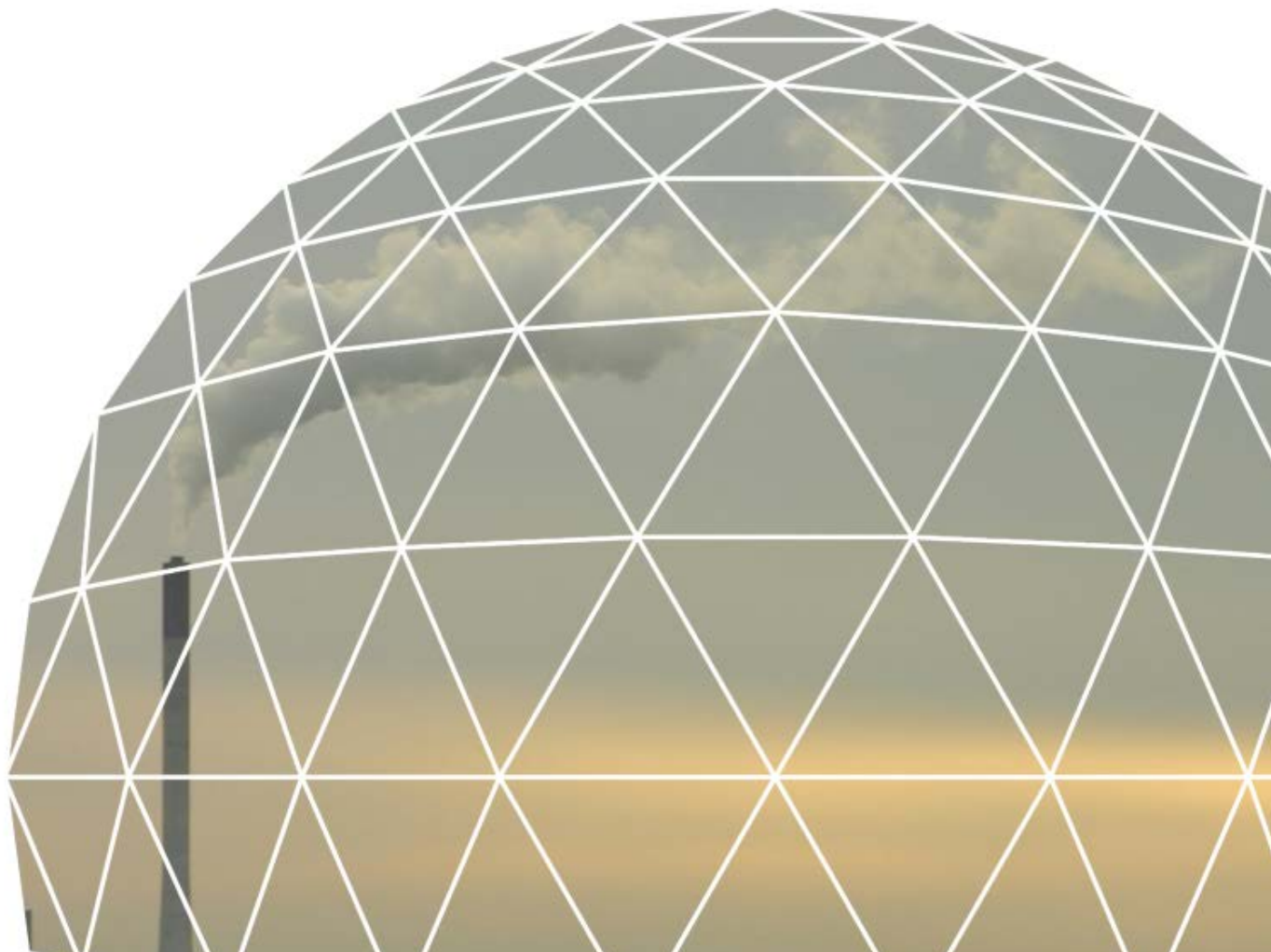




FEASIBILITY STUDY: EUROPEAN CITY PASS FOR LOW EMISSION ZONES

Annex A: Standards and Guidance Document

Client: European Commission, DG Environment



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Client: European Commission, DG Environment

Rotterdam, 30 January 2014

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ECORYS Nederland BV
Watermanweg 44
3067 GG Rotterdam

P.O. Box 4175
3006 AD Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com
Registration no. 24316726

W www.ecorys.nl

Preface

This Guidance Document has been prepared by the Ecorys Consortium under Specific Agreement 6 of Framework Contract ENV.C.3/FRA/2011/08. The project has been carried out by consortium members MWH, Milieu, Ecorys and Aarhus University, under MWH leadership.

The authors of this guidance document are:

Douglas Clark (team leader)

Rob Jeuring (task leader)

Willem Spit

Oskars Beikulis

Valts Vilnitis

Vladislav Bizek

Matthew Williams

Agnieszka Markowska

Niall Lawlor

Guillermo Hernandez

Lucy Sadler

Chetan Lad

Sarah Strickland

Table of Contents

| | |
|--|----|
| Preface | 3 |
| Lists of Figures, Tables and Boxes | 9 |
| List of Acronyms, Abbreviations and Symbols | 11 |
| Executive Summary | 13 |
| Introduction | 13 |
| Voluntary Standards for European LEZ | 13 |
| LEZ Planning and Implementation | 15 |
| LEZ Administration | 16 |
| Financial Aspects | 16 |
| Information Systems | 17 |
| Assessment and Monitoring | 17 |
| 1 Introduction | 21 |
| 1.1 Purpose | 21 |
| 1.2 Background | 21 |
| 1.3 Objectives | 22 |
| 1.4 Scope | 22 |
| 1.5 Overview | 23 |
| 1.6 References | 23 |
| 2 Voluntary Standards for European Low Emission Zones | 25 |
| 2.1 Introduction | 25 |
| 2.2 Overview | 26 |
| 2.3 National analyses of impact, cost-benefit and policy interaction | 27 |
| 2.4 Legal and institutional framework for LEZ | 28 |
| 2.4.1 EU legal framework | 28 |
| 2.4.2 National LEZ enabling legislation | 29 |
| 2.4.3 Municipal framework | 29 |
| 2.4.4 Financial incentives and complementary measures | 30 |
| 2.5 Emission classes | 30 |
| 2.6 Exemptions | 32 |
| 2.7 Retrofit emission control devices | 33 |
| 2.7.1 Introduction | 33 |
| 2.7.2 Existing REC regulations | 34 |
| 2.7.3 UNECE REC regulation | 35 |
| 2.7.4 EU legislation on retrofits | 36 |
| 2.7.5 National REC approval | 36 |
| 2.7.6 Information resources on retrofit emission control devices | 36 |
| 2.8 Stickers | 37 |
| 2.8.1 Form, Size, Symbols, Colours, Materials, Language | 37 |
| 2.8.2 Issuance of Stickers | 37 |
| 2.8.3 Mutual Recognition of Stickers | 37 |
| 2.9 LEZ Design and Implementation | 37 |

Table of Contents

| | | |
|----------|---|-----------|
| 2.10 | Signage | 38 |
| 2.10.1 | Form, Size, Symbols, Colours, Materials, Language | 38 |
| 2.10.2 | Placement of Signs | 38 |
| 2.11 | Air quality assessment, impact assessment and cost-benefit analyses | 38 |
| 2.12 | Public information | 40 |
| 2.13 | EU City Pass Vehicle Database | 40 |
| 2.13.1 | e-Reporting and database notification | 40 |
| 2.14 | EU LEZ web site | 40 |
| 2.15 | Barriers to harmonisation | 41 |
| 2.15.1 | Common barriers | 41 |
| 2.15.2 | Barriers for existing LEZ | 41 |
| 2.16 | References | 41 |
| 3 | LEZ Planning and Implementation | 43 |
| 3.1 | Introduction | 43 |
| 3.2 | Barriers and Risks | 43 |
| 3.2.1 | Introduction | 43 |
| 3.2.2 | Environmental barriers | 45 |
| 3.2.3 | Technical Barriers | 46 |
| 3.2.4 | Economic Barriers | 47 |
| 3.2.5 | Social Barriers | 47 |
| 3.2.6 | Political barriers | 47 |
| 3.2.7 | Conclusions | 48 |
| 3.3 | Integration of LEZ in urban air quality and mobility planning | 48 |
| 3.3.1 | Air quality planning | 48 |
| 3.3.2 | Strategic urban mobility planning (SUMP) | 49 |
| 3.3.3 | SUMP Framework- the basics | 50 |
| 3.3.4 | Green public procurement | 51 |
| 3.3.5 | Action plans for noise | 52 |
| 3.4 | Public and Stakeholder Participation | 52 |
| 3.5 | Setting Objectives | 54 |
| 3.6 | Establishing Zone Boundaries | 55 |
| 3.7 | Vehicle Criteria | 56 |
| 3.8 | Access Charges | 57 |
| 3.9 | Vehicle Identification and Enforcement | 59 |
| 3.10 | Special Considerations | 60 |
| 3.10.1 | Foreign drivers | 60 |
| 3.10.2 | Urban logistics and freight | 61 |
| 3.10.3 | Regional and tourist coach operators | 61 |
| 3.10.4 | Local businesses | 62 |
| 3.10.5 | Handicap transport | 63 |
| 3.10.6 | Emergency vehicles | 63 |
| 3.11 | Signage | 63 |
| 3.12 | Planning for Impact Assessment | 64 |
| 3.13 | References | 64 |
| 4 | LEZ Administration | 67 |

Table of Contents

| | | |
|----------|---|-----------|
| 4.1 | Introduction | 67 |
| 4.2 | Issuing Stickers | 67 |
| 4.3 | Vehicle Documentation | 68 |
| 4.4 | Retrofit Documentation | 68 |
| 4.5 | Approval of Sticker Vendors | 69 |
| 4.6 | Online Sale of Stickers | 70 |
| 4.7 | Permitted Exceptions | 70 |
| 4.8 | Approval and Mutual Recognition of Retrofit Devices | 71 |
| 4.9 | Methods of Payment | 71 |
| 4.9.1 | Purchase of Stickers | 71 |
| 4.9.2 | Entry Fees (if any) | 72 |
| 4.10 | Enforcement | 73 |
| 4.10.1 | Manual patrol enforcement | 73 |
| 4.10.2 | Entry or Toll Gates | 73 |
| 4.10.3 | Electronic identification (RFID) | 74 |
| 4.10.4 | License plate recognition | 74 |
| 4.11 | Penalties and Penalty Collection | 75 |
| 4.12 | References | 76 |
| 5 | Financial Aspects | 77 |
| 5.1 | Funding modalities for LEZ | 77 |
| 5.2 | Fees | 78 |
| 5.3 | References | 84 |
| 6 | Information Systems | 85 |
| 6.1 | Introduction | 85 |
| 6.2 | Information for users | 85 |
| 6.3 | Information for cities | 86 |
| 6.4 | Central (EU) Database and Website | 87 |
| 6.5 | National information services | 88 |
| 6.6 | Local information services | 88 |
| 6.7 | Common language and translation | 88 |
| 6.8 | e-Reporting | 89 |
| 6.9 | System Requirements | 89 |
| 6.10 | References | 90 |
| 7 | Assessment and Monitoring | 91 |
| 7.1 | Introduction | 91 |
| 7.2 | Tiers of Assessment | 92 |
| 7.3 | Evaluation Framework | 93 |
| 7.4 | Minimum Data Requirements | 95 |
| 7.5 | Air Quality and Climate | 95 |
| 7.5.1 | Introduction | 95 |
| 7.5.2 | Emissions Inventories | 95 |
| 7.5.3 | Dispersion Modelling | 98 |
| 7.5.4 | Recommendations | 100 |
| 7.6 | Health | 102 |

Table of Contents

| | | |
|--------|---------------------------------------|-----|
| 7.6.1 | Air quality | 102 |
| 7.6.2 | Noise | 103 |
| 7.7 | Mobility | 103 |
| 7.8 | Social | 105 |
| 7.9 | Cost-benefit Analysis | 106 |
| 7.10 | Performance monitoring and evaluation | 108 |
| 7.10.1 | Define SMART objectives | 109 |
| 7.10.2 | Draft a monitoring work plan | 110 |
| 7.11 | References | 111 |

Lists of Figures, Tables and Boxes

List of Figures

| | |
|---|-----|
| Figure 2.1 Conceptual sticker appearance. | 37 |
| Figure 2.2 Example LEZ sign showing that lorries with pollutant class 4 or higher are permitted to enter. | 38 |
| Figure 3.1 Examples of LEZ approach signage | 64 |
| Figure 5.1 Change in vehicles compliant with the London LEZ between February 2007 and August 2009. | 82 |
| Figure 7.1 Example evaluation monitoring and policy cycle in the Netherlands | 109 |

List of Tables

| | |
|--|-----|
| Table 2.1 Roles and responsibilities for harmonised LEZ | 27 |
| Table 2.2 Selected resources on financial incentives and complementary measures | 30 |
| Table 2.3 Vehicle emission criteria and retrofit requirements for pollutant emission classes based on Euro emission standards and retrofit equivalences. REC = retrofit emission control device meeting UNECE REC Regulation (proposed). | 31 |
| Table 2.4 Overview of national REC regulations pertaining to LEZ | 34 |
| Table 2.5 Minimum emission reduction requirements for retrofit emission control devices for heavy duty vehicles under the proposed UNECE REC Regulation and proposed amendment 01 | 35 |
| Table 2.6 Selected information resources on retrofit emission control devices | 36 |
| Table 2.7 Proposed roles and responsibilities for LEZ environmental, health and socioeconomic impact assessments and cost-benefit analyses | 39 |
| Table 3.1 Overview of barriers | 43 |
| Table 3.2 Barrier examples in the Moravian-Silesian region | 46 |
| Table 3.3 Selected resources and references on green public procurement and clean vehicles | 52 |
| Table 3.4 NO _x emission levels g/km for certain vehicle category | 56 |
| Table 3.5 Euro PM emission levels g/km for certain vehicle category | 56 |
| Table 5.1 Two principal types of LEZ with their funding implications | 77 |
| Table 5.2 Types of charges/fees relevant for LEZ | 79 |
| Table 5.3 Ecopass LEZ charges, Milan | 81 |
| Table 6.1 Requirements for central, national & local information systems | 89 |
| Table 7.1 Basic evaluation framework | 94 |
| Table 7.2 Extended evaluation framework | 94 |
| Table 7.3 types of air quality and climate assessments | 101 |
| Table 7.4 Concentration-response functions recommended by Aphekom | 102 |
| Table 7.5 Example monitoring scheme (indicators, tools, responsible institutions, budget, targets) | 110 |

List of Boxes

| | |
|---|-----|
| Box 5.1 Announcement about state grants from the British government for designing LEZ | 78 |
| Box 5.2 An example of nation-wide and regional penalties and waivers in the Netherlands | 82 |
| Box 5.3 An example of a retrofitting subsidy scheme for companies: Flanders | 83 |
| Box 7.1 The traffic barrier effect | 106 |

List of Acronyms, Abbreviations and Symbols

| | |
|-----------------|---|
| 24/7 | continuous operation 24 hours a day, 7 days a week |
| AAQD | Ambient Air Quality Directive (2008/50/EC) |
| ANPR | Automatic Number Plate Recognition system |
| AQG | WHO Air Quality Guidelines |
| ARM | Access Regulation Measure |
| ARS | Access Restriction Scheme |
| BaP | Benzo(a)pyrene |
| BC | Black carbon |
| BEV | Battery Electric Vehicle |
| CDR | Central data repository, at EEA |
| CLRTAP | UNECE Convention on Long-range Transboundary Air Pollution |
| CNG | Compressed natural gas |
| CO | Carbon monoxide |
| CO ₂ | Carbon dioxide |
| DG ENV | European Commission Directorate-General for Environment |
| DG MOVE | European Commission Directorate-General for Mobility and Transport |
| DOC | diesel oxidation catalyst |
| DPF | Diesel particulate filter |
| DPF | diesel particle filter |
| EEA | European Environment Agency |
| EGR | Exhaust gas recirculation |
| EMEP | European Monitoring and Evaluation Programme (under CLRTAP) |
| ETC/ACM | European Topic Centre / Air Quality and Climate Change Mitigation |
| EU | European Union |
| EU13 | “New” Member States of the EU |
| EU15 | “Old” Member States of the EU |
| EU27 | Member States of the EU prior up to 30 June 2013. |
| EU28 | Member States of the EU since 1 July 2013 (including Croatia). |
| EUCARIS | EUropean CAR and driving license Information System |
| FCREV | Fuel-cell Range Extender Vehicle |
| FFV | Flexi-fuel Vehicle |
| GRPE | Working Party on Pollution and Energy of the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) |
| HEV | Hybrid Electric Vehicle |
| HFCV | Hydrogen Fuel Cell Vehicle |
| ICE | Internal Combustion Engine |
| IIASA | International Institute for Applied Systems Analysis |
| ITS | Intelligent Transport System |
| Lden | Day-evening-night noise indicator |
| LEC | low emission certificate |
| LEZ | Low Emission Zone |
| LNG | Liquefied natural gas |
| Lnight | Night time noise indicator |
| LPG | Liquefied petroleum gas |
| mg | milligram |
| NFR | UNECE Nomenclature for reporting |
| ng | nanogram |

| | |
|-------------------|--|
| NMVOC | Non-methane volatile organic compounds |
| NO | Nitric oxide |
| NO ₂ | Nitrogen dioxide |
| NO _x | Nitrogen oxides (NO and NO ₂) |
| NRMM | non-road mobile machinery |
| O ₃ | Ozone |
| Pb | Lead |
| PHEV | Plug-in Hybrid Electric Vehicle |
| PM | Particulate matter |
| PM ₁₀ | Particulate matter smaller than 10 µm in diameter. Technical definition for monitoring: Particulate matter which passes through a size-selective inlet with a 50% efficiency cut-off at an aerodynamic diameter of 10 µm |
| PM _{2.5} | Particulate matter smaller than 2.5 µm, also known as fine particles. Technical definition for monitoring: Particulate matter which passes through a size-selective inlet with a 50% efficiency cut-off at an aerodynamic diameter of 2.5 µm |
| REC | retrofit emission control device |
| REEV | Range Extender Electric Vehicle |
| RPC | reduced pollution certificate |
| SCR | Selective Catalytic Reduction |
| SCR | selective catalytic reduction |
| SMART | specific, measurable, attainable, relevant and time-bound |
| SO ₂ | Sulphur dioxide |
| SUMP | Sustainable Urban Mobility Plan |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats. A structured planning method. |
| TSAP | Thematic Strategy on Air Pollution |
| UMP | Urban Mobility Package |
| UNECE | United Nations Economic Commission for Europe |
| VOC | Volatile organic compounds |
| WHO | World Health Organization |
| µg | microgram |
| µm | micrometer |

Executive Summary

Introduction

This guidance document is primarily directed to national governments considering implementation of a national LEZ framework, and to city governments considering a low emission zone (LEZ) as a measure to improve environmental quality and lower traffic-related health risks in their cities. This document proposes some specific common approaches for LEZ planning and implementation that will make it easier for users – in particular transport and logistics services and visitors – to comply with the city planners' intent.

These guidelines build on previous work done and the experiences in the many implemented LEZ's in cities across Europe.

Voluntary Standards for European LEZ

Voluntary standards for the "City Pass" framework for low emission zones in Europe are based on the concept of harmonised national LEZ frameworks rather than a centralised system at the EU level. The standards include ten key components to contribute to harmonisation of LEZ implementations:

1. national analysis of the impact, cost-benefit and policy interactions of implementing LEZ;
2. national legal and institutional framework for implementation of LEZ by municipalities and for associated national-level incentives and complementary measures;
3. a harmonized sequence of progressively stricter vehicle emission classes based on Euro standards and certified retrofit equivalents, for defining LEZ to reduce exhaust emissions of PM₁₀, PM_{2.5} and NO_x;
4. national synchronised timetables for LEZ phases;
5. standards for sticker-based LEZ that facilitate mutual recognition of national stickers;
6. national testing and certification scheme for retrofit emission control devices (REC) compliant with the UNECE 2013 REC Regulation¹;
7. national databases for vehicle emission qualifications to facilitate automatic recognition of the emission class of vehicles and provide an "electronic LEZ certificate" for each registered vehicle for entry into LEZ and for obtaining stickers and exemptions;
8. standards for data exchange between national and local databases of vehicle emission qualifications, and for international data exchange between national databases, consistent with EUCARIS² standards;
9. a European database and Internet information service for vehicle owners and operators on existing and planned LEZ³;and

¹ Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery equipped with compression ignition engines, ECE/TRANS/WP.29/2013/119. UNECE World Forum for Harmonization of Vehicle Regulations (WP.29), Adopted 13 November 2013. <http://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grpe/ECE-TRANS-WP29-GRPE-2013-09e.pdf>.

² EUCARIS is the EUropean CAR and driving license Information System, <https://www.eucaris.net/>.

³ A Commission tender is underway for a contractor to maintain and extend an European LEZ website for the next four years, building on the existing LEEZEN website www.lowemissionzones.eu.

10. a European information service providing or linking to guidance and best practices for cities to assist in the planning and implementation of harmonized LEZ as an element of an integrated and sustainable urban air quality and mobility strategy.

Building on the German framework for LEZ, a set of six harmonised pollutant emission classes is defined, labelled 2, 3, 4, 5, 6 and Z, based on Euro vehicle emissions standards and certified retrofit equivalents. The number classes correspond to Euro classes for diesel vehicles - Euro 2/II, 3/III, 4/IV, 5/V and 6/VI. Euro standards for petrol vehicles (and other fuels) are assigned to the emission classes based on equivalence to the diesel emission levels. The "Z" class is for zero-emission vehicles.

Classes 2, 3 and 4 correspond closely to the same numbered German classes, with certified PM retrofits enabling vehicles to be registered for the next higher emission class. Although real world NO_x emissions of Euro 5 diesel vehicles are not lower than Euro 4, LEZ emission class 5 lowers NO_x emissions by requiring Euro 3 or above for petrol vehicles, and retrofit equivalence for both PM and NO_x, as an interim step toward Euro 6, where NO₂ limit value compliance is a problem. Class 6 has significantly stricter requirements for both PM and NO_x, appropriate where compliance with limit values is projected to remain a problem after 2020. Class 6 also requires retrofits to satisfy Euro 6/VI emission limit values for both PM and NO_x. The LEZ emission classes do not include vehicle age requirements.

Retrofit devices are to be certified equivalent to Euro standards according to the 2013 UNECE Regulation¹ on retrofit emission control devices (REC) for heavy duty vehicles, including stricter specifications in the 01 amendments⁴. This requires national and/or EU adoption of the UNECE REC Regulation, and development of compliant national retrofit certification schemes. Adoption of compliant certification will facilitate cross-border recognition of retrofit installations and Euro equivalence.

The LEZ emission classes and allowed exemptions are to be adopted at the national level. It is also proposed that a national schedule for start and transition between emission classes be adopted at the national level, based on a national assessment. Municipalities may choose the types of vehicles restricted in a LEZ according to the degree of emission reduction that is needed – only heavy duty vehicles, or also light duty vehicles, passenger cars, motorcycles and scooters – based on local assessment.

The harmonized LEZ framework does not include a "City Pass" sticker, but sets standards for national stickers to facilitate mutual recognition and interchangeability between Member States. Standard sticker design elements are recommended, building on the German approach, with standard colour levels and general sticker format. A new feature is added to provide a unique identifier number encoded in barcode or QR code at the bottom of the sticker, to enable rapid scanning during manual enforcement. The unique identifier number is also a key for national "City Pass" LEZ vehicle databases containing emission characteristics for registered vehicles, and supporting cross-border retrieval of vehicle emissions information, consistent with the EUCARIS system. The LEZ vehicle databases and data exchange will facilitate automatic recognition of registered vehicles travelling into LEZ outside of the home country. The "City Pass" vehicle

⁴ Proposal for the 01 series of amendments to the UN Regulation on uniform provisions concerning the approval of Retrofit Emission Control devices for heavy duty vehicles (No. ECE/TRANS/WP.29/GRPE/2014/4).
<https://www2.unece.org/wiki/download/attachments/14319901/GRPE-66-07%20REC.docx?api=v2>.

databases will also provide an "electronic LEZ certificate" when a vehicle owner is applying for LEZ access permits or stickers.

LEZ Planning and Implementation

Guidance is provided on the planning process prior to implementation of a LEZ. The first stage involves clarification of the air quality and traffic problems to be addressed, with reliable local emission inventories, vehicle distributions and traffic data, and air quality modelling. The process continues with clear objectives and assessment of the potential of different LEZ designs to solve the problem and achieve the objectives – without excessive costs, both in terms of financial, and environmental-social dimension. Setting of SMART objectives (see Ch. 3.6. and Ch. 7) makes the evaluation process more manageable and facilitates monitoring of progress.

It is important to identify potential barriers and draft appropriate measures to overcome them. There can be environmental, technical, economic, social and political barriers to local LEZ implementation. Best practices help to overcome most barriers, including:

- The air quality impact assessment demonstrates that the LEZ is an effective and necessary element of the programme of planned measures to comply with air quality limit values and targets for population exposure reduction – with clear health benefits;
- The LEZ is an integral part of a Sustainable Urban Mobility Plan in combination with other measures to decrease car transport demand, reduce excess traffic, optimize traffic flow, and enhance public and alternative transport solutions;
- a detailed regulatory impact assessment (RIA) and cost-benefit analysis are carried out to take into account all environmental, technical, social and economic issues;
- remediation measures focused on low-income groups are planned;
- a targeted information and awareness campaign is carried out;
- financing for necessary infrastructure is available.

Further steps include establishment of the LEZ border and any exempted transport routes through the zone, deciding on the emission class of the LEZ and which vehicles types the restrictions apply to. The types of exemptions to be permitted must be decided, and the effect of exemptions on achieving the objectives assessed.

There are a number of considerations that have to be thoroughly analysed prior to making the decision in regards to these issues. It is particularly important to assess, how and to what extent the established exemptions will affect the objectives of LEZ, keeping in mind the possible cumulative effects.

When the basis for setting up a LEZ is prepared, there is a need to ensure the involvement of stakeholders and the public, and acquire general information on opinion of the public. Taking into consideration that LEZ in its nature restricts the access and transit through certain territories, it is important to take all necessary measures (e.g., ensure availability of by-pass roads, introduce park & ride system, etc.), in order to ensure compatibility with freedom of movement concept. It is essential to inform not only the local society, but also to provide comparable information to foreigners. This will be supported by a European LEZ website and database with frequently updated data on both existing and planned LEZs.

LEZ Administration

One of the first steps that have to be taken in a harmonised European LEZ system is the introduction of mutually recognized LEZ stickers. These are proposed to be implemented at the national level, due to the number of existing LEZ schemes. Harmonised stickers would be tied to a network of national LEZ databases that would facilitate cross-border purchase of stickers. This will also link to information on all EU LEZs, database data for LEZ administrators (interoperable with electronic enforcement systems), LEZ-specific sticker purchase system and online system for paying the penalties.

Another aspect that requires the EU response is the recognition of retrofit devices. As the introduction of harmonised stickers and vehicle databases will encourage LEZ planners to establish a system that will cover also foreign vehicles, it is crucial that retrofitting of vehicles is treated in the harmonised manner in all of the participating Member States.

Resolving previously problematic issues in relation to foreign vehicles, as well as providing a sufficiently clear and structured guidance for LEZ planners on choosing the most suitable enforcement mechanism will ensure more efficient operation of LEZs and provide better tools for planning.

Financial Aspects

Funding

Two main types of LEZ can be distinguished: with and without user charges. Each type has different implications for financing. Regardless of the type of the scheme, investment costs of setting up the system have to be covered up-front. Own (local municipality) resources and (partly) funding through national budgets are the most used funding mechanisms. In some Member States there could also be (co-)funding available from the Structural Funds. Local governments should ask the central government to include LEZ measures in the Operational Programmes.

It is not likely that the system will be self-financing; even with user charges the revenues will typically cover only a certain percentage of operational costs. Therefore, it is important that a cost-benefit analysis confirms social-economic efficiency of the scheme (i.e. that social benefits exceed social costs). Such an argument, together with social acceptability of such a programme, is essential for receiving external co-funding.

Fees

If a LEZ is designed with charges, a fundamental question arises about the pricing principles and the appropriate levels of charges. Three main functions of these economic instruments can be listed, namely:

1. Creating right incentives to making polluters pay for the burden they create. Recovering (part of) the costs of imposing certain environmental policies;
2. Creating revenue which may be used for example to alleviate the negative effects of pollution or to compensate some of the costs to the selected social groups;
3. Creating right incentives to change to lower emission vehicles.

The level of charges

The level of charges cannot be set uniform because every local situation is different regarding traffic intensity, socio-economic conditions, environmental goals etc.

Combining various charge rates with demand elasticity and with the current traffic intensity within the specific vehicle categories would allow estimating an expected drop in traffic intensity and, subsequently, drop in pollution resulting from imposing the charges.

Furthermore, several criteria can be used to evaluate and select methods for design of user fee rate structures for LEZ. These include:

- Legality. Different regulations applying to local authorities may be in place regarding imposing charges and penalizing non-compliance with the LEZ standards as well as regarding the use of the revenues;
- Equity. Because more environmentally friendly vehicles tend to be newer and more expensive, the scheme will likely have relatively heavier impact (cost burden) on low-income residents and SMEs than on richer groups of residents and large businesses;
- Revenue sufficiency. In LEZ with charges, the authorities may want to aim at (partly) recovery of operational costs;
- Flexibility. Some flexibility must be allowed so that periodical adjustments of fee level is possible;
- Data requirements and compatibility with the monitoring and data processing systems. If the charges are to be based on some technical standards (e.g. Euro standards), the relevant information about the vehicle characteristics must be possible to obtain and monitor;
- Revenue stability and sensitivity;
- Consistency with other funding and charging policies. LEZ charging might be designed in a way that is consistent with other (existing) policies such as toll roads, congestion pricing etc. LEZ made according to the same design might spread across countries or even larger regions such as the whole EU.

Information Systems

The aim of a LEZ is to improve the environment by restricting access by older, more-polluting vehicles; the quality and availability of information to potential visitors to a city is vital in maximising compliance with entry requirements. Information is likely to be obtained by visitors in two ways: through roadside signs and information and online via websites (including mobile websites) and satellite navigation systems. The main source of information for potential visitors to a city is likely to be the web, with access from mobile devices particularly important. Online information should be provided through a network of linked central, national and local information systems, providing up-to-date information for all types of users from frequent international travellers to single-time users as well as local authorities intending to set up an LEZ.

Assessment and Monitoring

Assessment of the effects of a Low Emission Zone is typically done for the decision on setting up a Low Emission Zone and how it should be defined. It is done before the LEZ is introduced ("ex ante"). Monitoring is carried out once a Low Emission Zone has been implemented.

Assessment types

There are various ways of carrying out an assessment.

- An **impact assessment** is a broad assessment in which all relevant effects for various stakeholders are being listed;
- A second way of assessing the relevant impacts is by carrying out a **cost benefit analysis** (CBA). A CBA is more restricted than an ex ante impact assessment, as it only takes into account those effects that have a net impact on total welfare of society, measured in monetary terms (i.e. euro's);
- A CBA is different from a **cost effectiveness analysis**. In a cost effectiveness analysis the costs to realise a certain goal (i.e. a reduction in NO_x concentration by 10%) are being assessed. But the benefit of the reduction is not translated in monetary terms.

Intermediate assessments

Mobility – It is important to estimate and monitor impacts on mobility, and the level and composition of traffic in the city and in the zone.

Air quality – A useful tool for assessing whether a LEZ will be an effective way for improving air quality is an Air quality impact assessment. Two types of assessments can be carried out:

1. An assessment of the impact of an LEZ on emissions CO₂ and other greenhouse gases can be carried out through the compilation of an atmospheric emissions inventory;
2. An assessment of the impact of an LEZ on ambient concentrations of pollutants, including NO₂ and particulates, can be carried out through dispersion modelling. Dispersion modelling requires the following inputs: Spatially resolved emissions data, temporal variation in emissions data, meteorological data and background concentrations.

Guidance on air quality assessment is available from FAIRMODE and the Implementation Pilot project.

Health – The main health impact of a LEZ is likely to be due to a reduction in pollutant concentrations, particularly NO₂ and particulates from vehicle exhausts. Health impact assessments (HIA) can be carried out using concentration-response functions (CRF) that link pollutant concentrations to the number of health events which occur.

Noise – The effect of an LEZ on noise is likely to be less significant than the effect on air quality, however, where significant changes in traffic flows are expected, the resulting health effect can be quantified by carrying out a noise health impact assessment.

Social – The possible social impacts of LEZ are intertwined with the environmental and economic impacts. Social impacts – can cover a range of impacts like social acceptability of the scheme, possible socio-economic regressiveness of the measures (for example higher burden for lower income residents and/or SME's), special groups (for example persons with a mobility reduction), employment effects, quality of life aspects (other than health-related).

Basic or extended level of assessment and monitoring

One can choose between a basic and more extended level of assessment and monitoring:

- **Basic level** – The basic level of assessment and monitoring is restricted to the information level that a city administration needs to decide on the introduction of a LEZ. On a basic level the

following aspects are assessed: Air quality, level, composition and emission characteristics of traffic in the city and in the zone;

- **Extended level** – A “golden” standard in assessment and monitoring would be to comprise additional aspects such as: Cost of operating a LEZ, costs of enforcement, costs for deliveries to shops and other businesses, revenues from entry fees, use of public transport, other effects on environment, such as emission of greenhouse gases, noise pollution, and accidents.

Program for evaluation and review

An evaluation framework and a monitoring program is needed to assess the effects, both for an ex ante assessment and for monitoring during its implementation. It depends on the chosen level of assessment (basic or more extended) and monitoring for which indicators data has to be collected. One should choose a limited number of easily-measurable indicators and avoid information overload, or a monitoring program that is too time consuming and costly.

Existing air quality monitoring networks should be reviewed with respect to the specific needs for continuing LEZ evaluation. If the existing monitoring programme fulfils the EU requirements for monitoring, there may be flexibility to use cost-effective options for additional supplementary monitoring stations to meet the needs for LEZ evaluation.

The steps in drafting and implementing monitoring and evaluation program are:

1. Define SMART objectives which are

- **Specific** – set the specific aspect or area that has to be assessed and/or improved;
- **Measurable** – propose indicators for measuring the progress;
- **Attainable** – state the results that can realistically be achieved within given period of time and available resources;
- **Relevant** – the objectives must not be based on external factors, but be relevant in a given situation;
- **Time-related** — set the timeframe for achievement of the objectives.

2. Draft a monitoring work plan

Once the SMART objectives have been defined a work plan should be drafted. For each indicator the related tool for data collection has to be defined, the responsibilities regarding the collection of data for the indicators has to be assigned and the planning of the data collection and monitor reports has to be set. Monitoring and evaluation is advised at regular intervals. In order to create transparency it's important to inform the stakeholders about the progress and consult them about the monitoring results.

1 Introduction

1.1 Purpose

This guidance is primarily directed to city governments considering a low emission zone (LEZ) as a measure to meet air quality obligations, improve environmental quality and lower traffic-related health risks in their cities. This document proposes some specific common approaches for LEZ planning and implementation that will make it easier for users – in particular transport and logistics services and visitors – to comply with the city planners' intent. The scope of the guidance goes beyond air quality planning for compliance with air quality limit values to encompass other mobility, economic and social issues that LEZ implementation entails. This guidance also refers the reader to other resources and guidance relevant to LEZ as an integral component of urban mobility measures that protect the urban environment and the quality of urban life.

1.2 Background

Air quality is a problem in many European cities. In many European cities, PM₁₀ and NO₂ concentrations still exceed EU air quality limit value set in 1999, which were to be met by 2005 or 2010. The newer PM_{2.5} limit value will be challenging to meet by 2015. The WHO (2013) has reconfirmed and strengthened the documentation of serious health impacts of urban air pollution and recommends revision of limit values to the even lower WHO guideline levels. As a result, many cities have introduced low emission zones (LEZ) to improve air quality and to meet the limit values. There is increasing evidence that LEZs can have significant benefits to human health, even though the reduction of PM₁₀ levels may be modest (Cyrys et al, in press).

There are no uniform regulations or standards for LEZs in the Member States, although a few (Germany, Denmark, Sweden, Netherlands, Czech Republic) have adopted national LEZ regulations. Even within the Member States with national LEZ regulations, each city may be free to implement LEZ with local conditions and administration, creating a patchwork of restrictions and procedures that can be a burden for intercity and international drivers and road transport operators. The guidance and proposed voluntary standards in this document are intended to assist Member States and municipalities to implement harmonised LEZ that minimize the social and economic impacts of LEZ, while maximizing the air quality, noise and health benefits.

We define low emission zones (LEZ) as urban areas or roads where the most polluting vehicles are restricted from entering. Vehicles can be excluded based on their emission levels, or in some cases charged a fee that depends on the emission level. LEZ have been introduced in many cities in various EU Member States¹. In parallel, technological progress has led to substantial improvements in classic vehicle engine and fuel environmental parameters as well as to introduction of hybrid vehicles or electrical vehicles. Moreover, many cities have introduced mobility and transport measures which have led to the reduction of air and noise pollution. Some cities have adopted innovative approaches in their implementations of LEZ. Innovative approaches and technology that solve environmental problems and contribute to effective urban mobility and economic growth are among the objectives of the Europe 2020 strategy, and referred to as eco-innovation. Introduction of LEZ at the EU level must be considered from the complex point of view of comparing pros and cons and to find optimal solution with balanced environmental improvements, technical and economic feasibility and social acceptability.

A large number of European cities have not been able to comply with the EU ambient air quality limit values for PM₁₀ and NO₂ at urban traffic locations. These were to be met by 2005 and 2010 respectively. The new limit value for PM_{2.5} (fine particulate, 25 µg/m³) must be met by 2015, and a lower indicative limit value (20 µg/m³) for 2020 could become mandatory as a result of the Commission's ongoing review of air quality policy.

Most Member States had been relying on the successive stages of EU's EURO vehicle emission standards to bring down emissions from traffic and lower roadside pollutant concentrations. It has become apparent that recent EURO standards have not delivered the expected reductions in vehicle emissions, due to differences between factory emission testing procedures and real-world driving conditions. This has heightened the need for cities to implement additional measures to comply with the air quality objectives. Low emission zones (LEZ) can be an effective measure to reduce traffic-related pollutant levels and shorten the time needed to achieve compliance with air quality limit values.

There are many approaches to implementing a LEZ. Requirements and procedures vary widely between cities and can be difficult for foreign drivers to understand.

1.3 Objectives

The objective of this report is to provide cities with guidelines relating to all aspect related to planning, implementing and operating low emission zones thereby contributing to an increase of the cost-effectiveness of LEZ's in European cities.

These guidelines built on previous work done (see 1.6 references) and the experience of the many implemented LEZ's in cities across Europe.

1.4 Scope

These guidelines handle the relevant aspects related to LEZ's planning and implementation. The report includes specific requirements and standards for more harmonized LEZ's and guidance for implementation of low emission zones.

The main audience for this guidance are the Member States and local authorities. The guidance is directed primarily to local authorities who are considering of have decided to implement a LEZ in their city. It advises on the process of implementing a LEZ, including the process to select the appropriate form of LEZ according to the local situation and environmental objectives, and for involving stakeholders and the public in the design and implementation process.

The guidelines includes the specific requirements and standards (if applicable) to be followed. For technical aspects which are highly complex and for which detailed technical standards are beyond the scope of this project - such as electronic devices and information management systems – the document specifies the main functional requirements and identifies the need for detailed design work or establishment of formal technical standards.

This guidance will be used by the Commission as well in consultation with Member States of the appropriateness of implementing a harmonized system of LEZ's. Depending on the outcome of these discussions, further steps to implement a harmonised system could be envisaged.

1.5 Overview

Chapter 2 presents a proposed framework of voluntary standards for harmonisation of low emission zones in Europe. Chapters 3 to 7 provide guidelines for low emission zones, into along five main topics:

- Voluntary Standards for European Low Emission Zones (Chapter 2);
- LEZ Planning and Implementation (Chapter 3);
- LEZ Administration (Chapter 4);
- Financial Aspects (Chapter 5);
- Information Systems (Chapter 6);
- Assessment and Monitoring (Chapter 7).

The subtopics handled in each chapter were selected after an assessment of a long list of possible topics.

1.6 References

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2 Voluntary Standards for European Low Emission Zones

2.1 Introduction

The first low emission zones (LEZ) were established in Sweden in 1996. There are now over 204 LEZs in operation or planning in 12 countries. Each country – in some countries each city – has defined its own criteria for its LEZ. Recognizing the advantages of harmonization, several countries and regions have coordinated and standardised LEZ criteria and implementations within their territories. Sweden, Germany and Denmark have national legal and technical frameworks for LEZ. The Netherlands has coordinated LEZ through a National Covenant signed by the government, municipalities and other stakeholders. The Czech Republic and Austria have national LEZ frameworks based on the German model, and the Czech Republic and Germany are discussing mutual recognition of their stickers. The UK is considering establishing a national LEZ system. Although Italy has no national LEZ framework, several regions in Italy have coordinated LEZ within their regions, including Valle d'Aosta, Bolzano, Emilia Romagna and Lombardy.

Countries and regions with coordinated LEZ frameworks have a clear advantage for the mobility of their citizens and businesses. The LEZ in these areas have the same criteria, or criteria drawn from a small number of choices. Differences between countries, regions and cities, each with differing LEZ designs and criteria, presents a confusing and sometimes costly hindrance to free movement by road within the EU. This study has sought to find a common ground for harmonisation of LEZ throughout Europe, which is presented in this chapter.

This chapter presents proposed voluntary standards for the "Euro Pass" framework for low emission zones in Europe. The framework is to be implemented in each participating State through appropriate policy, legal and technical instruments based on these harmonised guidelines but adopted to the national situation.

The primary purposes of a LEZ is as a measure to comply with EU limit values for PM₁₀, PM_{2.5} and NO₂. There are 645 cities and towns in Europe that exceeded PM₁₀ or NO₂ limit values at traffic or urban background stations in 2011. 123 of these exceedance cities (19%) already have or plan to have an LEZ⁵. There are 224 cities and towns in the newer EU13 Member States with exceedances in 2011, but only two of these have or plan to have LEZ. There thus leaving plenty of opportunities of LEZ to be considered in the newer Member States.

It is the 24-hour PM₁₀ limit value and/or annual NO₂ limit value that is exceeded in 99% of the cases.

Most LEZ in Europe are created to mitigate particulate matter. The progressively stricter stages of most LEZ exclude more and more of the older diesel vehicles without particle filters. The PM emission limit values for Euro IV heavy vehicles implies that Euro VI vehicles have particulate filters as standard equipment, while it is first with the Euro 5 standards that diesel passenger cars and vans need filters as standard equipment. The current highest stage of the German LEZ framework is class 4, corresponding to Euro 4/IV. The class 4 criteria can also be met by installing an approved diesel particulate filter on older vehicles.

⁵ This study, Final Report.

An LEZ by itself only reduces exhaust emissions. A large part of the PM₁₀ concentrations measured at roadside monitoring stations comes from the background PM₁₀, road and tyre particles and resuspended particles from the road surface, which are independent of the Euro stage of the vehicles. Exhaust PM consists of very small particles, while brake, tyre and road particles are larger. Exhaust PM represents a larger share of the ambient fine particulate matter (PM_{2.5}) concentrations at traffic stations. This should make the LEZ a more effective measure for complying with the PM_{2.5} limit value than for PM₁₀. Since exhaust PM consists largely of ultrafine particles including black carbon, the health benefits of reducing exhaust PM can be expected to be greater than the PM₁₀ or PM_{2.5} reductions would suggest.

2.2 Overview

The proposed voluntary "City Pass" framework for harmonisation of European LEZ is outlined in this section. Further details of each element are presented in subsequent sections of this chapter. Guidance for local authorities is presented in the remaining chapters of this document.

Key components of the voluntary framework for LEZ are:

1. national analysis of the impact, cost-benefit and policy interactions of implementing LEZ;
2. national legal and institutional framework for implementation of LEZ by municipalities and for associated national-level incentives and complementary measures;
3. a harmonized sequence of progressively stricter vehicle emission classes based on Euro standards and certified retrofit equivalents, for defining LEZ to reduce exhaust emissions of PM₁₀, PM_{2.5} and NO_x;
4. national synchronised timetables for LEZ phases;
5. standards for sticker-based LEZ that facilitate mutual recognition of national stickers;
6. national testing and certification scheme for retrofit emission control devices (REC) compliant with the UNECE 2013 REC Regulation⁶;
7. national databases for vehicle emission qualifications to facilitate automatic recognition of the emission class of vehicles and provide an "electronic LEZ certificate" for each registered vehicle for entry into LEZ and for obtaining stickers and exemptions;
8. standards for data exchange between national and local databases of vehicle emission qualifications, and for international data exchange between national databases, consistent with EUCARIS⁷ standards;
9. a European database and Internet information service for vehicle owners and operators on existing and planned LEZ⁸; and
10. a European information service providing or linking to guidance and best practices for cities to assist in the planning and implementation of harmonized LEZ as an element of an integrated and sustainable urban air quality and mobility strategy.

The standards are intended to serve three main purposes: 1) to establish a harmonised set of progressively stricter LEZ criteria that will be easier for residents, businesses and travellers to understand and adapt to, 2) to facilitate mutual recognition and interchangeability of national LEZ stickers, and 3) provide an established LEZ framework for cities and countries that have not yet decided on LEZ implementation. The standards are voluntary and represent minimum technical and

⁶ Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery equipped with compression ignition engines, ECE/TRANS/WP.29/2013/119. UNECE World Forum for Harmonization of Vehicle Regulations (WP.29), Adopted 13 November 2013. <http://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grpe/ECE-TRANS-WP29-GRPE-2013-09e.pdf>.

⁷ EUCARIS is the EUropean CAR and driving license Information System, <https://www.eucaris.net/>.

⁸ A Commission tender is underway for a contractor to maintain and extend an European LEZ website for the next four years, building on the existing LEEZEN website www.lowemissionzones.eu.

administrative requirements that will facilitate the achievement of environmental objectives for LEZ while minimizing the social, economic and mobility impacts of LEZ.

The "City Pass" framework for harmonisation of LEZ does not envision a centralised system at the EU level, but rather a harmonised system of national frameworks for LEZ. The costs and time needed for municipalities to establish LEZ are greatly reduced if fundamental analyses and basic framework are already in place at the national level. Within this context, the roles and responsibilities of the international, national and local institutions are summarised in **Table 2.1**.

Table 2.1 Roles and responsibilities for harmonised LEZ

| Institutional level | Roles and responsibilities |
|---------------------|---|
| UNECE | <ul style="list-style-type: none"> • UNECE Regulation on retrofit emission control devices (REC) for HDV (proposed). |
| EU | <ul style="list-style-type: none"> • Air quality legislation; • Euro vehicle emission standards; • LEZ guidance and best practices; • European LEZ database and website; • Technical standards (EETS). |
| National government | <ul style="list-style-type: none"> • National analysis of LEZ impact, cost-benefit and policy interactions; • National urban air quality and mobility strategy; • LEZ enabling legislation, including: <ul style="list-style-type: none"> - Legal basis for municipalities to establish LEZ; - Definition of LEZ pollutant emission classes and sticker design; - National schedule for LEZ phases; - Definition and criteria for permitted LEZ vehicle exemptions; - Retrofit approval scheme based on UNECE REC Regulation; - Incentives and complementary measures to support LEZ implementation; - National system for sale of stickers and approval of exemptions; - National LEZ database and website; - National vehicle database with emission characteristics, and exchange of vehicle data with other participating countries. • Option: National standard for automatic vehicle recognition. |
| Local government | <ul style="list-style-type: none"> • Local stakeholder and public consultation and participation; • Local LEZ air quality assessment, impact assessment and cost-benefit analysis; • Local air quality management plan (Air Quality Directive), consistent with national air quality strategy, NECD and MMR programmes of measures; • Sustainable urban mobility plan (SUMP); • Decide which vehicle types are restricted (HDV, LDV, PC, MC); • LEZ boundaries and exempted routes (transit, port, airport); • Enforcement method and infrastructure; • Inform the public and stakeholders; local LEZ website; • Signage compliant with national standard (based on EU guidance); • Monitoring and evaluation (ex post) of LEZ effectiveness and cost-benefit. |

2.3 National analyses of impact, cost-benefit and policy interaction

Each national LEZ framework should start with a comprehensive national feasibility study for establishing LEZ in the cities where exceedances of PM₁₀, PM_{2.5} or NO₂ limit values occur or are at risk of occurring. The study should encompass assessment of the environmental, health and socioeconomic impacts of implementing LEZ, cost-benefit analysis, and evaluation of interactions between LEZ and other policies and measures at the national or EU level.

The national feasibility study should establish the scope and common data needed by the cities for local impact studies and cost-benefit analyses.

Guidance on impact assessment and cost-benefit analysis is provided in Chapter 0.

2.4 Legal and institutional framework for LEZ

The harmonized "City Pass" framework for European LEZ envisions that each participating State established a national legal framework for LEZ that is consistent with the voluntary standards and guidance. That framework must respect EU legal principles and provide a clear division of roles and responsibilities between national and municipal authorities. Since a LEZ is an element of both air quality and mobility strategies, the national framework needs to support both aspects. The national framework may also provide incentives and complementary measures that enhance the effect, efficiency and acceptance of LEZ.

2.4.1 EU legal framework

The national and local frameworks for LEZ must take principles of EU law into account. The EU has limited direct involvement in urban traffic restrictions as long as they are implemented in a manner that respects the general principles of the EU Treaty⁹, in particular the freedom of movement principle. A LEZ is a potential barrier to free movement of goods and services, but justified under the Treaty by the European Council's Environmental Imperative¹⁰. This means that in practice that (Sadler, 2011):

- LEZs should have the same requirements for foreign vehicles to comply as for national vehicles. Information on the LEZ needs to be disseminated throughout the EU;
- Freedom of movement requires that the emissions standards and retrofit certification should be in line with the EU vehicle Euro standards, as these are the only emissions standards accepted throughout the EU. Standards derived from Euro standards, such as meeting the PM aspect of the Euro 4 emissions standard, are acceptable;
- Motorways and Trans-European Network (TEN)¹¹ key roads need to be exempted from LEZs, or have a reasonable diversion. The exception is motorways terminating in a LEZ (with all exits entering the LEZ). In this case there must be sufficient warning and an exempted turn around section if the driver mistakenly stays on the motorway. It is possible to include motorways if the number of vehicles affected is limited, the action is proportionate and other options have been tried. Motorway issues need to be discussed with the Commission early in the planning phase.

The European Court of Justice has made it clear that, to be compatible with the Treaty, any restrictions affecting intra-Community trade have to be necessary, proportionate and non-discriminatory. Proportional means that an LEZ may be no more restrictive to trade than is required to reduce the high level of ambient air quality.

Regarding necessity, the AAQD provides that "Member States shall take the necessary measures to ensure compliance with the limit values". Measures "to control and, where necessary, suspend activities, including motor-vehicle traffic" are explicitly referred to in Article 7(3) as possible

⁹ Treaty on European Union, Consolidated versions 2012/C 326/01 (OJ No. 2012/C 326/01). <http://eur-lex.europa.eu/JOHtml.do?uri=OJ:C:2012:326:SOM:EN:HTML>.

¹⁰ European Council in Dublin, 25-26 June 1990, Annex II, The Environmental Imperative. Declaration by the European Council. http://www.europarl.europa.eu/summits/dublin/default_en.htm
http://www.europarl.europa.eu/summits/dublin/default_en.htm.

¹¹ Trans European Network roads, a network of roads with European significance, which is also under development with EU funding. Most motorways, harbour access roads or key bridges (eg Rhine/Humber), as well as the Paris Peripherique would also be included.

elements in the action plans that member States must draw up, indicating the measures to be taken in the short term where there is a risk of the limit values and/or alert thresholds being exceeded. National and local impact assessments and cost-benefit analyses should confirm the benefit, cost-effectiveness and necessity of LEZ as an essential element of an integrated air quality and mobility plan.

Notification is a procedure in which a Member State conveys to the Commission a proposed or adopted law or regulation which is subject to notification. When a Member State undertakes measures that have the potential to affect the freedom of movement, or financial incentives that might give a commercial advantage to some enterprises, these measures should be notified to the Commission.

National legislation and regulations related to LEZ should in general be given notification, but it is usually not necessary for individual LEZs unless there is an aspect affecting international mobility such as a TEN highway, or access to an international port or airport involved. Subsidies, grants and economic incentives may also need to be notified to the Commission, although there are exceptions when they are under a certain limit. It is advisable to discuss the issues and need for notification with the Commission before preparing or submitting a notification.

2.4.2 National LEZ enabling legislation

It is recommended that national legislation for LEZ establish a harmonised LEZ framework to be applied throughout the country, and authorisation for municipalities to plan and implement a LEZ, in compliance with the "City Pass" standards and guidelines. The implementation of LEZs requires co-operation between the national government and local authorities to help ensure a common system within a country. The proposed elements of the national framework are listed in Table 2.1.

Harmonisation of sticker-based LEZ is achieved by establishing a standard set of LEZ sticker classes – based on Euro emission standards and certified retrofit emission control devices (REC). Standard LEZ sticker classes will facilitate mutual recognition of national stickers between Member States, and will simplify the planning process for cities considering a sticker-based LEZ. The European City Pass system does not propose a new type of sticker issued by EU, but harmonization to minimize the number of national stickers that a vehicle owner might need to acquire. The use of harmonised vehicle emission classes will make it easier for visitors and road transport providers to understand and adapt the requirements in different cities.

It is recommended to include civil penalties for 1) operation of a non-compliant vehicle in a LEZ, 2) misrepresentation of the emission characteristics of a vehicle or of installed REC, and 3) fraudulent use of stickers.

The national legislation should establish the competent authorities for:

- issuing of stickers and exemptions;
- type-approval, installation and inspection of REC;
- creation, access and update the national vehicle emission class database; and
- hearing of complaints related to LEZ.

2.4.3 Municipal framework

The municipal framework includes the item listed in Table 2.1. Local government has the primary budgetary responsibility for establishment of an LEZ and the associated technical and administrative infrastructure. Chapter 0 provides guidance on planning and implementation of LEZ,

and Chapter 0 discusses the administrative aspects. Guidance on financial aspects are provided in Chapter 0.

In States where a cities are authorized to establish LEZ, but there is not a national framework, it is recommended that cities adopt the standards and guidelines of the harmonised "City Pass" framework as the basis for design and implementation LEZ, to the extent possible under national law.

2.4.4 *Financial incentives and complementary measures*

The national framework should consider possible incentives to enhance the environmental benefits of LEZ and complementary measures to enhance local acceptance and compensate for social inequities. Examples include:

- Tax incentives for zero or low emission vehicles;
- Grants for diesel particle filters and/or filters that do not increase primary NO₂;
- Complementary local measures improving:
 - alternative transport solutions (public transport, bike, park & ride);
 - charging and parking possibilities for electric cars.

Table 2.2 Selected resources on financial incentives and complementary measures

Guidelines on financial incentives for clean and energy efficient vehicles - Commission Staff Working Document. European Commission, DG MOVE.
[http://ec.europa.eu/transport/themes/urban/vehicles/directive/doc/swd\(2013\)27-financial-incentives.pdf](http://ec.europa.eu/transport/themes/urban/vehicles/directive/doc/swd(2013)27-financial-incentives.pdf). EC (2013).

2.5 Emission classes

It is essential that emission criteria for exclusion of vehicles from a low emission zone are based on the EU Euro emission standards. The Euro standards apply equally to all vehicles sold or registered in EU Member States. Criteria which are not based on Euro standards might be considered discriminatory and could lead to legal challenges.

The "Euro Pass" framework for vehicle emission classes is based on the Euro emission standards. The scheme builds on the approach of the German LEZ regulation¹², adding three additional classes for possible future stages of restriction, and specifying retrofit equivalence requirements (for HDV) based on the draft UNECE REC Regulation.

The six pollutant emission classes are outlined in **Table 2.3** and the criteria are further explained below. Stickers for these classes are described in section 2.8.

¹² <http://www.bmu.de/en/topics/air-mobility-noise/air-pollution-control/umweltzonen-umweltplakette/low-emission-zone-emissions-control-windscreen-sticker/>.

Table 2.3 Vehicle emission criteria and retrofit requirements for pollutant emission classes based on Euro emission standards and retrofit equivalences. REC = retrofit emission control device meeting UNECE REC Regulation (proposed).

| Category | Motor | Pollutant emission class | | | | | |
|--|-------------|---------------------------------------|---------------------------------------|--|---|--|-----|
| | | 2 | 3 | 4 | 5 | 6 | Z |
| Passenger cars and light duty vehicles < 3500 kg | PI (petrol) | | | Euro 1,2 | Euro 3 | Euro 4,5,6 | |
| | CI (diesel) | Euro 2 Euro 1 + REC IIB (PM) | Euro 3 Euro 2 + REC IIB (PM) | Euro 4 Euro 2,3 + REC IIB (PM) | Euro 5 Euro 3,4 + REC IV (PM & NO _x) | Euro 6 Euro 4,5 + REC IV (PM & NO _x) | |
| Zero emission | | | | | | | All |
| Heavy vehicles ≥ 3500 kg | CI (diesel) | Euro II Euro I + REC IIB (PM) | Euro III Euro II + REC IIB (PM) | Euro IV Euro II,III + REC IIB (PM) | EEV, Euro V Euro II,III + REC IV (PM & NO _x) | Euro VI EEV,IV,V + REC IV (PM & NO _x) | |

The numbering of the pollutant emission classes corresponds roughly to the Euro levels for diesel vehicles, progressively excluding additional categories of older diesel vehicles. Classes 2, 3 and 4 have reduction of PM as the primary focus. Classes 5 and 6 are intended for cities where compliance with the NO₂ or PM_{2.5} limit values is not anticipated to be achieved in quickly enough with LEZ progressing only through classes 2 to 4. Retrofit equivalence is further discussed in section 2.7.

Several countries presently include vehicle age restrictions in their LEZ criteria in addition to Euro stage criteria, for example Sweden. The vehicle emission criteria presented in **Table 2.3** do not depend on vehicle age, except as implied by the Euro stages (and retrofit equivalents). This avoids making the criteria more complex than necessary and makes them more easily communicated and understood, especially to visitors.

Emission class 5

Pollutant emission class 5 provides additional emission reductions beyond the present top stage 4 in the German system, but primarily for passenger cars and light duty vehicles. Excluding Euro 1 and 2 petrol cars and vans reduces NO_x emissions. Compared to Euro 1 and 2, the Euro 3 NO_x emission per km. is 79% and 61% lower for petrol cars and 77% and 44% lower for LDV¹³. The benefit to overall NO_x emissions depends on the local fleet composition and mileage distribution. Euro 5 diesel cars and LDV do not contribute to lower NO_x emissions, but the PM emission limit value is 80% lower than the Euro 4 level, providing a significant additional reduction of diesel particulate emissions. Euro 5 reduces the diesel PM emission limit value to the same level as for petrol vehicles. Retrofit of Euro 3 and 4 diesel LDV to class 5 requires both the PM and NO_x emissions to comply with Euro 5.

Class 5 for heavy vehicles does not provide significant benefits. The Euro V PM limit value for heavy vehicles is unchanged from the Euro IV level, and NO_x emissions from Euro V diesel vehicles under real-world driving conditions for many, but not all, vehicles are equal or greater than Euro IV vehicles, in spite of lower limit values. Considering the lack of benefits for heavy vehicles, further consideration should be given to including Euro IV heavy vehicles in class 5, as well as in class 4, or Euro V in class 4. Benefit is obtained for retrofits by requiring compliance both the PM

¹³ based on EMEP/EEA Guidebook (2013) Tier 2 emission factors.

and NO_x to be retrofitted for Euro V. Retrofit of Euro IV heavy vehicles is not included in class 5 because it is covered under may be more cost-effective to upgrade Euro IV directly to Euro VI (class 6).

Emission class 6

Emission class 6 is proposed to provide a potential additional future phase for LEZ where limit values are projected to be exceeded in 2020 and beyond. For heavy vehicles, Euro VI PM is reduced 50% compared to Euro V, and the NO_x emission limit value is 80% lower. For cars and vans, the Euro 6 NO_x emission limit is 56% lower than Euro 5 for diesel vehicles and unchanged for petrol vehicles. The PM emission limit is unchanged from Euro 5 for both petrol and diesel vehicles.

Major benefits of the Euro 6/VI standards effective in 2014 are the introduction of new *world harmonised* test cycles (WHSC, WHTC) that more closely reflect real world driving conditions, on-road emission testing to confirm that the emission limit values are complied with under actual driving conditions, in a second "b" stage effective in 2017. Although the initial Euro 6/VI vehicles may not fully satisfy the emission limit values, emissions from second stage vehicles should be much closer to emission limit values. Beginning 2017, NO_x emissions from Euro 6/VI diesel vehicles can be expected to be much lower than in the previous Euro stages.

Emission class Z

An additional "Z" class is provided for vehicles with zero on-road emissions (electric and fuel cell). Class Z vehicles could be required in special situations, such as narrow or covered pedestrian malls, or be given special privileges like reserved parking as incentives to promote zero-emission vehicles.

2.6 Exemptions

An important issue for commercial fleet operators is obtaining exemptions for vehicles where permitted. Exemptions are presently defined and administered locally. Exemptions and the procedures to obtain them thus vary from city to city. This can create an unwieldy bureaucratic burden for national and international fleet operators, when exemptions are justified. It is proposed that exemptions be defined and administered at the national level in the "City Pass" framework. This should provide a significant harmonisation benefit, and also a significant administrative savings for cities.

A windscreen sticker is used for exemptions, as described in section 2.8.

As a general principle, exemptions should be clearly defined and limited in number and duration. Specialized vehicles and vehicles which are extensively outfitted for a specific commercial purpose can be exempted, if retrofitting is not a cost-effective option.

It is recommended to strictly limit the number and types of exemptions that are permitted.

Exemptions may include:

- Mobile machines, cranes and equipment;
- work vehicle;
- Agricultural tractors;
- Ambulances and specially outfitted vehicles for patient transport;
- Handicap vehicles;
- Specialised vehicles for work of the police, customs personnel, Coast Guard, doctor, nurse, midwife or veterinarian;

- Rescue vehicles;
- Antique or vintage vehicles;
- Military vehicles during military exercises (an agreement should be made with military authorities regarding compliance of military vehicles used for ordinary work within LEZ).

It is not recommended to exempt city buses and other municipal vehicles. Foreign commercial vehicles must have the same exemption privileges as national commercial vehicles, to avoid legal challenges due to discriminatory effect, or complaints of unfair competition from national operators.

2.7 Retrofit emission control devices

2.7.1 Introduction

Retrofit emission control devices (REC) can bring older vehicles into compliance with a higher Euro standard for specific pollutants – PM and NO_x in particular. The harmonised pollution emission classes presented in **Table 2.3** above permit the use of approved REC on diesel vehicles to be registered in the next higher emission class. Permitting vehicles to qualify for a higher pollutant emission class through retrofitting can facilitate acceptance of a stricter LEZ standard than without retrofits, as the cost of retrofitting is usually lower than replacing the vehicle.

It is important to note that retrofit devices cannot make a vehicle completely equivalent to a higher Euro stage, because the Euro standards include many other vehicle specifications than emissions limit values.

The major retrofit technologies are listed below. Retrofit technologies designed to control particulate matter (PM) include:

- Diesel oxidation catalysts (DOCs);
- Diesel particulate filters (DPFs);
- Flow through filters (FTFs);
- Closed crankcase ventilation (CCV).

Retrofit technologies designed to control oxides of nitrogen (NO_x) include:

- Exhaust gas recirculation (EGR);
- Selective catalytic reduction (SCR);
- Lean NO_x catalysts (LNCs or HC-SCR);
- Lean NO_x traps (LNTs).

Detailed descriptions of these retrofit technologies can be found in the references given in section 2.7.6.

DPF technology is the most frequently used technology for PM abatement. It is based on the ability of the DPF substrate to physically trap the solid fraction of PM, including soot. The substrate can be configured as an open, flow-through device or a closed or full, wall-flow device. A wall-flow DPF reduces PM by 95% or better, including ultrafine particles. Partial (through-flow) DPF have around 50% filter efficiency, are not as effective for ultrafine particles, and can release stored PM (blow out) at a later time. Partial DPF are maintenance free without interacting with engine functions, which is an advantage for retrofit operation. Some DPFs with oxidation filters (DOCs) or certain regeneration techniques increase direct NO₂ emission, but others do not. Some even reduce NO₂ and NO_x. NO₂ is not regulated in the Euro standards, making it difficult to regulate in for REC, although London and Italy have done this, and the UNECE REC Regulation include limits on the increase of NO₂.

2.7.2 Existing REC regulations

If retrofitting is allowed, then there needs to be a certification scheme, which in turn needs to be linked to the emissions testing of the Euro standards. Certification needs to be done carefully, to ensure that the desired outcome is achieved.

All of the countries which currently permit retrofits have certification systems for retrofit devices. These systems have many similarities, and in some cases directly refer to another country's certification system. The existing retrofit systems summarised in **Table 2.4**.

Table 2.4 Overview of national REC regulations pertaining to LEZ

| Country | LEZ Scope | Year | Key technical and certification requirements for retrofits |
|------------------------|---|------|--|
| Austria | HDV: PM, NO _x | | Retrofit must meet PM and NO _x emissions standards of the LEZ Euro stage (Euro I,II,III); not allowed on A12 motorway (Tirol). |
| Czech Rep. (Prague) | HDV & LDV ≥ 3.5 t: PM | | Euro III + approved DPF (proposed legislation similar to German). |
| Denmark | HDV: PM | | DPF with PM reduction ≥ 80% and type-approved under German regulation or equivalent in other Member State. (For diesel PC/LDV, DPF gives exemption from annual PM-tax (2009)). |
| France | (no LEZ yet) | 2013 | New REC regulation; REC to retrofit Euro II,III to III,IV require PM and/or NO _x reduction ≥ 50%; Retrofits to Euro V and EEV require PM reduction ≥ 90% and/or NO _x reduction ≥ 70%, on ETC test cycle. Also direct NO ₂ and NH ₃ requirements. |
| Germany | PC/LDV: PM, NO _x HDV: PM, NO _x | 2007 | Retrofit must meet PM emissions standards of the LEZ Euro stage (Euro II,III). Minimum PM reduction is 50% which allows open DPF. Detailed regulation for type-approval of REC. |
| Italy (varies by city) | HDV, LDV: PM | | DPF with no increase in NO _x , HC and CO emissions and a maximum of 30% NO ₂ in NO _x emissions. Allows partial (flow through) DPF. |
| Netherlands | | | retrofitted Euro 2,3 allowed in LEZ until 2010; retrofitted Euro 3 until 2013; full Euro 4 required since July 2013. |
| Sweden | HDV: all pollutants | | PM-only REC allowed until 2020. Recent changes require REC to meet all emissions standards of the LEZ Euro stage (Euro I, II, III, IV, V) and be approved by Swedish Transport Agency; Euro II, III can meet Euro V using REC for PM & NO _x . |
| Switzerland | (no LEZ) | | Switzerland has an advanced test standard ¹⁴ for REC ¹⁵ . |
| UK | HDV: PM | | Full DPF certified to meet the required LEZ Euro stage, with a maximum 30% NO ₂ increase. London: must meet Euro IV in 2012. |

Links to national retrofit webpages and lists of approved REC are found on the LEEZEN website¹⁶.

DPF certifications are based on compliance with emission limit values in the Euro standards, rather than percentage reduction efficiency, to ensure that they comply with the EU Freedom of Movement

¹⁴ SNV (2011). SN 277206:2011-02 Internal Combustion Engines – Exhaust Gas After-treatment – Particle Filter Systems – Testing Method. Swiss Association for Standardisation (SNV).
http://www.bafu.admin.ch/partikelfilterliste/10202/index.html?lang=en&download=NHZLpZeg7t.Inp6I0NTU042I2Z6In1ad1Iz4Z2qZpnO2Yug2Z6qpJCGfX5_fmym162epYbg2c_jiKbNokSn6A--.

¹⁵ FOEN (2012). Less soot from diesel engines; Switzerland's success in reducing emissions. Federal Office for the Environment
http://www.bafu.admin.ch/publikationen/publikation/01671/index.html?lang=en&download=NHZLpZig7t.Inp6I0NTU042I2Z6In1ad1Iz4Z2qZpnO2Yug2Z6qpJCGfIF_g2ym162dpYbUzd.Gpd6emK2Oz9aGodetmqaN19XI2ldvoaCVZ.s-.pdf.

¹⁶ <http://www.lowemissionzones.eu/retrofitting-mainmenu-149?showall=&start=7>.

principle. The Euro standards do not refer to direct emissions of NO₂, so few of the early REC approval regulations have direct NO₂ requirements.

While there are similarities between the various REC requirements, harmonisation to a common European REC standard is recommended.

2.7.3 UNECE REC regulation

In November 2013, the UNECE adopted in a new regulation on type-approval of REC for heavy duty diesel vehicles and non-road machinery. The Regulation covers REC for reduction of PM and NO_x. An amendment has been proposed which introduces a second level with stricter requirements.

The proposed REC Regulation defines four classes of REC:

- Class I PM reduction only, no increase of direct NO₂;
- Class II PM reduction only, limited increase of direct NO₂;
- Class II PM reduction only, limited increase of direct NO₂;
- Class III NO_x reduction only;
- Class IV Combined PM and NO_x reduction.

Under the Regulation, a REC must meet the Euro emission limit values for PM and/or NO_x of the next higher emission class, and also meet the minimum percentage reduction requirements and NO₂ limitations given in **Table 2.5**. The proposed 01 amendment splits Class II into IIA and IIB classes, to allow for a stricter limitation on the increase of NO₂. There has been considerable debate about the Class IIA NO₂ limitation, since this may require significantly more complex and costly DPF.

Table 2.5 Minimum emission reduction requirements for retrofit emission control devices for heavy duty vehicles under the proposed UNECE REC Regulation and proposed amendment 01

| Emissions measured in weighted WHTC or NRTC test cycle. | Proposed regulation (00) | Proposed amendment (01) |
|--|--------------------------|------------------------------|
| NO _x reduction requirement | 60% | 60% |
| PM mass reduction requirement | 50% | 90% |
| PM number reduction requirement | (not applicable) | 97% |
| Class II - maximum increase in NO ₂ above baseline percentage, in percentage points | 30 | Class IIA 20 Class IIB 30 |

The 90% PM mass reduction requirement of the 01 amendment ensures that open (flow-through) DPF cannot be used. This and the 97% particle number reduction requirement will provide very significant air quality and health benefits. The UNECE REC Regulation specifies use of the "world harmonized transient cycle" test cycle (WHTC), which more closely approximates real world driving conditions than previous test cycles, and thus ensures a more conservative test for compliance with emission limit values.

The UNECE REC Regulation applies only to heavy duty vehicles. The Regulation can also provide a basis for developing a national REC regulation for passenger cars and LDV. There are also several countries with REC approval regulations that cover passenger cars and/or LDV.

2.7.4 EU legislation on retrofits

At present, the European Commission does not at present intend to develop harmonised EU legislation for retrofit emission control devices based on the proposed UN Regulation and this is not on the Commission's work programme for 2013 or 2014¹⁷. Member States can adopt the UNECE REC Regulation with separate EU legislation is not necessary.

2.7.5 National REC approval

It is recommended that all participating States adopt the UNECE REC Regulation for HDV, and adopt (or amend) REC approval regulations to conform to the UNECE Regulation. The 01 amendments should be included, when adopted. The national regulation needs to identify the competent authority to grant type approvals for REC, and the authority or enterprises authorised to install, inspect and certify installation of approved REC. A certification form shall be issued that documents the certified installation of an approved REC, and is used to obtain LEZ stickers. Installers and inspectors should be authorised to enter and update retrofit information in the national vehicle emission registration database.

Participating cities shall recognize the certification of retrofit devices carried out in other Member States which conform to the UNECE Regulation. Participating cities shall recognize the vehicle emission class of foreign vehicles registered in another Member State on the basis of retrofit devices certified according to the proposed UNECE REC Regulation.

All LEZ certification schemes should accept as much of the information from other certification schemes as possible for practical as well as EU legal reasons. Foreign vehicles should be allowed to have any certified filter for EU legal reasons. Many existing LEZ schemes do this.

2.7.6 Information resources on retrofit emission control devices

Table 2.6 Selected information resources on retrofit emission control devices

| |
|---|
| AECC - Association for Emissions Control by Catalyst, 2013 Introduction to the technology for emissions control. http://www.aecc.eu/en/Technology/Introduction.html |
| ClientEarth, 2012 Reducing Particulate Matter Emissions from Diesel Vehicles and Equipment - A guide for fleet operators on retrofit diesel abatement for particulate matter. http://www.clientearth.org/reports/bcc-retrofit-guidance.pdf |
| Transport for London, 2013 Low Emission Zone - What are my options? Steps to fit a filter and case studies for lorries, buses, coaches and heavy specialist vehicles http://www.tfl.gov.uk/roadusers/lez/17701.aspx#tkt-tab-panel-1 |
| Manufacturers of Emission Controls Association (MECA), 2013 Diesel Retrofit - What is Retrofit? http://www.meca.org/diesel-retrofit/what-is-retrofit |
| Wagner, V., & Rutherford, D., 2013 Survey of Best Practices in Emission Control of In-Use Heavy-Duty Diesel Vehicles. International Council on Clean Transportation (ICCT); http://www.theicct.org/sites/default/files/publications/ICCT_HDV_in-use_20130802.pdf |

¹⁷ Draft Minutes for the 16TH GRPE Informal Group Meeting on Retrofit Emissions Control Devices (REC), 11 September 2013, <https://www2.unece.org/wiki/download/attachments/14319901/REC-16-06.docx?api=v2>.

2.8 Stickers

2.8.1 Form, Size, Symbols, Colours, Materials, Language

The physical stickers are patterned after the German stickers, with the addition of a barcode or QR code field under the colour circle, coded with a unique sticker identification number. The barcode will enable enforcement authorities to use portable barcode readers to quickly scan the identification number of the sticker, to obtain and confirm the registration with the City Pass vehicle database (see section 2.13 below).

The sticker colours are 3 – yellow, 4 – green, 5 – blue, 6 – violet, Z – white. A conceptual example is shown in Figure 2.1

Figure 2.1 Conceptual sticker appearance.



The nationality and license plate number of the vehicle shall be entered in the white field in permanent non-fading ink by the competent authority issuing the sticker. The sticker identification number is used as a unique identification number for the vehicle registration in the EU "City Pass" vehicle database.

The stickers shall be non-reusable, non-fading and forgery-proof, and designed to self-destruct on removal from the windscreen.

An exemption sticker could be similar to the above conceptual sticker, with a black or red "X". The exemption sticker also needs to have the expiration data, if applicable.

2.8.2 Issuance of Stickers

Stickers shall be issued by approved national authorities and the institutions or enterprises authorised to perform vehicle inspections and emission tests.

2.8.3 Mutual Recognition of Stickers

Participating cities shall recognize the City Pass compliant stickers issued in other Member States.

2.9 LEZ Design and Implementation

LEZ under the City Pass framework will follow the following guidelines:

- LEZ operate on a 24-hours basis, all days of the week, independent of any time-varying congestion charging or road pricing schemes which may be implemented;

- Cities whose air quality exceedances are due only to winter-time conditions may elect to operate on a fixed seasonal basis, beginning 1 October and ending 31 March. This shall be indicated on signs at the boundaries of the LEZ, and also on the city LEZ website and EU LEZ website;
- Changes in LEZs should be part of a planned strategy, with the future standards identified and communicated with time for operators to comply. The operation or criteria should be notified to the public and relevant information systems at the very least six months in advance of the date a change goes into effect.

2.10 Signage

Signage for LEZ is a local responsibility. Additional guidance on signage is provided in section 3.11.

2.10.1 Form, Size, Symbols, Colours, Materials, Language

Signs to mark the boundaries of LEZ shall consist of black text on a white background with a black border. The word "ZONE" shall appear at the top of the sign. The sign shall contain a centered red circle under the word ZONE. The red circle shall contain one or more vehicle symbols representing the vehicle types restricted within the zone. Under the red circle shall be single circle with the minimum pollutant emission class that may enter the LEZ, filled with the corresponding class colour. A conceptual example sign is shown below in Figure 2.2.

Figure 2.2 Example LEZ sign showing that lorries with pollutant class 4 or higher are permitted to enter.



Additional information signs, if any, shall be provided in both local language and in English.

2.10.2 Placement of Signs

Signs shall be placed at boundaries and entrances to the LEZ, clearly visible to motorists. Additional informative signs should also be placed on approach roads, to warn drivers of LEZ restrictions ahead.

2.11 Air quality assessment, impact assessment and cost-benefit analyses

Impact assessments and cost-benefit analyses must be carried out during the planning of the national LEZ framework, and also for each city where a LEZ is proposed. This section briefly

outlines the scope of these assessments. The division of roles and responsibilities envisioned regarding assessments is presented in **Table 2.7**. Further guidance is given in Chapter 0.

Local authorities in smaller cities often do not have the expertise and resources to devise a full CBA methodology and they often fail to recognise the savings which can be made by working with other authorities. It is challenging to devise a new methodology to assess the costs and benefits. For these reasons, and for cost efficiency, it is recommended for national authorities (or their appointed experts) to provide a common CBA framework with document template (e.g. Word/Excel) which covers the types of costs and benefits included in this guidance. Ideally, the local person would just have to obtain and enter data into a common template. The comparison of detailed information from existing LEZs would help national authorities devise such templates.

The national authority should be able to identify synergies from a (a) user point of view (intercity traffic flows and administrative duplication) and from an (b) authority perspective (what capital and operational expenditure can be shared at regional or national level and what should be left to local authorities). This goes beyond databases and stickers to cover the types of costs covered in this project's Final Report. This would allow for comparability, avoid duplication while allowing for local autonomy.

Table 2.7 Proposed roles and responsibilities for LEZ environmental, health and socioeconomic impact assessments and cost-benefit analyses

| Level | Assessment responsibilities |
|----------|--|
| EU | <ul style="list-style-type: none"> • Guidance, best practice methodology, templates, case studies; • Modelling and assessment of long-range transport of air pollutants, including impacts at urban level (in cooperation with CLRTAP/EMEP); • EU-wide ex-ante assessment of the cost-benefit of LEZ as a measure to achieve EU air quality objectives. |
| National | <ul style="list-style-type: none"> • National scenarios and projections for energy, road transport, vehicle fleet composition; • Projections of regional air quality (background concentrations); • National impact assessment and cost-benefit analysis on international and intercity transport; • Establish national methodology and models for impact assessments and cost-benefit analyses by local authorities, including guidance and templates (e.g. Excel); • Quality control of air quality monitoring and modelling. |
| Local | <p>Local impact assessment and cost-benefit analysis (ex-ante):</p> <ul style="list-style-type: none"> • Definition of objectives and baseline; • Scenarios for LEZ design and operation including the issues below; • Data collection: <ul style="list-style-type: none"> - urban vehicle fleet composition, traffic counts, traffic flows; - local emission inventory; - implementation costs; - annual operating costs; - cost of enforcement; - revenues from entry fees and fines; - compliance options and costs for vehicle owners [under national] - use of public transport. • The costs for deliveries to shops and other businesses inside the LEZ: <ul style="list-style-type: none"> - other factors (incentives, exemptions, low-income and small business measures, etc.); |

| Level | Assessment responsibilities |
|-------|--|
| | <ul style="list-style-type: none"> • Modelling of impacts and costs (basic or advanced); • Assessment of impacts; • Performance monitoring and ex-post impact assessment and cost-benefit analysis. |

2.12 Public information

Participating cities will operate LEZ websites to provide information on their LEZ, in native language and also in English as a minimum. Guidance and best practices for information services are presented in Chapter 0.

2.13 EU City Pass Vehicle Database

The EU will operate a "City Pass" vehicle database containing information on the emission characteristics of vehicles which are registered for LEZ access, national stickers and/or registered for approved retrofit devices. The database is intended to provide vehicle data for automatic vehicle recognition system, such as ANPR, for vehicles travelling outside of their home country. The database will also serve as "electronic LEZ certificate" containing the registered emission characteristics of a vehicle, to be used as documentation when purchasing stickers, and for on-line confirmation of vehicle characteristics during manual enforcement.

The database will include as a minimum:

- vehicle City Pass identification number (barcode number on sticker);
- City Pass pollutant emission class;
- vehicle license plate, nationality and date of first registration;
- vehicle owner and contact information;
- vehicle type, fuel and motor type, and Euro standard;
- certified emission characteristics of installed retrofit emission control devices.

The database is to be protected against fraud and unauthorised access.

2.13.1 e-Reporting and database notification

Data in the database is entered during the registration process to obtain a sticker, by nationally authorised institutions. This data is at the same time entered onto the "City Pass" vehicle database which is accessible by LEZ authorities. A data interchange standard is to be established for information to and from the "City Pass" vehicle database, in XML format, with appropriate security considerations.

2.14 EU LEZ web site

The EU will operate a web site providing current information on LEZ from all participating cities. The information will be available in multiple languages.

Cities are responsible for maintaining the information. Establishment or changes in LEZ shall be notified to the EU LEZ web site at least six months in advance of the effective date of change.

2.15 Barriers to harmonisation

2.15.1 Common barriers

Barriers to acceptance and implementation of "City Pass" harmonized standards and guidance for LEZ include the following issues for both existing and future LEZ:

- mutual acceptance of stickers from other Member States where the criteria for emission classes differ in some respect;
- if class (sticker) has lower requirements in neighbouring country, then operators may move their fleet registration to the neighbouring country, to avoid the additional compliance cost (such as higher retrofit costs).

2.15.2 Barriers for existing LEZ

At the national level, adapting an existing national LEZ framework to the "City Pass" standards will incur significant costs to revise legislation, update national publications and information services, and to revise support services and guidance to municipalities.

At the municipal level, adapting a LEZ to the "City Pass" standards may incur significant administrative costs to revise work procedures, inform and re-train administrative and enforcement personnel, inform the public and stakeholders, and update information services. There may also be significant costs for new signage. If the harmonised LEZ has higher requirements than the previous criteria, municipal fleets may be affected and require additional investment in new vehicles or retrofits.

Businesses, logistics operators and coach operators that have adapted their fleets and dispatching procedures to an existing LEZ will object to changes that necessitate a second, costly fleet reorganisation or replacement of vehicles to adapt to the revised LEZ criteria.

Where passenger cars are restricted, the public will object to any LEZ changes that add additional costs without demonstrable and significant environmental and quality of life improvements.

2.16 References

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3 LEZ Planning and Implementation

3.1 Introduction

The current chapter observes the main considerations to be addressed during the planning and implementation stage of LEZ. In order to make LEZ an effective and valuable tool for tackling local problems, there is a number of issues, to be ascertained before the implementation, these include possible barriers and risks, setting objectives and evaluation if LEZ is really an appropriate tool for that purpose, determination of exemptions, etc. Therefore the following sections will address these and other aspects to be addressed by parties responsible for LEZ planning.

3.2 Barriers and Risks

3.2.1 Introduction

The introduction of a LEZ can be associated with a number of barriers and risks of environmental, technical, economic social and political nature. Taking into consideration the different nature of both possible types of LEZs – *LEZs with payment* (including combination with congestion charging schemes) depending on emission class, *LEZs without payment*, prohibiting entrance of more polluting vehicles – they will be considered in these categories, when analysing possible barriers and risks. This chapter is built on the SWOT analysis of the 2010 ARS Study¹⁸ and results of the Task 2.3 - “Assessment of Potentials and Risks” – of the Feasibility Study¹⁹.

An overview of main barriers for both types of LEZ is presented in **Table 3.1**:

Table 3.1 Overview of barriers

| Dimension | Barrier or risk | without payment | with payment |
|---------------|--|-----------------|--------------|
| Environmental | Non-exhaust emissions of PM not influenced. | + | + |
| | Effect of LEZ is decreasing in time (with increasing quality of vehicle fleet). | + | + |
| | Traffic intensity within LEZ is not reduced (once free permit obtained, no restriction of entries in place; appearance of “clean congestions”). | ++ | ++ |
| | Efficiency reduced by exceptions. | + | + |
| | Potential air quality problems outside LEZ ²⁰ (Sources of emissions might move to populated areas outside; congestions with higher share of obsolete vehicles; possibility of increased exposure of population to air pollutants and noise outside LEZ ²¹). | + | + |
| Technical | Lack of necessary road infrastructure. | + | + |
| | Lack of alternative transport into and outside LEZ. | + | + |
| Economic | Cost of necessary infrastructure (by-passes, alternative roads for non-compliant vehicles, parking facilities, | + | + |

¹⁸ Study on Urban Access Restrictions. Final Report. Rome. December, 2010.

¹⁹ Feasibility Study: European City Pass for Low Emission Zones – Interim Report. September, 2013.

²⁰ Rauterberg-Wulff, Annette. Impact assessment of effects of measures on the example of the LEZ, particle filter retrofitting of busses and speed limit in Berlin. Senate Department of Urban Development and Environment Berlin.

²¹ Ibid.

| Dimension | Barrier or risk | without payment | with payment |
|-----------|---|-----------------|--------------|
| | optionally ANPR - Automatic Number Plate Recognition system). | | |
| | Lack of funding. | + | + |
| Social | Refusal / non-acceptance by a part of urban community. | + | ++ |
| | Unequal socio-economic impact which may lead to Increased social tensions in urban community (based on the feeling of exclusion). | + | ++ |
| Political | Refusal by municipal government or its part. | | |

Increased social tensions in urban community (based on the feeling of exclusion).

As it can be seen from the risks and barriers that may play a significant role when deciding on necessity of LEZ, there is a slight difference between fee-based LEZ and LEZ without payment. For example non acceptance and unequal social impact might be a bit larger barrier in a LEZ with than without payment. At the same time, some core considerations overlap. Keeping in mind that the overriding idea behind LEZ is to reduce emissions of air pollutants and improve local air quality, one important aspect to consider is that the number of vehicles within LEZ might increase again with time (due to substitution of old vehicles with the new ones, thereby increasing the share of the vehicle fleet allowed to enter the LEZ), thus the positive effect might decrease, compared to the situation right after implementation. On the other hand there might also be an opposite effect as some drivers may not change vehicle but shift to public transportation or bike. Some of the central barriers representing the economic dimension include high costs of additional infrastructure needed for implementation of LEZ. This consideration is especially relevant in case of EU 2004 enlargement countries, as road infrastructure in these new EU Member States is far from being completed (many cities do not have by-passes and transit transport is passing through their centres). Also an economic barrier as high operational costs may play a significant role – for example, according to ARS report²², the annual operational costs of London LEZ with payment amount to 11'900'000 EUR (at 2010 exchange rate).

As to the social dimension, one important factor to consider is that the introduction of LEZ mostly puts more burden on low-income vehicle owners, as generally they are the ones who own older, more polluting cars. Accordingly, such equity issues have to be considered and an analysis of potential financial burden on lower-income residents might be carried out at LEZ planning stage.

The abovementioned barriers and risks mark just the main issues that might deter municipalities from introducing LEZs. There might also be some municipality-specific consideration, which competent authorities have to address during the planning stage. At the same time, it has to be kept in mind that there is a variety of positive effects that stem from the introduction of LEZ, therefore it is important to weigh positive and negative effects when deciding if LEZ is an appropriate tool for tackling environmental problems of the particular municipality and if yes, then which type of LEZ is most suitable for the circumstances at issue.

Measures to mitigate risks and barriers are presented in the following sub-chapters.

²² Study on Urban Access Restrictions. Final Report. Rome. December, 2010.

3.2.2 Environmental barriers

Non-exhaust emissions of PM are not influenced

Problem: Emissions of PM from road transport comprise both exhaust emissions and non-exhaust emissions (automobile tyre and brake wear, automobile road abrasion). In the case of PM₁₀, the share of exhaust and non-exhaust emissions in total 2010 emissions from road transport in Europe was equal and in the case of PM_{2.5} non-exhaust emissions represented 37.5 % of total emissions from road transport.²³ In addition, it has been indicated that that a large part (about 50–85% depending on the location) of the total PM₁₀ concentrations originates from non-exhaust emissions.²⁴ While exhaust emissions are decreasing with improving emission parameters of engines (up to zero exhaust emissions in the case of electro-mobiles), non-exhaust emissions depend on several physical factors, fluency of vehicle motion being the most important one. It can be expected that non-exhaust emission will represent the majority of PM emissions from road transport in coming years.

Measures: Introduction of LEZ should be a part of integrated urban transport scheme and therefore accompanied with additional measures to improve road traffic fluency and to reduce excess traffic within the zone (optimization of traffic-light network, parking policy, telematics, P+R²⁵, ITS²⁶).

Effect of LEZ is decreasing in time (with increasing quality of vehicle fleet)

Problem: Composition of vehicle fleet is improving naturally which leads to continuous reduction of exhaust PM emissions but does not influence non-exhaust PM emissions.

Measures: Introduction of LEZ should be accompanied with additional measures to improve road traffic fluency and to reduce excess traffic within the zone (optimization of traffic-light network, parking policy, telematics, P+R, ITS). LEZ emission requirements could also be dynamical hence tightening the requirements over time.

If not charged, traffic intensity within LEZ is not reduced

Problem: Once permit obtained, no restriction of entries is in place which may lead to the decrease in traffic fluency and even to “clean congestions”, accompanied with higher exhaust emissions of air pollutants as well as non-exhaust emissions of PM.

Measures: Introduction charged entry to LEZ with rates differentiated in accordance with vehicle’s emission standard should be assessed when considering introduction of LEZ.

Efficiency reduced by exceptions

Problem: Obviously, exceptions are being granted to certain car users (e.g. residents, disabled persons, emergency vehicles, service vehicles). Some of these exceptions can be mandatory while others are optional.

Measures: Exceptions should be assessed carefully to avoid not necessary reduction of the LEZ impact on air quality.

²³ European Union emission inventory report 1990 – 2010 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP), EEA Technical report No 8/2012.

²⁴ Matthias Ketzel et al.: Estimation and validation of PM_{2.5}/PM₁₀ exhaust and non-exhaust emission factors for street pollution modelling; Atmospheric Environment 41 (2007) 9370–9385.

²⁵ Park and ride systems.

²⁶ Intelligent transport systems.

Potential air quality problems outside LEZ

Problem: Increased intensity of traffic with higher share of obsolete vehicles outside LEZ may lead to increased emissions of air pollutants and consequently to increased exposure of population to air pollutants and noise.

Measures: Impact of potential LEZ both inside and outside zone must be assessed carefully and measures must be taken, especially in infrastructure and traffic management. The LEZ needs to be large enough to affect the renewal rate of the vehicle fleet to avoid simply rerouting the more-polluting vehicles to different areas.

3.2.3 Technical Barriers

Lack of necessary road infrastructure

Problem: When LEZ is introduced, alternative must be available for vehicles which do not comply with LEZ requirements. In certain cases, especially in EU13 countries, lack of necessary road infrastructure represents major obstacle for the establishment of LEZ, as road infrastructure in these new EU Member States is far from being completed (many cities do not have by-passes and transit transport is passing through their centres). For instance, the City of Prague has a half of city by-pass completed by now. Examples of real barriers in road infrastructure in the Moravian-Silesian Region²⁷ is presented in the following table:²⁸

Table 3.2 Barrier examples in the Moravian-Silesian region

| City | Population | Area (km2) | Future LEZ | Reason |
|---------------|------------|------------|------------|--|
| Havířov | 82 896 | 32.08 | No | Missing road infrastructure |
| Karviná | 61 948 | 57.52 | Maybe | Part of infrastructure must be completed |
| Frydek-Místek | 58 582 | 51.53 | No | Missing road infrastructure |
| Nový Jičín | 25 862 | 44.70 | Maybe | Part of infrastructure must be completed |
| Krnov | 25 059 | 44.30 | No | Missing road infrastructure |
| Bohumín | 22 818 | 31.03 | Maybe | Part of infrastructure must be completed |

Measures: Sufficient road infrastructure must be completed.

Lack of alternative transport into and inside LEZ

Problem: Alternatives must be available for those persons entering LEZ who do not have compliant vehicle.

Measures: Introduction of LEZ must be accompanied by additional measures like sufficient parking capacity at the LEZ border close to public transport stations (park & ride type).

²⁷ North-Eastern part of the Czech Republic.

²⁸ Feasibility study for the establishment of LEZ in the Moravian-Silesian Region of the Czech Republic (in Czech), Centre for Transport Research. Brno, December 2011.

3.2.4 Economic Barriers

Cost of necessary infrastructure

Problem: Costs of road by-passes, alternative roads for non-compliant vehicles, parking facilities, optionally ANPR), implementation and enforcement may be very high and therefore considered not adequate to the expected effect of LEZ.

Measures: When considering the introduction of LEZ, detailed RIA (regulatory impact assessment) must be carried out to take into account all environmental, social and economic issues.

Lack of funding

Problem: Municipalities may refuse the introduction of LEZ due to lack of funding.

Measures: EU funding (CF, ERDF) should be considered to obtain additional financial sources, especially in new EU Member States.

3.2.5 Social Barriers

Refusal / non-acceptance by a part of urban community

Problem: Low-income citizens tend to have older cars as cannot afford to buy a new car. Business community (retailers) who may be afraid of reduced income. Non-acceptance is expected to be higher in the case of charged access to LEZ.

Measures: Scrappage incentive for low-income citizens to buy a new car as applied in several MS (e.g. Austria, Germany, and UK) recently²⁹. Incentive for retrofitting older cars. Potential incentives to low-income citizens for parking outside zone and / or for public transport. Exceptions in the case of charged LEZ.

Unequal socioeconomic impact

Problem: Introduction of LEZ may lead to increased social tensions in community as low-income citizens can have feeling of “additional” social exclusion.

Measure: Scrappage incentive for low-income citizens to buy a new car. Incentive for retrofitting older cars. Targeted information campaigns to non-compliant drivers/businesses should be in place.

3.2.6 Political barriers

Refusal by municipal government or its part

Problem: Municipal governments or their parts may refuse additional expenditures and or additional obligations related to the introduction of LEZ.

Measures: When considering the introduction of LEZ, detailed RIA (regulatory impact assessment) must be carried out to take into account all environmental, social and economic issues.

²⁹ See Milieu Ltd., National Environmental Research Institute (Denmark), & Center for Clean Air Policy. (2004). Assessment of the Effectiveness of European Air Quality Policies and Measures, Final Report on Task 3.2: Case studies comparing the EU experience with the experience of the USA and other countries; Case Study 3 - Comparison of the EU and US experiences with respect to controlling emissions from high emitting vehicles. http://ec.europa.eu/environment/archives/cafe/activities/pdf/case_study3.pdf.

3.2.7 Conclusions

The majority of the above mentioned barriers can be overcome provided that:

- Introduction of LEZ is a part of Sustainable Urban Mobility Plans and should be combined with other measures; especially with the measures focused on the decrease of car transport demand, reduction of excess traffic and on optimization of car traffic flow;
- detailed RIA (regulatory impact assessment) as well as cost-benefit analysis is carried out to take into account all environmental, social and economic issues;
- remediation measures focused on low-income groups are envisaged;
- targeted information campaign is carried out;
- financing for necessary infrastructure is available.

3.3 Integration of LEZ in urban air quality and mobility planning

3.3.1 Air quality planning

Programmes of reduction measures when limit value are exceeded

Air Quality Plans

The Air Quality Directive (2008/50/EC) requires Member States to prepare and implement air quality plans or programmes of measures to reduce air pollution in order to comply with limit values, when certain assessment thresholds set in the Directives are exceeded. A Commission Working Group on Implementation (2003) prepared guidance on drafting air quality plans and programmes³⁰. TNO (2007) has assessed plans and programmes submitted to the Commission.

These are likely to be a combination of local and national measures which address a range of sources of pollutants. The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM) published the Air Implementation Pilot: Management practices (update 2013). This aims to identify and create an inventory of effective policies and measures undertaken in a set of pilot cities. The measures identified include plans related to:

- industry;
- emissions from buildings;
- traffic technology and infrastructure;
- other traffic measures;
- campaigns and soft measures; and
- agriculture.

Traffic measures include:

- the creation of LEZs;
- improvement of public transport;
- promotion of cycling; management of traffic flows;
- change of speed limits; and
- investment in technology to reduce emissions from public transport.

Short term action plans (STAP)

Article 24 of the Air Quality Directive (2008/50/EC) requires Member States to prepare short term action plans (STAP) when and where there is risk of exceedance of an alert threshold. Short term action plans have been reviewed by Conlan (2012) and Voigt et al (2012). There are few cases where STAPs have been applied, so there is not enough data to evaluate their effectiveness. From

³⁰ Recommendations on plans or programmes to be drafted under the Air Quality Framework Directive 96/62/EC, July 2003. http://ec.europa.eu/environment/air/quality/legislation/pdf/recommendation_plans.pdf.

the few cases available it follows that good information to the public and agencies enhances the acceptance of the measures being applied.

There is no alert threshold for PM₁₀, so there is inconsistency among the Member States on when they apply STAPs and who is responsible for initiating and ending alert states. Examples of measures with a short term effect during pollution episodes that have been included in STAP are:

- traffic bans, or bans of heavy vehicles or vehicles without particle filters;
- reduction of speed limits;
- free public transportation;
- increased street cleaning (during dry periods);
- actions to decrease domestic heating emissions (for example wood burning).

The vehicle emission categories defined for LEZ could potentially be used for short term measures, such as temporary raising of the Euro level required for entrance to the LEZ. This could be activated on days projected to exceed the PM₁₀ daily limit value, if the expected exceedance was largely due to traffic. This would require a sophisticated automated system to predict the exceedance and inform the public (such as electronic signage), and an automated enforcement system such as ANPR to be effective.

3.3.2 Strategic urban mobility planning (SUMP)

It is advised to integrate planning and implementation of LEZ in the overall integrated sustainable urban mobility planning (SUMP).

At European level, the European Commission has actively promoted the concept of integrated transport planning for several years. EU projects and initiatives have brought together relevant stakeholders to analyse current practices in urban transport planning across the Union, discussing problem areas, and identifying best practice examples. From this work, the concept of Sustainable Urban Mobility Plans (SUMPs) – a term broadly used since the publication of the Commission's Action Plan on Urban Mobility in 2009 – gradually emerged and gained considerable traction.

A perfect sustainable urban Transport Plan covers all transport modes, handles these in an interrelated way and is the result of an integrated planning process.

Many EU cities have developed local air quality plans (LAQ) in which measures to reduce transport related emission are an important element. For example LEZ, parking pricing, as well as measures to increase the availability of alternative transport modes (PT, cycling, P+R, car sharing, mobility management). The transport part of the LAQ's therefore contains many elements of a SUMP, which should be integrated or at least be consistent with the overall SUMP. The same goes for integration and consistency with higher level (regional, national) policies.

Based on the assessment of the mobility, social and environmental problems and challenges, a benchmark SUMP concept has been defined. In practice, several European cities have implemented integrated approaches through Sustainable Urban Mobility Plans (SUMPs). These often vary in quality, ambition and effectiveness. The concept of SUMPs is here used to describe a true 'benchmark' integrated urban mobility approach. The benchmark SUMP includes the elements that are necessary to achieve the key EU Transport White Paper objective of a competitive and resource-efficient transport system.

The main idea behind the SUMP is that the effectiveness of an integrated planning process and an integrated package of measures is more effective than planning and implementation of individual

measures. Furthermore a basic element of a SUMP is that it has to contain a pledge to sustainability. Integrating of LEZ's in the SUMP planning process as one sustainable transport measures to be considered seems logical and cost effective.

The impact of LEZ's will probably increase when being part of a SUMP:

- Sump's cover the whole scope of urban transport and mobility including aspects like safety, provision of alternative mobility and parking solutions, or provision of charging facilities for electric vehicles etc. not only in relation to LEZ's, but to the whole urban transport. Planned and implemented SUMP measures as part of a SUMP aimed at all urban transport users will also be beneficial for users of vehicles not allowed in the LEZ, thereby probably contributing to an increase of the impact of LEZ's.

But not only with respect to the measures also when looking at the process, integration in the overall sustainable urban transport planning process will be beneficial:

- Identifying objectives and setting targets, baseline analysis, impact assessment, implementation plan, participatory approach, monitoring and evaluation are some elements of the SUMP process which apply to the planning process of LEZ's as well. Integrated in the SUMP process the planning, implementation and monitoring of a LEZ can be done more efficient and cost-effective.

The main information on monitoring and evaluation in relation to SUMP's can be found in the EU guidelines developing and implementing a Sustainable Urban Mobility Plan³¹.

For assessment and evaluation guidance there is the Strategic Environmental Assessment (SEA): EU Directive 2001/42/EC³². This guidance is not specifically applied to Urban Mobility Plans. In the UK where - similar to France Urban mobility plans are obligatory - a guidance was prepared by the Department for Transport (DfT) on how to carry out SEA for Local Transport Plans³³ Good examples where this method is applied are Nottingham³⁴ and West Midlands³⁵, In France the Plans de Déplacements Urbains (PDUs) are mandatory. An environmental impact assessment became obligatory for all PDUs after the adoption of the European Directive 2001/42/ CE in French law in 2005. Other good examples can be found on Mobility Plans portal.

3.3.3 SUMP Framework- the basics

Content

Minimum content and scope requirements:

- Addresses both freight and passenger transport;
- Addresses all transport modes;
- Public transport;
- Non-motorised transport;
- Road transport infrastructure;
- City logistics;
- Mobility management;
- Integration of transport modes/ intermodality.

³¹ <http://www.mobilityplans.eu/>.

³² <http://ec.europa.eu/environment/eia/pdf/SEA%20Guidance.pdf>.

³³ <http://www.dft.gov.uk/webtag/documents/project-manager/pdf/unit2.11d.pdf>.

³⁴ <http://www.apho.org.uk/resource/view.aspx?RID=117750>.

³⁵ <http://www.centro.org.uk/LTP/LTP.aspx>.

Additional comprehensive requirements:

- Consider specific measures/instruments: low-emission zones and urban pricing (urban road user charging/congestion charging, parking pricing and public transport pricing);
- Introduction of clean technologies and alternative fuels;
- Ensure interoperability and/or consistency in use of instruments across the EU.

*Process***Minimum processes and procedures:**

- Contains pledge to sustainability (3 dimensions: environmental, social, economic);
- Includes or is built on long-term strategy;
- Identifies objectives and sets targets in line with EU policy objectives;
- Includes baseline analysis including performance audit;
- Includes impact assessment on proposed measures;
- Provides short-term implementation plan (timetable + budget plan; allocation of responsibilities);
- Integrates different relevant policy areas, in particular land-use and transport planning;
- Considers all transport to, through and within the urban agglomeration area and coordination between different authority levels;
- Is developed in a participatory approach;
- Is based on integrated planning and implementation;
- Is adopted;
- Monitors implementation and performance;
- Ensures regular review and update of plans;
- Ensures conformity check in Member States.

Additional comprehensive requirements:

- Foresees mechanisms for monitoring at EU level;
- Foresees mechanism for review at EU level;
- Ensures conformity check at EU level;
- Sets mandatory performance targets.

3.3.4 *Green public procurement*

Green public procurement (GPP) is an important complementary measure for low emission zones, especially regarding municipal vehicle fleets. Establishing clean vehicle purchasing standards for all municipal departments and contractors (for example bus companies) can make a significant contribution to urban vehicle emission reduction, and also promote cleaner vehicles to the public. There can also be economic benefits from joint procurement agreements based on standardised clean vehicle requirements.

National procurement initiatives and incentives can provide significant support to local LEZ infrastructure and clean public vehicle fleets. As an example³⁶, the Slovenian National Procurement Agency is responsible for carrying out joint procurements for Slovenian public authorities. As part of its mandate, the Agency implements GPP criteria in its procurement of electricity, paper, office IT equipment and vehicles.

³⁶ http://ec.europa.eu/environment/gpp/pdf/news_alert/Issue17_Case_Study40_Slovenia_vehicles.pdf.

Table 3.3 Selected resources and references on green public procurement and clean vehicles

| |
|---|
| Commission web site on green public procurement http://ec.europa.eu/environment/gpp/index_en.htm . |
| GPP Training Toolkit (2008) web page. European Commission, DG Environment. http://ec.europa.eu/environment/gpp/toolkit_en.htm (EC DG ENV 2008). |
| Buying green! - A handbook on green public procurement, 2nd Edition. http://ec.europa.eu/environment/gpp/pdf/handbook.pdf (EC DG ENV 2011). |
| The Clean Vehicles Directive - Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles. European Union. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0033:EN:NOT . |
| Clean vehicle portal www.cleanvehicle.eu . |
| Green Public Procurement - Transport, Technical Background Report. http://ec.europa.eu/environment/gpp/pdf/tbr/transport_tbr.pdf (BRE 2011). |
| Guidelines on financial incentives for clean and energy efficient vehicles - Commission Staff Working Document, SWD (2013)27. European Commission, DG MOVE. http://ec.europa.eu/transport/themes/urban/vehicles/directive/doc/swd(2013)27-financial-incentives.pdf (EC 2013). |

3.3.5 Action plans for noise

The Environmental Noise Directive (2002/49/EC), also known as the "END", includes a requirement (Article 8) for competent authorities to prepare action plans to manage noise issues, to be progressively implemented. Actions can include road vehicles and infrastructure. Although LEZ alone have only small benefits for noise, they can be integrated with other traffic-related measures that provide more significant noise benefits. Such measures might include:

- Reducing traffic speed;
- Low-noise asphalt;
- Low-noise tyres. See FOEN (2013) Campaign for Better Tyres - The European Soundscape Award for 2013. http://forum.eionet.europa.eu/european-soundscape-award/library/campaign-better-tyres-foen/campaign-better-tyres/download/1/Contribution%20FOEN_European%20Soundscape%20Award%202013.pdf;
- Promotion and incentives for low-noise tyres. The Swiss.

3.4 Public and Stakeholder Participation

The dissemination of information prior and during operation of LEZ, as well as ensuring stakeholder participation is an indispensable step in the process of introduction of a new LEZ. The following paragraphs will provide a brief guidance through the steps to be taken in order to ensure the effective involvement of public both prior and during operation of LEZ.

Prior to implementation of LEZ

There are several steps relevant for stakeholder participation dissemination of information on LEZ that have to be undertaken prior to implementation of the LEZ. Even though particular public participation specifics might be provided in the national or local legislation of Member States, the general aspects remain equally important to all of the countries.

1. Identify the main target groups

The first step in the process of ensuring appropriate information and public participation is to identify the main target groups. It is crucial to involve different stakeholders – residents in the LEZ, residents in the vicinity of LEZ, local businesses, freight distributors, other private vehicle owners. It is also important to keep in mind that, when the LEZ likewise applies to foreign vehicles, it is

important to ensure dissemination of information to foreign drivers as well, especially in cases, when the territory of LEZ at issue has been previously widely attended by foreigners either as transit point or as a final destination. The equal informing of foreign vehicle owners ensures avoiding unnecessary restriction of movement of foreign drivers, if they are not acquainted with the LEZ requirements prior to entry, thus appropriate information campaigns aimed at foreigners would ensure the compliance with freedom of movement principle.

2. Identify media to be used

Second important step in the dissemination of information is the identification of appropriate media to be used for the purposes of informing the above-mentioned target groups. Taking into consideration various habits of public, it is important to ensure as wide coverage as possible. For that purposes the types of media to be covered should include the press, radio/TV, Internet, leafleting, posting (if necessary), and also providing clearly visible information at the future LEZ borders.

3. Identify the content

Not only is it important to merely inform people about the future LEZ, but also the information has to be sufficiently detailed, yet easily comprehensible. It is pivotal to include such minimal information as:

- The likely benefits and health reasons;
- Area covered by LEZ and its boundaries;
- Scheme and its rules (incl. operational hours, access criteria, access charges, foreign vehicles etc.);
- Sanctions for violations.

If available, it is possible to refer to the information provided in the air quality index, which allows comparing air quality levels in different cities and countries (in case the EU index is used). The provision of appropriate information can significantly decrease the possible violations in the future, when LEZ will be already operating. Even though not widely done in practice, it is suggested for LEZ operators to provide information on alternative options – both transport-wise (e.g., including references to public transport network, which covers the area at issue, or ensuring possibility to use a bike) and route-wise (e.g., provide information on possible detours). The lack of alternatives or information on alternatives may trigger people to return to their private vehicles and undermine the objective of LEZ.³⁷

4. Ensure possibility to participate

Prior to implementation of LEZ it is important to get acquainted with general public opinion on the scheme, thus it will help to determine if the public supports the introduction of LEZ or is strongly against it. One way to ensure direct contact with the public is by establishing an information desk at the municipality, where the interested ones could find more information and fill in questionnaires or leave their suggestions or comments on LEZ. Other options include ensuring especially dedicated phone line, e-mail address and/or postal address, considering that different target groups prefer different types of communication options. The best possible solution is to provide a combination of all of the abovementioned options. The previously listed options do not constitute an exhaustive list, and the size of LEZ, as well as available resources have to be considered, when deciding, what type of feedback possibilities to provide to the public.

During operation of LEZ

In order to ensure the continuous effectiveness of LEZ, it is important to provide information also during the operation of the LEZ. This is especially, yet not exclusively, relevant in case of foreign

³⁷ Study on Urban Access Restrictions. Final Report. Rome. December, 2010.

drivers. In operational phase the physical dissemination of information in form of leaflets, letters, TV airing time is not as vital as in the planning stage, therefore the volume of provision of information can decrease. Yet an important aspect is that the information at issue (involving all of the information mentioned in the previous section in the framework of activities prior to implementation of LEZ) has to be easily accessible, constantly updated and provided not only in local but also in other languages (e.g., English), in order to make it accessible to foreign drivers.

In addition, the information has to be supplemented with the statistical data, which allows public to get to know the advantages and effects of the implemented LEZ. Also, considering that the scheme has to be reviewed from time to time to ensure the highest possible effectiveness. All of the changes have to be communicated to the public; therefore the information available on the continuous basis has to be constantly updated. In case the changes in the scheme are considered to be significant (e.g., different access criteria, different borders) it would be useful to ensure the information dissemination campaign, which might be similar to the one held prior to implementation of LEZ.

An important aspect in the system of provision of information to foreign drivers is pointing them to central EU LEZ website³⁸ containing most recent and constantly updated information on all LEZs in the EU, so as the foreign drivers could easily exercise their right for freedom of movement. The information has to be available in most EU languages. There has to be a system in place ensuring that the municipalities communicate the information on their LEZs to the webpage administrator.

A good example on smooth launch of public awareness campaign was observed in the case of London Congestion Charging Scheme (not the same as London LEZ, as the primary goal of congestion charging scheme is to decrease traffic flow and thus the congestions, yet the experience on dissemination of information can be equally exercised in the case of introduction of LEZ). In the framework of public awareness campaign leaflets have been distributed to 3 million households and over 35'000 packs were made available to businesses operating fleets of 25 or more vehicles; a dedicated call centre has been created; advertising has been broadcast on TV, radio, newspapers and in the dedicated London Congestion Charging website; face to face activity has been carried out in boroughs; emails have been sent to businesses in and around London.³⁹

3.5 Setting Objectives

During the stage of LEZ planning, it is important to set SMART⁴⁰ objectives, as it will help to choose the most appropriate LEZ type and is also important when explaining the decision to introduce LEZ to the public. The objectives can be formulated after the indicators are selected and the data on the base line are collected and analysed.

Setting SMART objectives will help to avoid vague objectives. For example the mere “improvement of environment” as an objective may be difficult to measure, as it might include a number of parameters that are not only irrelevant in the case of LEZ, but are also hard to measure and attain data as it covers a broad area of possible environmental aspects. At the same time good example would be “reduction of NOx emissions by 10% by year 2015”, which represents the idea of SMART objectives. More on this topic can be found in Chapter 7.

³⁸ <http://www.lowemissionzones.eu/>.

³⁹ Study on Urban Access Restrictions. Final Report. Rome. December, 2010.

⁴⁰ Specific, measurable, attainable, relevant and time-bound.

3.6 Establishing Zone Boundaries

Primary LEZs should be planned in areas, where current air quality does not meet limit values set by national or local normative acts, as well as in areas, where air pollution level is increasing and there is a risk, that air quality would not meet the limit values in the future.

At the same time in many EU cities large urban development projects (residential areas, business centres etc.) will be realised in near future. It is recommended to analyse possibilities to define these development areas as LEZs, and to use LEZ as warranty tool for future air quality in development zones.

Important criteria for defining LEZ boundaries are coherent areas of high population density and high emission density as these areas have high population exposure to air pollution. Other criteria are that the area can be easily identified and understood (for example a ring road or municipal boarder) and large enough to create an impact.

A positive benefit-cost ratio could be another criteria.

It is strongly recommended to base determination of LEZ boundaries on urban mobility plans and use traffic modelling tools for LEZ impact analyses. Developers of LEZ must be familiar with specific area traffic network, request-demand matrices and should have the clear vision about future traffic trends with and without LEZ.

LEZ boundaries should be defined after evaluation of following main principles:

- Availability of public transport;
- Parking;
- By-pass and drive-through roads;
- Access points.

In the case if LEZs will affect passenger cars too, then sufficient public transport should be available to travel within, to or from LEZ. Regular public transport routes within LEZ, which are connected to the main public transport centres or destinations, should be accessible within 5 – 10 minutes walking distance. There should be regular public transport connections between LEZs and main destination centres outside the LEZ.

Near the main access points at the boundaries of LEZ parking places for private cars should be available. One of the best solutions in this respect is park & ride system. Also parking charges outside the LEZ should be lower than access charge.

Possibilities to drive around LEZ or access significant points of logistics, for example ports, should be analysed as well. It is not recommended to completely close access for certain vehicle categories, if there are no good by-pass options. Each by-pass option should be specially assessed to clarify the impact of increasing traffic intensity to the bounding areas of the certain by-pass road. In the cities, where significant transport centres are located within planned LEZ or where these centres cannot be accessed without crossing the LEZ, it is recommended to exclude major transport corridors from LEZ. TEN-T network roads should be excluded from LEZs.

Each LEZ should have sufficient amount of points, where LEZ border can be crossed. At the planning stage - when considering enforcement through an electronic control system - it is recommended to analyse LEZ access options and establish boundaries to reduce access point

amount. Reduced number of access points would allow to use electronic control systems (licence plate recognition, RFID) more efficiently and with lower installation and maintenance costs.

3.7 Vehicle Criteria

The harmonised LEZ emission classes presented in section 2.5 define the Euro classes of vehicles which are permitted to enter the LEZ, for each emission class. Phases of an LEZ are defined by establishing the schedule for introduction of each successive emission class to progressively exclude vehicles of lower Euro standard (higher emission). It is recommended that the schedule for successive LEZ classes be defined at the national level, but each municipality can decide which vehicle types are to be restricted in the LEZ.

Vehicle selection should be based on a traffic fleet analyses in each specific city. Before decision making LEZ planners should analyse the vehicle type composition and Euro classes of these vehicles. Information about retrofitted vehicles and the potential for retrofits should be analysed.

Table 3.4 and **Table 3.5** present the Euro PM₁₀ and NO_x emission limit values for diesel vehicles. The limit values for passenger cars and light duty vehicles are defined in g/km. Euro emission limit values for heavy duty vehicles (N3) are defined in g/kWh but are converted to g/km in this table for comparison⁴¹. Actual real world driving emissions are higher than the limit values for many types of diesel vehicles, and this should be taken into account when assessing the local vehicle criteria.

Table 3.4 NO_x emission levels g/km for certain vehicle category

| Vehicle category (diesel engine) | M (passenger cars) | N1-I (light duty vehicles ≤1305 kg) | N1-II (light duty vehicles 1305 - 1760 kg) | N1-III (light duty vehicles 1760 - 3500 kg) | N2 (MAX value) | N3 (heavy duty vehicles >12 t) (14-20t) |
|----------------------------------|--------------------|-------------------------------------|--|---|----------------|---|
| Conventional | - | - | - | - | 8.414 | 12.021 |
| Euro 1/I | - | - | - | - | 4.989 | 7.173 |
| Euro 2/II | - | - | - | - | 5.284 | 7.724 |
| Euro 3/III | 0.5 | 0.5 | 0.65 | 0.78 | 4.188 | 6.315 |
| Euro 4/IV | 0.25 | 0.25 | 0.33 | 0.39 | 2.544 | 3.734 |
| Euro 5/V | 0.18 | 0.18 | 0.235 | 0.28 | 1.503 | 2.24 |
| Euro 6/VI | 0.08 | 0.08 | 0.105 | 0.125 | 0.125 | |

Table 3.5 Euro PM emission levels g/km for certain vehicle category

| Vehicle category (diesel engine) | M (passenger cars) | N1-I (light duty vehicles ≤1305 kg) | N1-II (light duty vehicles 1305 - 1760 kg) | N1-III (light duty vehicles 1760 - 3500 kg) | N2 (MAX value) | N3 (heavy duty vehicles >12 t) (14-20t) |
|----------------------------------|--------------------|-------------------------------------|--|---|----------------|---|
| Conventional | - | - | - | - | 0.391 | 0.573 |
| Euro 1/I | 0.14 | 0.14 | 0.19 | 0.25 | 0.231 | 0.337 |
| Euro 2/II | 0.08 | 0.08 | 0.12 | 0.17 | 0.1 | 0.137 |
| Euro 3/III | 0.05 | 0.05 | 0.07 | 0.1 | 0.105 | 0.151 |
| Euro 4/IV | 0.025 | 0.025 | 0.04 | 0.06 | 0.02 | 0.03 |
| Euro 5/V | 0.005 | 0.005 | 0.005 | 0.005 | 0.02 | 0.03 |
| Euro 6/VI | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | |

⁴¹ <http://www.eea.europa.eu/publications/road-user-charges-for-vehicles>.

In Table 3.4, the main reasons, why in all current LEZs heavy good vehicles (HGV) are affected, can be identified. NOx emissions of N2 and N3 category vehicles are significantly higher than from other vehicle types with same Euro class.

At the same time there could be the districts of cities, where the amount of HGVs is very small. In such cases limitations for HGVs wouldn't give significant effect to the air quality.

Complete limitation of HDVs could lead to the situation, when goods are transported with smaller vehicles and increase traffic intensity. Usage of smaller capacity vehicles most probably would reduce NOx emissions, but would increase PM emissions. Special attention should be paid to the noise pollution, because at the moment only two small lorries emit the same noise level as one HDV.

At the time of planning stage before selection of affected vehicles it is recommended to:

- Collect data about traffic intensity and composition in peak hours and other periods of day;
- Collect statistics about average amount of vehicles belonging to the certain Euro class;
- Collect air quality monitoring data and identify most problematic periods;
- Estimate the total emission amount per 1 km for each vehicle category in peak hours and rest of the day;
- Analyse traffic impact to the air quality pollution;
- Identify main pollution sources (vehicle categories);
- Analyse few variants of affecting mechanisms, potential impact to the air quality and noise climate, transport system functionality and cost benefits.

After selection of possible affecting mechanisms (charging or access restriction) it is recommended to analyse alternative routes or mobility solutions, what can be used by affected drivers. Relocation of air pollution hotspots should be avoided.

It is recommended to do detailed analyses as it is mentioned above, because in most cases selection of affecting mechanisms is a political decision and LEZ planers should be ready to explain positive and negative aspects of each alternative.

3.8 Access Charges

As it was already mentioned, there can be various types of LEZs. One of such types is based on access charges. Establishment of LEZ on the basis of charging system is a practical example of implementation of "polluter pays" principle. It is important to note that even though the prime aspect of the charge-based LEZs is that entrance is allowed based on a "fee", it is still determined in accordance with the emission standard/ the vehicle type, therefore the factor of emission standard is present in all of LEZs, notwithstanding their operational nature.

When thinking about charging, it is important to keep in mind that charge-based LEZ might be less effective than the LEZ without charges that prohibits access of particular, more polluting vehicles. Yet charge serves a dual function – it works as a deterrence mechanism, if the fee is high enough to significantly decrease the number of most polluting vehicles, and the revenues from charges might be used to improve the environmental quality of the city, for example, by providing free-of-charge bike rental that will serve as an incentive not to access the LEZ by vehicle, or by investing in "greening" the public transportation network.

For a charge based LEZ to be effective, the charges have to be proportional, yet at the same time, as it was already mentioned, high enough to serve as deterrence for most polluting vehicles. For

the most effective result, this system shall be used in combination with standard based LEZ system – the most polluting vehicles (e.g. Euro 0, 1, and 2 diesel vehicles) shall be prohibited to enter the zone, (or charged very high), other vehicles shall be subject to charges (with few possible exemptions), allowing free of charge access only to the cleanest vehicles. A good example is Area C in Milan⁴², which, either not LEZ, but a congestion scheme, provides a good example of basis for determining differentiated fees that can also be applied in LEZs: 1) free access granted to electric vehicles, mopeds and motorcycles, and up to December 31, 2016 to hybrids, bi-fuel, CNG and LPF fuelled vehicles (after the determined date additional cost will apply); 2) access subject to charge applies to Euro 1 and later gasoline-fuelled vehicles, Euro 4 and later diesel-fuelled vehicles (incl. Euro 3 diesel vehicles fitted with particulate filter), up to December 31, 2016 Euro 4 gasoline- and diesel-fuelled vehicles without particulate filter (after the determined date the access will be prohibited); 3) access and transit prohibited to Euro 0, 1, 2 and 3 diesel-fuelled vehicles (except the exempted vehicles), Euro 0 gasoline-fuelled vehicles (except the exempted vehicles), vehicles and combination of vehicles greater than 7.5 m in length (except the exemptions).

Specific type of charging might be applied in case of HDV. The basis for that is established in the Eurovignette Directive (1999/62/EC, 2011/76/EC). Eurovignette system operates on the basis of taxes - the Directive indicates which taxes are concerned in each individual country. Each Member State has discretion in adopting procedures for levying and collecting these taxes, which are charged by the Member State in which the vehicle is registered. Member States may not set vehicle tax rates any lower than the minimum rates set out in the Directive. Under the Directive, Member States also have the option, in certain cases and subject to certain conditions, of applying reduced rates or granting exemptions.⁴³

As the economic situation in each country may differ rather significantly, it is impossible to suggest one particular charge standard. Each city has to decide it, based on the economic situation and thorough prior socio-economic assessment. Yet, as far as it goes to the general system behind charging, it is possible to outline general charging options. Accordingly, the operator of LEZ can carry out charging on the basis of three principles:

1. Charge per trip;
2. Daily charging (a good example of sophisticated daily charging system can be observed in the case of London LEZ⁴⁴, which provides various ways of payment – incl., mail, phone call, Internet –, that are precisely described to potential LEZ users on the LEZ webpage, clearly designating types of vehicles covered and applicable fees);
3. Annual fee.

It is rather important to take into consideration that some of the residents of LEZ, as well as people, whose work is located in the LEZ area, will be frequent users of LEZ system, therefore, in order to ease the charging system and reduce the burden, the annual pass should be available in such situations.

⁴² Area C. Comune di Milano, available at http://www.comune.milano.it/portale/wps/portal/CDM?WCM_GLOBAL_CONTEXT=/wps/wcm/connect/ContentLibrary/elenco+siti+tematici/elenco+siti+tematici/area+c.

⁴³ Taxation of heavy goods vehicles: Eurovignette Directive., available at http://europa.eu/legislation_summaries/internal_market/single_market_for_goods/motor_vehicles/interactions_industry_policies/l24045b_en.htm.

⁴⁴ Low Emission Zone. Transport for London, available at <http://www.tfl.gov.uk/roadusers/lez/17704.aspx><http://www.tfl.gov.uk/roadusers/lez/17704.aspx>.

3.9 Vehicle Identification and Enforcement

Vehicle identification methods can include:

- “Manual” identification;
- Entry/toll gates;
- Electronic identification (RFID);
- Licence plate recognition.

Detailed description of these methods is presented in sub-chapter 4.10. Practical example of possibilities for vehicle recognition can be found in DEFRA (2009) Practice Guidance to Local Authorities on Low Emissions Zones⁴⁵.

LEZ should not be considered as an isolated measure but must be a part of broader concept like Sustainable Urban Mobility Plan (see section 3.3). In any case, LEZ should be tailor-made in accordance of city features (attractiveness for tourist, geographic position) as well as existing measures and infrastructure.

When considering the introduction of LEZ and its parameters, the following issues should be taken into account by city planners:

Share of foreign vehicles entering/passing through the city

This information is important especially for the cities of high attractiveness for tourists with high share of foreign visitors.

LEZ rules applied in the neighbouring countries

This information is important especially for cities lying close to borders where many people from neighbouring countries are travelling regularly for business, jobs, leisure etc.

Existing measures (e.g. parking policy, congestion charges, penalty for exceedance of speed limits) including respective enforcement systems

Measures of this type are in place in huge majority of cities. In Prague, penalties for speed limit exceedance are being collected based on information from camera system.

Existing technical infrastructure - hardware (e.g. toll gates, camera systems controlling speed limits)

Camera systems are being operated in many European cities. In Prague, permanent radar measurements of speed connected to camera system are being operated at 17 points.

Existing technical infrastructure - software (e.g. databases, vehicle registers)

Register of vehicles exists in any country which includes information on respective emission standards.

Compatibility and inter-connectivity of technical infrastructure – software with other countries; special attention should be paid to neighbouring countries

This information is important for those cities of high attractiveness for tourists as well as for cities lying close to borders.

It is recommended to city planners to make use of existing measures and infrastructure in order to minimize additional costs related to the introduction and operation of LEZ.

⁴⁵ <http://archive.defra.gov.uk/environment/quality/air/airquality/local/guidance/documents/practice-guidance2.pdf>.

Cross-border exchange of vehicle registration data

Administration and enforcement of foreign vehicles in LEZ would be more efficient if cross-border access to vehicle registration data was available. This would facilitate verification of foreign vehicle Euro classification for sale and verification of stickers, recognition of foreign vehicles by ANPR systems, and obtaining foreign vehicle owner information for the purpose of billing and collection of LEZ access charges or penalties. This is important to facilitate the equal treatment of foreign vehicles. At present, bilateral agreements are necessary for exchange of vehicle registration data between Member States for use in LEZ administration and enforcement.

EUCARIS⁴⁶ (EUropean CAR and driving license Information System) is EU's data exchange mechanism for Member States' vehicle registration and driver licensing authorities. EUCARIS can also be used by governmental organisations responsible for tracing stolen vehicles, theft and fraud prevention, as well as police, customs and tax authorities.

Council Framework Directive 2005/214/JHA⁴⁷ on mutual recognition of financial penalties is potentially relevant for cross-border processing of LEZ penalties on foreign vehicles.

Council Decisions 2008/615/JHA⁴⁸ and 2008/616/JHA⁴⁹ on cross-border cooperation provides for conducting automated cross-border searching of vehicle registration data via EUCARIS software, primarily for serious crime. Directive 2011/82/EU⁵⁰ on cross-border exchange of information on road safety related traffic offences provides for exchange number plate data between member states to allow for cross-border enforcement of safety-related traffic offences, such as speeding, not stopping for red light, and drunk driving. The list of included offenses does not cover LEZ-type offenses, but this could be extended in the future, or implemented through bilateral agreements.

3.10 Special Considerations

One of the crucial points to be addressed during LEZ planning period is special considerations, which include possible exemptions. It is important to assess the level of exemptions and evaluate their possible influence on LEZ objectives. Based on the current practices, such special considerations as foreign vehicles, urban logistics and freight operators, tourist coaches, local businesses, handicap transport, and emergency vehicles have been outlined as the main categories. Some general issues regarding these considerations will be addressed in the further sections.

3.10.1 Foreign drivers

Some of the LEZs include foreign vehicles in their list of exemptions. Yet, exempting foreign vehicles partly undermines the effectiveness of the LEZs at issue. This situation exists in for example the Netherlands due to such factors as problems with enforcement.

⁴⁶ www.eucaris.net.

⁴⁷ Council Framework Directive 2005/214/JHA of 24 February 2005 on the application of the principle of mutual recognition to financial penalties. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32005F0214:EN:NOT>.

⁴⁸ Council Decision 2008/615/JHA of 23 June 2008 on the stepping up of cross-border cooperation, particularly in combating terrorism and cross-border crime. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008D0615:EN:NOT>.

⁴⁹ Council Decision 2008/616/JHA of 23 June 2008 on the implementation of Decision 2008/615/JHA on the stepping up of cross-border cooperation, particularly in combating terrorism and cross-border crime. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008D0616:EN:NOT>.

⁵⁰ Directive 2011/82/EU of the European Parliament and of the Council of 25 October 2011 facilitating the cross-border exchange of information on road safety related traffic offences. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32011L0082:EN:NOT>.

While it is easier to ensure the inclusion of foreign vehicles in national LEZ systems in cases of sticker-based systems, where a particularly good example is Germany, which has established a comprehensive system, where foreigners can order appropriate stickers prior to their arrival to Germany, it is more problematic in case of electronic enforcement systems as RFID or licence plate recognition based on cameras. The lack of a common EU-wide database, which is accessible by the member states, containing information on all of the vehicles makes it particularly difficult to expand local licence plate recognition or RFID enforced LEZs to the foreign vehicles.

Nevertheless, it is important to note that, as far as it is possible, the LEZ can be more effective and the effects more predictable if it applies also to foreign vehicles. The considerations undermining the establishment of enforcement and penalty collection system that would also be applicable to foreign vehicles will be discussed in the chapter on LEZ administration (see Ch. 4).

3.10.2 *Urban logistics and freight*

Currently a considerable number of LEZ are applicable to vehicles >3.5 t (heavy duty vehicles or HDV), due to the fact that they are considered as more polluting both in terms of air (especially older, diesel-powered vehicles) and noise. Yet there are a number of issues to consider before deciding to include HDV in the LEZ scheme.

One of the first aspects to consider is the necessity to access, if the city subject to LEZ introduction is an important transit route. In case it is, there are several issues to tackle in order to make the LEZ operate effectively without impeding the surrounding environment. First solution is to ensure an effective detour that would not put a significant burden to HDV operators by impeding their freedom of movement, considerably lengthening the route and thus also having a negative effect on the global environment. Non-effectively planned alternative infrastructure, while improving the local air quality within the LEZ, can have a considerable negative impact on global environment by increasing greenhouse gases and air pollutant emissions.

Another solution is to exempt the main transit road from the LEZ. This might require the division of LEZ into several sections, as the transit road might cross LEZ in different points. Yet such solution would allow avoiding re-planning in terms of freight logistics, at the same time ensuring environmental benefits in the territories falling under the scope of the LEZ.

Accordingly, the matters discussed above can be effectively tackled when planning urban mobility (see section 3.3). Sophisticated existing urban mobility plans would facilitate more efficient LEZ planning.

3.10.3 *Regional and tourist coach operators*

Taking into consideration that one of the implied prerequisites of LEZ is a sufficiently developed public transport network within LEZ, the municipality can decide whether to apply the general requirements of LEZ to regional buses and tourist coach operators or to exempt them. In case the general requirements are applicable, the respective bus operators will have several options, depending on the type of LEZ:

1. Charge-based LEZ:
 - a) If the pollution class of the bus complies with the requirements, the respective bus can enter LEZ without payment.
 - b) The older buses, with lower Euro class can pay the fee and enter the LEZ.

- c) The older buses can organize a bus stop near LEZ (relevant in case of regional buses), where the people can change transport and take municipal public transportation in order to reach destination within the LEZ.
2. Emission level-based LEZ:
- a) If the pollution class of the bus complies with the requirements, the respective bus can enter LEZ;
 - b) The older buses that do not correspond to the emission standards can organize a bus stop near LEZ (relevant in case of regional buses), where the people can change transport and take municipal public transportation in order to reach destination within the LEZ.

3.10.4 Local businesses

Notwithstanding the fact that limiting or prohibiting the entry of freight transport that does not meet the LEZ emission standards can have a significant negative effect on local businesses, heavy duty vehicles are the most frequent targets of LEZ restrictions. Yet, taking into consideration interests of local businesses, cities are sometimes addressing urban freight as a separate consideration and apply particular exceptions, trying to find a balance between environmental and economic priorities.

Several approaches to tackling issue of logistics of local businesses in the context of operating LEZ can be observed. First of all, if the sole/primary aim of the LEZ is the improvement of air quality, it is possible to prohibit entry of the most polluting heavy duty vehicles, while still allowing the access to Euro 5 and 6 heavy duty vehicles involved in distribution of freight for local business operation. It might have some economic impact on local companies, as they will have to renew their fleet prior to the end of economic life of the vehicles or retrofit the existing vehicles, yet thus they will still be able to operate within the LEZ.

Another option is to allow access to light duty vehicles (either without emissions standard or applying more lenient access requirements than in the case of heavy duty vehicles), as they are considerably less polluting than HDVs. This might require relocation of large retailers (huge supermarkets, big scale furniture and home supply stores etc.) or the use of distribution centres outside LEZ, as for SMEs logistics it might suffice to use several LDVs, thus still being more environmentally beneficial than use of HDVs. The SME then has to make a trade-off between the costs of extra transport when using smaller vehicles and for example costs of retrofitting. Depending on the Euro class and types of vehicles at issue, it can be calculated, if the substitution of one HDV by several LDV is better in the context of LEZ objectives, especially in terms of environmental noise, as in terms of emission of air pollutants, LDVs are much more “cleaner”, while few LDVs can already emit higher noise levels than one HDV. Yet it is evident that in case of large scale retailers that use many HDVs during their day-to-day business, it is costly to divide the freight among many LDVs. In addition, the application of such system might also have economic downside – the increase in number of LDVs, as the business owners would have to split their goods in smaller loads, will also result in increased costs that would be ultimately passed onto the consumers. Accordingly, such system that focuses on strict standards for HDVs and more lenient standards for LDVs, might result in different solutions for different retailers – in case of smaller retailers, they would most probably shift to LDVs, yet the bigger enterprises would most probably choose to retrofit their HDVs or buy new HDVs, in case if HDVs are allowed to enter LEZ, but they have to be Euro 5 or newer, or, if entry is prohibited for all HDVs, then relocate their businesses outside the territory of LEZ.

Yet another solution, which goes in line with the general objectives of LEZ, is to apply “LEZ operating hours” system to local business freight vehicles. Depending on the type of LEZ and

pollution peak hours, freight transport would be allowed to enter LEZ either free of charge (if the LEZ operates solely on Euro standard, without charges) or at significantly decreased cost outside pollution peak hours. Such approach would help to decrease air pollution problems, accordingly distributing traffic flows, as well as will not impede the business activities of local retailers. Yet implementation of such system might be complex in terms of enforcement, as the system would have to differentiate not only in terms of Euro class and type of the vehicle, but also in regards to time of the day. Therefore such system would be more easily integrated in manual enforcement mechanism, at the same time requiring more advanced technological solutions for electronically operated LEZs.

3.10.5 Handicap transport

Taking into consideration the specific issues considering handicap transport and relative proportion of such vehicles, the municipalities shall have possibility to exempt such vehicles from the general LEZ requirements. In case of sticker-based system, it shall be enough to present the handicap vehicle documents (e.g., sticker, card), and in case of electronically enforced LEZs, the vehicle shall be included in the database as the exempted vehicle or acquire particular sticker with microchip, if the LEZ uses such system. Such exemptions shall apply equally to local and foreign handicap transport.

3.10.6 Emergency vehicles

Emergency vehicles are among the most frequently met exemptions amidst currently operating LEZs. Emergency vehicles cover a broad spectrum of public services – ambulance vehicles, fire trucks, police vehicles etc. During the LEZ planning stage the municipality can decide, what type of exemptions to apply to what type of vehicles. If the LEZ is operating on the basis of access charge, the revenue earned from the fees can be invested in the renewal of, for example, ambulance vehicle fleet or fire trucks in order to make them compatible with general LEZ requirements.

3.11 Signage

To inform drivers about LEZ, restrictions and driver rights special roadside signs should be placed at the border of LEZ and in advance to approaching LEZ, in other parts of city. LEZ signage can be divided in two groups – LEZ border marks and informative signs outside LEZ.

LEZ border mark proposal is shown in the chapter 2.5. Border marks should be placed near all access roads on the border of LEZ. It is recommended to place signs in places, where driver still has a possibility to choose another way. Additional information plates of border mark should contain information about restrictions, payment possibilities (if applicable) and penalty measures.

It is recommended to place informative signs and plates outside LEZ borders on the major access and by-pass routes. Informative signs should contain the same information that is placed on the border signs, and it is recommended to add additional informative plates or maps about by-pass, parking and public transport options (see examples in pictures). Schematic map of LEZ placement would inform driver about necessity to enter or cross LEZ to reach the destination point.

Today, when many drivers are using navigation devices, what guides them to destination point via shortest or fastest way, it is recommended to place direction road signs near the by-pass roads to guide drivers around the LEZ. Installation of direction road signs would give two positive effects – it will guide drivers and it is possible to guide them via desired by-pass route.

Figure 3.1 Examples of LEZ approach signage



3.12 Planning for Impact Assessment

At the time of planning stage of LEZ it is important to assess environmental and economic effect of planned LEZ. Strategic environmental impact assessment and cost-benefit analyses should be based on detailed data about current situation and estimated future scenarios. It is recommended to evaluate several alternative solutions to provide options for decision makers.

Cost benefit analyses should be done for each LEZ alternative and should cover planned LEZ and bounding areas. More on this topic can found in Chapter 7.

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4 LEZ Administration

4.1 Introduction

Currently there is no unified LEZ system that would ensure the smooth functioning of LEZ enforcement mechanisms notwithstanding where the vehicle is registered. So as to make LEZs more effective in terms of application to foreign vehicles in the same manner as to the local, and to help LEZ planners to choose the best solution in terms of LEZ administration, the following sub-chapters analyse the relevant considerations in the context of LEZ enforcement, as well as provide a guidance for introduction of unified EU-wide common system, that would ease the enforcement process and make LEZs more effective, providing possibility for equal application to both – local and foreign vehicles.

4.2 Issuing Stickers

Taking into consideration that there is an overarching need to establish unified system of the EU LEZs, covering also inclusion of foreign vehicles, the solution for recognition and identification of foreign vehicles has to be introduced. Acknowledging the various existing types of LEZ enforcement and already developed practice of local vehicle recognition system (i.e. stickers), the transfer to a standardized LEZ access sticker system can cause some resistance. Yet it is evident that there is a need for a system that would ensure a full integration of foreign vehicles into local LEZ systems.

One of the possible solutions in this respect is an introduction of unified EU vehicle “passport” in the form of a sticker that would list the data, on the basis of which the vehicle operator could easily acquire LEZ-specific access sticker. The common sticker will provide the following information:

- Vehicle type and license plate;
- Emission class (N2, N3, N4 etc. Euro 1, 2, etc.);
- Information on retrofitting (REC IIB, RECIII, RECIV etc.);
- In the future possibly also data on noise levels.

Member States will have to designate competent institutions (e.g. Vehicle Inspection Authority) that will be responsible for issuance of common stickers. Taking into consideration that the data is of a technical nature, it might be reasonable to assign the authority that is responsible for vehicle technical inspection.

The introduction of such system will require the response from Member States that currently have sticker-based LEZ system – so as to make the LEZ applicable to foreign vehicles in the same manner as it is to the residents, the network of LEZ vendors has to be expanded, including such establishments as gas stations, located outside borders of LEZ. The sales of appropriate stickers in such places will be subject to ownership of EU common sticker, which will provide all of the data that is necessary for vendor to determine which Member State-specific LEZ sticker to sell to the vehicle owner.

4.3 Vehicle Documentation

In order to acquire common EU sticker, the vehicle owner will have to present technical documentation on the vehicle. Currently the mutual recognition of vehicle registry documents is governed by the Directive 1999/37/EC on the Registration Documents for Vehicles, which ensures that the registration documents of vehicles registered in one of the EU Member States are recognized all across the EU.

In case the competent authority is also the authority responsible for technical inspection of the vehicles, it would probably have a database with information on vehicles registered in the state. Yet, if the stickers are issued by other bodies, the state will whether have to ensure an access to such database or issue the relevant documentation upon technical inspection and/or registration of vehicle.

In addition, the access to documentation plays a significant role in cases, where LEZ is enforced by such means as automatic licence plate recognition. In respect to such LEZs, the common sticker does not play such a significant role, as the more practical way to ensure that the LEZ of such type also applies to foreign vehicles, would be to develop a common EU electronic database with information on vehicles planning to access LEZs. The access to the database shall be available to competent authorities of the Member States, thus at the same time when issuing an EU common sticker, the authority can upload necessary documentation and information in the common database, which will be integrated in states' licence plate recognition systems.

4.4 Retrofit Documentation

For the purposes of successful system ensuring mutual recognition of retrofit devices and technical documentation of retrofitted vehicles, it is crucial to introduce a unified system of documentation on retrofitting.

Two important aspects that have to be harmonized in order to ensure flawless functioning of the retrofitted vehicles mutual recognition are:

- Harmonized standard for application for approval of retrofit devices;
- Harmonization of documentation on retrofitted vehicles.

First of all, as far as it goes to the approval of retrofit devices, there are some good examples, how this situation is treated currently. The French Order on Retrofits⁵¹ sets out the standard requirements for certificate of retrofit devices and contents of retrofitted vehicle documentation that partly mirror the requirements included in the UNECE proposal for uniform provisions concerning the approval of Retrofit Emission Control Devices for HDV⁵² (see more in Ch. 4.8). Yet, while the draft UNECE regulation applies particularly to HDVs, the French legislation covers also M1 category vehicles (i.e. passenger vehicles). Following the current practices, the retrofit device approval documentation shall contain at least such information (at the same time the draft regulation sets out much more detailed requirements):

- Information on manufacturer of the device (name, legal address, registration number etc.);
- Type of device (particulate filter, catalyst, etc.);
- Registration number of the device;

⁵¹ Arrêté du 15 mai 2013 visant les conditions d'installation et de réception des dispositifs de post-équipement permettant de réduire les émissions de polluants des véhicules en service.

⁵² Proposal for a new Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery equipped with compression ignition engines. Reference number WP.29/2013/119.

- Pollutants concerned (PM, NOx);
- Compatible vehicles and effectiveness of device after installation in respective vehicles;
- Information on tests.

After the installation of the retrofit device, the designated authority (or service) will have to issue documentation on retrofitted vehicle. The retrofitted vehicle documentation shall contain at least such information:

- Vehicle type, name and registration information (incl., licence plate number);
- Technical information (engine type, etc.);
- Information on authorized installer (service name, legal address, registration number etc.);
- Type and registration number of device (particulate filter, catalyst, etc.);
- Pollutants concerned (PM, NOx);
- Baseline pollution class of the vehicle (Euro class prior to retrofitting);
- Pollution class of the vehicle after retrofitting (Euro class after retrofitting).

The general information on retrofit of a vehicle will be included in the EU sticker, which will be issued to the vehicle owner based on the technical documentation on retrofit. Taking into consideration the already mentioned different types of enforcement in LEZs, there would also be a need to integrate data on retrofit in the common database. This requires development of a system that would ensure automatic recognition of retrofit documents after uploading/filling in data in the database, so as to ease the process of accessing LEZs operating with licence plate recognition system.

4.5 Approval of Sticker Vendors

As it was already discussed in the previous chapters, the unified system of European LEZs foresees introduction of the common EU stickers. At the same time, some municipalities might choose to continue using LEZ-specific or a national sticker system, without shifting towards electronic vehicle recognition methods. This implies the existence of two different systems of sticker sales.

Approval of common EU sticker vendors

There are several options for Member State to organize the sales of common EU stickers. One of the options is to designate an authority, responsible for technical inspection of the vehicles (e.g. Vehicle Inspection Authority). Such option would be the most efficient one, as the vehicle inspection authorities are generally also responsible for vehicle registration and holding of data on the vehicle. Thus, designating an institution that is responsible for administration of all technical documentation on the vehicles registered in the Member State would ease the process of access to the technical documentation of the vehicle and submission of data to the EU database.

Another possibility is to establish a chain of authorized vehicle repair shops/services that would sell stickers on the basis of technical documentation and inspection of the vehicle. Such option would require introduction of authorization system and could be more complex than in the case of one body responsible for selling stickers.

Approval of MS LEZ-specific sticker vendors

As it was already mentioned in the beginning of the chapter on issuing stickers (Ch. 4.2.), the current LEZ-specific sticker vendor network will have to be expanded in order to make it more accessible to the foreign drivers. Currently countries that use sticker system, which is also applicable to the foreign drivers, realize the sale of stickers mostly through the internet (see

example of Germany⁵³), and respective sticker is later dispatched to the vehicle owner via postal services.

As the common EU stickers will include all of the information necessary for issuing appropriate LEZ sticker, they can be sold in such places as gas stations. Both EU and LEZ sticker will have to be located in the visible place (e.g., windshields) and used together, when entering the LEZ.

Member States have discretion to decide, how to expand the LEZ-sticker vendor network, as they can choose to make it available not only in such places as gas stations, but in car repair shops, supermarkets or other places, as long as there is a sufficient territorial coverage and accessibility not only during the day time, but also at night and holidays. These aspects make gas stations the most suitable vendors. In addition, the Member States can decide on the most appropriate authorization system of vendors and registration of sold stickers.

4.6 Online Sale of Stickers

As it was already mentioned, some of the countries are practicing sales of their LEZ stickers online. After the introduction of the new system, the system of online sales of stickers can be simplified, introducing e-sticker, that does not require the delivery of printed sticker. At the same time such system will not be applicable to the common EU stickers, which will have to be physically attached to the vehicle at all times, when it enters LEZ.

Accordingly, the LEZ-specific e-sticker system would work as follows: the vehicle owner, who has already acquired printed common EU sticker, will access the common EU webpage that has information on all of the LEZs in the Member States. The webpage will either have a redirection system to the respective LEZ's administrator's webpage or will provide national LEZ e-sticker purchase service directly in the common webpage. After filling in the information on particular vehicle, the system will compare it with the information available in the common EU database, where the data on respective vehicles will be submitted after acquiring the common EU sticker, and, after making a payment, the vehicle operator will be provided with information on his e-sticker. Such system allows entering the sticker-operated LEZs without LEZ-specific sticker, as the patrol services will be able to check in the database, if the vehicle at issue has acquired a sticker, and if this sticker corresponds to LEZ requirements (this should already be visible from the common EU-sticker, as it depicts the information in accordance with which the vehicle owner is issued a LEZ-specific sticker).

4.7 Permitted Exceptions

As it was already mentioned in the Chapter 3 of these guidelines, there are usually a number of excepted vehicles that can enter LEZ notwithstanding possible incompatibility with the general requirements. These groups of vehicles are usually either indispensable part of the public services or are exempted from general requirements due to the specific circumstances.

The list of exceptions may include *inter alia*:

- Emergency vehicles (e.g., ambulance, fire trucks, police vehicles);
- Handicap vehicles;

⁵³ Low Emission Zone/ Environmental Badges in Germany. TÜV NORD, available at http://www.tuev-nord.de/de/umweltplakette/ENGLISH_Low_Emission_Zone_8648.htmhttp://www.tuev-nord.de/de/umweltplakette/ENGLISH_Low_Emission_Zone_8648.htm.

- Antique vehicles;
- Local public transportation;
- Diplomatic transport;
- Military transport;
- Other possible exceptions.

It is important to mention that currently a number of LEZs do not apply to the foreign vehicles due to enforcement issues, yet it is highly encouraged to develop a system that would facilitate a full application of LEZ requirements to the foreign vehicles. As to the other exceptions, municipalities have discretion to assess the possible impact of introducing exceptions and accordingly choose which types of vehicles to exempt from the local LEZ system. Overall, when establishing the exemptions, the planners have to assess both – the effect on LEZs objectives and considerations relevant for enforcement of exemptions, i.e., how the exempted vehicles will be recognized and how the exemptions are notified or registered (if necessary).

Another issue to consider is the application for granting of an exception.

4.8 Approval and Mutual Recognition of Retrofit Devices

Currently there is no unified system for recognition of retrofit vehicles in the EU MS LEZs. The first step towards mutual recognition of retrofitted vehicles is establishment of standardized certification and documentation system for retrofit devices (discussed in the Ch. 4.4 above). Such mutual recognition system has to pertain to the European emission standards, and retrofitting the vehicle shall ensure decrease of emissions and thus also higher Euro emission standard.

Currently the area is not sufficiently regulated. Yet the UNECE has introduced a “Proposal for a new Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery equipped with compression ignition engines”⁵⁴. Even though the regulation is still not formally adopted, Member States can use the regulation when developing retrofitting requirements not only for HDV, but also for other types of vehicles (as in the example of France, addressed in Ch. 4.54) to ensure the application of harmonized system throughout Europe. It outlines the detailed requirements applicable to manufacturers of retrofit devices, including certification requirements (the simplified version already discussed in Ch. 4.54), testing requirements, emission reduction levels etc.

4.9 Methods of Payment

When establishing a harmonized system for LEZ administration that fully includes foreign vehicles, an important issue to address is the way of payment. The issue of fees, even though topical in both types of LEZ, can cause more problems, if is not resolved in regards to charge-based zones. The following sections will provide a brief description of possible payment methods.

4.9.1 Purchase of Stickers

When addressing the issue on purchase of stickers, it is important to make a distinction between the common EU sticker and LEZ-specific sticker. Taking into consideration that the former is subject to the common standard, while in the case of the latter Member States have a high level of

⁵⁴ Reference number WP.29/2013/119.

discretion in terms of system applying to sticker sales and prices. The conditions surrounding purchase of stickers will be observed separately for each of the types.

Common EU sticker

The system for issuing the EU common sticker shall be developed and adopted on the EU level, thus ensuring the necessary level of harmonization and application of common standards. When developing the system, as well as when implementing it in MS, the following considerations have to be regarded:

- The sticker has to be sold at a standard prize, which is the same in all of the Member States (converted to MS currency, where applicable);
- The method of payment (bank transfer prior to acquiring sticker, payment in cash or card upon acquiring the sticker) left at the discretion of the Member State.

LEZ-specific stickers

The establishment of harmonized LEZ-specific sticker purchase system is a more complex issue, as there are number of discretionary components underlying the sales of such stickers in Member States. Yet, in order to ensure the highest possible effectiveness and inclusion of foreign vehicles, the following aspects should be considered by the local authorities and LEZ planners:

- MS have discretion to decide on reasonable price of stickers, taking into consideration the local conditions;
- MS have to develop a sticker vendor network that would ensure sufficient territorial coverage in the MS at issue;
- MS have to ensure that the vehicles owners could obtain stickers both via Internet or directly from vendors, thus implying possibility of using various payment methods.

4.9.2 Entry Fees (if any)

A more complex set of issues have to be observed when addressing the methods of payment in LEZs operating on the basis of the entrance fee that depends on the emission class of the vehicle. Such zones differ from the ones operating without fee (oftentimes regulated by sticker), as they allow entrance of older, more polluting vehicles, applying additional entry fee, thus also serving as a deterrence mechanism. The main aspects that have to be considered, when establishing a system with an entry fee element, are as follows:

- The levels of fees to be applicable to the drivers have to correlate with the objectives of LEZ;
- Payment of the fee possible prior to, during or after visiting the LEZ (depending on the enforcement mechanism);
- Ensuring online payment system, which is connected to the database containing data on vehicles that have been issued the common EU sticker; such system has to be easily available and comprehensible to foreign drivers;
- Taking into consideration that the entry charges and enforcement methods can differ from LEZ to LEZ, there is a need to provide a “one stop shop” system, where the drivers can gain information on all of the LEZs in the EU and pay the entry fees via Internet prior to commencing the trip.

It is also important to note that the charges can be divided as follows:

- Charge per trip;
- Charge per day;
- Charge per year.

The necessity for annual charge option is a crucial way to avoid additional burden for frequent travellers - for example, people, who work inside LEZ or reside in LEZ.

4.10 Enforcement

As it can be already be derived from the previously discussed topics, it is not feasible to introduce the common LEZ enforcement mechanism in the EU. Member States have competence to decide, which is the most suitable type of enforcement mechanism, as the enforcement systems differ not only in terms of the actual enforcement means (i.e. manual, technological), but also in regards to implementation and operational costs, necessary human resources, technological support, administration etc. For example, while camera-based enforcement might require higher setting up costs, it can be cheaper during the operational phase. At the same time the operational costs of manual enforcement can vary, depending on such aspects as frequency of control, funding of police and how much can be built into already existing traffic enforcement.⁵⁵ The following sections will briefly address the main considerations, as well as advantages and disadvantages of four LEZ enforcement types.

4.10.1 Manual patrol enforcement

Manual enforcement is a rather common measure in sticker-based LEZ systems; in such case, the enforcement is usually carried out by random police checks, without stopping the vehicles at the border of LEZ.

One of the main drawbacks of the manual enforcement is that it might not be as effective as the electronic, especially in cases, where random police checks are being carried out in sticker-operated LEZs. At the same time, manually operated LEZs do not depend on the prerequisite of establishment and administration of common EU database, as current practices (e.g. case of Germany) show that such LEZs can also apply to foreign vehicles.

4.10.2 Entry or Toll Gates

The system encompassing charging on the basis of toll gates includes any form of charging on a stretch of infrastructure. Toll gate schemes are by definition priced per trip, can include different charging methods (cash, credit card, pre-paid card or electronic toll collection system), and are generally installed on the roadways. Even though there are still some cash-operated toll gates, the electronic toll collection system is becoming more and more widespread. One of the reasons for that factor is the introduction of the Electronic Fee Collection Interoperability Directive⁵⁶, establishing European Electronic Tolling Service (EETS). The operators of toll gates are encouraged to apply EETS in accordance with the directive, thus ensuring easy and fast application of system to both national and foreign vehicles.

Before introducing the toll gate system, there are several considerations to be addressed in order to assess, if it is an efficient solution:

- Introduction of toll gates has significant capital and operating costs;
- Tolls should not be considered for roads with traffic of less than some 10'000 vehicles per day, to keep the administrative costs at a relatively even level in regards to collected revenues;
- Toll systems also reduce the economic benefits of the tolled facilities by minimizing entry and exit points, delaying traffic at tollbooths and diverting traffic to parallel roads with higher vehicle operating costs.⁵⁷

⁵⁵ Low Emission Zones in Europe for the UK Department for Transport. Sadler Consultants. February, 2010.

⁵⁶ Directive 2004/52/EC on the interoperability of electronic road toll systems in the Community.

⁵⁷ Queiroz, Cesar et al. Road User Charges: Current Practice and Perspectives in Central and Eastern Europe. The World Bank Group, November 2008.

4.10.3 Electronic identification (RFID)

Radio-frequency identification (RFID) operates on the basis of wireless radio-frequency electromagnetic fields that are used to transfer data for the purposes of automatically identifying and tracking tags attached to objects. Such tags can be attached to the vehicle and contain all of the data that is necessary for the purpose of determining, if respective vehicle has a right to access the LEZ at issue.

RFID can be used independently in the LEZs without charges or be integrated in the toll gate system. In the former example the vehicle owner will have to purchase the tag that will contain all of the necessary information on the vehicle. Such tags might be sold separately on the basis of the data provided in the common EU sticker, or RFID chips can also be incorporated in the common EU sticker, thus ensuring the ease of access (if the vehicle complies with the LEZ requirements) to LEZs and avoiding additional burden of purchasing tags.

In the latter example, where the RFID system is used together with toll gates, the RFID tags are tied to the bank account of the vehicle owner, thus allowing making automatic payments upon access to charge-based LEZs.

Yet the use of RFID systems has already caused a wave of controversies, particularly connected with security concerns and protection of privacy. The best solution would be to allow vehicle owners to choose, if they would like to acquire usual EU common sticker or the sticker with an integrated RFID technology.

Norway's AutoPASS⁵⁸ and the Danish BroBizz⁵⁹ are EETS-compatible RFID systems for road and bridge tolls. They are also used for ferry charges. These two systems permit mutual recognition of either payment system. This cooperation has been expanded to Austria, under the name EasyGO⁶⁰. A new EasyGo+⁶¹ on-board unit for heavy vehicles permits coding of the vehicle Euro class, in support of Austria's Euro-based road tariff system. This cross-border cooperation on an EETS-compatible RFID with potential to include Euro classification may offer interesting possibilities for use in LEZ.

Oslo's road charging system includes both the AutoPASS RFID system and ANPR. ANPR is used to read number plates on vehicles without installed AutoPASS on-board units, including foreign vehicles.

4.10.4 License plate recognition

License plate recognition system is becoming more and more popular and has been already applied in a number of LEZs. It operates on the basis of cameras installed at the LEZ entry points and that can also be scattered inside territory of LEZ. The cameras are scanning the licence plate number of vehicles entering the LEZ and comparing it with the list of vehicles uploaded on the database. In the case the common EU database is developed, the licence plate based access would also allow to easily apply the system to foreign vehicles.

Currently licence plate system has been successfully operating in London, Milan and other LEZs. For example, in case of London LEZ cameras read number plate as a vehicle drives within the LEZ and check it against the database of registered vehicles. This database is compiled using

⁵⁸ www.autopass.no.

⁵⁹ www.brobizz.dk.

⁶⁰ www.easygo.com.

⁶¹ <http://easygo.com/en/easygoplus>.

information from The Driver and Vehicle Licensing Agency (DVLA), the Vehicle Operator Services Agency (VOSA), generic vehicle weight data typical of the make and model, and drivers and operators who have registered with Transport for London (TfL). This tells automatically, if the vehicle meets the standards, is exempt, is registered for discount or has already paid a daily charge.⁶² London LEZ also applies to foreign vehicles, yet they have to register with the TfL prior to entering the LEZ. In the case a common EU database will be introduced, it can lift the burden of multiple registrations with local authorities in case the vehicle owner's route crosses several LEZs.

4.11 Penalties and Penalty Collection

One of the issues, which is up until now unresolved in a number of LEZs, is collection of penalties from foreign drivers. This is among the main reasons (along with recognition of foreign vehicles in LEZs operated by technological means), why many LEZs do not apply to foreign drivers. While it is less problematic in cases of manual enforcement, in the systems, where there is no manual enforcement the collection of penalties may cause more problems. In addition, also the question of the amount of penalty to be imposed upon unauthorized access to the LEZ has to be addressed.

As to the setting the penalties, the similar situation as in the case of setting the entry fees persists, – it is competence of national authorities to determine the level of penalties to be set for violation of LEZ requirements. Yet, when determining the penalties, the following considerations have to be kept in mind:

- The penalty has to be proportional to the violation; and
- The penalty has to serve as a deterrence mechanism, so as to discourage the vehicle operators from violating the rules governing access to LEZ.

As it was mentioned in the paragraph above, the most of the problems in penalty collection might be associated with attaining data on foreign vehicles. Some information on possible means for cross-border exchange of data, the currently operating EU database of vehicle registration data, as well as legal basis for cross-border cooperation is provided in section 3.9 above.

Currently some of the LEZs, that encompass also foreign vehicles, have signed bi-lateral agreements with other states or contracts with undertakings involved in collection of debts across the EU. For example, Italian Limited Traffic Zones have established cooperation with the company called European Municipality Outsourcing (E.M.O.), which mostly works in the international management and notification of administrative sanctions issued by the local Police in connection with the violation of the Highway Code rules.⁶³ The comparable scheme for collection of foreign operators' debts is operating in regards to the London LEZ – "Recovery of unpaid penalties to non-GB registered vehicles is undertaken by a dedicated European debt recovery agency. TfL works together with a European debt recovery agency and has established links with many European vehicle licensing agencies"⁶⁴. Accordingly, currently municipalities are using similar systems for enforcement of penalties in terms of foreign vehicles. Yet, considering the introduction of a unified EU database and website on LEZs, the webpage can integrate the penalty payment system, thus providing a pan-European penalty collection service that is easily accessible by all of the operators, irrespective of the Member State of registration. This requires an action from the EU, establishing legal basis for cross-border enforcement of LEZ penalties.

⁶² About the LEZ. Transport for London, available at <http://www.tfl.gov.uk/roadusers/lez/17678.aspx#tk-tab-panel-4>.

⁶³ Study on Urban Access Restrictions. Final Report. Rome. December, 2010.

⁶⁴ Penalty Charges. Low Emission Zone. Transport for London, available at <http://www.tfl.gov.uk/roadusers/lez/17703.aspx>.

The introduction of the common database and users' webpage is a prerequisite in regards to many aspects discussed in the current guidelines. In order to include penalty and payment information (in regards to entry in LEZs operating on the basis of entry fee, or purchase of e-sticker), the webpage has to provide individual access to operator's information by developing users' account system, that would contain all of the topical data on vehicle. The account details and registration can be carried out at various stages – upon registration of vehicle, when acquiring EU common sticker, or providing voluntary registration at any instance. Yet the most appropriate solution would be to provide user details upon application for common EU sticker, as it implies the operator's intent to access other Member States' LEZs, and this is the point, when the data on vehicle is submitted to the EU common database.

4.12 References

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5 Financial Aspects

5.1 Funding modalities for LEZ

When considering how to finance a LEZ scheme it is important for local authorities to prepare a plan that identifies strategic decisions and guides the program evolution together with the funding decisions. Various approaches can be used for funding LEZs with different implications in terms of who will pay and what procedures must be followed. Two main types of LEZ can be distinguished: with and without user charges. Each type has different implications for financing; these are described in the table below.

Table 5.1 Two principal types of LEZ with their funding implications

| LEZ type | Description | Advantages | Disadvantages | Example |
|----------------------|--|--|--|-----------------|
| Without user charges | Command-and-control type of regulation. Certain vehicles are restricted from entering LEZ based on technical standards (e.g. Euro categories) or on other considerations (e.g. alternate driving days based on licence plate numbers). | Investment and operational costs are typically lower than in the system with user charges (no system of fee collection needed). | No possibility of (partial) cost recovery for the authorities. | Dutch HDV zones |
| With user charges | User charges constitute an economic instrument. The fees for entering LEZ are typically differentiated so that more polluting vehicle drivers have to pay more for access to LEZ. | Fee revenues can be used to (partly) recover operational costs of running the scheme. Private-public partnerships may be possible. | Administrative costs are typically higher (need to devise a system of fee calculation and collection). | London LEZ |

Depending on the design and socio-economic structure of the population, some decisions can be taken which will influence the share of the costs to be borne by the residents and businesses registered within the zone and the stakeholders from outside the zone. For example, in the system without user charges, certain groups of residents may be allowed a longer transition period to retrofit/replace their cars or a system of financial rebates may be devised. Also in the system with user charges, special treatment may be applied to the selected groups of users who might be exempt from paying the fees.

Regardless of the type of the scheme, investment costs of setting up the system have to be covered up-front. The costs to implement and operate an LEZ will depend on a number of variables. These include the size of the zone, whether manual or automatic enforcement is chosen; all vehicles or just heavy duty vehicles are included. Camera enforcement is generally more expensive to set up but can be cheaper to run. Experience from the Netherlands indicates that implementation costs with manual enforcement for an average sized city (population around 200,000) equal around €100,000, with annual enforcement costs at the level of around €75,000, increasing for larger cities. Set-up of camera enforcement is estimated at around €10-50,000 (Sadler Consultants, 2011).

Some possible sources of funding for LEZ are listed below:

- Own resources generated from local taxes or other local revenues;
- Municipal bonds. These may be general bonds or revenue bonds issued for a specific project (in this case for setting up the LEZ);
- Direct transfers or grants from state government or from regional/provincial budgets. Many state governments create special programmes for supporting environmental policies at local level (see Box 5.1).

Box 5.1 Announcement about state grants from the British government for designing LEZ

Councils in Birmingham, Bradford and Devon were each awarded £150,000 this week to investigate the possibilities of bringing in zones similar to those used in London since 2008 to tackle air pollution. The grants were announced on Monday as part of 36 funding awards to local authorities across England covering 42 projects designed to tackle nitrogen dioxide emissions. These include initiatives to create best practice guidance and tools for local authorities that want to decrease emissions, and efforts to improve communication around air quality risks.

Source: Businessgreen (2013).

- EU funds. EU funding opportunities may be available especially for New Member States and Cohesion regions⁶⁵. Integrating LEZ with the Sustainable Urban Mobility Plans (SUMP), Air Quality Plans and/or Noise Plans may increase the chance of co-financing from the EU assistance Structural Funds;
- Loans from commercial institutions. Obviously, the loans at some point have to be repaid, which makes this option equivalent to the option of using own resources. It should be noted here that usually local authorities have to face regulatory limits of debt (a certain ratio of total debt or debt repayment to budgetary revenues) thus they cannot go beyond certain thresholds. The limits may be different in different Member States;
- Soft loans from international financial institutions. Among those, European Investment Bank is the most logical source of possible co-financing of LEZ for the EU Member States;
- Subsidies or soft loans from environmental funds⁶⁶.

Own (local municipality) resources and (partly) funding through national budgets are the most used funding mechanisms.

After setting up the system, there is a possibility to recover a part of the operational costs by using the revenues from the collected charges (fees and penalties). It is not likely that the system will be self-financing; even with user charges the revenues will typically cover only a certain percentage of operational costs. Therefore, it is important that a cost-benefit analysis confirms social-economic efficiency of the scheme (i.e. that social benefits exceed social costs). Such an argument, together with social acceptability of such a programme, is essential for receiving external co-funding.

5.2 Fees

If LEZ is designed with charges, a fundamental question arises about the pricing principles and the appropriate levels of charges. This will be the focus of this section.

⁶⁵ See information on EU funding opportunities at http://ec.europa.eu/environment/funding/intro_en.htm. The website provides a link to a handbook on a EU funding in the environment (the handbook relates to the years 2007-2013 but many of the opportunities mentioned will be extended into the future financing period.).

⁶⁶ Environmental funds are institutions collecting the revenues coming from various environmental charges (e.g. pollution or mining fees) and subsequently providing subsidies and loans for environmental investments. Environmental funds are active in several EU Member States, especially in Central and Eastern Europe.

Definitions and theoretical underpinnings

Charges are typical economic instruments broadly used within environmental policy in various forms (including taxes, fees and user charges). Four main functions of these economic instruments can be listed, namely:

1. Creating right incentives i.e. making the polluters pay for the burden they create. Consequently, the external costs imposed on the society by the polluters are being internalized and the scale of pollution and the related harmful impacts is supposed to decrease;
2. Recovering (part of) the costs of imposing certain environmental policies;
3. Creating revenue which may be used for example to alleviate the negative effects of pollution or to compensate some of the costs to the selected social groups;
4. Creating right incentives to change to lower emission vehicles.

It is worth noting that charges are consistent with the Polluter Pays Principle (PPP), which constitutes one of the principal environmental policy guidelines within the OECD countries.

In the case of LEZ, the charge/fee to be paid by vehicle drivers within LEZ can be seen as a combination of a user charge and a pollution charge.

A *user charge* is a fee paid in exchange for providing certain services to the user, with the idea of at least partial recovery of the costs incurred for providing the service. In the case of LEZ the urban road infrastructure can be considered to constitute “the service” for which the payment is made. A *pollution charge* in turn is a fee imposed on a party which discharges certain polluting substances into the environment. The charge is usually proportional to the quantity of the pollutants that are discharged.

The last type of the fees relevant for the LEZ are *non-compliance charges*. These can be used both within the LEZ schemes designed with user/pollution charges and within the LEZ without user charges. Table 5.2 gives a summary of these economic instruments.

Table 5.2 Types of charges/fees relevant for LEZ

| Type of charges/fees | Description | Example |
|------------------------|---|---|
| User charge | Payment in exchange for a particular service usually aimed at cost recovery of collective services. | Toll roads |
| Emission charges/taxes | Fees based on a quantity or quality of pollutants released into the environment. | Carbon tax |
| Non-compliance charge | Payments made by polluters or resource users for non-compliance, usually proportional to damage or to profit gains. | Penalty fees for surpassing regulatory limits set in pollution permits (such as water permits, integrated permits). |

Source: Perman et al. (2011)

The charges applied within LEZ may be focused partly on the cost recovery aspect and partly on the incentivising aspect, with the latter being the main reason underpinning the creation of LEZ. Creating additional revenue (i.e. above cost recovery) is not likely in this case.

The level of charges

In order to be most economically efficient and consistent with the PPP rule, the pollution charge should ideally be devised in a form of a uniform rate per unit of a given pollutant. In this way, the

more pollution released, the more payment would be collected. Theoretically appropriate (economically efficient) charge rate would have to be equal to the marginal damage cost related to emission of this specific pollutant⁶⁷.

In practice, however, such an approach is hardly ever used. While it is still likely to be followed or approximated in designing pollution taxes for large industrial sources, regulating mobile sources would impose too high administrative costs (monitoring etc.). It would not be practical (and probably prohibitively costly) to design a system where different pollutants' levels would have to be monitored per each kilometer driven within the LEZ by each vehicle.

Even if the theoretically appropriate design of the charging system is not feasible to implement, some elements promoting economic efficiency and consistent with the PPP rule can still be kept. The main idea behind the LEZ scheme with charges is that the operators of the most polluting vehicles are supposed to pay proportionally more than the operators of "cleaner" vehicles. This idea can be implemented through a design where the vehicles with more stringent pollution standards (e.g. according to Euro classification) would be charged less than more "dirty" vehicles.

The issue of pollution from motorised two-wheelers and three-wheelers should not escape attention of the policy makers. In some places pollution from this type of vehicles is a growing problem which may indicate that emissions from motorcycles and alike should also be included in the charging system.

London and Budapest are examples of fee-based LEZ. The Milan Ecopass system was in effect from 2008 to 2011 but in 2012 it was replaced with a conventional congestion charge. Table 5.3 below gives an example of the LEZ charging system in Milan in 2010.

⁶⁷ Depending on the situation and methodology adopted, such a charge (tax) rate might be designed to approximate the value estimated either based on damage cost approach or on abatement (avoidance) cost approach.

Table 5.3 Ecopass LEZ charges, Milan

| Ecopass Class | Euro/Emissions Class | Minimum standard | Ecopass Cost | | |
|--|--|--|--------------|------------|-------------------------|
| | | | Daily | Multiple * | Yearly – residents only |
| Class I | LPG, natural gas, electric, hybrid vehicles | Alternative fuel | Free Access | | |
| Class II | Petrol cars & goods vehicles (GVs) Euro 3+ Diesel cars & goods vehicles with diesel particulate filters (dpfs) Euro 5 diesel cars with factory fitted dpfs Euro 4 diesel cars without dpf (until 31.12.2009) Euro 4 & 5 diesel goods vehicles without dpf (until 31.12.2009) | Petrol cars & GVs Euro 3 Diesel cars & GV with dpf Until 2010: Diesel cars & GV Euro 4 | Free Access | | |
| Class III | Euro 1, 2 petrol cars & goods vehicles | Petrol cars & GVs Euro 1 | €2 | €50 / 60 | €50 |
| Class IV | Pre-Euro petrol cars & goods vehicles Euro 1, 2, 3 diesel cars Euro 3 diesel goods vehicles Euro 4&5 diesel coaches | Petrol - Euro 0 Diesel cars- Euro 1 Diesel GV - Euro 3 Coaches - Euro 4 | €5 | €125 / 150 | €125 |
| Class V | Pre-Euro diesel cars Pre-Euro, Euro 1, 2 diesel goods vehicles Pre-Euro, Euro 1, 2, 3 diesel coaches Mopeds and motorcycles^ | Diesel cars- Euro 0 Diesel GV - Euro 0 Coaches - Euro 0 2-wheelers^ | €10 | €250 / 300 | €250 |
| * There are no reductions for commercial vehicles. The multiple entry Ecopass allows you to enter the Ecopass area on 50 – not necessarily consecutive – days, with a 50% reduction on the daily Ecopass charge and for a further 50 days with a 40% reduction. There are no multiple entry reductions from the 101 st day onwards. | | | | | |
| ^ Mopeds and motorcycles are exempt from the charge | | | | | |

Source: Sadler Consultants, 2010.

The level of charges in Europe cannot be set uniform because every local situation is different regarding traffic intensity, socio-economic conditions, environmental goals etc. While designing the level of charges, the following information and data have to be compiled and analysed:

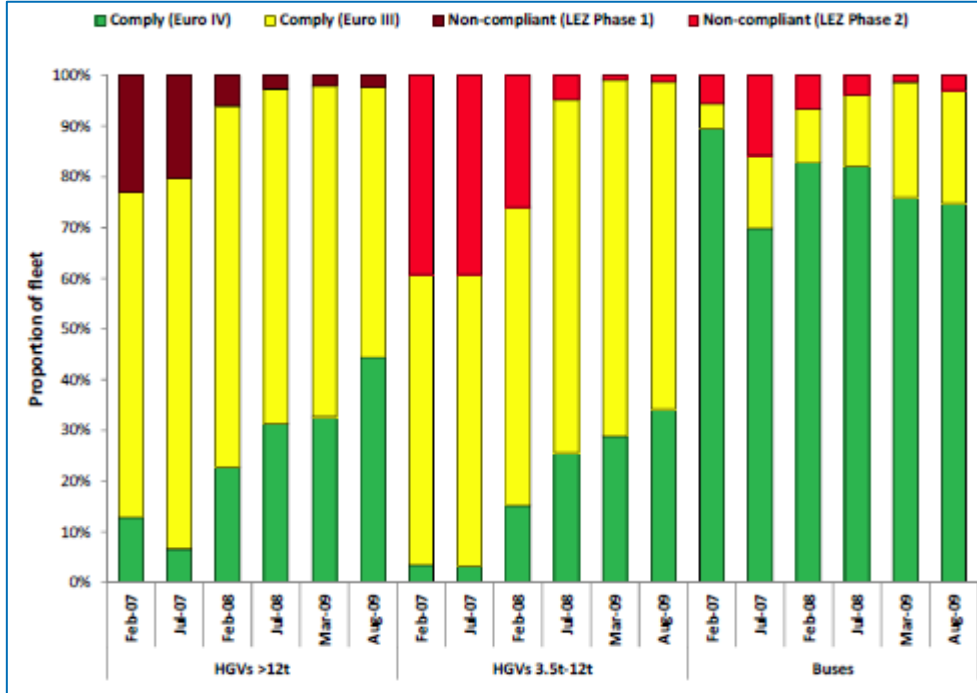
- Current levels of traffic-related pollution and their origin according to various types of vehicles;
- Desired drop in traffic-related pollution after LEZ implementation;
- Demand elasticity estimates for various groups of vehicle drivers to help estimating sensitivity of demand to price increase.

Penalties for non-compliance with the LEZ standards (in LEZ without charges), if set at an appropriate (not too low) level, give a right incentive for undertaking compliance actions such as retrofitting or replacing a vehicle.

Combining various charge rates with demand elasticity and with the current traffic intensity within the specific vehicle categories would allow estimating an expected drop change in traffic intensity according to the specific categories and, subsequently, drop in pollution resulting from imposing the charges. Examples of how a system with charges works in the existing LEZ (e.g. in London) would definitely be very helpful in designing a new scheme. An example of the London LEZ shows that very high charges⁶⁸ resulted in a relatively quick and effective elimination of non-compliant vehicles. At Figure 5.1 it is visible that 1.5 year after introduction of the London LEZ, the number of non-compliant vehicles decreased, with especially sharp drop in the group of the HGV between 3.5 and 12 tonnes gross vehicle weight (drop in non-compliant vehicles share from c.a. 40% to c.a. 2%).

⁶⁸ These are in fact sort of non-compliance penalty fees, in the order of 100-200 GBP per day for the vehicles which do not meet the LEZ standards, <http://www.tfl.gov.uk/roadusers/lez/17701.aspx>.

Figure 5.1 Change in vehicles compliant with the London LEZ between February 2007 and August 2009.



Source: Barrat (2013).

Introduction of standards accompanied with non-compliance penalty fees and/or a system with charges needs an appropriate notice so that the vehicle owners are given sufficient time to take the necessary compliance-related actions. Some (temporary) exemptions can be used. In Germany, where LEZs have been implemented with less than a year notice, interim exemptions have been used, which were phased out after about a year. Other exemptions from paying charges/penalties might be needed. "Hardship exemptions" are used in Germany and the Netherlands for those for whom complying with the LEZ would cause significant financial difficulties. These 'hardship exemptions' can be used to reduce the potential socio-economic impact of the LEZ without reducing significantly its impact, if they are strictly implemented. These are implemented as local exemptions for the specific town/city where the applicant lives or works and needs to access. The applicant must prove that retrofitting is not possible and they cannot afford a replacement vehicle. Businesses have to prove that the vehicle is essential to their business, they do not have the funds to replace the vehicle and retrofitting is not possible and risks the viability of their business (Sadler Consultants, 2011). Other common exemptions include historic vehicles, special/agricultural vehicles, armed forces, disabled drivers' vehicles, vehicles where no DPF is available or certified, or fitting a DPF is not technically possible (Sadler Consultants, 2010).

National co-ordination of exemptions increases clarity, acceptability and administration. In Germany and the Netherlands there are national exemptions, plus local exemptions valid just for that town – the best practice towns/cities having fewer local exemptions (see also Box 5.2). In Sweden and London there are no exemptions, although in London day passes can be purchased. In Denmark there are national exemptions plus exempted key roads locally.

Box 5.2 An example of nation-wide and regional penalties and waivers in the Netherlands

In the Netherlands, the same entry requirements are valid in the whole country. Only 'clean' lorries are allowed to enter LEZs. To be clean, diesel lorries weighing over 3,500 kg must comply with the Euro 4 emission standard or higher. These entry requirements have recently become more strict (last amendment was introduced in July 2013). Nation-wide penalty for non-compliance with the admission criteria equals € 220. Also, there are some groups of special vehicles (like fire trucks or cherry pickers) which are granted a

national waiver. Another rule of entry is that a lorry has to be replaced with a new vehicle within 8 years. Not all trucks fit this rule so there are waivers (both on local and on national level).

The cities of Eindhoven, Tilburg, 's-Hertogenbosch and Breda, which are located in the south of the Netherlands (Noord-Brabant province) have a closer cooperation scheme. The rules within the province are more harmonized than with the other cities. Some waivers and rules are enforced jointly. In these cities 3 types of waivers exist:

- One-day waiver which can be granted to one party up to 12 times a year (costs €25);
- Temporary waiver for those who bought a new LEZ compliant truck and wait for its delivery (costs €25);
- A waiver for the entities who claim to bear especially high costs related to introduction of the LEZ ('hardship clause' (costs €150).

Measures to support the incentivising role of the fees

One of the most important roles of the fees applied within LEZ is to create incentives for vehicle owners/users to change to lower emission vehicles. While fees themselves create an economic incentive to change behaviour (e.g. retrofit or replace a vehicle), some additional (temporary) measures may be needed to supplement this market mechanism. These measures include:

- Subsidies, grants or tax exemptions for installing retrofit devices. For example in Denmark there is a tax on PM emissions from diesel passenger cars, however in case if an approved DPF is installed, tax exemption is applied. See also Box 5.3;
- Scrappage incentives (for example for low-income citizens);
- Parking privileges or subsidies for low emission or zero-emission vehicles.

Box 5.3 An example of a retrofitting subsidy scheme for companies: Flanders

In Flanders, an ecological subsidy has been set up as a financial incentive for companies investing in environmental projects, including retrofitting existing Euro I, II or III freight trucks with diesel particulate filters (DPF). To be eligible for the subsidy, the DPF must either be listed on the Swiss VERT list or have obtained from the Dutch RDW type approval for wall-flow DPFs (Class A). The total cost, i.e. DPF plus installation, qualifies for the subsidy which can represent up to 20% of the amount for small- and medium-sized companies, and up to 10% for larger companies.

Source: <http://www.dieselretrofit.eu/incentives.html>.

Summary criteria for setting up and evaluation of charges

Summing up, several criteria can be used mentioned to evaluate and select methods for design of user fee rate structures for LEZ. These include:

- **Legality.** Different regulations applying to local authorities may be in place regarding imposing charges and penalizing non-compliance with the LEZ standards as well as regarding the use of the revenues created in the system with charges. These need to be explored while designing the scheme;
- **Equity and social acceptability.** Because more environmentally friendly vehicles tend to be newer and more expensive, the scheme will likely have relatively heavier impact (cost burden) on low-income residents and SMEs than on richer groups of residents and large businesses. These discrepancies can be addressed through designing a system of rebates, exclusions and transition periods, which will also help achieving a better social acceptability;
- **Revenue sufficiency.** In LEZ with charges, the authorities may want to aim at (partly) recovery) recovery of operational costs. It has to be assessed case-by-case what recovery rate is feasible. The issue of social acceptability of the charges has to be taken into account as well;
- **Flexibility.** Some flexibility must be allowed so that periodical adjustments of fee level is possible. The adjustments may be due to inflation indexing, equity considerations, need to tighten/soften the standards because of environmental considerations, increase the impact etc.;

- Balance of rates with level of service. To some extent, the fees should be aligned with the quality of the service provided by the authorities. By “the quality of the service” it is meant the quality of road infrastructure and monitoring/fee collecting devices;
- Data requirements and compatibility with the monitoring and data processing systems. If the charges are to be based on some technical standards (e.g. Euro standards), the relevant information about the vehicle characteristics must be possible to obtain and monitor;
- Revenue stability and sensitivity. The revenue collected from charges will depend on the number of vehicles in each category passing through the LEZ. It may be expected that as time goes, “clean vehicles” will gradually replace more “dirty” vehicles. This trend will contribute to diminishing the revenues. In order to counteract this phenomena, over time the standards might be tightened;
- Consistency with other funding and charging policies. LEZ charging might be designed in a way that is consistent with other (existing) policies such as toll roads, congestion pricing etc. LEZ made according to the same design might spread across countries or even larger regions such as the whole EU.

5.3 References

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6 Information Systems

6.1 Introduction

Low Emission Zones are increasingly common across Europe, as an intervention measure to improve inter alia traffic congestion, public health (primarily through air quality), and climate change impact. There are great variations in the LEZ schemes in different urban areas within the same country and between different countries. This causes difficulties for citizen travellers and businesses and potentially discrimination against travellers and vehicles from other parts of the EU.

The effectiveness of a LEZ will depend partly on the availability of reliable, up-to date information. Centralised public information can reduce stakeholder resistance. A system of linked and up-to-date information systems should provide the following information:

1. Practical information for users (vehicle owners and operators, businesses) including access restrictions, geographical extent, hours of operation, payment options etc.;
2. Information for cities planning a new LEZ (policy, guidance, example of best practice etc.);
3. Information systems for operation of the LEZ (vehicle registration, payment and enforcement systems etc.).

This system should consist of a combination of a central (EU) database, national and local information services all offering consistent up-to-date information for the public, businesses and local and national government. Information systems for operation of the LEZ are covered in Sections 3.109, 4.109 and 4.11 of this document; this section covers information for cities and users.

6.2 Information for users

LEZs will have a range of users, including frequent, occasional and one-time users, with varying needs including:

- Local residents;
- Local businesses;
- Visitors (tourists and business);
- Logistics operators; and
- Transport operators (regional and international, scheduled and non-scheduled).

The basic information on the LEZ required by all these users will include:

- the geographic extent of the LEZ;
- hours of operation;
- vehicle categories affected;
- retrofit options;
- registration/payment options for access, if available;
- exemptions; and
- penalties for non-compliance; and
- details of how to plan a journey to avoid the zone.

These should be available to users both in advance of a journey to enable planning and also ideally on-the-move via smart phones, tablets and telephone information. Smartphone apps could also be provided which would use GPS to alert users to any LEZs that they were approaching and facilitate

registration and payment where necessary. Similarly, LEZs could appear on in-vehicle satellite navigation systems, online maps, Google Earth etc.

6.3 Information for cities

Cities considering setting up a LEZ should have access to a range of information aiding them in their decision-making. This should include detailed guidelines for setting up LEZ and examples of best practice in all aspects of LEZ.

Access to vehicle registration data

Vehicle registration data will be vital for cities to firstly determine whether and LEZ would be an effective measure, then to decide on access criteria and finally in the administration and enforcement of the LEZ. Registration data is usually held by the national transportation agency and should be made available to the cities. This data should include the vehicle Euro class and details of any installed retrofit devices.

Cross-border exchange of vehicle registration data

Administration and enforcement of foreign vehicles in LEZ would be more efficient if cross-border access to vehicle registration data was available. This would facilitate verification of foreign vehicle Euro classification for sale and verification of stickers, recognition of foreign vehicles by ANPR systems, and obtaining foreign vehicle owner information for the purpose of billing and collection of LEZ access charges or penalties. This is important to facilitate the equal treatment of foreign vehicles.

EUCARIS⁶⁹ (European CAR and driving license Information System) is EU's data exchange mechanism for Member States' vehicle registration and driver licensing authorities. EUCARIS can also be used by governmental organisations responsible for tracing stolen vehicles, theft and fraud prevention, as well as police, customs and tax authorities.

Directive 2011/82/EU⁷⁰ on cross-border exchange of information on road safety related traffic offences provides for exchange number plate data between member states to allow for cross-border enforcement of safety-related traffic offences, such as speeding, not stopping for red light, and drunk driving. This could potentially be extended to additional offences in bilateral agreements, to include administrative penalties such as LEZ penalties and parking fines. Proposed regulation COM(2012)0164⁷¹ includes procedures and specifications of vehicle registration data to be exchanged between Member States – including the Euro class of vehicles.

Council Decisions 2008/615/JHA⁷² and 2008/616/JHA⁷³ on cross-border cooperation may also be relevant, regarding provisions for conducting automated cross-border searching of vehicle registration data via EUCARIS software, although this Directive is oriented to more serious crime.

⁶⁹ www.eucaris.net.

⁷⁰ Directive 2011/82/EU of the European Parliament and of the Council of 25 October 2011 facilitating the cross-border exchange of information on road safety related traffic offences. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32011L0082:EN:NOT>.

⁷¹ Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL simplifying the transfer of motor vehicles registered in another Member State within the Single Market; COM(2012)0164 final. Retrieved from <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012PC0164:EN:NOT>.

⁷² Council Decision 2008/615/JHA of 23 June 2008 on the stepping up of cross-border cooperation, particularly in combating terrorism and cross-border crime. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008D0615:EN:NOT>.

⁷³ Council Decision 2008/616/JHA of 23 June 2008 on the implementation of Decision 2008/615/JHA on the stepping up of cross-border cooperation, particularly in combating terrorism and cross-border crime. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008D0616:EN:NOT>.

6.4 Central (EU) Database and Website

A central database and website for LEZ in Europe should have two key goals:

- To inform potential LEZ users in order to help them plan their road transport. This would be particularly beneficial for citizens and businesses who use road transport to move people or goods long distances;
- To provide a platform for public authorities (at city, national and European level) to share information and best practises about access restriction schemes;
- To provide reliable (open access) data free for use by private organisations like providers of travel information systems etc.

It should therefore:

- Contain up-to-date information;
- Enable drivers and business managers to easily determine whether their vehicles can gain access to the scheme (e.g. determining emissions standards), and find out what steps are necessary to gain access (e.g. retrofits, payment);
- Be useful to travellers during their journeys (the website should be usable on smartphones and tablets, and there may be a role for smartphone apps);
- Be useful to travellers from different countries (it should be translated into all official EU languages); and
- Link to national and local websites.

There is an existing website <http://www.lowemissionzones.eu/> provided by the Low Emission Zone in Europe Network (LEEZEN) project. This is a good resource and provides an updated single source of information on LEZs in Europe. The European Commission is committed to its continued development. DG-MOVE recently published an invitation to tender with a view to “implement and maintain a comprehensive Europe-wide information resource, publicly available, providing updated information on existing and planned urban vehicle access restriction schemes (ARS, including LEZs), in the form of a single window.” to combine information on LEZs with that on other ARS.

The website will initially include:

- A comprehensive, user-friendly and regularly updated website of urban access restriction schemes, including a database of such schemes;
- Access to web-based payment or registration for access restriction schemes;
- Background and supporting information on access restriction schemes;
- Information on cities and towns that have implemented an access restriction scheme;
- Information on cities and towns that have decided not to implement an access restriction scheme;
- General and specific information regarding the evaluation and effectiveness of access restriction schemes, including guidance/reference documents for a standardized European low emission zone;
- Information on how to meet emission standards;
- Updated list of all retrofits certified in EU;
- Full information on access restriction schemes in EU, with a harmonized, user-friendly format with easily-navigable links to further information;
- List of all access restriction schemes with their emission standards and dates, listed by, scheme type, country/city or by date;
- General background information on access restriction schemes;
- Information on the evolution of access restriction schemes over time;
- Categorisation of different types of access restriction scheme;
- Background on EU air quality limit values;

- Links to other relevant information sources.

6.5 National information services

A national information service should share similar goals as to the central EU information system. It should be kept up to date and There must be no contradictory information on national or contain information consistent with that presented at the EU and local levels.

However, the services will have a different focus from the central EU system. The national information services should provide more detailed information on:

- national, as well as EU, air quality policy and national air quality limits;
- national, as well as EU, policy, initiatives and projects;
- sharing of information between public authorities on best practise within one nation;
- regional sharing of information between neighbouring countries in the EU (e.g. INTERREG).

Information on planned LEZ's should be available 6 month's prior to implementation.

6.6 Local information services

The requirements outlined in 6.4 also apply to local information services. However, the services will have a different focus from the national information services, providing more detailed information on:

- regional and local policy and initiatives;
- current or forecast air quality;
- LEZ monitoring information;
- sharing of information between public authorities on best practise within one city or urban area.

Information on planned LEZ's should be available 6 month's prior to implementation.

A number of existing LEZ have high quality web sites, including:

- London <http://www.tfl.gov.uk/roadusers/lez/default.aspx>;
- Berlin http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/en/luftreinhalteplan/umweltzone_allgemeines.shtml;
- Copenhagen http://www.miljozone.dk/vognmand_english.php.

6.7 Common language and translation

The central EU information system should be translated into all official EU languages.

Resource limitations will probably prevent national systems being translated into all official EU languages. Where nations are multi-lingual, the information systems should provide information in all the languages that are used. It would be beneficial if these systems also supported languages used in neighbouring EU countries.

6.8 e-Reporting

A key requirement of any information system for LEZ throughout Europe would be to provide up-to-date information for the public and businesses. A central e-reporting system would enable the easy updating of all key information regarding an LEZ by the city and the automatic update of the associated national and central information systems. The minimum information required for an LEZ would include:

- Vehicle standards permitted;
- Dates and times operational;
- Geographical extent;
- Exemptions;
- Payment & penalties;
- Contact details, web links etc.

6.9 System Requirements

Table 6.1 shows a summary of the requirements of central, national and information systems with recommendations for minimum requirements and suggestions for more advanced systems.

Table 6.1 Requirements for central, national & local information systems

| | Central | | National | | Local | |
|--|---------|----------|----------|----------|-------|----------|
| | Basic | Advanced | Basic | Advanced | Basic | Advanced |
| Website | x | | x | | x | |
| Basic information for each LEZ including: | | | | | | |
| • Extent | | | | | | |
| • Hours of operation | | | | | | |
| • Access criteria | x | | x | | x | |
| • Exemptions | | | | | | |
| • Payment options | | | | | | |
| • Penalties & Enforcement | | | | | | |
| Info on retrofit options | x | | x | | x | |
| Map of LEZs | | x | | x | | x |
| Info on EU policy, AQ limit values etc. | x | | x | | | |
| Info on national policy, AQ standards | | | x | | x | |
| Info on local policy & AQ initiatives | | | | | x | |
| Info on alternative transport options/routes | | x | | x | | x |
| Air quality information/data | | | | x | | x |
| Feasibility/monitoring reports | | | | | x | |
| Links to central/national/local websites | x | | x | | x | |
| Online payment/registration | | x | | x | | x |
| Smart-phone enabled website | | x | | x | | x |
| Information for cities setting up LEZ e.g. guidelines, examples of best practice | x | | x | | | |
| Translation | x | | | x | | x |
| Smart-phone apps | | x | | x | | x |
| online payment/registration | | x | | x | | x |

| | Central | | National | | Local | |
|---|---------|----------|----------|----------|-------|----------|
| | Basic | Advanced | Basic | Advanced | Basic | Advanced |
| GPS-enabled | | x | | x | | x |
| Current or air quality forecasting | | x | | x | | x |
| Other systems | | x | | x | | X |
| Integration into other apps e.g. Google maps, GPS, satnav | | x | | x | | x |

6.10 References

- Call for tenders N° MOVE/DDG1/C/1-2012-403-1, Directorate-General for Mobility and Transport <http://ec.europa.eu/transport/facts-fundings/tenders/doc/specifications/2013/s138-239089-specifications.pdf>.

7 Assessment and Monitoring

7.1 Introduction

This chapter deals with the assessment and monitoring of the effects of a Low Emission Zone. Assessment of the effects of a Low Emission Zone is typically done in order to collect information for the decision on setting up a Low Emission Zone and how it should be defined. It is done before the LEZ is introduced ("ex ante"). The purpose of an ex ante assessment is to identify the relevant information to enable a well informed decision on installing a LEZ. Such an assessment ideally comprises all relevant aspects that are being affected by the introduction of the LEZ.

Monitoring is carried out once a Low Emission Zone has been set up. The aim of the monitoring exercise is to get information on the actual effects of the LEZ and to assess whether changes in the setup of the LEZ are needed to improve the results. Also the monitoring ideally comprises all relevant aspects as selected for the ex ante assessment.

Assessment

There are various ways of carrying out an assessment. An **impact assessment** is a broad assessment in which all relevant effects for various stakeholders are being listed. These impacts are usually grouped by stakeholder, enabling an overview of the main advantages and disadvantages of the LEZ per stakeholder. An impact assessment can be carried out before a decision is taken, as a basis for that decision. In that case it is called an ex ante impact assessment.

In the EU countries strategic environmental impact assessment (SEA) should be done for significant planning documents that are related to the agriculture, forestry, fisheries, energy, industry, transport, waste/ water management, telecommunications, tourism, town & country planning or land use and which set the framework for future development consent of projects listed in the EIA Directive. The SEA Directive (2001/42/EC) defines the framework for environmental impact assessment and is in force since 2001 and should have been transposed by EU member states until July 2004.

A second way of assessing the relevant impacts is by carrying out a **cost benefit analysis** (CBA). A CBA is more restricted than an ex ante impact assessment, as it only takes into account those effects that have a net impact on total welfare of society, measured in monetary terms (i.e. euro's). One of the characteristics of the CBA is that positive and negative effects for various groups may be taken together. In such a case the fact that some groups may suffer (while others win) may not be reflected in the CBA. A second characteristics is that those effects which are important but are difficult to quantify may be taken into account in qualitative terms.

In identifying the net effect on welfare of society and comparing this with the costs to society, the CBA gives insight in whether or not the measure increases welfare of the city (or is cost efficient).

In this respect a CBA is different from a **cost effectiveness analysis**. In a cost effectiveness analysis the costs to realise a certain goal (i.e. a reduction in NOx concentration by 10%) are being assessed. In this a way a cost per % reduction can be calculated. But, as the benefit of the reduction is not translated in monetary terms, it is not possible to assess whether the value of the reduction is larger than the costs to be made to realise the reduction.

Monitoring

Once a decision has been taken on introduction of an LEZ, monitoring of the effects can help to assess whether the anticipated and desired effects indeed take place. For this purpose a monitoring system needs to be set up that provides the necessary information. The system may concentrate on the effects on mobility and air quality only, but may also include other effects, such as on safety, vehicle park, emission of greenhouse gases, etc.

The data should be collected for LEZ and bounding areas. Situation and changes outside LEZ borders should be analysed too.

7.2 Tiers of Assessment

Introduction

As described elsewhere in these guidelines, there are various possibilities for the design of a LEZ, ranging from a relatively simple system, e.g. based on Euro norms and with on street enforcement only, to a LEZ which is more elaborate, e.g. time based, for which fees have to be paid and enforced with electronic means. Likewise, also in the assessment and monitoring there is a choice to be made. A city can go for a “basic” assessment and monitoring or a more elaborate (“golden standard”) in both assessment and monitoring. Both in a basic assessment as well as in a more elaborate assessment it is essential to distinguish LEZ impacts from other impacts, like increase of e-commerce (more deliveries with small pick-up trucks vehicles), economic circumstances etc.

Basic level of assessment and monitoring

The basic level of assessment and monitoring is restricted to the information level that a city administration needs to decide on the introduction of a LEZ. The final decision on the information profile needed is, of course, with the administration, but some guideline can be given on the minimum information for decision making.

The key aspects of a LEZ are related to traffic and air quality. Information will be needed on these aspects in the situation without the LEZ, but also on the situation with the LEZ. This implies that the following information will be required for the “without LEZ” and the “with LEZ” situation:

- Air quality in the city and in particular in the area for which a LEZ is contemplated;
- The level of traffic per vehicle type in the city and in the zone;
- Fleet composition in the city and the zone;
- The emission characteristics of the traffic (in relation to the number and type of vehicles).

In order to assess the situation with the LEZ ideally a modelling exercise will be needed for which the city’s own traffic model could be used. If such a model is not available, a more general model may be used, or a comparable analytical framework. The model exercise needs to give an indication of the effect of the LEZ on:

- Changes to the level and composition of traffic, both inside and outside the LEZ;
- Changes in vehicle fleet composition (Euro classes) by number plate recognition;
- The possible effects on the routing and flow of traffic;
- Possible effects on the emission of substances which are detrimental to air quality and modelling of impacts to air quality.

Such aspects would also be part of the monitoring of effects of the LEZ. Ideally this monitoring, also in the basic situation, is based on actual counts of vehicles (by emission characteristics) at various points in the city network (both within and outside the LEZ) and on actual measurements of air quality.

Elaborate level of assessment and monitoring

A “golden” standard in assessment and monitoring would be to comprise more indicators, and perhaps a more elaborate/specific traffic model and a more elaborate network of measuring points (both for traffic and air quality). Moreover, it would include also additional aspects, such as:

- Cost of operating a LEZ (excluding enforcement);
- Cost of enforcement of the LEZs;
- The costs for deliveries to shops and other businesses inside the LEZ;
- Revenues from entry fees;
- Use of public transport and P+R;
- Other effects on environment, such as emission of greenhouse gases, noise pollution;
- Accidents.

Also in the case of the “golden” standard, the indicators that are part of decision to introduce a LEZ need also be included in the monitoring system. In this way the monitoring can help to identify whether the anticipated effects of the LEZ indeed take place.

7.3 Evaluation Framework

An evaluation framework will help to assess the effects, both for an ex ante assessment and for monitoring during its implementation. This sections suggest such a framework. The framework exists of impacts and the reasoning for such impacts and proposes indicators to be used to assess the impacts. The various impacts are grouped by stakeholder.

In a basic evaluation framework it is suggested that the city concentrates on measuring the main direct impacts of an LEZ for the main groups of stakeholders, i.e. city’s government, its population, its visitors and the transport sector servicing the city:

- For a city government the decision to start a LEZ will have implications for its budget. This relates to the investment and operation of the LEZ, including the enforcement. The information can also be used as input in the assessment of the costs of the LEZ;
- The main objective of a LEZ is to improve the air quality of the city. The impact on the air quality is thus a major element in these benefits. The impact can be assessed by monitoring the air quality at certain points in the city, and by dispersion modelling based on information about changes in traffic, vehicle fleet, emissions etc. Dispersion modelling can isolate the impact of the LEZ. In order to have a precise actual measurement of the impact, the choice of measuring points can be crucial. It is a technical challenge to isolate the impact of the LEZ in analysis of air quality measurements before and after the implementation of LEZ as many other parameter change e.g. meteorology, traffic, background concentrations, less emission due to natural turnover of the vehicle fleet. An integrated monitoring approach relying on air quality measurements and dispersion modelling is suggested;
- A main result of an LEZ may be that visitors to the city and suppliers of goods to businesses in the city have to invest in new technology. In case of investments by logistic service providers there may be an impact on their charges for the supply of goods to businesses. This impact is an important element in the primary sector to be affected by an LEZ. Any change in transport charges may affect the business community of the city and may therefore also have an impact on the attractiveness of the city for such sectors. Both for an assessment of the benefits of the LEZ, as well as for monitoring purposes these transport charges are thus valuable information.

Table 7.1 Basic evaluation framework

| Stakeholder | Impact | Indicator |
|---|-------------------|---|
| City government | Expenses | One off investment costs. |
| | | Annual operating costs, including enforcement. |
| Inhabitants, visitors of a city | Air quality | Traffic and vehicle fleet; Modelled emissions; Modelled and measured concentration of e.g. NO _x , NO ₂ , PM _{2.5} , PM10, etc. at various locations in the city. |
| Transport operators, logistics services providers | Operational costs | Investment needs for vehicle park, operational costs of the freight vehicles. |

A more extended evaluation framework also includes a more extensive range of impacts, as well as more indirect impacts to various stakeholders.

In those cases where a LEZ has a charging system for vehicles entering the zone, it will be interesting for the city's government to monitor whether the revenues fully cover operating costs of the LEZ.

For the city's inhabitants and visitors a LEZ may not only affect their mobility, but it may also have an impact on the traffic flows related to the LEZ area, as well as those outside the LEZ. Because, due to the LEZ traffic flows may be diverted to other routes, which may become more congested. This could be a possible negative impact of a LEZ.

A second impact of the LEZ for inhabitants and visitors may be that the LEZ stimulates the change towards cleaner technology. Such a change can be monitored by surveying the composition of the vehicle park in the city (both of inhabitants and visitors). Changes in the composition of the park may illustrate whether the LEZ is realising its goals.

An indirect effect of a LEZ may be that transport charges for movements into the zone increase, due to the use of newer technology and/or due to the fees that need to be paid for entering the LEZ. This may affect the competitive position of business in the city centre. Besides the measurement of such impacts at the logistics providers, this possible impact can also be measured with the business community, i.e. the receivers of these supplies.

Table 7.2 Extended evaluation framework

| Stakeholder | Impact | Indicator |
|---------------------------------|-------------|---|
| City government | Expenses | One off investment costs. |
| | | Annual operating costs, including enforcement. |
| | Revenues | Income from user fees. |
| Inhabitants, visitors of a city | Air quality | Traffic and vehicle fleet; Modelled emissions; Modelled and measured concentration of e.g. NO _x , NO ₂ , PM _{2.5} , PM10, etc. at various locations in the city. |

| Stakeholder | Impact | Indicator |
|--|-----------------------------|---|
| | Vehicle park | Percentage of vehicles entering the city that complies with LEZ conditions. |
| | Traffic congestion | Travel speeds in certain corridors within the and into the city. |
| | Alternative modes | Use of PT, P~R, Bike. |
| Businesses in the city | Ease and cost of deliveries | Transport costs for supplies. |
| Transport operators, logistics services providers. | Operational costs. | Investment needs for vehicle park, operational costs of the freight vehicles. |
| | | Annual costs for entering LEZ. |

7.4 Minimum Data Requirements

The previous section suggested a minimum and an extended set of impacts and associated indicators.

For a meaningful ex ante assessment of a LEZ, a minimum set of impacts is needed. This would include at least the impacts on air quality and the impact on the city's budget. The impact on air quality is difficult to assess directly, but can be derived from air quality measurements and dispersion modelling.

The air quality impact is the most important immediate impact to be expected. There are, however, also costs involved. Such costs are with the city government that needs to invest in the LEZ and needs to operate it, as well as with the vehicle owners, be it private persons or companies.

7.5 Air Quality and Climate

7.5.1 Introduction

A useful tool for assessing whether a LEZ will be an effective way for improving air quality is an environmental impact assessment. These can be carried out at varying levels of detail to quantify the likely impacts of a range of options, for example setting different vehicle standards or geographical extents in order to aid decision making and build public support.

Two types of assessment can be carried out:

- An assessment of the impact of an LEZ on emissions CO₂ and other greenhouse gases can be carried out through the compilation of an atmospheric emissions inventory;
- An assessment of the impact of a LEZ on ambient concentrations of pollutants, including NO₂ and particulates, can be carried out through dispersion modelling.

7.5.2 Emissions Inventories

The first stage in an environmental impact assessment is to compile an atmospheric emissions inventory. This involves the identification and quantification of all sources of key pollutants to air for any scenarios to be considered: for example a current inventory and future with and without LEZ scenarios. The quality of any further assessment of air quality and health will directly depend on the scope and quality of the emissions inventory.

The pollutants covered by an emissions inventory are determined by its use. The minimum requirement for assessing the impact of an LEZ will be emissions of nitrogen oxides and particulate matter, as the policy focus of LEZs is usually the meeting of EU air quality Limit Values for NO₂ and PM₁₀. Apportionment of particulate matter into PM_{2.5} and Black Carbon provides additional information for assessing the impact of the LEZ in meeting EU Limit and Target Values for PM_{2.5} and for more detailed health impact assessments. Air quality and greenhouse gas emissions can be compiled in the same inventory or in parallel due to commonalities in the activity data.

The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM) Air Pollution Implementation Pilot (Nagl & Schenk, 2013) and deliverables from the EU funded CiteAir II project (Davison et al, 2011) provide recent guidance on the compilation of atmospheric emissions inventories. The synergies between inventories for air quality and climate change, and the benefits of integrated inventories for policy making are discussed in detail in both of these guidance documents.

Under the obligations of the Covenant of Mayors (<http://www.covenantofmayors.eu/>) many cities may have compiled climate change emissions inventories as part of a Sustainable Energy Action Plan (SEAP). Where air quality emissions inventories are not available, data collected under SEAPs will provide a starting point for their compilation. In general, emission inventories providing source data for air quality modelling require higher spatial resolution emissions data, such as traffic data on a road-by-road basis, compared to climate change inventories which will focus on total emissions by sector. Guidance by the FAIRMODE community (Denby, 2011) provides details on emission inventory requirements for dispersion modelling.

Usually the geographical extent of emissions inventories are determined by municipal boundaries to allow integration with other policy assessment and strategic planning such as SEAPs and transport planning. In some instances, such as regional LEZ, a larger inventory geographical extent will be required, however the inventory must allow for the extraction of emissions data on a municipality level. For example, the spatial assignment of emissions in the London Atmospheric Emissions Inventory (LAEI) (TfL, 2013), allows emissions for each of the 33 London Boroughs making up Greater London to be extracted from the inventory.

Assessing the impact of LEZ requires particular consideration of traffic emissions. Attention should be paid to obtaining:

1. Detailed data on the existing fleet composition;
2. Information on how the fleet will change after implementation of the LEZ;
3. Information on how traffic levels will change outside the LEZ;
4. Representative emission factors.

1. Detailed data on the existing fleet composition

A LEZ will accelerate the uptake of newer technology vehicles, therefore an important factor determining the precision of an ex-ante assessment will be the accuracy of the existing fleet in baseline emissions inventories.

Typically the EIA will include the compilation of an emissions inventory for a recent year to be used for the verification of dispersion modelling and at least two future year scenarios: with and without the LEZ. The consideration of additional future years would provide information on how the effect of the LEZ changes over time.

The fleet data for the future year scenario without the LEZ will be based on existing fleet composition and projections of vehicle renewal rates without the intervention of an LEZ. The fleet

composition data required include details of vehicle types: by engine size; weight; fuel used, including alternative technologies; Euro emissions standard category; and the retrofitting of emission reduction technologies.

For most European countries, data for existing fleets and future year projections will be available from top-down sources. Examples include country specific fleet data compiled for the COPERT 4⁷⁴ road transport emissions tool and fleet composition produced by national government, such as the National Atmospheric Emissions Inventory (NAEI, 2012) produced on behalf of the UK Department for Environment and Rural Affairs (Defra).

To account for the variation in a local fleet, it is recommended that national or regional fleet averages are complemented by bottom-up fleet data. Local data for the public transport fleet should be considered a minimum requirement, whereas a more detailed study may also include local data for private vehicles.

Public transport fleet composition will be affected by local government policies and / or agreements with bus operators regarding minimum emissions standards. These data are likely to be readily available to local authorities through fleet monitoring programmes associated with the policies or agreements.

Private vehicle fleets may also vary, across the city as a whole and spatially across the city, due to factors such as its economic activity and affluence compared to national averages. These data can be collected effectively through electronic systems such as Automatic Number Plate Recognition (ANPR) which can be used both as a method for enforcement of an LEZ, once the scheme is operational, and as a source of provide valuable information on the types of vehicles entering the LEZ area, prior to implementation. ANPR is used in a number of cities including London (Kelly et al, 2011) and in Copenhagen for ex ante and ex post evaluation of the LEZ (Jensen et al, 2011).

2. Information on how the fleet will change after implementation of the LEZ

Projections of fleet changes due to the implementation of an LEZ need to account for the LEZ standard to be implemented, compliance rates and any exemptions to the scheme. The LEZ fleet projections can be calculated based on informed assumptions from previous studies and / or detailed traffic modelling.

An LEZ scheme will improve the fleet both inside and outside the LEZ, however the fleet changes within the LEZ may be greater than outside, as owners of non-compliant vehicles may avoid driving in LEZ rather than retrofitting or renewing their vehicle.

3. Information on how traffic levels will change outside the LEZ

If owners of non-compliant vehicles avoid the LEZ rather than retrofitting or renewing their vehicles it may increase traffic levels outside the LEZ and decrease levels inside the LEZ. Any changes can be predicted using detailed traffic modelling.

4. Representative emission factors

Frequently used emission factor datasets for Europe include the Handbook of Emission Factors for Road Transport (INFRAS 2010) and COPERT 4 (Katsis et al, 2012). It is recommended that the latest versions of these emission factor datasets are used.

Recent changes to these datasets have attempted to address issues with differences between emission rates in real-world driving conditions compared with emission limit values. It is likely these

⁷⁴ <http://www.emisia.com/copert/General.html>.

emission factor datasets will be revised further, as new research becomes available regarding emissions from real-world driving conditions. This is especially important for newer vehicles and alternative fuels / technologies, where the current emission factors are based on a small sample of vehicle tests.

As emissions standards for vehicles are tightened and exhaust emissions reduce, particulate emissions from brake, tyre and road wear, as well as resuspension, are making up an increasing proportion of total particulate concentrations in urban areas. LEZs are likely to result in a decrease in exhaust emissions due to improved vehicle standards and also a possible reduction in traffic levels, but the impact on non-exhaust emissions will be smaller, resulting only from the reduction in traffic levels. It is therefore important that these non-exhaust sources are included in the LEZ assessment.

The proportion of NO_x emitted as NO_2 (primary NO_2) from vehicle exhausts varies depending on the fuel used and the engine technology. The compilation of emissions inventories for LEZ assessment should include both NO_x and NO_2 emissions to account for the variation primary NO_2 due to changes in vehicle technology of the fleet.

Road NO_2 emissions can be calculated globally, by applying a single primary NO_2 factor representative of the whole fleet, however, detailed dispersion modelling studies would be improved by using road-by-road primary NO_2 emissions which account for differences in the traffic flow breakdown.

7.5.3 Dispersion Modelling

To assess the impact of an LEZ on air quality concentrations requires dispersion modelling. This modelling should be complemented by appropriate air quality monitoring, for verification of the model set-up and on-going assessment of the scheme after implementation.

The characteristics of dispersion models and their suitability for different types of modelling are discussed in detail in guidance by the FAIRMODE community (Denby, 2011). An impact assessment of an LEZ will involve modelling of an urban area, focussing on the air quality impact of changes to road emissions, therefore a suitable dispersion model must be capable of modelling on urban scale with detailed treatment of both open and street canyon roads.

Based on the FAIRMODE guidance both Gaussian (including Gaussian/Lagrangian models for large urban areas) and Lagrangian particle models are suitable for an LEZ assessment. Dispersion modelling requires the following inputs:

1. Spatially resolved emissions data;
2. Temporal variation in emissions data;
3. Meteorological data; and
4. Background concentrations.

Model output will assess the impact of the LEZ on meeting air quality standards at discrete receptor points, such as the location of air quality monitoring, and across an urban area. For more detailed assessments source apportionment modelling can be carried out. Modelling should include urban background and street levels as street level has higher impacts compared to urban background level (roof top level, parks, backyard etc.).

1. Spatially resolved in emissions data

The emissions data inputs for dispersion modelling will be derived from the compiled emissions inventory. As described in the previous section, the spatial resolution of the emission inventory should take account its use for dispersion modelling.

The road sources should include street canyon data. Where possible this information should be included in the emission inventory compilation, to ensure that source data parameters remain consistent through various stages of modelling.

2. Temporal variation in emissions data

The inclusion of temporal variations in emissions in dispersion modelling is especially important for road traffic sources, where there is significant diurnal variation in traffic flow. Many dispersion models allow the input of diurnal profiles for different days of the week e.g. weekdays, Saturday and Sunday, as well as monthly variation in traffic flows.

It is recommended that at least diurnal variation in traffic flows should be accounted for in the temporal variation of road transport emissions. These profiles can be derived from automatic traffic count data. More detailed diurnal profiles can be generated by accounting for the variation in speed and vehicle breakdown throughout the day.

In some cities it may be necessary to account for monthly variation in emissions, such as lower domestic heating emissions and traffic flows during the summer. Some models also allow hour-by-hour emission profiles to be entered for a whole year; this option maybe useful for roads where detailed automatic count data are available, but should be used with care as such detailed historic data are unlikely to be completely applicable to future scenarios.

3. Meteorological data

The dispersion calculations in air quality models are driven by meteorological data inputs. For urban scale modelling either diagnostic or prognostic meteorological models are generally used (Denby 2011), based on the input of observational data. Meteorological pre-processors are also used, where the observational data do not include the parameters required for dispersion modelling.

These models will calculate wind fields and turbulence parameters for dispersion modelling, taking into account the characteristics of the modelling area and terrain where appropriate. Examples of these are given in the FAIRMODE guidance. For example, the ADMS-Urban dispersion model (CERC, date) includes an in-built meteorological pre-processor, developed by the UK Met Office, and a diagnostic wind field model, FLOWSTAR, that accounts for the effects of surface terrain and land use across a modelling area to generate 3D wind fields for dispersion modelling.

Observational meteorological data must be representative of conditions of the wider area; therefore the meteorological site should be free from obstacles such as buildings that will affect wind flow. Rooftop measurements in urban areas, should be made well above the roof top to avoid the influence of obstacles in an urban environment. Observations from nearby non-urban areas are more commonly used, as the meteorological pre-processors in most dispersion models allow for extrapolation of meteorological data from a non-urban to an urban environment by taking account for the differences in land use and atmospheric stability i.e. the urban heat island effect.

SYNOPTIC meteorological observations should be used for dispersion modelling. Statistical meteorological data are not recommended, as output from dispersion modelling using these data cannot be directly compared to short-term air quality standards.

A minimum one year of meteorological data should be used for the LEZ assessment. Multiple years of data should be used where variation in meteorology needs to be investigated. Where multiple years of data are used, each year should be modelled separately to show inter-year variations.

4. Background concentrations

Background concentrations are required in the modelling to account for concentrations from outside of the modelled urban area. Sources of background concentrations include monitoring sites from outside the modelled area or output from regional models.

Background concentrations are also important for the calculation of NO₂ concentrations, for dispersion models that include photochemical NO_x chemistry models. FAIRMODE guidance (Denby 2011) recommends photochemical models above statistical or empirical models for NO_x chemistry, because statistical or empirical models are based on site-specific relationships therefore only relevant for the areas they were developed for and are only suitable for calculating annual mean concentrations. In addition, for the assessment of an LEZ, a statistical or empirical chemistry model may not capture the impact of changes in primary NO₂ emissions due to LEZ fleet changes.

A photochemical model for NO_x chemistry requires background concentrations NO_x, NO₂, O₃ and VOCs whereas a simple photochemical model only requires background concentrations of NO_x, NO₂, and O₃. For modelling particulate matter, as well as background concentrations of PM₁₀ and PM_{2.5}, some models may also require SO₂ concentrations where the chemistry module includes calculations for sulphate formation.

Model output

Before dispersion modelling of LEZ scenarios, model verification for a recent year should be carried out. Model verification involves comparing modelled concentrations against monitored concentrations at the location of air quality monitoring sites, comparing agreement for annual statistics and hour-by-hour concentrations. Tools such as the MyAir model evaluation toolkit (Stidworthy, 2013), produced as part of the EU 7th Framework project PASODOBLE, provide standardised methods for assessing the performance of an air quality model.

After the model set-up has been verified, future year scenarios with and without an LEZ can be modelled. Dispersion models provide specified point output, for pollutant concentration predictions at locations such as an air quality monitor, and for grid of output points for the production of pollution maps for a city.

For a detailed modelling study, source apportionment modelling can be carried out to provide further understanding of a proposed LEZ. Typically a source apportionment study will provide a breakdown of the contribution of different vehicle types to total pollutant concentrations at locations across a city, providing information on the extent to which the policy will affect concentrations at pollution hot-spots.

7.5.4 Recommendations

The table below summarises types of air quality and climate assessments into three levels of complexity: Basic; Intermediate; and Advanced. A Basic assessment is a simple assessment of emissions only; an Intermediate study will include assessment of emissions and concentrations through dispersion modelling; and an advanced assessment includes more detailed air quality modelling elements.

Table 7.3 types of air quality and climate assessments

| | Basic | Intermediate | Advanced |
|---|-------------------------------------|---|---|
| Emissions Inventory | ✓ | ✓ | ✓ |
| Pollutants – Air quality | NO _x PM ₁₀ | NO _x , NO ₂ , PM ₁₀ , PM _{2.5} | NO _x , NO ₂ PM ₁₀ , PM _{2.5} , PM ₁ , BC |
| Pollutants – Greenhouse gas | CO ₂ | CO ₂ , CH ₄ , N ₂ O | CO ₂ , CH ₄ , N ₂ O HFC, PFC, SF ₆ |
| Emissions – Totals by sector | ✓ | ✓ | ✓ |
| Emissions – Major roads on road-by-road basis | | ✓ | ✓ |
| Road transport fleet data – national projections | ✓ | ✓ | |
| Road transport fleet data – local data for public transport | | ✓ | ✓ |
| Road transport fleet data – local data for private vehicles | | ✓ | ✓ |
| Road transport emission factors – European / national datasets | ✓ | ✓ | ✓ |
| Road transport emission factors – Local real-world driving emissions | | | ✓ |
| Road transport emission factors – non-exhaust particles | ✓ | ✓ | ✓ |
| Road transport emission factors – primary NO ₂ proportion | | One value for all roads | Road-by-road values |
| Air Quality Modelling | | ✓ | ✓ |
| Temporal data – basis diurnal profile(s) | | Traffic flow data | Traffic flow Speed Vehicle type |
| Temporal data – monthly / seasonal profile(s) | | (Domestic emissions) | Traffic data Domestic emissions |
| Meteorology – data & models | | Observations with met pre-processor | Observations with met pre-processor & diagnostic or prognostic model |
| Meteorology – number of years of data | | One | Multiple |
| Model output – model verification | | ✓ | ✓ |
| Model output – LEZ scenarios receptor points | | ✓ | ✓ |
| Model output – LEZ scenarios gridded output | | | ✓ |
| Model output – Source apportionment | | | ✓ |

7.6 Health

The ultimate aim of a LEZ is to improve the health of residents and visitors by improving air quality. Additional direct and indirect health effects can also occur, including due to changes in noise levels.

The impact of the LEZ on health can be quantified by carrying out a Health Impact Assessment either before the implementation of the LEZ and subsequently to monitor its effectiveness.

7.6.1 Air quality

The main health impact of an LEZ is likely to be due to a reduction in pollutant concentrations, particularly NO₂ and particulates from vehicle exhausts. Health impact assessments (HIA) can be carried out using concentration-response functions (CRF) that link pollutant concentrations to the number of health events which occur; CRF are expressed as a percentage change in the number of health events per unit change in pollutant concentration. Detailed guidelines and Excel spreadsheet tools for this approach are set out as part of the Aphekom project (Aphekom, 2011). The guidelines set out the following steps in carrying out an HIA:

1. Definition of a study period;
2. Definition of a study area;
3. Selection of air pollution indicators, collection of environmental data and assessment of the exposure to air pollution;
4. Selection of health outcomes and collection of health and population data;
5. Selection of CRFs;
6. HIA calculations, using a standardised methodology.

The guidance focuses on using air quality monitoring data as indicators, however the same approach can be taken using modelled concentrations as part of an air quality impact assessment; this has the advantage of enabling the estimation of health impacts prior to the implementation of the LEZ and also provides a more robust assessment of exposure, taking into account the spatial distribution of pollutants and population.

The guidance recommends the use of the following CRFs, set out in **Table 7.4**, which are assumed to be linear for smaller changes in concentrations.

Table 7.4 Concentration-response functions recommended by Aphekom

| Short-term impacts of PM ₁₀ | Ages | Relative risk per 10 µg/m ³ |
|--|-------|--|
| Non-external mortality | All | 1.006 |
| Respiratory hospitalisations | All | 1.0114 |
| Cardiac hospitalisations | All | 1.006 |
| Short-term impacts of ozone | | |
| Non-external mortality | All | 1.0031 |
| Respiratory hospitalisations 15-64 | 15-64 | 1.001 |
| Respiratory hospitalisations >= 65 | >=65 | 1.005 |
| Long-term impacts of PM _{2.5} | | |
| Total mortality | >30 | 1.06 |
| Cardiovascular mortality | >30 | 1.12 |

The guidance also describes how to use mortality data to estimate a gain in life expectancy.

Particulate composition

While the main indicators for urban air quality are concentrations of NO₂, PM₁₀ and PM_{2.5}, recent studies have investigated the health impacts of black carbon (WHO Europe 2012, Rohr & Wyzga, 2012) and have concluded that exhaust particulate emissions are more harmful to health than secondary particulates formed in the atmosphere; the World Health Organisation has recently classified diesel exhaust particulates as carcinogenic (WHO, 2012).

In the future, more advanced health impact assessments are likely to take into account the composition of particulate emissions, however at present there is no standard methodology for such assessments.

7.6.2 Noise

The effect of an LEZ on noise is likely to be less significant than the effect on air quality, however, where significant changes in traffic flows are expected, the resulting health effect can be quantified by carrying out a noise health impact assessment.

Guidelines for carrying out full-chain noise health impact assessments have been set out as part of the Heimtsa project (Heimtsa, 2011). The approach takes into account the effect of noise on annoyance, sleep disturbance and myocardial infarctions and calculates the impact in terms of disability-adjusted life years (DALYs) and health related costs in Euros. Additional useful information on health effects of noise can be found in EEA “Good practice guide on noise exposure and potential health effects”⁷⁵, which inter alia provides end users with practical and validated tools to calculate health impacts of noise in all kinds of strategic noise studies. In addition, the most significant studies and news, as well as legislation can be accessed through the EC noise webpage⁷⁶.

7.7 Mobility

The introduction of an LEZ might impact urban vehicle mobility both inside and outside the designated zone. One might expect that within the zone, the overall traffic volume to drop, especially in the short term. This could be due to a lower number of vehicles entering the zone, as certain types of vehicles will be restricted or banned because of environmental considerations. It has to be said though that in existing LEZ’s, especially in HDV-focused ones, hardly any impacts on traffic flows are found. This is evident for example in the German and the London LEZs (Barrat, 2013).

In the long term, ‘dirtier’ vehicles⁷⁷ will gradually be replaced by more environmentally-friendly types of vehicles and, as such, the overall traffic volume need not necessarily decrease. As the main goal of LEZ is to improve environmental and health parameters through restricting vehicle pollutant emissions, such a development (with overall increase of traffic volume) would not *per se* contradict this goal.

⁷⁵ Good practice guide on noise exposure and potential health effects. EEA, Technical Report No 11/2010.

⁷⁶ European Commission. Environment. Noise, available at <http://ec.europa.eu/environment/noise/>.

⁷⁷ This could also apply to two and three wheelers, for which also Euro classes are defined. Examples of LEZs where access criteria for two and three wheelers based on the Euro classification are defined are limited.

It is important to estimate possible impacts of the LEZ on mobility in the design phase. Given the uncertainty of impacts, it is also important to monitor changes and impacts on an on-going basis. Therefore it is important to develop robust intermediate indicators for assessing mobility and estimating emissions.

In a basic assessment the following indicators can be used to keep track of urban mobility changes:

- Number of vehicle-kilometres driven within the zone, disaggregated by vehicle types and road links. This would be a principal indicator of mobility allowing prediction (at the stage of design) and assessment (at the stage of implementation and evaluation) of the results of the LEZ introduction. Disaggregation into vehicle types (e.g. Euro standard categories) is especially important while having in mind that overall, only negligible traffic change has been observed in non-charging LEZs. When combined with information on the types of the vehicles and the relevant emission factors, this indicator would allow for an estimation of the lower pollutant emissions achieved due to reduced or restricted vehicle mobility. Disaggregation by road links allows better understanding of mobility trends and its changes. Such estimates of traffic intensity should ideally be provided separately for peak and off-peak hours in order to allow assessing congestion;
- Number of vehicles registered within the zone and the city, according to types and characteristics of vehicles. This indicator would provide specific information about the vehicles registered within the zone, both for residential and business use. The information provided for the purpose of car registration should be broad enough to distinguish types of the vehicles according, for example, to Euro standards, level of emissions, age etc.

In a more extended assessment also any shift away from private vehicle use to other public or non-polluting forms of transport should be assessed. Indicators here would include:

- Number of passengers and passenger-kilometres travelled using public transport⁷⁸. Introduction of LEZ may have impact on the intensity of public transport use. Therefore, this aspect should be monitored to provide a better picture of urban mobility changes;
- Number of bikes and bike-kilometres travelled. Similar as in case of public transport, introduction of LEZ may lead to shifting to alternative transport modes such as bikes. This aspect should also be monitored.

It can be noted that the first two indicators mentioned, i.e. the number of vehicle-kilometres driven within the zone and the number of vehicles register within the zone, are the most essential and should be included even in a basic impact assessment of LEZ.

It is advised that all the above indicators are calculated on an annual basis in order to allow for comparison and reduce the impact of daily and seasonal fluctuations. The traffic volume estimates may also be presented as average daily traffic estimates (with peak and off-peak traffic volumes during an average working day given a separate consideration in order to assess congestion).

The same set of indicators should be collected in the area outside the zone (in the whole city and/or region) in order to be able to assess the broader impacts of introduction of the LEZ. It may be expected that as the traffic volume especially in the segment of more heavily polluting vehicles within the LEZ decreases, a reverse trend might occur outside the zone. Collecting the indicators in a broader area would enable assessment of such effects.

⁷⁸ It is assumed here that public transport would benefit vis-à-vis private transport from the introduction of the LEZ.

7.8 Social

The possible social impacts of LEZ are intertwined with the environmental and economic impacts. For example, the main objective of LEZ being improvement of air quality within the zones impacts on health of the community affected. In turn, the level of health is not only one of the main components of the quality of life but it also affects, in various ways, the economy. For example, more healthy people live longer lives, they are more productive in their jobs and exhibit lower expenditures on health care. Hence, the term – social impacts – can cover a range of impacts⁷⁹. Therefore, in this section we will focus on those social aspects of LEZ which have not been discussed in other parts of the report that are related specifically to economic or environmental/health impacts. These remaining social effects include, but are not limited to, the following:

- Social acceptability of the scheme. Social acceptance will depend on the overall average perception of the scheme as being beneficial/desired or alternatively, as being a nuisance for the local community. Depending on the way the LEZ is designed, specific groups of the residents/businesses active within the zone will have to bear a varying burden of costs while the air quality benefits will accrue mostly and more or less equally to the residents of the zones. A key issue is that awareness of immediate costs may be greater than more long-term benefits;
- Special care should be taken of possible socio-economic regressiveness of the measures which would occur if lower income residents of the LEZ bear a relatively higher cost burden of the measures than more wealthy residents. They have relatively older cars and at the same more difficulties to bear the costs of retrofitting a vehicle or buying a new one because of more stringent environmental standards within the LEZ. The costs of fees/fines would also typically fall on vehicle users/owners;
- Low-income residents with older cars who can't afford to buy a newer one would also be more often "forced" to use public transport than more wealthy residents. Good quality public transport within LEZ should be available to those without access to a compliant vehicle;
- The above issue applies also to the business sector: small and less capital abundant companies might have to bear relatively higher cost burden related to compliance with LEZ (measured as a share of their sales than large businesses). In addition, the costs of retrofitting a vehicle or buying a new one because of more stringent environmental standards within the LEZ as well as the costs of fees/fines would typically fall on vehicle users/owners. Special mechanisms such as exemptions and transitional periods of implementation could be devised to improve social acceptability of the schemes;
- Furthermore, the economically disadvantaged often live in more polluted areas which makes them more prone to the negative health effects. All these factors should be taken into account in social assessment (being a part of a feasibility study);
- Necessity to include special measures for certain groups of the society such as persons with physical disabilities or others facing mobility problems (e.g. persons with temporary injuries, persons with babies and young children), or service providers operating emergency vehicles etc.;
- Employment effects. The potential impacts of LEZ on employment may indirectly result from the following pathways:
 - Increase in demand for new vehicles complying with more stringent environmental standards. This depends on the number of localities operating LEZs. The impact of one specific LEZ on the car industry is not expected to be significant. It is also not likely that increased demand for employees in the car manufacturing sector will affect local job market and therefore, this aspect is not of much interest for the local authorities;
 - Changes to the demand for services of the business sector within the zone. This aspect depends on the character of the zone and on the types of the businesses situated within the

⁷⁹ see also TfL (2011) Stricter emissions standards for central or inner London.

zone. For example, in an attractive tourist area, the introduction of an LEZ may result in the development of specific tourist-oriented services (cafés, souvenir shops). This might boost local employment in related sectors. In other circumstances, however, some businesses may decide to move their premises out from the LEZ because of less convenient business operations conditions, longer commuting time etc. This might contribute to shrinking of the local employment opportunities. This aspect has to be assessed case-by case.

- Quality of life aspects (other than health-related). Positive social effects of LEZ may include better integrity of the local community. These positive social effects would occur especially in the zones where LEZ requirements would lead to a significant drop of urban traffic intensity. Urban streets with busy traffic are known to cause a so-called 'barrier effect' (see Box 7.1). Introduction of very restrictive LEZ might diminish this negative social phenomena.

Box 7.1 The traffic barrier effect

The barrier effect undermines both the movement function and the social function of the pedestrian network. The nuisance due to intensive urban traffic provokes negative psychological effects such as stress, insecurity and discomfort. Children, disabled and elderly people are relatively more vulnerable and more threatened by the traffic. The barrier effect hinders the development of children's physical capability and social cognition. Parents often decide to accompany the children, particularly on the way to school, to lower the risk of accidents. Social networks in areas with heavy urban traffic are less dense than in the areas with less busy roads. Appleyard (1981) shows that residents of San Francisco streets with light volumes of traffic have three times as many local friends and twice as many acquaintance as those living along heavily travelled streets.

Source: Soguel, 1995.

It can be noted that negative impact of LEZ on business community prior to implementation is often overestimated. This was the case in the Netherlands and Germany. Prior to implementation the business community claimed that many firms would have to go out of business, many jobs would be lost etc. After implementation the business communities confirmed that there has been no measurable impact (Sadler Consultants, 2010). Better air quality, better safety, lower noise and complementary logistic measures often make the cities with implemented LEZ more attractive for business location, and for living, an effect which is difficult to quantify.

7.9 Cost-benefit Analysis⁸⁰

Cost-benefit analysis (CBA) is a way of assessing whether the total benefits of implementing LEZ exceed the total costs. CBA strives to quantify all the relevant costs and benefits in monetary terms, including those not captured by regular markets. All the costs and benefits which accrue during the predetermined course of the project lifetime are discounted so as to assure comparability of values occurring in different time periods. Summary indicators such as net present value (NPV) and benefits-to-costs ratio (B/C) allow policy makers to judge whether or not a given project proposal is economically efficient (i.e. beneficial to the affected society/community as a whole).

The basic steps of conducting CBA include the following considerations⁸¹:

1. Deciding which benefits and costs count (standing). In the case of LEZ, the analysis would typically be made from the point of view of the city or a broader region where LEZ is being planned. Defining the point of standing is important especially for projects implying financial transfers (e.g. fees). For example, while such transfers would be seen as neutral in case of

⁸⁰ See also to OPERA LIFE project which supports regional/local authorities in the definition, application and evaluation of air quality plans policies and cost-effective policy decision making. (<http://www.operatool.eu/html/eng/index.html>).

⁸¹ Based on Boardman, 1996.

adopting nationwide scope of analysis, in the case of city- or region-level analysis fee revenues from non-residents entering the zone would to be treated as financial inflows (benefits) and not as transfers;

2. Selecting the project options. Among many possible scheme designs, usually 2-3 alternatives are chosen for performing a full CBA. These might be, for example, scenarios for LEZs with and without fees, or scenarios with different Euro standards that are made mandatory or remain voluntary for all or certain vehicle types. An important element at this step is defining a business-as-usual scenario (BAU), which is the scenario where no LEZ is implemented. All other scenarios should be compared to the BAU in order to assess the overall impact of the LEZ;
3. Making an inventory of potential impacts. In the case of LEZs, the following impacts could be identified⁸²:
 - Avoided emissions of the specific pollutants;
 - Safety benefits due to avoided car accidents;
 - Noise reduction;
 - Investment costs for the city/region authorities;
 - Operating costs of the zones;
 - Fee revenues;
 - Retrofitting costs;
 - Costs of obligatory earlier replacement of old vehicles;
 - Time costs due to longer commuting time;
 - Time benefits due to less congestion.
4. Assessing quantitative impacts over the lifetime of the project. A key aspect of conducting a CBA is to set an appropriate project lifespan. For an LEZ CBA, one might choose a period of 10 years. This is the often used depreciation period of a car and it is the time which best reflects the useful lifetime of vehicles and system monitoring devices and IT for example. For more capital intensive projects (e.g. bridge construction) the lifespan would be longer. For each of the analysed scenarios, the impacts in the subsequent years after the LEZ implementation should be quantified. For example, if the scheme is being implemented gradually, avoided emissions will not be the same each year but will be increasing over time;
5. Monetising all the impacts. This stage of the CBA is the most challenging, especially in relation to some of the identified beneficial impacts. While the costs (both the investment and the operational costs) are usually pretty straightforward to estimate, monetising for instance the increased life longevity due to better air quality is often not free from controversy (e.g. on ethical or on methodological grounds) and cannot be performed with precision. In such instances the analysts would often use the statistical life value estimates such as VOLY (value of life year) or VPF (value of prevented fatality);
6. Discounting the values. The values attached to all the identified impacts in the subsequent years have to be expressed using a common time denominator, i.e. they have to be discounted so as to result in present value figures. The discounting factor recommended for a CBA of an LEZ scheme should be set 4%, which is consistent with the EC Impact Assessment guidelines⁸³;
7. Calculation of the CBA indicators. The principal CBA indicator is Net Present Value (NPV) which is a measure of total net benefits of the investment. This indicator is obtained simply by subtracting the present value of total costs from the present value of total benefits. A positive NPV means that the project is beneficial to the analysed community as a whole;
8. Assessment of the distribution effects. The general CBA indicators relate to the global impact of LEZ within the territorial scope as defined in point 1. There might be, however,

⁸² The list presents exemplary items and should not be treated as exhaustive. Some of the items listed may be not relevant for the particular LEZ designs.

⁸³ http://ec.europa.eu/governance/impact/commission_guidelines/commission_guidelines_en.htm.

certain stakeholders or community groups which could be specifically or disproportionately affected by certain impacts of LEZ. During the course of performing the CBA this aspect needs to be given appropriate attention;

9. Performing sensitivity and risk analysis. Sensitivity analysis is a way of dealing with uncertainty related both to the volume of physical impacts and to their valuation. At this stage, the analysts adopt varying assumptions related to the selected indicators. Varying discount rate is one of the indicators typically adopted for performing sensitivity analysis. Other varying assumptions may relate for instance to the value of statistical life or to the predicted decrease in vehicle-kilometres driven;
10. Recommending the best project alternative. The analysis of the scenarios and the calculated indicators should indicate the most beneficial alternative for implementation of the LEZ. Alternatively, if the present value of costs exceeds the present value of benefits in all the defined scenarios, the conclusion would be that implementing the given LEZ would not be worthwhile.

It should be noted that while CBA is a useful tool for assessing the economic efficiency of various investments and for comparing specifically defined scenarios of these investments, it should not be treated as the only decision-making rule. There might be other important considerations that are impossible to monetise but which nevertheless constitute important driving forces for the decision about implementation of LEZ.

Practical guidance on designing LEZ has been prepared by the British Department for Environment, Food and Rural Affairs – see DEFRA (2009).

LEZ may not necessarily provide the most cost-effective solution to local air quality problems. EU co-funded project Opera (within the EU-LIFE program) provides an evaluation tool for local authorities which can be useful in choosing optimal emission reduction measures to improve air quality at minimum costs⁸⁴.

7.10 Performance monitoring and evaluation

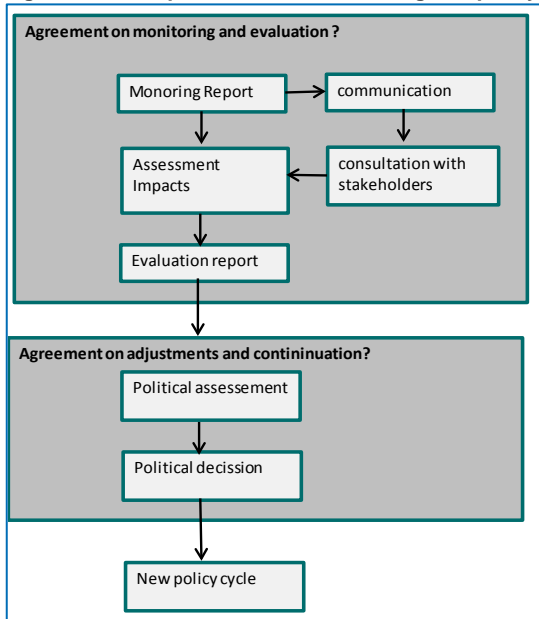
In the previous paragraphs it is described which impacts can or should be assessed (ex ante and ex post) and monitored and on which indicators data can be collected.

For this a performance monitoring and evaluation programme has to be drafted and agreed on (including planning and budget) for:

- evaluation monitoring and reporting to stakeholders;
- assessment of the effectiveness in environmental terms and (social) cost / benefit ratio, and revise the scheme if needed given the monitoring results.

⁸⁴ <http://www.operatool.eu/html/eng/tool.html>.

Figure 7.1 Example evaluation monitoring and policy cycle in the Netherlands



The monitoring and evaluation mechanisms should be defined early and integrated in the planning process.

The steps in drafting and implementing monitoring and evaluation program are.

7.10.1 Define SMART objectives

Most of the times the decision to introduce LEZ will be grounded in multiple objectives, where the primary notion behind the objective will be the improvement of air quality (thus the term – low emission zone), yet it can also have impact on other objectives, like decrease of traffic volume in highly congested areas:

- **Specific** – set the specific aspect or area that has to be assessed and/or improved;

First one should decide on the level of assessment and the specific aspects to be assessed. If one choose for a basic assessment level, expenses for the city, air quality and intermediate traffic and fleet aspects, as well as operational costs for transport operators, logistics services providers are the minimal aspects to be monitored. If one choose for an extended assessment including social, economic, health and noise the aspects should be extended accordingly.

- **Measurable** – propose indicators for measuring the progress;

For each of the selected aspects measurable indicators have to be defined. Monitoring of the LEZ needs to be done very carefully, monitoring and modelling, source apportionment, comparing areas also should be used. Indicators like PM10, PM2.5, black smoke, PM1, particulate number should also be assessed where possible. Fleet and mobility as in intermediate indicators are essential in monitoring and assessment, since that's what LEZ are affecting. One should limit the number of indicators to the most essential ones to avoid information overload, or a monitoring program that is too time consuming and costly.

- **Attainable** – state the results that can realistically be achieved within given period of time and available resources;

- **Relevant** – the objectives must not be based on external factors, but be relevant in a given situation;
- **Time-related** — set the timeframe for achievement of the objectives.

Attainable, relevant and time related objectives can be set when the base line data have been collected and analysed, for example in the ex ante assessment.

7.10.2 Draft a monitoring work plan

Once the SMART objectives have been defined a work plan should be drafted. For each indicator the related tool for data collection has to be defined. It is advised to estimate the budget needed for data collection (including modelling) and reserve the needed budget and time for this. Then the responsibilities regarding the collection of data for the indicators has to be assigned, as well the planning of the data collection and monitor reports.

Monitoring and evaluation is advised at regular intervals, at least at the end of each implementation phase, and at the halfway point for long phases: this option will apply in most cases. A yearly monitoring and evaluation is advised, at least on the basic indicators regarding air quality and the intermediate aspects traffic and vehicle characteristics.

In order to create transparency it's important to inform the stakeholders about the progress and consult them about the monitoring results.

Publishing monitoring and evaluation reports, for example on a website for example, is an important means of ensuring transparency⁸⁵.

Table 7.5 Example monitoring scheme (indicators, tools, responsible institutions, budget, targets)

| indicator | monitoring tool | responsible | budget | current value | target value |
|--|--|----------------------------------|--------|---------------|--------------|
| Emission and related mobility indicators | | | | | |
| Concentration of NOx, NO2, PM10, PM2.5 at various locations in the city | air quality emissions inventories | environmental department | | | |
| | air quality modelling | transport and traffic department | | | |
| Number of vehicles registered within the zone and the urban area, according to types and characteristics of vehicles | national vehicle database (not always available) | transport and traffic department | | | |
| Number of vehicle-kilometres driven within the zone, disaggregated by vehicle types and road links | traffic survey (camera's) | transport and traffic department | | | |
| Percentage of vehicles entering the city that complies with and without LEZ conditions | traffic survey (camera's) | transport and traffic department | | | |
| Travel speeds in certain corridors within and into the city | automatic traffic counters | transport and traffic department | | | |

⁸⁵ • Ademe, French Environment and Energy Management Agency, Monitoring & evaluating climate change adaptation at local and regional levels.

| indicator | monitoring tool | responsible | budget | current value | target value |
|--|---|----------------------------------|--------|---------------|--------------|
| | real time traffic speed data (TomTom, Nokia platform for example) | transport and traffic department | | | |
| Operational indicators | | | | | |
| Annual operating costs, including enforcement | LEZ administration | environmental department | | | |
| Income from user fees | LEZ administration | environmental department | | | |
| Transport costs for supplies | Survey | environmental department | | | |
| Investment needs for vehicle park, operational costs of the freight vehicles | Survey | environmental department | | | |

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P.O. Box 4175
3006 AD Rotterdam
The Netherlands

Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com
W www.ecorys.nl



Avenue Reine Astrid 92
1310 La Hulpe
Belgium

T +32 (0) 2 655 22 30
F +32 (0) 2 655 22 80
W www.mwhglobal.com

P.O. Box 4175
3006 AD Rotterdam
The Netherlands

Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com

W www.ecorys.nl

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