	116.9
NO_x - Artic HGV	262.33	246.84	224.29	203.92	185.03	168.92	155.15	143.85	135.69
NOx total	517.49	480.44	433.32	390.64	353.17	322.29	293.73	270.54	252.55
PM_{10} - Rigid HGV	7.1	6.0	5.1	4.4	3.7	3.2	2.7	2.3	2.0
PM_{10} - Artic HGV	8.43	7.34	6.29	5.37	4.56	3.89	3.34	2.91	2.62
PM_{10} total	15.55	13.35	11.40	9.76	8.29	7.09	6.05	5.23	4.63

4.8. Note that the estimates illustrate a decline in emissions over time due to vehicle replacement rates and more stringent Euro standards in new vehicles.

Estimated effect of varying the emission standard to be achieved

4.9. The baseline HGV fleet can be analysed for realistic options for setting future emission standards. Between 2008-11 the majority of vehicles are of Euro III standard or better. Therefore the objective of an LEZ during this period may be for all vehicles to achieve a Euro III standard or better. From 2011 onwards the contribution of Euro III standard vehicles is also in decline hence during that period a LEZ scheme may require a Euro IV standard or better vehicle.

4.10. From 2008 onwards Euro V standard vehicles are increasingly available. Theoretically it would be possible for a fleet operator to buy vehicles second-hand if they are compliant with whatever euro standard is selected as the criteria for a scheme but this example assumes that replacement is always to a brand-new vehicle.

4.11. The tables below illustrate the changes to the baseline HGV fleet and emissions that would occur if the fleet had by 2010 to achieve:

- a Euro III standard (requires all pre-Euro III vehicles to be replaced)'

- a Euro IV standard (requires all pre-Euro IV vehicles to be replaced)'
- a Euro V standard (requires all pre-Euro V vehicles to be replaced).

4.12. The tables include a calculation of the difference in annual emissions relative to the base case.

Criteria	Euro III standard									Euro IV standard									Euro V standard								
Rigid HGVs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015
Euro I	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Euro II	0.29	0.24	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.24	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.24	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Euro III	0.51	0.47	0.43	0.39	0.33	0.27	0.22	0.17	0.12	0.51	0.47	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.47	0.43	0.00	0.00	0.00	0.00	0.00	0.00
Euro IV	0.14	0.23	0.23	0.21	0.19	0.19	0.17	0.15	0.12	0.14	0.23	0.23	0.21	0.19	0.19	0.17	0.15	0.12	0.14	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Euro V	0.00	0.03	0.14	0.40	0.47	0.54	0.61	0.68	0.76	0.00	0.03	0.14	0.79	0.81	0.81	0.83	0.85	0.88	0.00	0.03	0.14	1.00	1.00	1.00	1.00	1.00	1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Emission rate																											
NO_X (g/km)	5.78	5.35	4.83	3.59	3.39	3.20	3.00	2.82	2.63	5.78	5.35	4.83	2.40	2.38	2.37	2.34	2.30	2.26	5.78	5.35	4.83	2.07	2.07	2.07	2.07	2.07	2.07
PM (mg/km)	0.16	0.14	0.12	0.08	0.07	0.06	0.06	0.05	0.04	0.16	0.14	0.12	0.03	0.03	0.03	0.03	0.03	0.03	0.16	0.14	0.12	0.03	0.03	0.03	0.03	0.03	0.03
Emissions (tonnes)																											
NO_X	255.16	233.60	209.04	153.56	145.60	138.22	130.38	122.91	115.36	255.16	233.60	209.04	102.58	102.22	102.30	101.50	100.34	98.96	255.16	233.60	209.04	88.79	89.20	89.59	90.01	90.42	90.82
PM_{10}	7.12	6.02	5.12	3.27	2.98	2.70	2.43	2.20	1.96	7.12	6.02	5.12	1.30	1.30	1.31	1.32	1.32	1.33	7.12	6.02	5.12	1.30	1.30	1.31	1.32	1.32	1.33
Artic HGVs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015
Euro I	0.027	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000
Euro II	0.210	0.149	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.210	0.149	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.210	0.149	0.101	0.000	0.000	0.000	0.000	0.000	0.000
Euro III	0.587	0.518	0.441	0.360	0.274	0.201	0.143	0.098	0.067	0.587	0.518	0.441	0.000	0.000	0.000	0.000	0.000	0.000	0.587	0.518	0.441	0.000	0.000	0.000	0.000	0.000	0.000
Euro IV	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.093	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.093	0.175	0.280	0.274	0.000	0.000	0.000	0.000	0.000	0.000
Euro V	0.000	0.035	0.175	0.39	0.50	0.60	0.70	0.78	0.84	0.000	0.035	0.175	0.75	0.77	0.80	0.84	0.87	0.91	0.000	0.035	0.175	1.00	1.00	1.00	1.00	1.00	1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Emission rate																											
NO_X (g/km)	11.77	10.79	9.55	7.63	6.98	6.41	5.91	5.51	5.19	11.77	10.79	9.55	5.29	5.20	5.10	4.98	4.87	4.76	11.77	10.79	9.55	4.45	4.45	4.45	4.45	4.45	4.45
PM (mg/km)	0.38	0.32	0.27	0.19	0.16	0.14	0.12	0.11	0.10	0.38	0.32	0.27	0.08	0.08	0.08	0.08	0.08	0.08	0.38	0.32	0.27	0.08	0.08	0.08	0.08	0.08	0.08
Emissions (tonnes)																											
NO_X	262.33	246.84	224.29	183.73	170.72	159.12	149.04	140.87	134.74	262.33	246.84	224.29	127.36	127.09	126.57	125.50	124.49	123.45	262.33	246.84	224.29	107.06	108.70	110.39	112.03	113.72	115.37
PM_{10}	8.43	7.34	6.29	4.55	3.98	3.49	3.10	2.79	2.58	8.43	7.34	6.29	1.90	1.93	1.96	1.99	2.02	2.05	8.43	7.34	6.29	1.90	1.93	1.96	1.99	2.02	2.05
Emissions (tonnes)																											
Total NO_X	517.49	480.44	433.32	337.29	316.32	297.34	279.41	263.78	250.10	517.49	480.44	433.32	229.93	229.31	228.87	227.00	224.83	222.41	517.49	480.44	433.32	195.84	197.90	199.98	202.04	204.15	206.19
Total PM_{10}	15.55	13.35	11.40	7.82	6.97	6.19	5.53	4.99	4.55	15.55	13.35	11.40	3.20	3.24	3.27	3.31	3.35	3.38	15.55	13.35	11.40	3.20	3.24	3.27	3.31	3.35	3.38
Difference from																											
Baseline (tonnes)																											
Total NO_X	0.00	0.00	0.00	53.35	36.85	24.95	14.32	6.76	2.44	0.00	0.00	0.00	160.70	123.87	93.43	66.73	45.71	30.14	0.00	0.00	0.00	194.80	155.27	122.31	91.69	66.39	46.36
Total PM_{10}	0.00	0.00	0.00	1.93	1.32	0.89	0.52	0.24	0.09	0.00	0.00	0.00	6.56	5.05	3.81	2.74	1.89	1.25	0.00	0.00	0.00	6.56	5.05	3.81	2.74	1.89	1.25

Estimated effect of varying the implementation year

4.13. The baseline HGV data can be analysed for realistic options for setting the year by which standards should be achieved.

4.14. In this example it is assumed that the emission standard to be achieved is Euro III (ie all pre-Euro III vehicles are replaced.) The effects of requiring this change by 2010, 2012 and 2015 are examined.

4.15. Examining the baseline data table it can be seen that the 2010 compliance date will affect around 15% of rigid HGV and 7% of articulated vehicles, the 2012 date would affect 7% of rigid HGV and 3.5% of articulated vehicles whereas the 2015 date will affect only <1% of rigid HGV and <1% of articulated vehicles due to the predicted natural replacement rate of vehicles over this period. From this it follows that compliance with the 2012 and 2015 dates would cost operators less but would also have a lesser effect.

4.16. This discussion illustrates the important point that setting an early compliance date will achieve more local air quality and emission benefits but usually at higher costs.

4.17. The tables below illustrate the changes to the baseline HGV fleet and emissions that would occur for the examples that if the fleet complies with the Euro III standard by 2010, 2012 and 2015 respectively.

4.18. Key points to note are that the 2010 implementation date would deliver several years of benefits relative to the base case, whereas the 2012 case would deliver fewer benefits and for a shorter period. As time passes the gap between the base case and the Euro III standard decreases due to natural replacement of older vehicles. By 2015 the benefits due to the Euro III standard is very small. The policy of requiring the Euro III standard by 2015 would only deliver a small benefit – this policy delivers too little too late.

Criteria	2010 compliance date									2012 compliance date									2015 compliance date								
Rigid HGVs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015
Euro I	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.054	0.033	0.015	0.006	0.000	0.000	0.000	0.000	0.000	0.054	0.033	0.015	0.006	0.000	0.000	0.000	0.000	0.000
Euro II	0.29	0.24	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.294	0.237	0.187	0.138	0.098	0.000	0.000	0.000	0.000	0.294	0.237	0.187	0.138	0.098	0.066	0.035	0.016	0.000
Euro III	0.51	0.47	0.43	0.39	0.33	0.27	0.22	0.17	0.12	0.510	0.474	0.428	0.392	0.332	0.274	0.219	0.170	0.123	0.510	0.474	0.428	0.392	0.332	0.274	0.219	0.170	0.123
Euro IV	0.14	0.23	0.23	0.21	0.19	0.19	0.17	0.15	0.12	0.137	0.230	0.232	0.207	0.195	0.189	0.170	0.146	0.119	0.137	0.230	0.232	0.207	0.195	0.189	0.170	0.146	0.119
Euro V	0.00	0.03	0.14	0.40	0.47	0.54	0.61	0.68	0.76	0.000	0.027	0.137	0.257	0.375	0.537	0.611	0.683	0.757	0.000	0.027	0.137	0.257	0.375	0.471	0.575	0.667	0.757
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Emission rate																											
NO_X (g/km)	5.78	5.35	4.83	3.59	3.39	3.20	3.00	2.82	2.63	5.78	5.35	4.83	4.36	3.91	3.20	3.00	2.82	2.63	5.78	5.35	4.83	4.36	3.91	3.55	3.19	2.91	2.63
PM (mg/km)	0.16	0.14	0.12	0.08	0.07	0.06	0.06	0.05	0.04	0.16	0.14	0.12	0.10	0.09	0.06	0.06	0.05	0.04	0.16	0.14	0.12	0.10	0.09	0.07	0.06	0.05	0.04
Emissions (tonnes)																											
NO_X	255.16	233.60	209.04	153.56	145.60	138.22	130.38	122.91	115.36	255.16	233.60	209.04	186.72	168.14	138.22	130.38	122.91	115.36	255.16	233.60	209.04	186.72	168.14	153.37	138.58	126.69	115.36
PM_{10}	7.12	6.02	5.12	3.27	2.98	2.70	2.43	2.20	1.96	7.12	6.02	5.12	4.39	3.73	2.70	2.43	2.20	1.96	7.12	6.02	5.12	4.39	3.73	3.20	2.70	2.32	1.96
Artic HGVs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007	2008	2009	2010	2011	2012	2013	2014	2015
Euro I	0.027	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.018	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.027	0.018	0.009	0.003	0.000	0.000	0.000	0.000	0.000
Euro II	0.210	0.149	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.210	0.149	0.101	0.069	0.051	0.000	0.000	0.000	0.000	0.210	0.149	0.101	0.069	0.051	0.035	0.021	0.010	0.000
Euro III	0.587	0.518	0.441	0.360	0.274	0.201	0.143	0.098	0.067	0.587	0.518	0.441	0.360	0.274	0.201	0.143	0.098	0.067	0.587	0.518	0.441	0.360	0.274	0.201	0.143	0.098	0.000
Euro IV	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.093	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.093	0.175	0.280	0.274	0.253	0.226	0.195	0.160	0.126	0.000
Euro V	0.000	0.035	0.175	0.39	0.50	0.60	0.70	0.78	0.84	0.000	0.035	0.175	0.316	0.449	0.603	0.696	0.775	0.840	0.000	0.035	0.175	0.316	0.449	0.569	0.675	0.765	1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Emission rate																											
NO_X (g/km)	11.77	10.79	9.55	7.63	6.98	6.41	5.91	5.51	5.19	11.77	10.79	9.55	8.47	7.57	6.41	5.91	5.51	5.19	11.77	10.79	9.55	8.47	7.57	6.80	6.16	5.62	4.45
PM (mg/km)	0.38	0.32	0.27	0.19	0.16	0.14	0.12	0.11	0.10	0.38	0.32	0.27	0.22	0.19	0.14	0.12	0.11	0.10	0.38	0.32	0.27	0.22	0.19	0.16	0.13	0.11	0.08
Emissions (tonnes)																											
NO_X	262.33	246.84	224.29	183.73	170.72	159.12	149.04	140.87	134.74	262.33	246.84	224.29	203.92	185.03	159.12	149.04	140.87	134.74	262.33	246.84	224.29	203.92	185.03	168.92	155.15	143.85	115.37
PM_{10}	8.43	7.34	6.29	4.55	3.98	3.49	3.10	2.79	2.58	8.43	7.34	6.29	5.37	4.56	3.49	3.10	2.79	2.58	8.43	7.34	6.29	5.37	4.56	3.89	3.34	2.91	2.05
Emissions (tonnes)																											
Total NO_X	517.49	480.44	433.32	337.29	316.32	297.34	279.41	263.78	250.10	517.49	480.44	433.32	390.64	353.17	297.34	279.41	263.78	250.10	517.49	480.44	433.32	390.64	353.17	322.29	293.73	270.54	250.10
Total PM_{10}	15.55	13.35	11.40	7.82	6.97	6.19	5.53	4.99	4.55	15.55	13.35	11.40	9.76	8.29	6.19	5.53	4.99	4.55	15.55	13.35	11.40	9.76	8.29	7.09	6.05	5.23	4.55
Difference from																											
Baseline (tonnes)																											
Total NO_X	0.00	0.00	0.00	53.35	36.85	24.95	14.32	6.76	2.44	0.00	0.00	0.00	0.00	0.00	24.95	14.32	6.76	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.44
Total PM_{10}	0.00	0.00	0.00	1.93	1.32	0.89	0.52	0.24	0.09	0.00	0.00	0.00	0.00	0.00	0.89	0.52	0.24	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09

Conclusions

4.19. In terms of emissions and air quality benefits the main points to be considered for any vehicle replacement policy are as follows.

1. To set an appropriate emission standard (bearing in mind the cost to those operators affected) to achieve an outcome where there are local emissions reductions relative to the base case. The higher the Euro standard the bigger the potential reductions.
2. To set an appropriate implementation year to achieve an outcome where there are local emissions reductions relative to the base case. Earlier is better.
3. To consider setting further Euro standards and implementation years (ie subsequent phases of emission reduction) otherwise the benefits of the policies will be eroded over time by natural vehicle replacement rates.
4. That the emission standards and implementation years have to be balanced up against issues of costs but also the level of action required to achieve the air quality objectives in the AQMA.

4.3 Cost assessment, cost-effectiveness and Cost-Benefit Analysis

4.20. An example of the cost analysis for a LEZ is shown below, comparing alternative options. The Base scheme in this illustrative example refers to an access control scheme giving priority to public transport in a small city centre area, enforced using ANPR. Schemes A to C are potential developments of this Base scheme into a LEZ, with progressively greater numbers of permitted vehicles meeting specified emissions criteria. Schemes A to C require additional ANPR camera sites, plus accompanying back-office systems and operating staff.

4.21. First the cost estimates are presented, showing the cost elements for capital and operating costs for a base scenario, and then three alternative schemes comparing different vehicle types.

Table 9: Cost estimates for Low Emission Zone scheme

	Base scheme	**Scheme A. Bus**	**Scheme B. HDV, Coach, Bus**	**Scheme C. HDV, Coach, Bus, LGV, Car, Taxi**
Start-up (capital) £				
Equipment	150,000	250,000	250,000	350,000
Central system	50,000	100,000	150,000	200,000
Other	70,000	100,000	200,000	250,000
Total start-up	**270,000**	**450,000**	**600,000**	**800,000**
Operating costs (end of year 1) £				
Maintenance	10,000	20,000	20,000	30,000
Central system, premises, supplies	65,000	75,000	80,000	150,000

Staff costs	120,000	170,000	230,000	330,000
Total operating	**195,000**	**265,000**	**330,000**	**510,000**

4.22. The costs of the scheme over the lifetime then has to be calculated, and expressed in equivalent terms, as a present value of costs. For the analysis here, we assume that the scheme starts the following year (year 1). In each case, the costs in each year are multiplied by the discount factors, to allow the discounted costs to be estimated. The sum of these discounted costs gives the present value of costs. These are then converted to an equivalent annual cost for the cost-effectiveness analysis (using either the Equivalent Annualised Cost equation[3] , or the excel formula, see worksheet example). As an example, the values for scheme A are shown below. The calculation is provided in the worksheet example.

Table 10: Estimation of Present Value of Costs, and Equivalent Annual Cost – Scheme A

Scheme A	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
Capital costs £	450,000							
Ongoing costs £	265,000	265,000	265,000	265,000	265,000	265,000	265,000	265,000
Total £	715,000	265,000	265,000	265,000	265,000	265,000	265,000	265,000
Discount factor	0.96620	0.93350	0.90190	0.87140	0.84200	0.81350	0.78600	0.75940
Discounted cost £	690,833	247,378	239,004	230,921	223,130	215,578	208,290	201,241
Present value £	2,256,374							
Equivalent annualised cost £	328,250							

4.23. The values for all three schemes are summarised below.

Option	**Base**	**A**	**B**	**C**
Present value (sum)	1,601,285	2,256,374	2,848,107	4,278,649
Equivalent annualised cost	232,949	328,250	414,333	622,444

4.24. This provides an estimate of the equivalent annualised costs of each scheme, which can be compared with the annual tonnes abated from each option [not calculated here], to derive estimates of cost-effectiveness (costs per tonne abated). However, to accurately capture the full costs of each

[3] Equivalent annualised cost = NPV multiplied by

$$\left[\frac{r(1+r)^n}{(1+r)^n-1}\right]$$

where r is the discount rate (3.5% in the UK, i.e. 0.035) and n is the scheme length in years.

scheme, and undertake this cost-effectiveness analysis, it is also necessary to estimate the costs to operators for each scheme as well as the scheme costs. This will include the costs to non-compliant vehicles that will be affected. The section on benefits gave the information on estimating the number of vehicles affected by the scheme, consistent with the analysis of emission benefits. These estimates can be used to estimate the costs to operators. This will involve the estimates of retrofitting or vehicle replacement.

4.25. Note that, however, a LEZ will reduce both PM and NO_x emissions (and may also have effects on other pollutants on greenhouse gas emissions). A cost-effectiveness analysis can only take one pollutant into account at a time (this is one of the problems with cost-effectiveness). It is possible to address this by estimating 'net' cost-effectiveness of options to correctly prioritise measures taking other objectives into account (see below).

4.26. Guidance on the estimation of the costs to operators is given in the other guidance notes on vehicle retrofit and low emission vehicles. The Practice Guidance on retrofitting vehicles provided an example with retrofitting Diesel Particulate Filters (DPFs) showing the estimation of costs and cost-effectiveness. Note that in this analysis, it is the resource costs of technology that are used in the economic appraisal, rather than the market prices. The Practice Guidance on LEVs provided an example for the costs of new vehicles, based on the additional marginal technology costs of these vehicles over a standard new vehicle.

4.27. Note that there are some different issues when considering vehicle replacement, rather than just the consideration of retrofits or alternative new vehicles, for a LEZ. In the case where vehicles are replaced by operators as a result of LEZ, it is important to consider what happens to the replaced vehicles. This can be very complex, and depends on operator behaviour, market values – see the London LEZ considerations as an example. In a case where an older vehicle is retired prematurely, it is necessary to consider the useful resources of that vehicle that are being lost. This is usually estimated by calculating the market value of the vehicles in the year that they are being retired[4]. There may also be other effects in such a case with changes in fuel efficiency (as above). In other cases, vehicles may be moved to other routes (fleet switching) without retirement, or vehicle may be sold on.

4.28. One additional problem with cost-effectiveness analysis for LEZs is the issue of declining benefits above the baseline, i.e. the fact that emissions benefits are not constant over time. Whilst it is possible to estimate the benefits in the first year as a proxy for the benefits of different schemes, this approach effectively over-estimates the benefits in future years. Some consideration of these issues is important in comparing schemes, and ensuring that schemes are adjusted over time to maximise benefits (see earlier sections).

[4] This approach was used in the IGCB analysis, and reflects an estimate of the value of the service the vehicle would have provided fro the rest of its lifetime, had it not been retired early.

4.29. It is also possible to address the overall benefits and costs of the schemes, taking any such effects over time into account, through the use of cost-benefit analysis.

4.30. The first stage in a cost-benefit analysis is to estimate the monetary value of the benefits. The valuation of emission benefits can be undertaken using the Defra damage costs, which give the benefits in (£) per tonne of pollutant reduced, using the Defra damage cost spreadsheet, available at (http://www.defra.gov.uk/environment/airquality/panels/igcb/guidance/index.htm. The benefits in each year over the scheme lifetime are used (rather than the benefits in one year), and the total monetary benefits of all pollution benefits (for multiple pollutants) are estimated. So, for example, the emission benefits of the schemes can be input into the calculator and the benefits identified. Examples of the use of the damage cost calculator are given in the Practice Guidance on

.

4.31. The estimated present value of benefits can then be compared against the present value of costs. Note that for the latter, this should include the costs associated with scheme start-up and operation (see above), but also the costs to vehicle operators to comply with the scheme (see the examples in Practice Guidance Measures to Encourage the Uptake of Low Emission Vehicles and Practice Guidance Measures to Encourage the Uptake of Retro-Fitted Abatement Equipment on Vehicles). The total present value of benefits can be compared with present value of cost to estimate the overall NPV for each scheme.

4.32. The information from a cost-benefit analysis can also be used to consider other environmental objectives as part of a 'net' cost-effectiveness analysis. For the case of air pollution, where we are concerned with achieving air pollution targets in a given year, this is estimated from the estimation of annualised costs less annualised benefits / by reduction in tonnes pollutant. The advantage of this 'net' cost-effectiveness assessment is it allows consideration of other air quality pollutants, and greenhouse gas emissions, in the cost-effectiveness ranking and so provides a more holistic overall ranking method. More details are given in the Practice Guidance on Econmic Principles, Practice Guidance Measures to Encourage the Uptake of Low Emission Vehicles and Practice Guidance Measures to Encourage the Uptake of Retro-Fitted Abatement Equipment on Vehicles. The advantage of this approach is it allows multiple pollutants (for example NO_x and PM_{10} benefits) to be taken into account when undertaking the cost-effectiveness ranking between options.

5 Examples of Low Emission Zone schemes

5.1. The purpose of this chapter is to provide key information on existing or planned LEZ schemes. This includes a brief description of how key implementation and enforcement issues are addressed in these schemes.

5.2. Traffic control schemes are common in UK towns and cities. Linking a variety of access control schemes on sections of the public highway builds up the overall traffic management approach in many city and town centres. A small number of such traffic control schemes in the UK have either been designed to include emission criteria or have been examined for such a modification, and therefore can be considered small-scale examples of LEZ.

5.3. Larger LEZs, with enforceable restrictions on vehicle access, from across Europe include:

- Swedish environmental zones, where HGV over a certain age are banned from entry;
- Netherlands LEZ, where minimum Euro standards and/or retrofit technologies are required for HGV;
- the German LEZ regulations, which a city can apply to all vehicles except motorbikes based on a range of environmental standards and with a strong focus on diesel-fuelled vehicles;
- Japanese LEZ in the Greater Tokyo area, where emissions standards have applied to both light and heavy diesel vehicles since 2003;
- Austrian A12 motorway, with Euro standard limit on HGV that also vary by time of day.

5.4. A number of schemes achieve their emission objectives by applying charges to more polluting vehicles:

- London LEZ;
- Milan Ecopass; and
- Bologna Limited Traffic Zone (LTZ).

5.5. Information on a wide number of current and planned LEZs across Europe can be found via the EU-wide LEZ Network (www.lowemissionzones.eu). The web site provides information about network members' schemes and is a mechanism for members to publicise access restrictions on a pan-Europe basis.

5.6. Low emission zones from a range of countries are included in this section. Where possible these are presented by country as there are often similarities in the scheme design and operating rules within the same country.

5.7. Key summary information on the schemes is provided in Table 11 whereas more detailed information is found in the following text sections.

Table 11: Summary of key information on example schemes in this guidance

Scheme	**Basis**	**Area**	**Vehicles**	**Standards (retrofit/incentives)**	**Enforcement**	**Mgt of permitted vehicles**	**Comments** (Strengths/weaknesses)
Sweden - Environmental Zone	Traffic restriction	City centres or key districts	HDV (HGV and bus)	HGV: age limit of six years. Allowance for trucks between six and eight years old if retrofitted for PM.	Manual enforcement by Police. Scheme applies to foreign vehicles.	Sticker permits denote compliant vehicles. Retrofit for PM possible for narrow age band.	Age based system is relatively simple.
Greenwich Peninsula	Planning obligation	190 acres of development site.	All vehicles.	Various, depending on land-use and vehicle type. Based on Euro standards.	Non compliance will be a breach the agreement.	To be confirmed. Retrofitting of HDV possible for PM.	Management and operation is responsibility of developer.
Bath - PAS	Traffic restriction	One key route through centre	Priority/access for bus and taxi, plus a few permitted Goods Vehicles.	Free access to bus and taxi. Supermarket delivery vehicles must be of latest Euro standard.	Manual, by Police. Vehicles without transponders cannot trigger green light to pass through access point.	Bus, taxi, permitted Goods Vehicle apply for transponders.	Simple addition of environmental criteria to ensure high standards from non-public transport vehicles. Enforcement depends on Police support.
Milan - EcoPass	Charge	City centre	All vehicles.	Charge related to level of PM emissions. Cleanest diesel and petrol vehicles gain free entry.	43 entrance points with CCTV and ANPR cameras. Penalty is 75€ to 275€ depending vehicle size.	Daily and multi-day/annual passes can be purchased. Cost based on Euro standards. Alternative fuels and retrofit for PM possible.	Reduces congestion as well as emissions (due to charge). Revenue can be used to improved transport. Complex scheme rules with variety of passes.
London - LEZ	Charge	Greater London	HDV (HGV, Coach etc), with heavy vans to be added later.	From 4th Feb. 2008, a standard of Euro 3 for PM for lorries over 12 tonnes Gross Vehicle Weight (GVW), and buses and coaches over 5 tonnes GVW. From July 2008, a standard of Euro 3 for PM for lorries between 3.5 and 12 tonnes,	Large network of ANPR cameras. Penalty for non-compliance and non-payment is £500/£1000 depending vehicle size.	Compliant vehicles self-registered via number plate and DVLA records. Non-standard cases and retrofit vehicles required to register vehicle, and retrofit vehicles inspected annually by VOSA. Daily charge (£200 or	Phased approach to ensure tightening emission standards.

Scheme	**Basis**	**Area**	**Vehicles**	**Standards (retrofit/incentives)**	**Enforcement**	**Mgt of permitted vehicles**	**Comments** (Strengths/weaknesses)
				buses and coaches. From Oct. 2010, a standard of Euro 3 for PM for larger vans and minibuses. From Jan. 2012, a standard of Euro 4 for PM for lorries over 3.5 tonnes GVW, buses and coaches over 5 tonnes GVW.		£100, depending on the size/type of vehicle) for vehicles who do not comply. Retrofit for PM possible.	
Netherlands - LEZ (Milieuzone)	Traffic restriction	Central city areas	HGV	Min standard of Euro 2 and 3 plus particulate filter or Euro 4 will be in force up until 1 Jan. 2010. Between 1 Jan. 2010 and 1 July 2013 the minimum standard will be less than eight years or Euro 3 plus PM filter. After 1 July 2013 the minimum standard is Euro 4.	Manual, plus some (increasing number of) ANPR camera. Penalty is 150€.	Retrofit for PM possible.	Phased approach to ensure tightening emission standards.
German LEZ (Umweltzone)	Traffic restriction	Central city areas	All vehicles	Vehicle owners required to purchase stickers (20 €) stating environmental standard. Each LEZ signs which is minimum sticker/standard required for access. Standards tougher for diesel vehicles.	Manual enforcement. 40 € fine plus 1 point in national traffic penalty register for German vehicles	Stickers denote emission level of all relevant vehicles. Sticker must be shown if vehicle to be driven in any LEZ. Certification system for retrofit vehicles. Retrofit for PM (cars and HGV) possible.	Flexible framework for cities to choose from emission standards. Includes cars and encourages PM retrofitting.

Sweden – environmental zones

5.8. Swedish environmental zones have the longest history of LEZ, since the law passed in 1996 by Parliament, and operate in the four largest cities including Stockholm. The LEZ apply to HGVs with an age limit of six years, with some allowance for trucks between six and eight years old if they had retrofitted exhaust treatment.

5.9. The initial environmental zones covered relatively small areas of the cities of Stockholm (5x7km), Gothenburg (3x5km) and Malmo (3x3km). In some cases a strategic route through the zone is left for crossing the zone and due to lack of city jurisdiction over such roads. Extension of the zones has been considered/planned in some cases. Enforcement is carried out by Police, based on manual spotting of vehicles.

Netherlands – low emission zones

5.10. In the Netherlands seven LEZ were in operation by the end of 2007 (including Maastricht, Rotterdam and Utrecht) with several more being prepared. There is a national framework that cities may opt to join which means all LEZ have the same emissions requirements. Currently LEZ apply only to HGVs, over 3.5 tonnes.

5.11. The vehicle emission rules are a combination of age and Euro standards depending on the year in question:

- a minimum standard of Euro 2 and 3 plus particulate filter or Euro 4 will be in force up until 1 January 2010;
- between 1 January 2010 and 1 July 2013 the minimum standard will be a mixture of both an age-based standard (less than eight years) or Euro 3 plus filter;
- after 1 July 2013 the minimum standard is Euro 4.

5.12. Manual enforcement is planned until networks of automatic cameras are in place. Fines are set at 150 €.

Germany – low emission zones

5.13. As of 1 January 2008 three major cities in Germany (Berlin, Hanover and Koln) had LEZ in operation. However, up to fourteen cities in total have confirmed their planned introduction of LEZ (Umweltzone) in the remainder of 2008, with another seven by 2010.

5.14. A national framework sets out vehicle emissions standards, and the cities choose whether to introduce, what vehicles to cover, which year and what area will be covered by their LEZ. German LEZ affects all vehicle types except motorcycles.

Table 12: German Low Emission Zone standards

Emission class	1	2	3	4
Sticker type	No sticker available			
Diesel vehicles	Euro I or older	Euro 1 or Euro 2 plus particulate filter	Euro 2 or Euro 3 plus particulate filter	Euro 3 or Euro 4 plus particulate filer
Petrol vehicles	Without catalytic converter (i.e. Pre-Euro 1)			Euro1 with a catalytic converter or better.

5.15. Vehicle owners are required to purchase stickers (at a cost of around 20 €) which denote the environmental standard of their vehicle if they are to drive on any local roads passing through the LEZ participating cities. These must be displayed inside the windscreen and are then valid for all German LEZ. Emission standards can vary city by city, within the same national framework. There are four levels of emission class and the boundary signing for each LEZ denotes the emission standard required for entry. The penalty for not displaying a sticker or driving a vehicle with the wrong sticker is a 40 € fine, and one point in the national traffic penalty register for German vehicles.

Figure 1: German Low Emission Zone sign

5.16. Primarily, the German scheme targets diesel vehicles, as any Euro 1 petrol vehicle (i.e. post 1993) will gain the highest standard ‘green’ sticker. In contrast, Euro 1 and older diesel car owners cannot buy any type of sticker. Older vehicles can receive stickers after emission system upgrades, which must be issued directly from a certified local emission repair garage after passing the emission standards test. The scheme has the effect of incentivising owners of diesel vehicles, including cars, to retrofit particulate filters. Encouraging diesel car retrofit has been done in Germany through various initiatives for a number of years.

Japan – Nitrogen oxides and particulate matter law

5.17. The Japanese NO_x and PM Law was designed to try to ensure that the Ambient Environmental Quality Standards for nitrogen dioxide (NO_2) and suspended particulate matter (SPM) were met by the end of 2010, through special regulation and other measures for vehicles. The area covered is large, including 276 municipalities in the Tokyo Metropolis and the Prefectures of Saitama, Chiba, Kanagawa, Aichi, Mie, Osaka, and Hyogo.

5.18. Vehicles covered by the law are HGV, vans, buses, and diesel passenger cars. Therefore, diesel-fuelled vehicles are the main focus. In the prefectures affected, programmes for total emission control have been set up according to a basic plan established by the national government to ensure systematic promotion of different measures. This includes traffic management to improve traffic flows and support for businesses with 30+ vehicles to implement fleet improvement plans.

5.19. The scheme was introduced in 2002 and, for the time, very tough emission standards were set for all new registered vehicles. For these, PM emissions equivalent to the planned emission standard for diesel vehicles in 2005 were required, which had the impact of incentivising low PM fuels such as CNG and LPG.

London – Low Emission Zone

5.20. The London LEZ started operation in 2008. The aim of the scheme is to improve air quality in the city by deterring the most polluting vehicles from driving in the area. The vehicles affected by the LEZ are older diesel-engine lorries, buses, coaches, large vans, minibuses and other heavy vehicles that are derived from lorries and vans, such as motor caravans and motorised horse boxes. Cars and motorcycles are not affected by the scheme. As a result, the scheme tends to target heavy diesel-powered vehicles, thereby prioritising PM reduction.

5.21. The LEZ commenced on 4 February 2008 for lorries over 12 tonnes, with different vehicles affected over time and tougher emissions standards due to be introduced in January 2012.

5.22. The London LEZ emission standards describe the minimum Euro standard which vehicles must meet to be exempt from a charge. Meeting these emission standards can be done by using a vehicle whose engine was type approved to this standard (or better) or by retrofitting exhaust after-treatment technology to raise the emission standard. Further information on LEVs can be found in the Practice Guidance Measures to Encourage the Uptake of Low Emission Vehicles. Further information on retrofitting can be found in the Practice Guidance Measures to Encourage the Uptake of Retro-Fitted Abatement Equipment on Vehicles. The standards by vehicle/weight and timescale are:

- from 4 February 2008, a standard of Euro III for PM for lorries over 12 tonnes,

- from 7 July 2008, a standard of Euro III for PM for lorries between 3.5 and 12 tonnes and buses and coaches over 5 tonnes ,
- from 4 October 2010, a standard of Euro III for PM for larger vans and minibuses,
- from 3 January 2012, a standard of Euro IV for PM for lorries over 3.5 tonnes and buses and coaches over 5 tonnes.

Figure 2: Entrance sign to London LEZ

5.23. While the London LEZ has the same objectives as the environmentally-focussed schemes in Sweden and Germany, it actually operates as a road charging scheme. The important differentiator is that polluting vehicles are not banned from entering the London LEZ, they simply incur a discouragingly high charge to enter or their drivers risk a penalty if they do not pay. It was set up using a Scheme Order, which is the same legal basis as the London CCS. However, it is not a congestion charge as the objective is not to reduce traffic levels.

5.24. The London LEZ began operation in 2008. Transport for London has planned a work programme that will undertake an analysis and it is expected that results will be made public in due course. The scheme has been scrutinised closely during its development and a recent TfL analysis of the potential impacts of the scheme (TfL, 2007) found the following. The LEZ is anticipated to produce significant air quality benefits both within and beyond the LEZ boundary. In 2008 the scheme is expected to reduce the area of Greater London that exceeds the daily PM_{10} limit by 7% and by 15% by 2012. By 2010 the scheme is expected to reduce the area of Greater London that exceeds the annual mean NO_2 limit by 4% and by 16% by 2012. Health benefits associated with these changes are estimated to be £170-250 million due to predicted reduction in illness and in extended life expectancy (years of life gained).

Milan Eco Pass

5.25. The City of Milan has introduced a charge, known as Eco Pass, for all vehicles entering the main city centre of the Cerchia dei Bastoni area. Eco Pass came into effect on 2 January 2008 and aims to reduce PM emissions, relieve congestion (and therefore speed public transport journeys) and raise

revenue for public transport. It can be considered to combine the objectives of both the London LEZ and the London CCS.

5.26. Eco Pass consists of a charge applied to vehicles circulating within the city centre area during week the from 7.30 am to 7.30 pm (changing to 7.00 am to 7.00 pm from 15th of April 2008). Drivers pay a charge (from 2 € to 10 € for daily entrance) corresponding to the levels of PM emissions from their vehicle, with the cleanest petrol and diesel vehicles paying no charge. There is also zero charge for alternative fuels and hybrid vehicles.

5.27. In addition, a simple LEZ approach is applied in Milan at night-time in winter months (15 October to 15 April). During these months pre-Euro and Euro 1 petrol and diesel cars, as well as mopeds and motorcycles, are forbidden to enter the central area from 7.30 am to 7.30 pm.

UK access control schemes

5.28. Access control schemes in various areas of England have tended to prioritise types of vehicle rather than particular emission standards. These include schemes such as bus priority schemes, bus gates and access control schemes in residential areas.

5.29. The main objective of the Bath Priority Access Scheme (PAS) is to reduce congestion from through-traffic and prioritise space for pedestrians and public transport. Buses and taxis are permitted to use a traffic signal controlled ‘gate’ that regulates cross-city traffic, and can call for a green signal using an in-vehicle transponder. In addition, the scheme design permits a small number of supermarket delivery vehicles which must meet the latest emission standards. The use of new vehicles is a condition under which they receive permits (and traffic light transponders). This scheme has only a limited application of specific environmental criteria, via the permitted vehicle approach, but is a demonstration of the legal principals in a UK setting.

UK and mainland Europe - parking controls

5.30. Historically, parking controls have been used to manage demand for scarce road space and to support the safe and efficient flow of traffic. PPG 13 notes that the availability of car parking has a major influence on the means of transport people choose for their journeys. It goes on to summarise that some studies suggest that levels of parking can be more significant than levels of public transport provision in determining means of travel (particularly for the journey to work) even for locations very well served by public transport.

5.31. A number of local traffic authorities have adjusted the operation of their parking management schemes with more specific environmental objectives that aim to discourage use of the most polluting vehicles and simultaneously incentivise LEVs. Further information on LEVs can be found in Practice Guidance on Measures to Encourage the Uptake of Low Emission Vehicle .

5.32. A range of approaches to parking controls can be seen in these examples, which include discouragement and/or incentives for one or both of toxic pollutants and greenhouse gas emissions:

- City of Westminster and London Borough of Croydon parking charge discounts for electric vehicles;
- City of Stockholm parking discounts for electric vehicles, biomethane vehicles and hybrid vehicles;
- London Borough of Richmond parking permit scheme with charges based on CO_2 ratings or engine sizes;
- City of Winchester parking permit scheme discounts for vehicles in the two lowest CO_2 emission bands;
- City of Graz (Austria), discount on parking charges for vehicles with a combination of latest Euro pollutant emission standards and low CO_2 rating.

UK - planning obligations

5.33. The transportation aspect of development control is usually only one of a number of factors that relate to a development proposal. However, the development control process provides an opportunity to influence future use and access to a site in the medium to long term.

5.34. The Greenwich Peninsula Low Emission Strategy places restrictions on the use of more polluting vehicles, with compliance being a legal obligation of the sale of land for development, and will also be passed directly on to dwelling purchasers.

5.35. Low Emission Zone controls are applicable to the Greenwich Peninsula development (Dome/MDL) and which form part of the Section 106 legal agreement, signed on the 23 February 2004. The Greenwich Peninsula LEZ will apply to the 190 acres of land approved for development on the 17th April 2003. The LEZ will apply until the completion of the development, anticipated in 2021. A range of controls are initially outlined for different aspects of the development where an impact on air quality is envisaged.

5.36. Residential parking permits will be given to vehicles that comply with:

- affordable Housing – Euro 3 after 1 January 2009 or 36 months after the residential block is completed, whichever comes sooner; and
- private Residential – Euro 4 after 1 January 2009 or 36 months after the residential block is completed, whichever comes sooner.

5.37. The annual parking service charge will be free/less for compliant vehicles, with an incentive for vehicles to exceed the compliance standard. Non-compliant vehicles will be surcharged a public transport levy that will go towards initiatives aimed at encouraging residents not to own a car, for example Car Club, transport voucher, cycle voucher.

5.38. Other areas of the development are covered as follows:

- O2 Arena Suite and Arena Premium Parking will set a standard of Euro 4IV;
- reasonable endeavours will be used to ensure that coaches accessing the site will be of the same, or better, than the emission standard of TfL buses;
- Limited office parking space permits will be issued to vehicles complying with Euro 4;
- the hotel will operate with a minimum of Euro 2 from the outset, with a target of achieving Euro 4 by 1 January 2009.
- management company vehicles should be of the highest Euro standard and a minimum of Euro 4 by 1 January 2009.
- For HGVs/ Construction Vehicles over 7.5 tonnes when 80% of HGVs will achieve a minimum of Euro 2 plus Reduced Pollution Certificate up to 1 January 2007, with a view to achieving Euro 4 by 1 January 2010. Initial HGV controls have some flexibility, to take account of reasonable financial limits.

5.39. The Greenwich Post Office scheme was an earlier (2000) instance of this London Borough using planning conditions to specify vehicle emission standards. To minimise NO_x and SO_x emissions the Post Office agreed to:

- use low sulphur diesel in vehicles at the sorting office development;
- fit PM abatement technology to vehicles when it becomes reasonably practicable; and
- use vehicles that comply with Euro 3 standard by 2004.

5.40. A major 76 acre site, the Royal Arsenal, Woolwich (LB of Greenwich) is a mixed urban development regenerating a riverside location in London. The agreement requires the developer to submit to the council for approval details of a LEZ, and LEZ controls. The agreement goes on to outline more detailed provisions to be included for both the construction and operational phases of the development.

6 Conclusions

6.1. A range of schemes can be developed by local authorities to directly influence the emission standards of vehicles downward in sensitive areas on the public highway or private land. Traffic and parking restrictions can be developed into such schemes by the Highway Authority, and development control schemes by Planning Authorities.

6.2. Schemes based on traffic restrictions on public highway are closest in nature to the concept of a LEZ, and may have the greatest scope for application in towns and cities working towards improved air quality. Powers are available for Highway Authorities to use a traffic restriction for the improvement of air quality.

6.3. The London LEZ (and Milan Eco Pass) are based on charging for access with exemptions for the cleanest vehicles and as such are charge-based schemes. Many of the functions and processes required for setting up and operating the scheme are the same, whether the basis is a restriction on a vehicle or a charge. The London LEZ has provided considerable experience within TfL and Government Agencies, and elements of the scheme design could be replicated elsewhere.

6.4. A range of current LEZ based on traffic restrictions show that key variables in scheme characteristics to be:

- scheme size and land-use type;
- vehicle types;
- emission standards and pollutant types;
- management of permitted vehicles; and
- vehicle detection and enforcement methods.

6.5. Such LEZ tend to be focussed on city and town centres, where land-use is dense, traffic is heavy and population exposure is high. There is the highest value in such areas from restricting, discouraging or deterring the use of more polluting vehicles. Source apportionment should be used to determine which vehicles and which pollutants are the most relevant to target. This should be considered as part of the scheme design, to determine the cost-effectiveness of various options.

6.6. From existing examples, the most common vehicles to target in a scheme with enforceable restrictions are HDVs (and bus fleets in particular) due to their cost-effectiveness relative to schemes that would restrict other vehicle types. The most common toxic pollutant to target is PM. It is likely this is due to a number of factors:

- HDV produce higher levels of emissions than lighter, smaller engined vehicles;
- the options for retro-fitting HDV are better developed and more cost-effective given the cost of PM abatement equipment compared to NO_x abatement, cost of retrofitting as a proportion of HDV value, and the potential reduction in overall level of emissions (compared to a LDV);

- a scheme that encompasses more vehicles will generally be more costly to set-up and administer, therefore in value for money terms it is more cost effective to target those vehicles with the highest overall emission contribution first (for example bus fleets with large urban centre activity), which is also where any grants or subsidies for retrofitting should be aimed;
- diesel vehicles tend to produce higher levels of PM emissions than the equivalent petrol vehicle, and reduction in PM emission generates significant levels of health benefits.

6.7. The worked example in this guidance illustrated the key points that the scheme should aim to regulate emissions to a sufficiently high standard and early enough to produce benefits over and above the business as usual case. Between now and 2010-2012 a Euro III standard should be considered as the minimum standard for LEZ schemes. From 2010-2012, higher standards should be considered. Following this recommendation is predicted to produce three to four years of benefits, albeit diminishing. However, local authorities will need to consider their own case, costs and benefits when setting emission standards and compliance dates.

6.8. Similar standards within a country are useful, but not essential to setting up and operating a LEZ. A common framework, with cities free to choose the level of standard within it, forms a possible model (seen in Germany). A common set of standards across all vehicles, with authorities choosing which vehicles from the framework to include in their scheme and how to enforce it, might provide another model. When choosing standards, co-operation between neighbouring authorities can be useful, to harmonise standards and reduce competition between those with LEZ and those without.

6.9. The most effective methods of managing permitted vehicles (for traffic, parking or development control schemes) will be to use existing systems and sources of information as far as possible. Unfortunately, existing systems will probably not provide a complete solution and the example LEZ show that new systems and processes were required. Taking a practicable approach to completing gaps in information, and making the scheme as straightforward as possible for the user is recommended. There may need to be some trade-off between the optimum operation of a scheme (for emission reduction and cost) against ease of use and acceptance.

6.10. Given constraints on revenue budgets a scheme which has low operating costs will tend to be more attractive from a whole-life cost viewpoint. However, this needs to be carefully balanced against the resulting level of compliance by users with the scheme emission standards, or the purpose and value of the scheme is undermined.

6.11. Small areas, road networks with limited access points, and areas with existing traffic restrictions (for example pedestrian zones) provide scope for adding LEZ components at relatively low cost , and if air quality assessments justify it these can be the most cost-effective areas to tackle first.

6.12. A significant number of LEZ are now in place or under development in Europe. Examples of LEZ from mainland Europe include manual and low-

tech enforcement methods as well more complex and capital intensive camera based systems. The London Lorry Control Scheme is an example of a manually enforced vehicle restriction scheme. These indicate the importance of UK local authorities investigating lower-cost vehicle detection and enforcement methods when scoping possible scheme designs for overall value for money.

6.13. Relevant parking schemes have tended to focus on passenger cars and CO_2 reduction in the UK to date. Examples from mainland Europe show a broader application, and include criteria for toxic pollutant emissions.

6.14. Relevant UK parking incentives for LEVS have been based on, or adapted from, more traditional residential parking or season ticket holder schemes. This provides the local authority with a proven and existing administration system in many cases, that for only a small additional cost can be tailored to local environmental objectives. An existing scheme on which to base a parking incentive scheme appears to be a factor in successful operation to date. On-street pay and display parking with discounts for cleaner vehicles will require additional systems and processes, which are likely to be more costly than adapting an existing season ticket holder scheme for a off-street car park.

6.15. The use of planning conditions and obligations can have significant potential for specific locations. To date there are two major examples of setting emission standards through the development control process in Greenwich. A smaller scheme was also successfully implemented for a new Post Office sorting office in the same area. The cost of designing and operating a planning obligation scheme can be borne by the developer. A scheme can apply to both construction and operational phases of a development, with obligations passed onto future occupiers. Such an approach provides a useful method of incorporating vehicle specific environmental criteria into planning decisions.

Appendices

Appendix 1: Glossary

Appendix 2: References

Appendix 1. Glossary

ANPR	automatic number plate recognition
AQMA	Air Quality Management Area
CCS	Congestion Charge Scheme
CO_2	carbon dioxide
Defra	Department for Environment Food and Rural Affairs
DfT	Department for Transport
DSRC	Dedicated Short Range Communication
EA 1995	Environment Act 1995
EETS	European Electronic Tolling Service
FPN	Fixed Penalty Notice
GVW	Gross Vehicle Weight
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicle
IGCB	interdepartmental group on costs and benefits
LAQM	local air quality management
LDV	Light Duty Vehicle
LGV	Light Goods Vehicle
LEV	Low Emission Vehicle
LEZ	Low Emission Zone
LTZ	Limited Traffic Zone
NATA	New Approach to Transport Appraisal
NO_x	oxides of nitrogen or nitrogen oxides
NO_2	nitrogen dioxide
OCR	Optical Character Recognition
PAS	Priority Access Scheme
PCN	Penalty Charge Notice
PM_{10}	particulate matter smaller than 10 microns
RPC	Reduced Pollution Certificate
RTRA 1984	Road Traffic Regulations Act 1984
SPC	Shadow Price for Carbon
SPM	Suspended Particulate Matter
TMA 2004	Traffic Management Act 2004
TfL	Transport for London
TRO	Traffic Regulation Order

VED	Vehicle Excise Duty
VRM	Vehicle Registration Mark
WebTAG	web-based Transport Analysis Guidance

Appendix 2: References

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