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Success stories within the road transport sector on reducing greenhouse gas emission and producing ancillary benefits

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Acknowledgements

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The EEA project manager was Jan Karlsson.

Summary

The European Climate Change Programme (ECCP 1) was launched in 2000 and followed by ECCP 2 in autumn 2005. A number of separate working groups were formed to address different issues under these programmes, one of which was a transport sub-group. In its final report this group concluded that 'there are a number of solid measures taken across different EU Member States (MS) which are not necessarily part of all MS's transportation policies, indicating that significant work needs to be done in identifying and promoting best experiences and practices on a MS level'. The EEA therefore commissioned the Transport Research Laboratory (TRL) to undertake a study identifying and reporting on 'success stories' in the road transport sector.

Using reduction of greenhouse gases and additional ancillary benefits as criteria to determine success, TRL undertook an extensive review of case studies from across the EEA member countries by going through more than 10 different data bases. This initial review identified very few good examples of post-implementation evaluation reports, including results on carbon dioxide (CO_2) emission reductions.

Despite these difficulties, TRL found some information in the reports of the effect that the implementation of measures had had on greenhouse gas emission reduction. However, the aims of measures implemented in these cases were primarily to achieve local objectives rather than specifically GHG emission reductions.

The final choice of case studies was, in addition to the criteria on reduction of greenhouse gas emissions and ancillary benefits, intended to cover different types of measures. The size of the project limited the total number of 'success stories' identified and reported upon in this study to a total of 6. They represent various levels of implementation (national, local/city level, and organisation/business); a range of target groups (private, public and freight), types of measure (planning, regulatory, economic and information); and types of impact (environmentally friendly vehicles, transport efficiency, mode shift and urban planning). The schemes and their key results in terms of CO_2 emission reductions are summarised below:

- Ecodrive programme, Netherlands: In 2004 ecodriving resulted in a reduction in CO_2 emission of between 97 000 and 222 000 tonnes. Although the programme has the potential to have a positive effect on the reduction of greenhouse gas emission, it is expected that further driver training and promotion of the programme will be needed to maintain reduced fuel consumption. To instil the ecodriving principles at an early stage, they should be incorporated in new driver tests.

- Speed control measure, Rotterdam: This measure has proved successful in reducing emissions in a targeted area (a 3.5 kilometre stretch of motorway) by reducing and strictly enforcing speed limits. Here, CO_2 was reduced by 15 % (a saving of approximately 1 000 tonnes) in the first year of scheme operation. However, more widespread controls on speed are required to achieve CO_2 emission reduction on a larger scale;

- Congestion charging, London: The congestion charging scheme in London has been successful in terms of discouraging private car use in favour of public transport, cycling and walking. As a result, scheme implementation achieved a reduction of 16.4 % in CO_2 emission in 2003 compared to the previous year (prior to scheme implementation). Similar schemes have been successfully implemented in other cities for example in Stockholm, Oslo and Trondheim. For the two latter cities the main purpose of the scheme was to raise revenues.

- Environmental zone, Prague: The environmental zone in Prague has been successful in reducing emissions from heavy vehicles entering the city centre area through weight restrictions (estimated reductions of 1 650 tonnes CO_2 per year). The measure has encouraged the use of more suitable routes for heavy vehicles, the purchasing/upgrading of fleets to comply with more stringent emission standards or application for permits to enter the city. Environmental zones, or low-emission zones/clear zones, have been implemented in a range of European cities. Sweden was one of the early adopters and implemented low-emission zones, primarily aimed at heavy vehicles, in Stockholm, Malmö and Gothenburg. As in Prague, the zones were enforced through a permit system with manual inspection. At the moment, schemes are being considered in Berlin and London.

- Freight Construction Consolidation Centre, London: The Freight Consolidation Centre has been successful in minimising the number of larger or half-empty freight vehicles servicing construction centres in the London area by consolidating deliveries and using the 'just-in-time' delivery principle. Compared to the trips that would have previously been made, it is estimated that CO_2 emission has been reduced by 75 %. Similar freight consolidation centres have been implemented extensively throughout Europe, including in Germany, Spain, Sweden, the Netherlands, France and the United Kingdom.

- Teleconferencing, the United Kingdom: The use of teleconferencing enabled British Telecom to reduce the impact of its business-related travel, both within the United Kingdom and internationally. For 2006 it was calculated that the use of various teleconferencing technologies to replace trips led to a reduction in CO_2 emission of just under 100 000 tonnes. However, it is not expected that teleconferencing will replace all business travel within this company, and may not be suitable for other businesses where face-to-face meetings are a necessity.

This study identifies and explores a range of factors contributing to the success of measures. It further discusses factors affecting the transferability of measures to other EEA member countries and looks at the cost effectiveness of mitigations in the transport sector.

Although it was difficult to find projects that had been designed to achieve certain precise targets on greenhouse gas emission reduction, this small study has indicated that it may be possible to achieve such reductions in a cost-efficient way and at the same time achieve ancillary benefits. This report also includes some general recommendations and observations:

- implementation of accompanying measures is often necessary to achieve full benefit from the projects. These supporting measures may be in the form of additional or alternative public transport services, increases in parking restrictions or prices, access restrictions for certain types of vehicles, introduction of other fees and taxes, and awareness campaigns;

- strong leadership or strong political acceptance is necessary especially for measures that initially seem controversial, particularly if they result in travel restriction;

- awareness-raising about the potential benefits when implementing measures are crucial. Awareness raising may be targeted at the public, various media — including printed and television campaigns, the private sector, transport operators, retail, government departments and other stakeholders;

- many factors can affect the success of measures, for example differences in geography, population density, cultural aspects and affluence (ECCP 2006). Key issues that should be taken into consideration when considering the possibilities of transfer to other cities, regions or countries include the geographic scale, technological and resource requirements, potential legislation, awareness and acceptance issues and operating features.

1 Introduction

1.1 Background

The transport sector contributes to a variety of environmental problems, including poor air quality, noise and habitat fragmentation. Even if improvements can be achieved in some of these areas, we are far from seeing a solid and consistent development towards an environmentally sustainable transport system.

Perhaps the most serious and difficult problem is climate change. In most countries and in the European Union (EU) as a whole, the transport sector is responsible for the greatest increase in greenhouse gas emissions. It is therefore crucial to find solutions to significantly decrease emissions from this sector in order to meet short-term and long-term climate change targets. All modes of transport have to be addressed, but above all the main contributors — road transport and aviation. Consequently, the transport sector is and will be of high priority on environmental agendas, including that of the EEA.

The EU Council has proposed that developed countries should commit to cutting their emissions by an average of 30 % from 1990 levels by 2020. If no such agreement is reached, the EU is making a commitment to reduce its emissions by at least 20 %. A proposed legislation on those targets was presented by the European Commission was presented 23 January 2008.

A first phase of the European Climate Change Programme (ECCP-1) was launched in 2000 followed by a second phase — ECCP-2 — launched in autumn 2005. The results of working groups under ECCP-2, presented in spring 2006, addressed a range of issues directly or indirectly linked to transport.

One working group was especially evaluating ECCP-1, including a separate transport sub group. Its final report contained significant observations and proposals, For instance, to achieve the necessary emission reductions, cost-effective action in the transport area needs to:

- evaluate the degree to which savings can be achieved from different policies;
- combine the most suitable tools to act on appropriate aspects of the transport chain in a coordinated way; and
- develop synergies to the maximum extent — demand, mobility, modal choice, vehicle efficiency, efficiency of vehicle use, carbon intensity of the energy used, but also synergies with other policies tackling air quality, congestion, etc.

The working group also compiled a list of specific needs and recommendations. The draft report can be found at http://forum.europa.eu.int/Public/irc/env/eccp_2/library?l=/eccp_transport_measures/eccp_transport_ekdoc/_EN_1.0_&a=d.

The final report concludes that 'there are a number of solid measures taken across different MS which are not necessarily part of all MS's transportation policies, indicating that significant work needs to be done in identifying and promoting best experiences and practices on a MS level'.

The EEA has decided to take initial steps towards raising awareness about existing good practice focusing on the road transport sector by presenting a range of success stories consisting of measures and policy instruments that have demonstrated a potential to reduce emission of greenhouse gases. However, the EEA acknowledges that the instruments presented here are not key in tackling the problem, and that there is a need to identify and implement initiatives that may achieve more in terms of greenhouse gas emission reductions. Environmental studies tend to focus on one environmental issue at a time and because transport causes a number of serious environmental problems, the identification of ancillary environmental benefits has also been an important consideration for this study.

This technical report aims to identify projects carried out at a local, national or international level that have successfully reduced greenhouse gas emission and generated ancillary environmental benefits.

By providing an overview of some of the instruments that could be promoted to improve the environmental situation within the transport sector, this report also aims to encourage the implementation of similar actions in other countries, regions and cities.

It is important to bear in mind that measures discussed in the case studies presented, whilst making a valuable contribution, will not on their own be enough to achieve the necessary greenhouse gas emission reductions required to tackle the climate change problem. Thus identification and use of further measures and policy instruments are required.

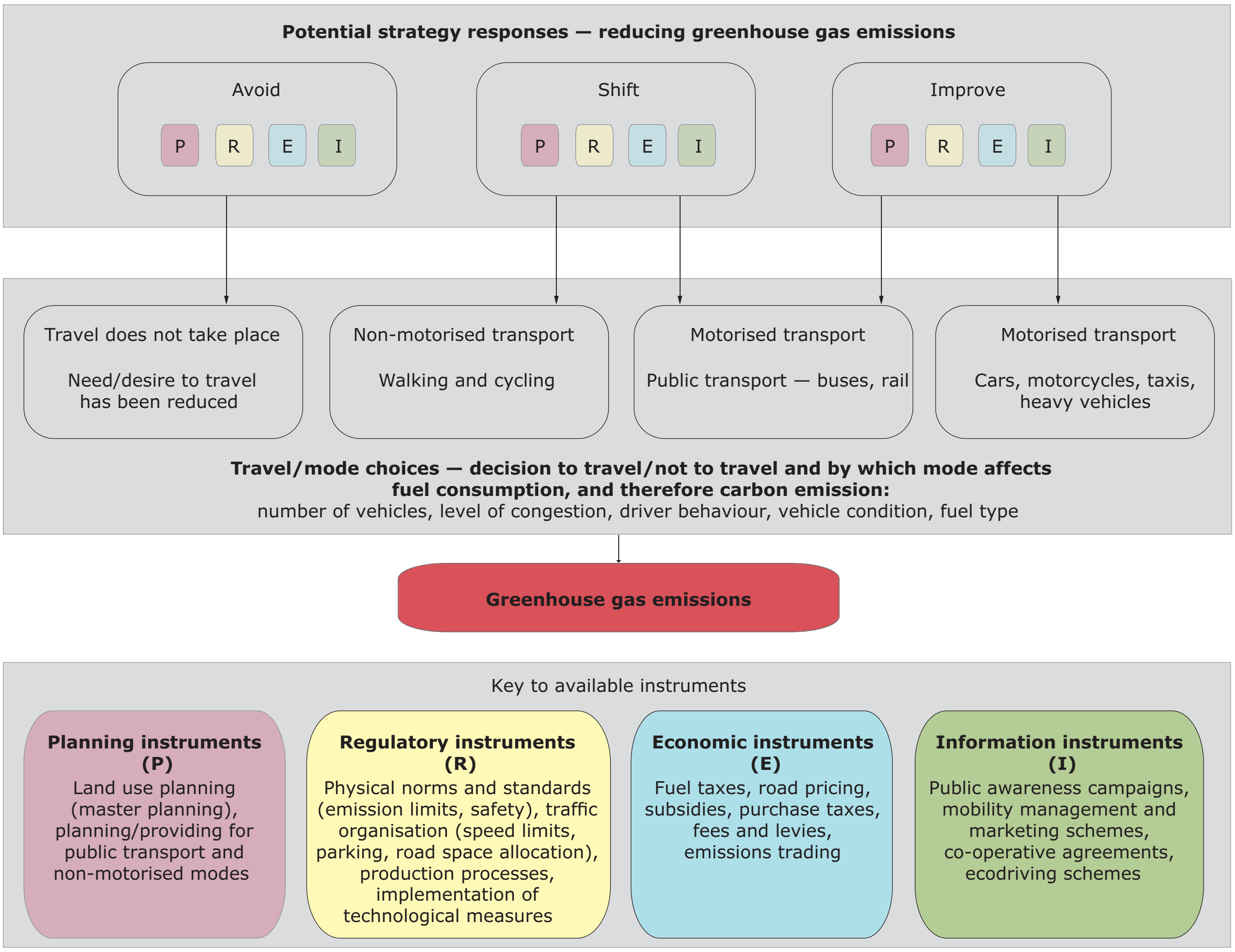
Key requirements of the report are to:

- briefly describe the important measures used to reduce emissions of greenhouse gases and achieve other environmental improvements, and indicate criteria for success stories;
- analyse the reasons for the success of the projects and, where possible compare with similar projects that did not succeed; and
- cover a range of measures that could be used in a large number of Member States. This includes measures that can be implemented whilst avoiding future problems, as well as measures that can be used to limit or eliminate problems that already exist.

Figure 1 illustrates a range of policy instruments that can be used to implement measures that reduce greenhouse gas emission and alleviate other environmental problems. The responses to those instruments include:

- avoid (travel or travel by motorised modes);
- shift (to more environmentally friendly modes); and

Figure 1 Sustainable transport instruments and their impact on greenhouse gas emission



Source: Brannigan and Dalkmann, 2007.

- improve (energy efficiency and technology of vehicles).

The key at the bottom of Figure 1 describes four key groups of policy instruments: planning, regulatory, economic and information, which can play an important part in reducing greenhouse gas emissions from transport and achieving other ancillary benefits.

Although it is acknowledged that there is a wide range of existing examples where those instruments have been used, resources available for this report have only allowed for analysis of a limited number. In addition, a template has been developed that can be used by EEA member countries to report on other successful case studies.

In this report we have tried to follow the above principles when analysing the different case studies.

1.2 Context in an EU perspective

This report does not aim to analyse the full potential for greenhouse gas emission from road transport. More extensive studies and additional instruments, including modelling, would be required to achieve that. Such studies have previously been carried out by the Commission linked to different legal proposals in the transport and environmental field. Furthermore the EEA publishes an annual report — *Greenhouse gas emission trends and projections in Europe*. The latest report (EEA, 2007) shows that greenhouse gas emission from the transport sector within the EU are projected to grow by approximately 26 % (or 209 Mt CO_2-equivalent) between 1990 and 2010. To change this trend and to assist in meeting the long-term targets discussed in Section 1.1, a variety of measures must be implemented and a number of policy instruments used.

This report is a vehicle for the dissemination of knowledge about some successful projects that have been or are about to be implemented in EU Member States. These success stories may then duplicated in other countries to bring about the widespread implementation of small-scale projects necessary to significantly reduce greenhouse gas emissions within the transport sector.

2 Methodology and measure selection

Prior to examining success stories in reducing greenhouse gas emission from the road transport sector, it was necessary to develop a method to select relevant measures, which is presented in more detail in this chapter.

2.1 Selection criteria

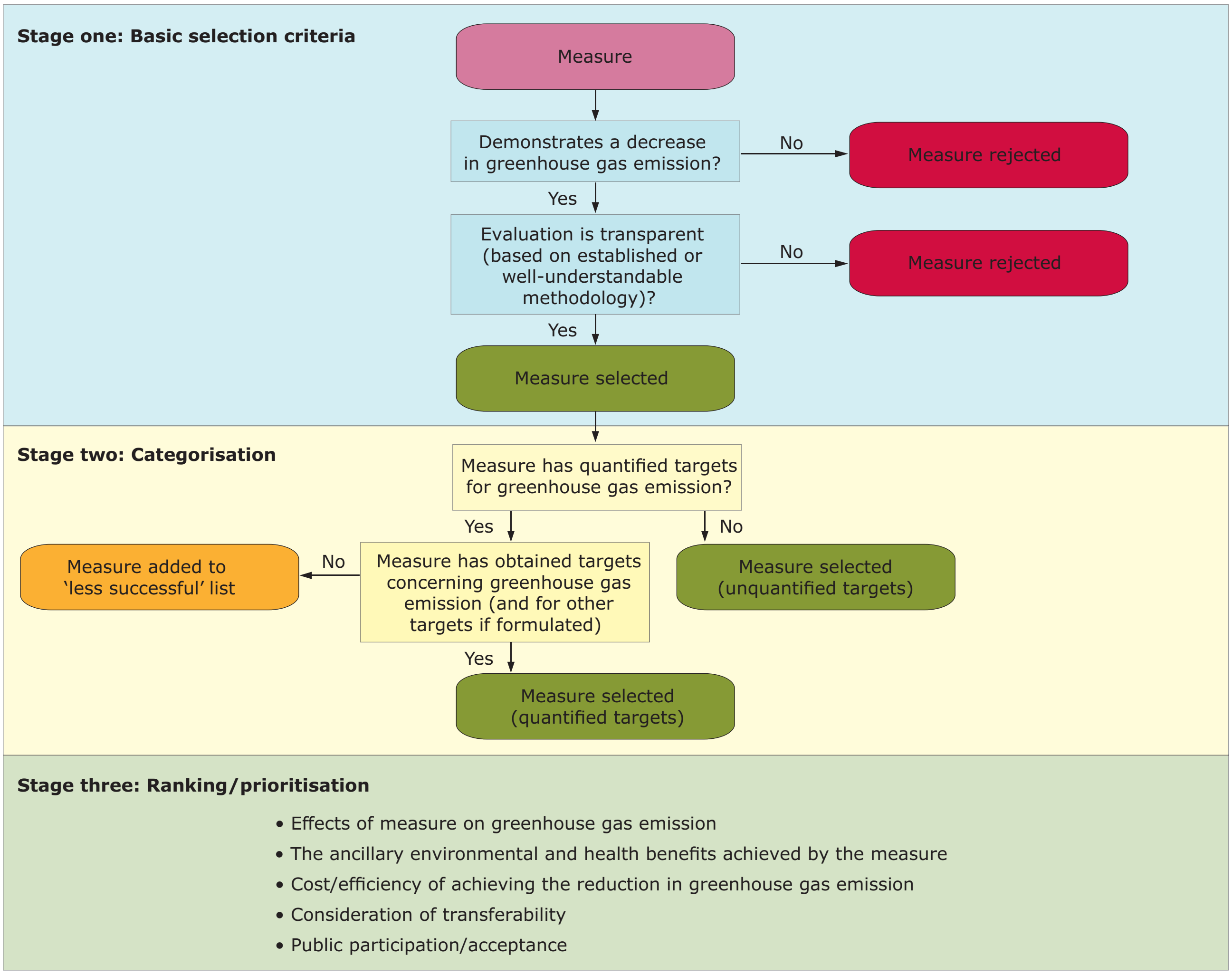
The first task involved developing criteria to aid the selection of measures to be included within the report. This comprised three stages: basic selection, categorisation of measures and ranking/prioritisation of measures (see Figure 2).

2.1.1 *Stage one: Basic selection*

Stage one of the selection criteria is related to the basic selection of measures. The key selection criteria were:

- Has the measure demonstrated a decrease in greenhouse gas emission?
- Is the evaluation of the measure transparent (i.e. is it based on methodology that is established or easy to understand)?

Figure 2 Measure selection criteria



By evaluating each of the identified measures against these criteria, a list was compiled of measures that potentially could be included in the report.

2.1.2 Stage two: Categorisation of measures

Stage two involved the categorisation of measures into 'successful' and 'less successful'. The criteria for this stage were:

- Does the measure have quantified targets for greenhouse gas emission?
- If the measure does not have any quantified targets regarding GHG emissions, it can be categorised as a 'successful measure (un-quantified targets)'. However, if quantified targets exist, then question 2 should also be answered:
- Has the measure achieved the targets set for greenhouse gas emissions (and for other targets if formulated)?

If the measure has been unsuccessful in achieving the quantified targets for GHG emissions (or others), it is categorised as a 'less successful measure'. However, if it is successful in achieving targets, it should be categorised as 'successful measure (quantified targets)'.

2.1.3 Stage three: Ranking/prioritising measures

Depending on the number of measures identified, it was agreed that ranking or prioritisation was needed to determine the final list of measures. Primary and secondary criteria were developed to aid this final selection. The primary priority group was:

- effects of measure on GHGs;
- the ancillary environmental and health benefits achieved by the measure;
- economic efficiency related to achieving the improvements concerning GHG emissions;
- consideration of transferability; and
- public participation/acceptance.

Annex A provides more detailed information on the measure selection criteria, including the full prioritisation criteria.

2.2 Measure selection

Existing European Community (EC) project databases were consulted to identify potential measures to test against the criteria for selection. Projects considered included CIVITAS I and II (SMILE, SUCCESS, CARAVEL, MOBILIS, VIVALDI, Trendsetter, TELLUS and MIRACLES), ELTIS, JUPITER, THERMIE, CUTE, CANTIQUE, MURE, TRANSPLUS, PROPOLIS, CITY FREIGHT, PROMPT and PROSPECTS amongst others (See Box 1 for an overview of projects). If available, other measure examples outside these projects were also considered.

It is acknowledged that Member States themselves may have important information on measures. However, due to the limitated size of this project, full consultation was not possible.

This initial review of projects yielded a long list of potential measures. These measures were assessed against the selection criteria outlined above (see also Annex A). During the selection process, a number of barriers were identified as listed below.

Availability of evaluation reports — there were many examples of implemented sustainable transport measures that achieved a reduction in traffic through mode shift or improvements in fuel efficiency. However, the assessment revealed a lack of evaluation reports or evidence relating to measures that demonstrated a decrease in greenhouse gas emission. The majority of existing evaluations were concerned primarily with local issues, such as air quality, noise or safety and no evaluation had been undertaken.

Transparency of evaluation — where evaluation reports were available, the methods used to calculate or report on reductions in greenhouse gas emission or other ancillary benefits demonstrated little transparency or explanation. It was therefore difficult to assess the robustness of results or identify assumptions that had been made.

Achievement of greenhouse gas emission reduction targets — the majority of measures identified had targets (quantified or otherwise) relating to local objectives (air quality, noise etc), rather than specific targets relating to the reduction of greenhouse gas emission. However, evaluations did provide limited information on the reductions in CO_2 emission achieved as a result of measure implementation. Therefore, none of the selected measures were specifically designed to meet greenhouse gas emission reduction targets, but nevertheless demonstrated reductions in subsequent evaluations. This has implications for assessing the 'success' of measures.

Geographical spread of measures — it was originally intended that the measures selected would represent a wide geographical spread within Europe. However, few examples of measures meeting the selection criteria could be found in eastern European countries. Therefore the selected measures are mainly from western European countries. Where possible, the transferability of measures to eastern Europe is discussed.

Range of measures — as discussed earlier, due to limited evaluation of existing measures and resources available for the report, the full range of sustainable transport measures available to Member States and their national/local administrations have not been covered. Ideally, further examples of good practice will be identified and explored in the future, leading to a wider-ranging suite of measures. Potential measures that require further investigation include land-use planning, technological advances and alternative fuel types, along with public transport service and infrastructure improvements.

Six measures were selected for inclusion within the report as shown in Table 1. All met the key criteria of achieving a reduction in greenhouse gas emission and displayed evidence of achieving ancillary benefits. The measures also represent various levels of implementation (national, local/ city level, organisation/business) as well as a range of target groups (passenger, public and freight); types of measure (planning, regulatory, economic or information) and types of impact (environmentally

Box 1 European transport projects

- CITIVAS — CIty-VITAlity-Sustainability http://www.civitas-initiative.org/cms_pages.phtml?id=348&lan=en
- ELTIS — European Local Transport Information Service http://www.eltis.org/Vorlage.phtml?sprache=en
- JUPITER — integrated measures
- THERMIE — demonstrating clean, efficient, cost-effective and environmentally friendly energy technologies
- CUTE — Clean Urban Transport for Europe http://www.fuel-cell-bus-club.com
- CANTIQUE — cost effectiveness of non technical measures to reduce emissions
- MURE — Measures d'Utilisation Rationelle de l'Energie — Identification and comparison of energy conservation measures carried out in the 15 EU Member States (1)
- TRANSPLUS — Transport Planning Land Use and Sustainability http://www.transplus.net/
- PROPOLIS — Planning and Research for Land Use and Transport for Increasing Urban Sustainability http://www.ltcon.fi/propolis
- CITY FREIGHT — Inter- and Intra-City Freight Distribution Networks
- PROMPT — New means to PROMote Pedestrian Traffic in cities http://prompt.vtt.fi/
- PROSPECTS — Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems

(1) 15-EU Member States refer to Member States of the European Union prior to the accession of ten candidate countries on 1 May 2004. EU-15 include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

friendly vehicles, transport efficiency, mode shift and urban planning).

The search for measures, as reflected in those selected for inclusion in this report, revealed that evaluations tend to centre on measures implemented at a local/city level, or within businesses or organisations. Only one of the measures selected has been implemented at the national level (the ecodrive programme in the Netherlands, Chapter 4).The majority of those implemented nationally which aim to reduce CO_2 emission have little or no evaluation and only forecast likely impacts on CO_2 emission.

2.3 Report preparation

The information on the selected measures is based on the literature identified at the measure selection stage, including journal articles, evaluation reports, measure websites and case study reports. Where possible, international experts were contacted for their input and TRL experts in the relevant fields were also consulted.

Table 1 Overview of selected case studies

Case study title	Level of implementation			Target group			Type of measure				Strategy impact			Priority Group 1 elements *				
																Ancillary environmental and health benefits		
	National implementation	Local/city implementation	Business/ organisation	Private	Public	Freight (road)	Planning	Regulatory	Economic	Information	Avoid	Shift	Improve	Effects on green-house gases	Cost efficiency	Noise/ vibration	Air quality	Safety
Ecodrive programme (Netherlands)	✓			✓		✓			✓	✓			✓	✓	✓			✓
Speed control (Rotterdam)		✓		✓	✓	✓		✓					✓	✓		✓	✓	✓
Congestion charging (London)		✓		✓		✓		✓	✓			✓		✓	✓	✓	✓	✓
Environmental zone (Prague)		✓				✓		✓					✓	✓		✓		✓
Freight Consolidation Centre (London)		✓	✓			✓	✓						✓	✓				
Teleconferencing (United Kingdom)			✓	✓				✓			✓			✓	✓			

Note: * Ancillary benefits identified in initial measure search.

3 Measures to reduce greenhouse gas emission from the transport sector: European Member States

Member States within Europe have already implemented a number of measures designed to contribute to reducing greenhouse gas emission from the transport sector on an EU-wide, national or local level.

The European Conference of Ministers of Transport (ECMT) recently published a database of nationally implemented measures and initiatives aimed at reducing greenhouse gas emission, which can be found at: http://www.cemt.org/topics/env/envdocs1.htm (see National Transport Sector Abatement Policies and Measures Database, October 2006). The database contains the following information:

- country;
- policy approach (fiscal, information, research etc.);
- name of measure;
- status (active, planned etc.);
- description;
- impact type (fuel efficiency, mode shift etc.);
- mode (car, bus, rail, freight etc.);
- sources, references;
- cost; and
- impact in 2010 (Mt CO_2-equivalent pa) (ECMT, 2006).

In addition, the EEA/ETC has compiled a database of policies and measures (PAM) that have been reported by Member States to the Commission or under the United Nations Framework Convention on Climate Change (UNFCC), see http://www.oeko.de/service/pam/index.php. This is a useful starting point for European Member States when considering potential measures to reduce greenhouse gas emission from the road transport sector.

The ECCP conducted a review with European Member States to identify measures and actions that Member States found successful in achieving reductions of CO_2 emission from the transport sector. These included:

- the establishment of a package of measures: fiscal, technical, administrative, awareness raising;
- combination of urban with transport planning;
- energy-saving agreements with transport operators;
- new service concepts (for example, mobility management, environmental procurement of transport services);
- shift to industries that are less transport intensive;
- technical optimisation;
- increase of diesel market share;
- higher share of smaller vehicles in current passenger car fleet; and
- fuel and vehicle taxation (ECCP, 2006).

There are also a wide variety of measures and policies currently being discussed that are designed to reduce CO_2 emission, which include the following issues:

- community strategy on CO_2 emission from passenger cars;
- environmentally enhanced vehicles;
- regulations on emission of CO_2 from light commercial vehicles (N1);
- Framework Directive infrastructure use and charging;
- shifting the balance of transport modes;
- fuel taxation;
- mobile air conditioning systems: HFCs; and

- mobile air conditioning systems: CO_2 (ECCP, 2006).

In terms of proposed strategies, short-term actions include focusing on the issues listed above as being most successful and effective at reducing CO_2 emission from the transport sector.

In the long term, Member States need to be aware of and take into consideration the following:

- societal changes, demand projections and potential technological advances that may affect travel;
- accessibility to goods and services, focusing on better integration of transport and other policy areas, including land use planning, health and education;
- the implications of new and improved infrastructure, bearing in mind that some infrastructure changes can cause increased volumes of traffic, whilst other improvements can aid smooth traffic flow and lead to reduced CO_2 emission;
- reducing or ensuring compliance with speed limits; and
- effective land use planning, with an emphasis on reducing the need to travel or encouraging the use of public transport (ECCP, 2006).

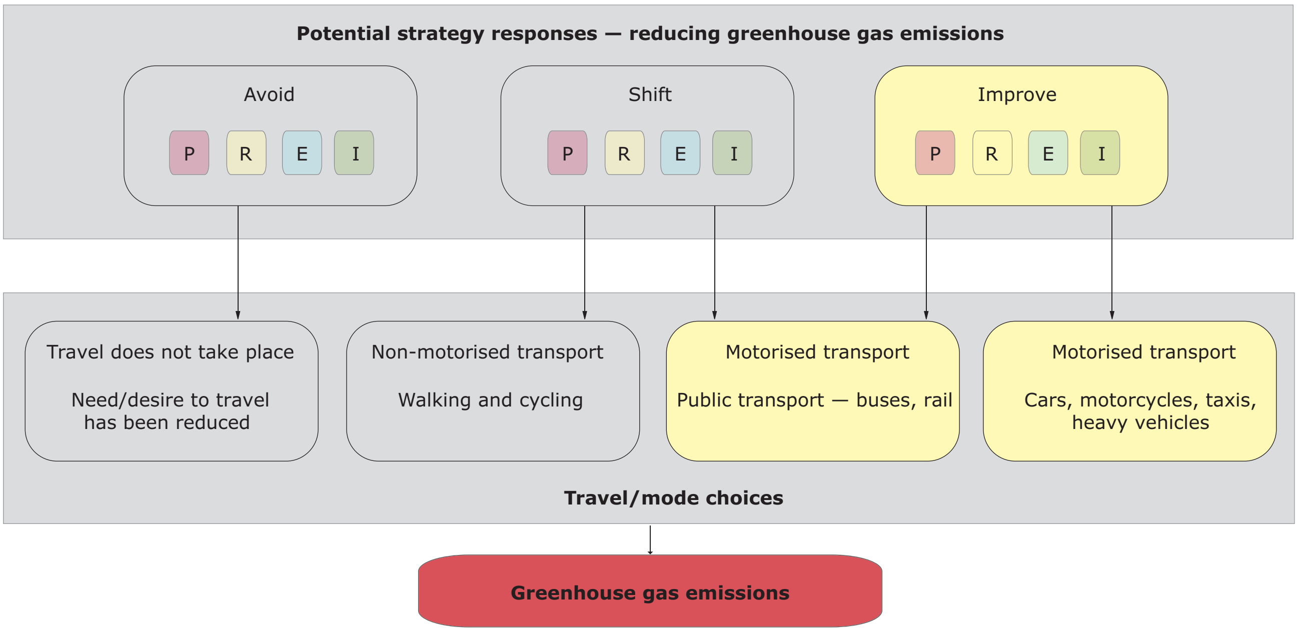
These sources provide a useful overview of the measures and instruments that may be valuable in the future in attempting to reduce greenhouse gas emission from the transport sector in Europe. However, only in time will the success of these measures and the extent to which they are able to reduce emission in a cost-effective manner be revealed.

4 Ecodrive programme — Netherlands

Case study	Ecodrive training
Implementation level	National [local/city, business/organisation]*
Target group	Private, freight — road (public)
Type of measure	Economic, Information
Strategy impact	Improve
Effectiveness of measure — key benefits	Increasing fuel efficiency, leading to reduced emissions
Greenhouse gas emission reduction	Total avoided emission of CO_2 in 2004 — 97 000 to 222 000 tonnes
Ancillary benefits	Economic gains (reduced fuel costs, maintenance costs); increased road safety; and reduced local emissions and noise

Note: * Elements in square brackets are not part of this example, but could relate to the measure when implemented elsewhere.

Figure 3 Netherlands — Ecodrive programme



4.1 Overview

The objective of the ecodrive programme implemented in the Netherlands is to 'stimulate individual drivers, professional chauffeurs and fleet owners in more energy-efficient purchase and driving behaviour, leading to a reduction in CO_2 emission' (van den Hoed *et al.*, 2006). Specific targets were to reduce CO_2 emission by:

- 0.8 Kt annually by 2010 (that is a 2.4 % reduction in emission as a result of road transport by 2010);
- 0.5 Kt for in-car devices and drive style changes; and
- 0.3 Kt via improved tyre pressures.

The Dutch National Climate Change Action Plan (1999) was developed to aid the achievement of targets set out in the Kyoto Protocol. The national-level ecodrive programme was listed as one of the measures that will contribute to reducing emissions. It is estimated that the ecodrive programme will contribute about 2 % of the target 6 % reduction (40 kt CO_2) by 2010.

The ecodrive programme addressed five key issues:

- **Driving school curriculum:** in order to reach new drivers, ecodrive principles have been integrated into the driving school curriculum and the driving theory test. Driving instructors have been trained in ecodriving.

- **Re-educating licensed drivers:** this includes subsided training for groups of professional drivers, the development of a drive simulator that can be used at conferences and workshops and an extensive media campaign on television, radio and the internet.

- **Fuel saving in-car devices:** to stimulate the purchase and use of in-car devices such as econometers and cruise control, the programme lobbied for and achieved tax incentives for the devices. The programme increased public awareness of the devices via campaigns and demonstration programmes.

- **Tyre pressures:** demonstrations, training, tyre checks and a publicity campaign to raise awareness of the need to check tyre pressures frequently.

- **Purchasing behaviour:** the programme hopes to stimulate the purchasing of more efficient vehicles through raising the awareness of ecodriving through the driving school curriculum, drive-style training and publicity campaigns (van den Hoed *et al*., 2006).

The ecodrive programme targets new and existing drivers, including professional drivers, individual drivers and fleet owners.

4.2 Responsibilities of key stakeholders in implementation

Senter Novem (Dutch Agency for Energy and the Environment) runs the ecodrive programme on behalf of the Dutch Ministry of Transport. Approximately 20 consumer and retail organisations are involved in the programme which, to be successful, is heavily reliant on collaboration with network partners. These companies from the transport and car business sector comprise most of the relevant stakeholders related to the automobile sector, including consumer organisations, environmental non-governmental organisations, trade organisations (for example for drivers, vehicle suppliers, entrepreneurs in mobility and logistics companies), tyre suppliers, oil companies, lease companies and driver training organisations (van den Hoed *et al.*, 2006).

Levels of involvement vary, for example some of the organisations simply endorse the programme while others actively organise training and raise awareness of the programme with their members (van den Hoed *et al*., 2006), but all have signed a voluntary agreement endorsing the ecodrive programme.

4.3 Effectiveness of the measure — key benefits

The programme has successfully led to increased fuel efficiency, and hence reduced emissions. For example, using higher gears is more fuel efficient compared to using lower gears for longer periods of driving — therefore by moving up the gears at lower speeds fuel consumption and hence CO_2 emission decreased.

The longer term impacts of this Ecodrive Programme are yet to be evaluated, including whether reduced fuel consumption was maintained by drivers in the longer term.

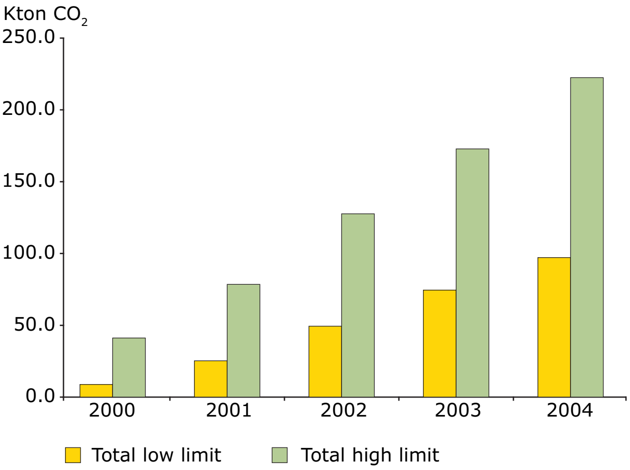
4.3.1 Greenhouse gas emission

Evaluation of the ecodrive programme has shown that it has resulted in a reduction in CO_2 emission (between 97 and 222 Kt in 2004), as shown in Figure 4.

The majority of CO_2 emission reductions can be attributed to the communication activities for existing drivers ([2]). In more recent years, the inclusion of ecodriving in the driving curriculum for new drivers is increasingly contributing to reduction in emissions. In-car devices have made the greatest and most sustained contribution to the CO_2 emission reductions. Estimates of the CO_2 emission avoidance

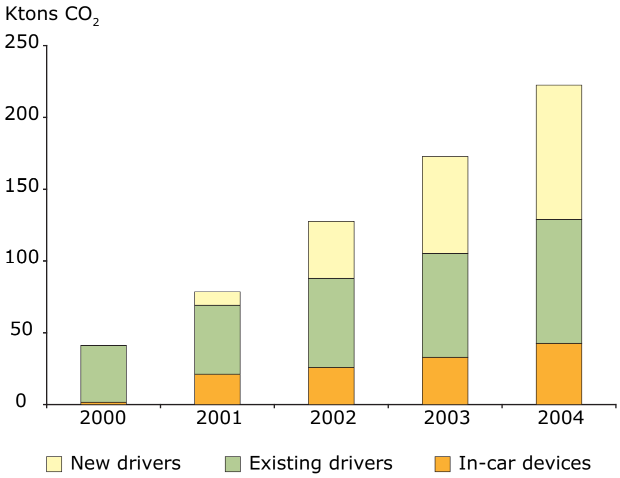
([2]) Targeting existing driver's licence holders and professional drivers through training of instructors in Ecodrive principles, subsidising training for groups of professional drivers, development of a drive simulator (for use in workshops, conferences etc.), and extensive media campaigns (television, radio, websites etc.).

Figure 4 Avoided emissions — upper/lower limits



Source: van den Hoed *et al.*, 2006.

Figure 5 Avoided emissions — high range



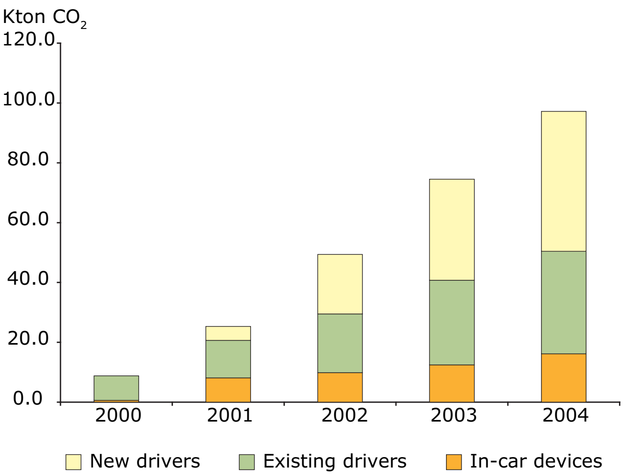
Source: van den Hoed *et al.*, 2006.

for each of the methods for both high and low assumption ranges are shown in Figures 5 and 6. The assumptions related to the low and high limits are displayed in Table 2.

4.3.2 Ancillary benefits

The primary objectives of the ecodrive programme were to reduce emission of CO_2. However, ancillary benefits were also identified as a result of programme implementation, including:

Figure 6 Avoided emissions — low range



Source: van den Hoed *et al.*, 2006.

- economic gains (reduced fuelling costs and maintenance costs);
- increased road safety; and
- reduction in local emissions and noise (van den Hoed *et al.*, 2006).

Quantitative evaluations were not available for the ancillary benefits listed.

4.3.3 Economic efficiency of measure

Objectives for cost efficiency of the ecodrive programme were set at EUR 9/tonne of CO_2. Assumptions used to calculate the cost effectiveness of measures are displayed in Table 3, with an overview of cost efficiency by sector in Table 4.

The cost effectiveness discussed here does not take into consideration the economic gains, increased road safety and reduction of local emissions and noise as these factors are difficult to quantify and substantiate.

4.4 Conditions affecting the success of the measure and lessons learnt

4.4.1 Public acceptance

The ecodrive programme received a high level of public recognition via a broad range of communication activities; approximately 31 % of the population was aware of the Programme in 2004. This was partly due to effective stakeholder engagement.

4.4.2 Stakeholder engagement

Successful approaches to raising awareness about the programme included multimedia games, simulators and website simulators alongside

Table 2 Summary of assumptions for assessing margins of the net impact of the ecodrive programme

Assumption element		Assumptions for low limits (impacts)	Assumptions for high limits (impacts)
Assumptions regarding in-car devices	Freeriders (those drivers purchasing in-car device outside of the tax exemption scheme *)	50 %	33 %
	CO_2 emission reduction due to in-car devices	1.25 %	2.5 %
Assumptions regarding existing drivers	Familiarity with ecodrive principles (through e-communication campaigns)	12 %	29 %
	Reduction in the effectiveness of driver behaviour changes as a result of communication campaigns over time	5–1 %	10–2 %
Assumptions regarding new drivers	Reach in personal transport	17.5 %	35 %
	Reach in goods transport	50 %	100 %

Note: * In this project 'Freeriders' is the term given to those drivers that would have purchased an in-car device in the absence of the tax-incentive scheme. Assumptions related to the impacts of the Ecodrive scheme are therefore a low impact if 50 % are freeriders, and high impact if 33 % are freeriders (assumptions have been based on data from neighbouring countries where tax incentives for the purchasing of in-car devices are not available).

Source: van den Hoed *et al.*, 2006.

Table 3 Assumptions made to calculate low and high cost efficiency of ecodrive programme

	Low	High	Relevant for
Average tax exemption per in-car device	EUR 150	EUR 200	In-car device costs for government (deferred tax income)
Average end-user contribution to in-car device	EUR 50	EUR 150	In-car device costs for end users/cost efficiency for society
Freeriders in-car devices	33 %	50 %	In-car devices cost for (i) government (deferred tax income) (ii) end users (contribution in purchase of devices)
Use level of in-car devices	50 %	80 %	(i) cost savings (end users) and (ii) tax income losses (government)
Annual savings with in-car device	1 %	2 %	(i) cost savings (end users) and (ii) tax income losses (government

Source: van den Hoed *et al.*, 2006.

Table 4 Summary of cost efficiency of ecodrive programme for society, government and end users

Who	Cost per avoided tonnes CO_2
Society	EUR 350 to — EUR 38 per avoided tonne of CO_2
Government	EUR 9 to EUR 20 per avoided tonne of CO_2 (excluding tax exemption)
	EUR 68 to EUR 99 per avoided tonne CO_2 (including tax exemption)
End users	EUR – 210 to EUR – 418 per avoided tonne CO_2

Source: Adapted from van den Hoed *et al.*, 2006.

messaging via TV, magazines and newspapers. However, attempts to train significant numbers of existing drivers through training and subsidised/programme activities were less successful (van den Hoed *et al.*, 2006).

4.4.3 Implementation considerations

Involvement and active participation of stakeholders is key if a programme like this is to succeed. The network of stakeholders who have been involved in the ecodrive programme from the start has ensured that necessary structures are in place for learning, for example the curricula and training. The network also provided legitimacy and credibility to the ecodrive programme and provided a communication channel to many of the stakeholders involved in ecodriving, from end users to car dealers (van den Hoed *et al*., 2006).

4.4.4 Operation considerations and enforcement

As the principles of ecodriving are based around achieving what can be a particularly complex behavioural change, it is suggested that further research should be undertaken to substantiate any assumptions made, and to evaluate the effectiveness of the communication campaign on changed travel behaviour on existing drivers. In addition, more research is required into sustaining the benefits of ecodriving and the realistic day-to-day fuel savings that can be achieved.

4.4.5 Other

The evaluation stressed the importance of the use of financial instruments to aid the adoption of energy-efficient devices, such as in-car devices.

4.5 Transferability

Similar ecodrive programmes have been implemented in a number of European countries, (for example Germany, Finland and Switzerland) at varying levels (national, regional/local, business/organisation) and aimed at a variety of transport target groups, for example freight.

Although the Dutch ecodrive programme targeted all groups (individuals, professional drivers and fleet owners), other countries/organisations have implemented similar, smaller-scale programmes aimed at more specific target groups.

In Greece, the Centre for Renewable Energy Sources (CRES) undertook an ecodriving pilot study in collaboration with the Organisation of Urban Transport of Athens and the Thermo Bus Company to assess the changing urban bus drivers' style (Zarkadoula *et al.*, 2007). Bus drivers were provided with instructions on driving styles (targeted at urban buses with automatic gear boxes) and underwent training courses. Monitoring took place to determine any changes in fuel consumption as a result of the ecodriving training. The impact on fuel consumption is shown in Table 5.

The implementation and operation costs should be taken into account when considering the implementation of an ecodrive programme. The Dutch ecodrive programme had a budget of EUR 10 million (Ecodrive I 1999–2005), which was raised to EUR 15 million for Ecodrive II (2003–2006). It is estimated that approximately half of this budget was required for the setting up of the communication campaigns, with the remaining funds used for subsidised and contracted projects together with project implementation costs.

Table 5 Average specific fuel consumption per km (pre- to post-training phase)

	Bus one	Bus two
Average specific fuel consumption (pre-training phase) (l/km)	1.072	1.094
Average specific fuel consumption (post-training phase) (l/km)	1.024	1.048
Difference (%)	– 4.5	– 4.2

Source: Adapted from Zarkadoula *et al.*, 2007.

Box 2 Transferability considerations — ecodrive programme

Geographic scale

- Ecodriving can be implemented on a range of geographic scales, from national level down to individual organisations or businesses. However, success will depend on the methods used (for example, training sessions, awareness campaigns, in-car devices) and the target audience (general public, freight sector etc).

Legislation

- Where ecodriving is introduced through inclusion in the new driver programme, consideration may have to be given to potential legislation implications.

Stakeholders

- Prior to programme implementation, it is advisable to identify a group of willing and supportive stakeholders from a wide variety of sectors, including freight or public transport operators, media and public relations, government departments and agencies as well as other interested non-governmental organisations.

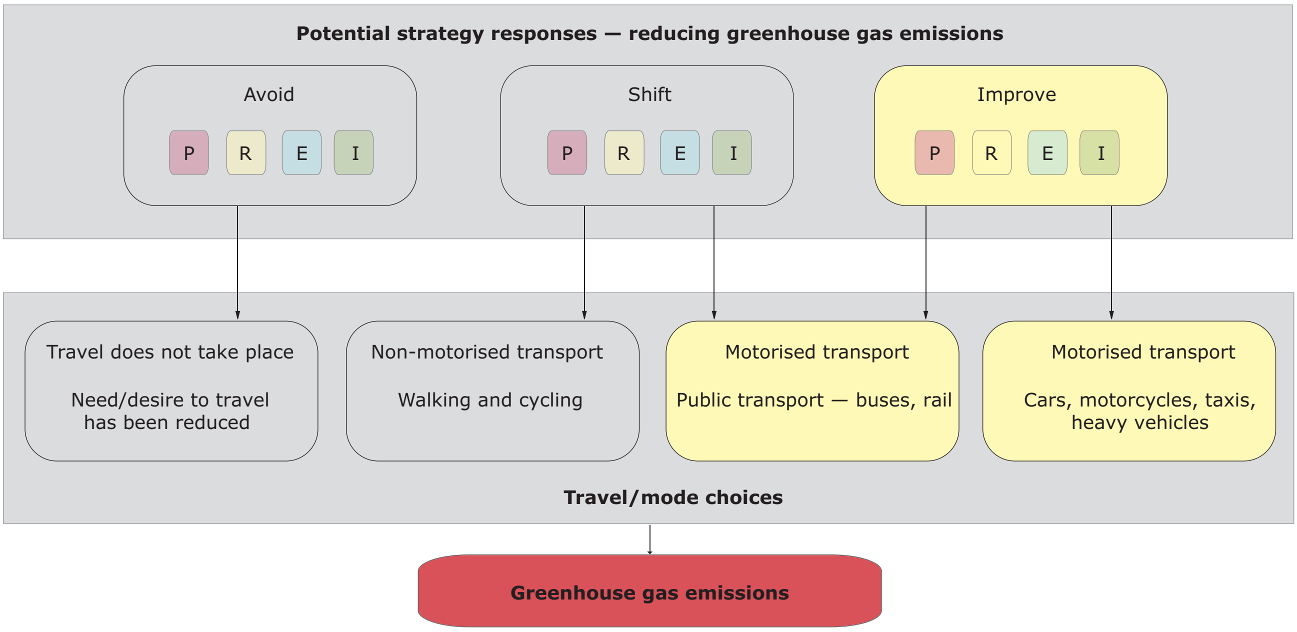
Technology

- If technology transfer is likely to be a problem (for example, in-car devices), other elements of the ecodriving methods can be implemented, including communication campaigns, awareness raising and training.

5 Speed control — Rotterdam

Measure	Speed control
Implementation level	Local/city
Target group	Private, public, freight (road)
Type of measure	Regulation
Strategy impact	Improve
Effectiveness of measure — key benefits	Successful in reducing speeds on A13 motorway
Greenhouse gas emission reduction	CO_2 emission reduced by 15 %
Ancillary benefits	Reductions in oxides of nitrogen (NO_X), particles measuring 10µm or less (PM_{10}) and carbon monoxide (CO), decrease in accidents (60 %) and casualties (90 %), and decreases in noise from traffic (50 %)

Figure 7 Rotterdam — Speed control



5.1 Overview

The speed at which a vehicle travels has a strong correlation with fuel consumption, and hence the level of emissions and concentration of various pollutants. By imposing more restrictive speed limits on certain roads, emissions can be reduced and ancillary benefits achieved.

Rigidly enforced vehicle speed restrictions were introduced at Overschie in Rotterdam in 2002. This pilot measure was in response to poor air quality and health concerns along a 3.5 kilometre stretch of the A13 motorway that cuts straight through the suburban Overschie district. This particular stretch of road was selected because of frequent congestion and its proximity to residential and other sensitive land uses. The speed limit in the controlled zone was reduced from 120 kph to 80 kph.

The measure aimed to reduce congestion, improve traffic flow, improve traffic safety, reduce air pollution and generally improve the quality of life within Overschie. Reduction in greenhouse gas emission was observed as an ancillary benefit.

The speed limit was enforced via a series of cameras monitoring vehicle average speed within the controlled zone. Any vehicle that exceeded the average speed limit was subject to an immediate automatic fine (Kroon, 2005).

5.2 Responsibilities of key stakeholders in implementation

Key stakeholders instrumental in the implementation and operation of the measure included the Ministry of Transport, Municipal Health Service, Department of Public Works, Rotterdam City Council, local members of parliament and residents.

The Municipal Health Service was initially involved in a study of the implications for health of poor air quality experienced along the A13. The results showed that residents breathing the air immediately along the motorway were affected as if passively smoking 16 cigarettes per day (VROM, 2003).

Local residents formed a residents' forum, Gezond Overschie (Healthy Overschie), which provided feedback to the relevant local authorities, and participated in workshops on the proposed solutions for tackling the poor air quality. Campaigns were also started for structural solutions to the problem (VROM, 2003).

The Department of Public Works in the Netherlands is responsible for making key decisions regarding motorways and was involved in the scheme implementation at an early stage.

Initially, there was some opposition to the scheme, particularly from the Ministry of Transport and freight lorry drivers. However, the media were strongly supportive and represented the residents, who wanted action to address poor air quality that had already contributed to the closure of a primary school.

The operation and enforcement of the speed control measure is the responsibility of the Bureau Verkeershandhaving OM (Bureau Traffic Enforcement of the Public Prosecution Service). The police receive the vehicle registration details (photographs) of speed offenders. These details are then sent to the Drivers and Vehicle Licensing Agency, which identifies the driver/vehicle owner. The Central Fine Collection Agency (CJIB) then issues and collects the appropriate speeding fine.

5.3 Effectiveness of the measure — key benefits

The speed restrictions implemented on the A13 in Overschie were successful in reducing traffic speeds. The average speed over a 24-hour period fell from 93 kph to 70 kph (A13 east) and from 89 kph to 72 kph (A13 west). This reduction resulted in calmer and more homogenised traffic and reduced downstream bottlenecks and congestion. Enforcement through the use of cameras and the average speed check also led to a high level of driver compliance, with only a 2 % offence rate (Kroon, 2005).

5.3.1 *Greenhouse gas emission reductions*

It is estimated that the speed limit restrictions resulted in a 15 % reduction of CO_2 emission — a reduction of 1 000 tonnes from the previous total of 41.6 kt (Kroon, 2005).

5.3.2 *Ancillary benefits*

For a year before and after implementation, the authorities monitored the impact of the scheme, looking at air quality and metrological and traffic flow measurements.

Table 6 Percentage emission reductions

Pollutant	**NO_x**	**PM_{10}**	**CO**
Emission reduction (%)	15–25	25–35	21

Source: Wesseling *et al.*, 2003, in Kroon, 2005.

Table 7 Average improvement in air quality due to scheme under westerly wind conditions

Location	Improvement in NO_2	Improvement in PM_{10}
50 metres from roadside	5 μg/m³	4 μg/m³
200 metres from roadside	3 μg/m³	1 μg/m³
Reduction in contribution from A13 up to 200 metres from roadside	25 %	34 %
Overall air quality improvement up to 200 metres from roadside	7 %	4 %

Source: Wesseling *et al.*, 2003, in Kroon, 2005.

Table 6 shows the percentage emission reduction for NO_X, PM_{10} and CO following speed control implementation.

Table 7 shows the average improvement in air quality in various locations for NO_2 and PM_{10} as a result of speed control implementation.

In addition to improved air quality benefits, the number of accidents decreased by 60 % and number of casualties decreased by 90 % (Olde Kalter, van Beek, Stemerding, 2005), whereas noise was reduced by about 50 % and there was an improved public perception of road transport.

5.3.3 *Economic efficiency*

At 2004 prices, the capital cost of setting up the scheme was approximately EUR 1.2 million, with an annual operational cost of approximately EUR 50 000. Revenues from fines levied are small in relation to the operational cost. **Using a social cost discount rate of 4 %** and estimating that the scheme will provide air quality benefits for a period of 10 years, the present value of the scheme is estimated to be EUR 1.56 million, with an annualised value of EUR 192 000. However, this is based only on benefits from reduced NO_X and PM_{10} emission and does not take into account lower accident rates, lower emission of CO_2, lower noise levels or, on the negative side, likely longer journey times.

5.4 Conditions affecting the success of the measure and lessons learnt

5.4.1 *Public acceptance*

Local residents supported the scheme because they were concerned about the potential health impacts of traffic on the A13, including problems caused by poor air quality and noise. Road users accepted the scheme because it did not involve road barriers, tollbooths or any additional costs for the speed-compliant driver.

5.4.2 *Implementation and operation*

The technology used in the Overschie speed control measure has been instrumental in its success in reducing emissions from transport. The use of section control along the route reduces the reliance on the police and other enforcement agencies to identify non-compliant drivers, and automatic registration mark recognition and issuing of fines reduces resource inputs.

5.4.3 *Effective enforcement*

Due to the nature of enforcement, compliance is extremely high. The levy of automatic fines for speeding drivers removes the need for manual monitoring and ensures that drivers comply with the new reduced limits.

5.5 Transferability

Speed control measures are relatively simple to transfer to other cities and countries. In the case of the Netherlands, this initial speed control measure at Overschie was implemented specifically as a response to poor environmental conditions. Following its implementation, similar speed control measures were rolled out to other sections of the highways of Rotterdam.

In France, speed control is one of the measures incorporated in the national climate change plan, which will aid the reduction of emissions from transportation by 2010. The French transport sector currently contributes one quarter of national greenhouse gas emission and one third of CO_2 emission (MEDD, 2004). The plan focuses on improving vehicle engines and fuels, changing driver behaviour and improving the national transport system (MEDD, 2004). When drivers comply with speed limits, less fuel is used and CO_2 emission falls, therefore France plans to implement speed compliance measures throughout its national road system. The average speed on the roads has reduced by between 5 and 10 km/h over the past year and further improvements of a similar order are expected (MEDD, 2004). Estimates indicate that full compliance with speed limits could reduce CO_2 emission by 2.1 Mt CO_2-equivalent for private cars, 0.4 Mt CO_2-equivalent for heavy goods vehicles and 0.5 Mt CO_2-equivalent for light utility vehicles, a total reduction of 3 Mt CO_2-equivalent (MEDD 2004).

In the United Kingdom, studies examining the potential of blanket enforcement of a 70 mph (113 kph) speed limit have suggested that this policy would be very costly compared to the majority of other measures. This is primarily because of the cost of enforcement using SPECS (time over distance) speed cameras to deliver carbon savings with a high level of certainty. If 100 % compliance were to be achieved, enforcement of 113 kph (70 mph) could save 0.6 Kt carbon in 2010 at GBP 410 per tonne of carbon (EUR 593), whereas enforcement at 97 kph (60 mph) could achieve a saving of 0.9 Kt of carbon at GBP 190 t/C (EUR 275) (Defra 2007 in CfIT, 2007).

Issues relating to enforcement may need to be considered by Member States intending to implement speed control measures, particularly in the light of current legislation regarding whether it is the driver or the owner of the car who is responsible for paying any fines incurred. If the driver is held responsible, technology used needs to be able to identify the driver or it will be difficult to recover fines. Although this technology will aid the recovery of fines, it will be expensive to install and operate.

The success of transferring speed control measures to other Member States and cities depends entirely on the current local situation. In the case of Overschie, speeds prior to the control implementation were relatively high; the subsequent reduction had a positive effect on CO_2 emission and generated ancillary benefits. Also, the larger the area covered by the measure, the greater the reduction in CO_2 emission.

Box 3 Transferability considerations — speed control

Geographic scale

- Speed restrictions over longer lengths of road may be more effective in terms of achieving associated benefits (in the case of Overschie, the scheme covered a 3.5 kilometre stretch). Speed restrictions on shorter lengths of road may not be as successful because of increased emissions caused by deceleration and acceleration at either end of the restricted area.

Technology

- The enforcement used in Overschie is a particularly successful 'no tolerance' method. Other speed control schemes (involving lowering of speed limits through regulations) may be less successful due to the large resources that would be required to implement manual enforcement.

Resources

- The regulatory authorities must have the appropriate administration capabilities to cope with the issue and collection of enforcement fines.

- The enforcement technology is a reasonably expensive initial financial outgoing (EUR 1.2 million in the Overschie case study), and incurs an annual operating cost (in the region of EUR 50 000 in the Overschie case study). Implementing authorities should consider these costs and need to identify and obtain funding prior to implementation.

Effectiveness of measure

- Authorities should consider the mode split on routes where speed controls may be implemented. Where heavy goods vehicles make up a large proportion of traffic using a particular route, reductions in emissions may be limited as these vehicles are often already restricted to lower speeds. However, authorities may achieve other benefits such as smoother traffic flow and less congestion.

- If the scheme is implemented on a much wider scale, benefits in terms of reducing greenhouse gas emission from transport may be greater.

- An assessment of alternative routes should be made to ensure that traffic is not displaced in attempts to avoid the speed control measures. Where identified, appropriate mitigation should be implemented.

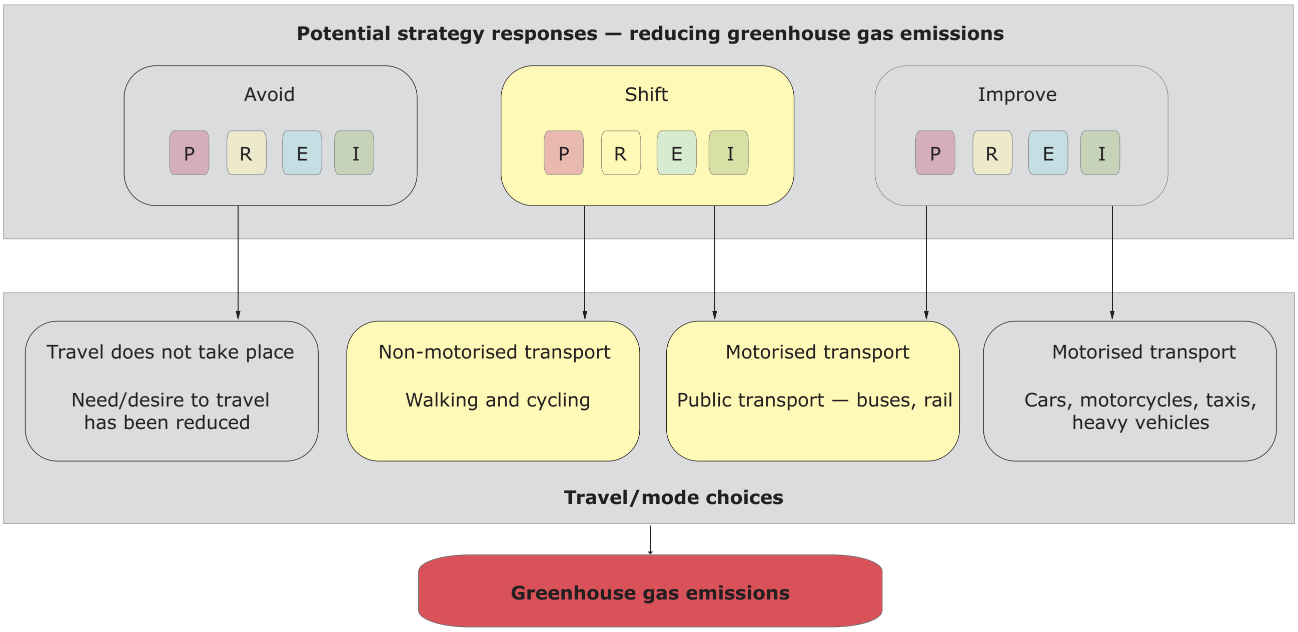
Enforcement

- Authorities should consider traffic legislation covering whether it is the driver of the car or the owner of the car who is responsible for paying fines. In Overschie, the drivers cannot be seen on any of the camera footage. Therefore, it is the owner of the car who receives and is required to pay the penalty fine. In countries where the driver pays the fine, it may be more difficult to ensure that fines are collected, particularly if the evidence is not available from the enforcement cameras.

6 Congestion charging — London

Measure	Congestion charging
Implementation level	Local/city
Target group	Private, freight (road)
Type of measure	Regulation, economic
Strategy impact	Shift
Effectiveness of measure — key benefits	Traffic flow decreased and there was a reduction in the level of congestion within the zone and an increase in the use of public transport
Greenhouse gases emission reduction	Between 2002 and 2003, it is estimated that greenhouse gas emission fell by 16 %
Ancillary benefits	Reductions of NO_X and PM_{10} within the zone and on the inner ring road and increased road safety.

Figure 8 London — Congestion charging



6.1 Overview

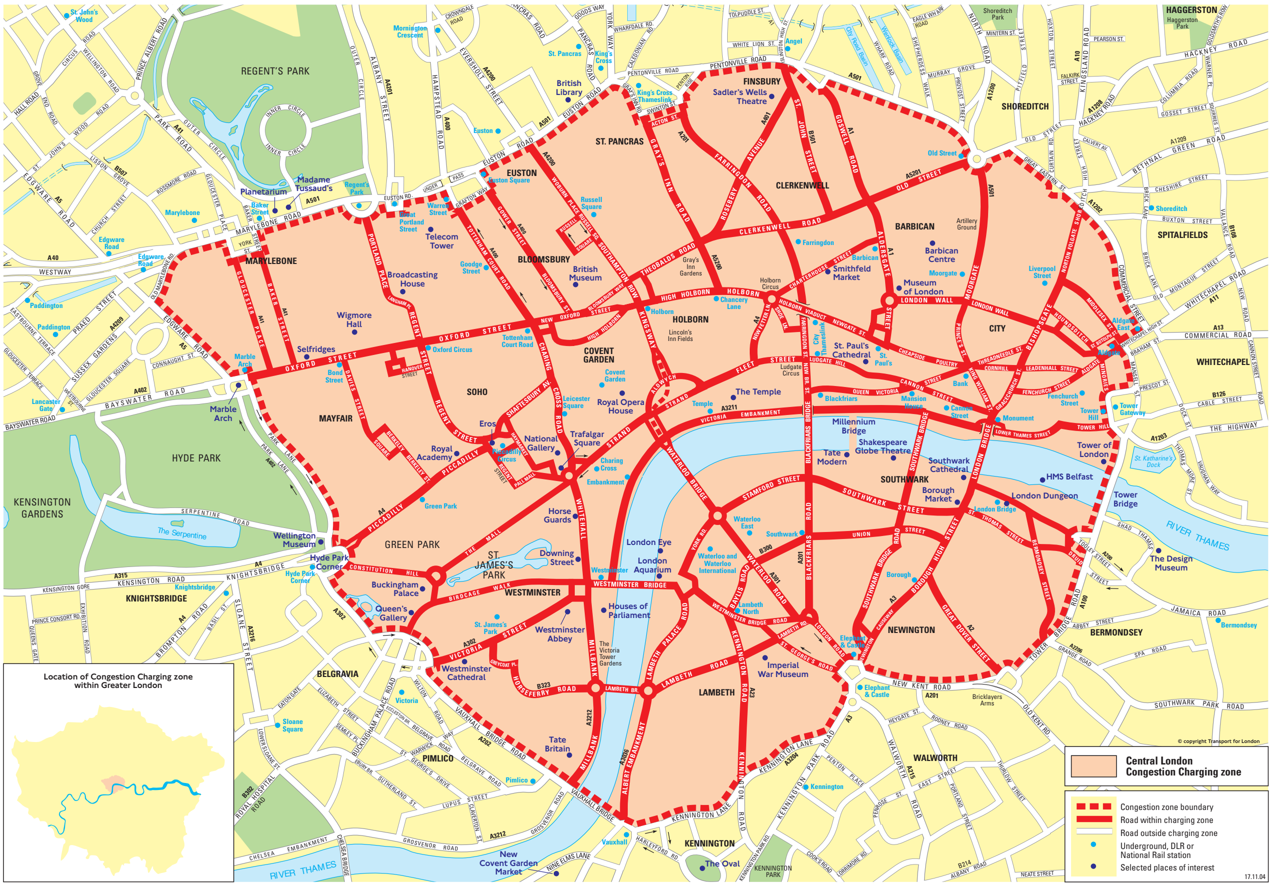
Congestion charging and road user charging schemes aim to reduce vehicle use by charging users to pay for entering or travelling in a specific zone, or for using a particular stretch of road. There are many examples of congestion and road user charging schemes in operation on highways across Europe, where drivers pay by cash or token for using the bridge or tunnel as they pass through a toll plaza.

In February 2003, the London congestion charging scheme came in to force. The scheme covered a 22 square kilometre area, bounded to the east by the London Inner Ring Road (see Map 1). The congestion charge zone almost doubled in size on 19 February 2007 to include a large area of west London (see Map 2).

Drivers of non-exempt vehicles must pay a charge to enter and travel within the zone, which is operational on Monday to Friday, between 7 am and 6 pm. When the London congestion charging scheme was initially implemented in 2003 the charge was GBP 5 (EUR 7), this was increased to GBP 8 (EUR 11) in July 2005. A range of vehicles and drivers are exempt from paying the charge or are entitled to receive a discount, including disabled 'Blue Badge' holders, residents living within the zone, drivers of alternative fuel vehicles, motor tricycles, vehicles with nine or more seats and emergency service vehicles. Vehicles that run on alternative fuels such as electric, hydrogen and liquid petroleum gas, present positive environmental benefits compared to normal vehicles whilst driving in the congestion charge zone and are therefore exempt from paying the congestion charge. Whilst this is an incentive to use these alternatively fuelled vehicles, only anecdotal evidence exists to suggest that the implementation of the congestion charge has influenced vehicle purchasing behaviour. However, it is thought that the congestion charge is boosting the sale of hybrid cars, which are also exempted, and Honda and Toyota are planning to increase their supply of hybrid vehicles during 2007 (Richard, 2007).

The scheme is enforced by a network of automatic number plate recognition cameras that record all vehicles entering or exiting the zone. Vehicle number plates are read and registration marks stored on a database; drivers must register their vehicle registration mark on the database either prior to or just after (up to midnight the next day) entering the zone. At the end of each 24-hour period, the vehicle registration data held in the database is crosschecked against vehicle registration data

Map 1 **Map of the London congestion charge zone 2003 to 2007**



Note: Reproduced with the kind permission of Transport for London.

Source: TfL, 2006a.

collected from drivers known to have paid to enter the charging zone. Drivers found to be evading payment are issued with a penalty charge notice.

Factors that prompted the implementation of congestion charging were:

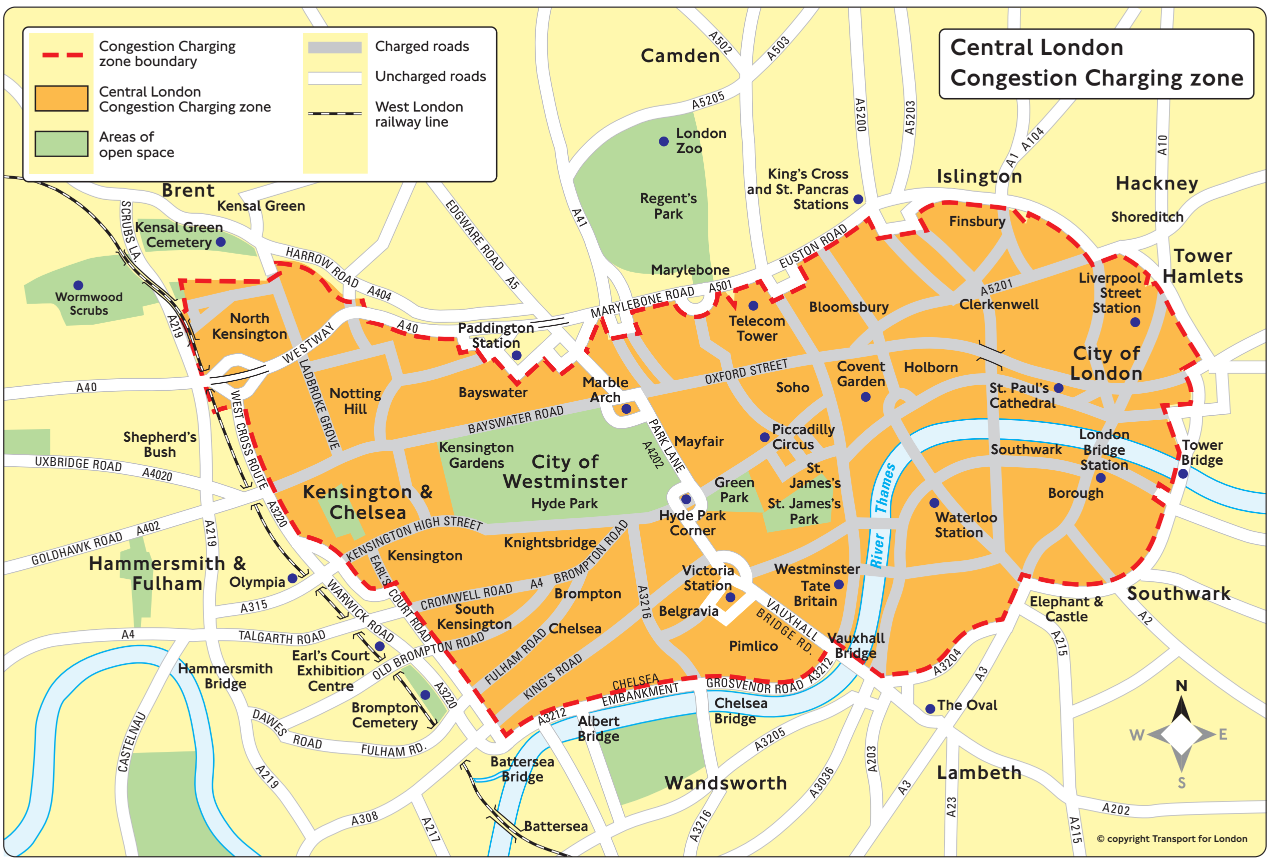
- London suffered the worst traffic congestion in the United Kingdom and amongst the worst in Europe;
- it was estimated that drivers in central London spent 50 % of their time in queues;
- it was estimated that the equivalent of 25 busy motorway lanes of traffic attempted to enter London every week day morning; and
- it was estimated that London lost between GBP 2 million (EUR 2.9 million) to GBP 4 million (EUR 5.9 million) every week in terms of lost time caused by congestion (TfL, 2007a).

The scheme was designed to contribute to four of the Mayor's transport priorities, as set out in the Mayor's Transport Strategy for London. These are to:

- reduce congestion;
- make radical improvements to bus services;
- improve journey time reliability for car users; and
- make distribution of goods and services more efficient (GLA, 2001).

Improvements to bus services were planned based on anticipated reduced congestion and also through the introduction of 300 new buses (an increase of 1.5 %) on the same day as the start of the congestion charge. Ongoing work is focusing on introducing universal access buses, improved bus shelters, improved bus tracking and timetabling systems and other wider public transport measures.

Map 2 Map of the London congestion charge zone including western extension: 2007



Note: Reproduced with the kind permission of Transport for London.

Source: GLA, 2005.

In 2003, Transport for London also introduced a new form of electronic ticketing (the Oyster card) that simplified ticket purchase and lowered some fares on buses and Underground trains.

6.2 Responsibilities of key stakeholders in implementation

Transport for London is the body responsible for London's transport system. Its key role is to implement the Mayor of London's Transport Strategy and manage the City's transport services and it has primary responsibility for the effective implementation of the London congestion charging scheme ([3]). This includes:

- issuing of the penalty charge notices;
- since 2005, controlling the charge payments with new mobile enforcement units;
- implementation of the monitoring programme, which helps Transport for London understand and interpret the changes that congestion charging has caused;
- Transport for London's congestion charge enforcement also helps the Metropolitan Police and other enforcement agencies to monitor criminal activity in and around the charging zone.

Outside the core scheme delivery team, a wide range of stakeholders have been involved in the implementation or operation of the scheme. These are outlined below:

- London Boroughs and utilities: coordination of street works;
- Transport for London: real-time traffic information infrastructure;
- police and Transport for London's enforcement services: provision of operational support around implementation;
- Driver and Vehicle Licensing Agency: provision of vehicle keeper information for enforcement purposes;
- Parking and Traffic Appeals Service: provision of an independent appeals route for those enforced against under the provisions of the scheme.

6.3 Effectiveness of the measure — key benefits

In terms of the scheme's objectives, the London congestion charging scheme can be considered a success as it has:

- reduced congestion by 26 % compared to 2002 levels;

Table 8 Changes in traffic entering the congestion charge zone

Vehicle type	2002	2003	2004	2005	% change 2005 versus 2002
Vehicle four or more wheels	62 500	48 500	47 200	48 800	– 22 %
Potentially chargeable vehicles	53 400	37 500	36 100	37 500	– 30 %
cars	37 500	23 600	22 700	24 200	– 35 %
vans	12 800	11 000	10 900	10 700	– 16 %
lorries	3 000	2 900	2 300	2 400	– 20 %
Non-chargeable vehicles	19 200	21 700	21 800	21 500	12 %
licensed taxis	6 900	7 800	8 400	8 500	23 %
buses and coaches	2 200	2 600	2 800	3 000	36 %
pedal cycles	3 900	4 400	4 500	4 900	24 %
powered two-wheelers	6 200	6 200	6 200	5 400	– 12 %
All vehicles	72 500	59 200	57 900	59 000	– 19 %

Source: Adapted from TfL, 2006a.

([3]) Capita Group holds the contract with Transport for London to operate the scheme until 2009. Responsibilities include the processing of payments and fines.

- brought about increased use and effectiveness of public transport, in particular buses. The first year saw a 37 % increase in the number of passengers entering the charging zone by bus during charging hours; and
- raised GBP 122 million net in 2005/2006 for public transport investment (TfL, 2006a).

Reduced traffic flows, and subsequently congestion levels within the scheme, were key aims of the congestion charging scheme. Table 8 shows changes in all traffic flows between 2002 and 2005 (TfL, 2006a). It shows that within the charging zone the number of vehicles subject to the scheme charges fell by 30 % between 2002 (prior to implementation) and 2005, whereas the number of non-chargeable vehicles increased by 12 %. Overall, the number of vehicles entering the zone fell by 19 % during this period.

6.3.1 Greenhouse gas emission reductions

Although the original objectives did not specify emission reductions, reduced congestion and traffic levels have contributed to this wider aim. Road transport is the largest source of emissions in London. The Transport for London Impacts Monitoring Report (TfL, 2007b) indicates that congestion charging has contributed to emission reductions with the charging zone (see Table 9).

The CO_2 emission estimates are closely correlated with the number of vehicle kilometres driven and fuel consumption. Reductions in CO_2 emission can be attributed to less traffic within the zone, and to reduced congestion levels (more fuel-efficient driving conditions). Transport for London estimates that the traffic and speed changes observed within the zone have led to a 16.4 % reduction in CO_2 emission. Small increases in traffic flow were observed on the inner ring road (which surrounds the congestion charge zone), leading to a proportionate increase in CO_2 emission (TfL, 2007b).

6.3.2 Ancillary benefits

Annual impact monitoring reports produced by Transport for London include the effects of the charging scheme on local air quality. Table 10 shows the principal changes to emission of NO_X and PM_{10} within the charging zone and on the inner ring road between 2002 (prior to implementation) and 2003 (after implementation). Decreases in NO_X by 13.4 % were seen within the zone and by 15.5 % on the inner ring road. Reductions were also achieved for PM_{10}, which decreased by 6.9 % within the zone and by 6.8 % on the inner ring road.

Benefits were also identified in terms of increased road safety. Road traffic accidents resulting in personal injury (reported) in 2004 have continued to reduce across London and within the charging zone. This indicates that there are broader trends affecting safety statistics as a result of continuing road safety initiatives. Transport for London (and independent statistical treatment of data) estimated that the changes in traffic within the zone have been responsible for between 40 and 70 fewer accidents resulting in personal injury within the zone and on the inner ring road.

Table 9 Principal changes to emission of CO_2, percentage change in 2003 compared to 2002

Change	Charge zone	Inner ring road
Flow change — motorcycles	0.2	1.0
Flow change — taxis	2.4	2.1
Flow change — car	– 11.2	– 3.9
Flow change — buses and coaches	1.2	1.4
Flow change — light goods	– 0.1	2.3
Flow change — rigid goods	– 0.7	0.7
Flow change — articulated heavy goods	– 0.2	0.2
Traffic volume change	– 8.7	3.8
Speed change	– 7.3	– 8.5
Traffic volume and speed change	– 15.7	– 4.7
Vehicle stock change	– 0.7	– 0.7
Overall traffic emission change 2003 versus 2002	**– 16.4**	**– 5.4**
Additional 'background' change from technological improvement (fleet turnover) 2003–2006	– 3.4	– 2.4

Source: Adapted from TfL, 2007b.

Table 10 Principal changes in emission of NO_x and PM_{10}: percentage change in 2003 compared to 2002

Change	NO_x		PM_{10}	
	Charging zone	Inner ring road	Charging zone	Inner ring road
Flow change — motorcycles		0.4	0.2	2.4
Flow change — taxis	2.3	3.8	2.0	3.6
Flow change — cars	– 4.5	– 4.6	– 1.6	– 1.8
Flow change — buses and coaches	2.9	1.0	3.2	1.1
Flow change — light goods	– 0.1	– 0.1	1.7	3.2
Flow change — rigid goods	– 1.6	– 1.0	1.6	1.0
Flow change — articulated Heavy goods	– 0.4	– 0.2	0.4	0.2
Traffic volume change	– 1.4	– 0.8	7.4	9.7
Speed change	– 6.5	– 5.5	– 7.7	– 6.9
Traffic volume and speed change	– 7.9	– 6.3	– 0.2	2.8
Vehicle stock change	– 5.5	– 9.2	– 6.7	– 9.6
Overall traffic emission change 2003 versus 2002	**– 13.4**	**– 15.5**	**– 6.9**	**– 6.8**
Additional 'background' change from technological improvement (fleet turnover) 2003–2006	– 17.3	– 23.8	– 17.5	– 20.9

Source: Adapted from TfL, 2007b.

6.3.3 *Economic efficiency*

Table 11 shows the reduction in vehicle km travelled and fuel consumption per year for both the GBP 5 and GBP 8 congestion charging zone entry charges. The assumptions used to calculate the costs associated with CO_2 emission reductions are:

- average CO_2 emission rate around 25 kg per litre of fuel (2.4 kg petrol and 2.7 kg diesel);
- tonne of carbon valued at about GBP 75 ([4]) (EUR 111); and
- tonne of CO_2 therefore valued at around GBP 20.45 (EUR 30) (where carbon represents 6/22 by weight).

The costs and benefits of the scheme in terms of all of its objectives (not just CO_2) have been considered. Table 12 outlines this assessment. For the EUR 7 charge, cost efficiency is EUR + 63 million, whereas the EUR 11 charge manages to achieve cost efficiency of EUR + 78 million.

6.4 Conditions affecting the success of the measure and lessons learnt

6.4.1 *Public acceptance and consultation*

The scheme has been seen as controversial and has faced strong opposition from sections of the media, politicians, motorist groups, business interests, some London residents, and labour organisations.

Table 11 Estimated savings per year

	GBP 5 (EUR 7) charge	GBP 8 (EUR 11) charge
Vehicle km saved	211 million	237 million
Fuel savings (litres)	44 million	48 million
Savings (tonnes)	110 000	120 000
Savings (GBP)	GBP 2.3 million (EUR 3.4 million)	GBP 2.5 million (EUR 3.7 million)

Source: Adapted from Evans, 2007.

([4]) Based on Defra working paper *Estimating the social cost of carbon emissions*, 2002; reconfirmed in light of *Stern review on the economics of climate change*, 2006.

Extensive public consultation, both informal and formal, throughout the scheme development, resulted in a number of revisions to the scheme proposals, and reports were published on the feedback received. Focused public information campaigns and media relations to raise awareness about scheme operation and potential implications have been important to the success of the scheme.

Table 12 Transport costs, 2005 market prices, GBP m per year

	GBP 5 (EUR 7) Charge			GBP 8 (EUR 11) Charge		
	Vehicles/ occupants	Bus/ passengers	Total	Vehicles/ occupants	Bus/ passengers	Total
Individual travellers (non-business travel)						
Travel time	54 (80)	35 (51)	89 (131)	65 (96)	35 (51)	100 (148)
Travel time reliability	5 (7)	8 (11)	13 (19)	5 (7)	8 (11)	13 (19)
Vehicle operating costs — fuel	5 (7)		5 (7)	6 (8)		6 (8)
Vehicle operating costs — non-fuel	4 (6)		4 (6)	4 (6)		4 (6)
Chargepayer compliance costs	– 6 (– 8)		– 6 (– 8)	– 5 (– 7)		– 5 (– 7)
Chargepayer payments	– 72 (– 106)		– 72 (– 106)	– 79 (– 117)		-79 (– 117)
Disbenefits to deterred trips	– 12 (– 17)		– 12 (– 17)	– 19 (– 28)		– 19 (– 28)
Sub total — individual benefits	– 22 (– 32)	43 (63)	21 (31)	– 23 (– 34)	43 (63)	20 (29)
Business travellers						
Travel time	142 (10)	0	142 (210)	163 (241)	0	163 (241)
Travel time reliability	22 (32)	0	22 (32)	27 (40)	0	27 (40)
Vehicle operating costs — fuel	10 (14)		10 (14)	10 (14)		10 (14)
Vehicle operating costs — non-fuel	7 (10)		7 (10)	8 (11)		8 (11)
Chargepayer compliance costs	– 16 (– 23)		– 16 (– 23)	– 14 (– 20)		– 14 (– 20)
Chargepayer payments	– 143 (– 211)		– 143 (– 211)	-157 (-232)		– 157 (– 232)
Disbenefits to deterred trips	– 8 (– 11)		– 8 (– 11)	– 12 (– 17)		– 12 (– 17)
Sub total — individual benefits	14 (20)	0	14 (20)	27 (40)	0	27 (40)
Business — private sector providers: additional bus services, car park operators						
Bus revenues	19 (28)		19 (28)	19 (28)		19 (28)
Bus operating costs	– 18 (– 26)		– 18 (– 26)	– 18 (– 26)		– 18 9 (– 26)
Net car park revenues	– 10 (– 14)		– 10 (– 14)	– 10 (– 14)		– 10 (– 14)
Sub total business providers	– 9 (– 13)		– 9 (– 13)	– 9 (– 13)		– 9 (– 13)
Society impacts						
Accidents			14 (20)			14 (20)
			2 (3)			2 (3)
NOX and PM10			1 (1.4)			1 (1.4)
Sub total — society			17 (25)			17 (25)
Transport economic efficiency net annual benefits			+ 43 (63)			+ 53 (78)

Note: Figures in brackets are in EUR.

Source: Adapted from TfL, 2007b.

6.4.2 Implementation and operation

Due to the technology and infrastructure, the initial implementation costs for the London congestion charging scheme were extremely high — GBP 162 million (EUR 240 million) (excluding operating costs) The start up cost was funded by Transport for London's General Fund. This high financial outlay at the start of any scheme could deter some authorities, particularly where funds may not be recouped in the longer term through revenues.

Schemes like this, with high capital and operating costs, require significant revenue and are therefore especially suitable for larger cities..The operating expenses and revenues from the first four years of the scheme are shown in Table 13.

Operating costs have totalled GBP 289 million (EUR 428 million), whereas the total income was GBP 592 million (EUR 877 million), creating net revenue of GBP 303 million (EUR 448 million).

Since the scheme was implemented, the actual revenues from charges have been much lower than expected. However, there has also been a much higher level of penalty charges issued, which has ensured net revenues exceeding the total operating expenses of the scheme.

It is therefore implied that implementation of a congestion charge in a larger city such as London is cost efficient. Although it requires high investment costs during the implementation stages, the returns in terms of operation and charge income can mean that the initial investment could be paid off in five years.

6.4.3 Strong leadership and political engagement

This issue is closely linked to public acceptance as discussed earlier. Ken Livingstone, Mayor of London, participated in continued engagement throughout the period leading up to implementation. The Mayor was able to set out a vision for London and technical planning including the definition of objectives within a deliverable programme. As Ken Livingstone has devolved powers, he was able to drive forward the implementation of the scheme on his own authority, despite large-scale opposition. However, other UK cities aiming to introduce a similar scheme must seek and gain the approval of the Secretary of State for Transport (under the Transport Act 2000).

6.4.4 Research and monitoring

Transport for London undertook extensive transport modelling exercises, allowing mitigation measures to be implemented where appropriate. Monitoring of traffic and wider impacts of the scheme have also enabled any changes that have resulted from scheme implementation to be documented, providing an evidence base for responding to stakeholder comments and future amendments to the scheme.

6.4.5 Awareness raising

The implementation of the London congestion charging scheme in 2003 has been successful in terms of stimulating UK-wide debate on the introduction of further charging and pricing schemes. A similar congestion charging scheme was proposed for the City of Edinburgh but was not adopted, primarily because of lack of public support and general opposition to the scheme. Currently, a congestion charging scheme is proposed for Manchester, for implementation in 2010/2011, and others are being considered for Nottingham, Derby and Leicester.

6.5 Transferability

The London congestion charging scheme has been a success in terms of meeting its congestion reduction targets, and has achieved a range of other ancillary

Table 13 Net proceeds from 1 April 2002 to 31 March 2006

	GBP millions rounded, audited (EUR)			Unaudited	
	2002/2003	2003/2004	2004/2005	2005/2006	Total
Total operating expenses	17 (25)	93 (137)	90 (133)	88 (130)	289 (428)
Charge income	18 (26)	116 (171)	117 (173)	144 (213)	395 (585)
Enforcement income	1 (1.5)	55 (81)	75 (111)	66 (97)	197 (291)
Total income	19 (28)	171 (253)	192 (284)	210 (311)	592 (877)
Net revenues	2 (3)	78 (115)	102 (151)	122 (180)	303 (448)

Note: Figures in brackets are in EUR.

Source: Adapted from TfL, 2006.

benefits. However, congestion charging still remains a contentious issue and may not be as easy to replicate in other European cities. Despite this, there are a number of similar schemes (in varying forms) around Europe, for example in Stockholm, in addition to pricing schemes whose primary objective is to raise revenues, for example, in Trondheim and Oslo. As mentioned above, congestion charging is being considered for other major cities within the United Kingdom.

A recent congestion charging trial was undertaken in the City of Stockholm. The results of the trial were (source: http://www.civitas-initiative.org/measure_sheet.phtml?language=en&id=388):

- reduced traffic: major reduction (about 30 %) in car traffic within the inner city charging zone in the morning and afternoon rush hours;
- reduced congestion: improved accessibility within the zone and on major traffic routes. Queues still occurred, but they were not as severe;
- reduced emission: – 110 tonnes NO_X, – 37 tonnes PM_{10} and positive effects (+ in the five-degree scale used in the Trendsetter project) on emission of CO_2 in the inner city;
- reduced noise levels; and
- change to more sustainable transport modes: reduced % share of private cars, increased use of public transport, cycling and walking (Blomberg, 2007).

The biggest success was a larger than expected reduction in traffic flow. Moreover, the positive effects of the measure were witnessed outside the main zone, which resulted in additional benefits for the environment and health.

Both the London and Stockholm congestion charging schemes resulted in positive benefits for the environment. Congestion and local air pollution were reduced in both city centre areas.

Box 4 Transferability considerations — congestion charging

Geographic scale

- Where there is extensive pedestrianisation or other traffic reduction schemes in place, the effectiveness of congestion charging in terms of further reducing traffic may not be may not be appropriate or effective.
- Smaller schemes may simply move congestion from one area to another, with little to deter drivers from using alternative modes.
- Initially, the London scheme was based around a central zone inside a ring road and this helped avoid problems of zone-edge congestion by allowing traffic an easy path to avoid the zone. With the extension to west London this mitigation is less clear and to help avoid new zone-edge congestion, charge-exempt paths through the zone have now been incorporated.

Technology

- The London scheme uses automatic number plate recognition technology, which eliminates the need for toll booths. Although expensive to implement, the London scheme has shown that large cities can benefit from congestion charging.

Resources

- Authorities should ensure they have the appropriate administration capabilities to cope with the issue and collection of enforcement fines, and relevant access to vehicle driver databases.
- Authorities will have to identify and secure funds for initial implementation of such schemes, and be aware that these costs may be considerable. For example, implementation costs for the London congestion charging scheme were GBP 162 million (EUR 240 million) (this figure excludes operating costs).

Box 4 Transferability considerations — congestion charging (contd)

Legislation

- Authorities should ensure relevant legislation is in place to allow implementation of road user charging and enforcement.

Awareness and acceptance

- Authorities should undertake extensive public consultation throughout scheme development and operation.
- Focused public information campaigns and media awareness of scheme operation and potential implications were important contributors to the success of the London scheme.
- Due to perception of success and less impact on business than initially feared, overall public and business acceptance of the scheme increased after initial opposition. Businesses located in the area are likely to oppose such schemes because they anticipate reduced visitor numbers and negative impact on business turnover. However, in London the congestion charging scheme has had an overall neutral effect on the central London economy (TfL, 2006a).
- Provisions have been made for certain groups to qualify for discounted access to the zone, including disabled 'Blue Badge' holders, residents living within the zone, drivers of alternative fuel vehicles, motor tricycles, vehicles with nine or more seats and emergency service vehicles.
- Political will and support were not only instrumental in the implementation of the congestion charging scheme, but also in raising support from other sectors, including the public.

Supporting measures

- To avoid mobility and access problems (and issues of equity), authorities should ensure effective, reliable and cost-efficient transport alternatives are in place prior to scheme operation so that drivers can switch from private vehicle use to enter the zone. In the case of London, the net revenues from the scheme are being used for major public transport service improvements, including more buses and improving bus facilities (for example, by expanding the bus lane system and increased bus lane enforcement) and renovations to the Underground system.
- In London, extensive traffic modelling exercises prior to scheme implementation were undertaken to aid the identification of appropriate scheme boundaries, traffic displacement issues and potential areas that would benefit from mitigation measures.

Operating features

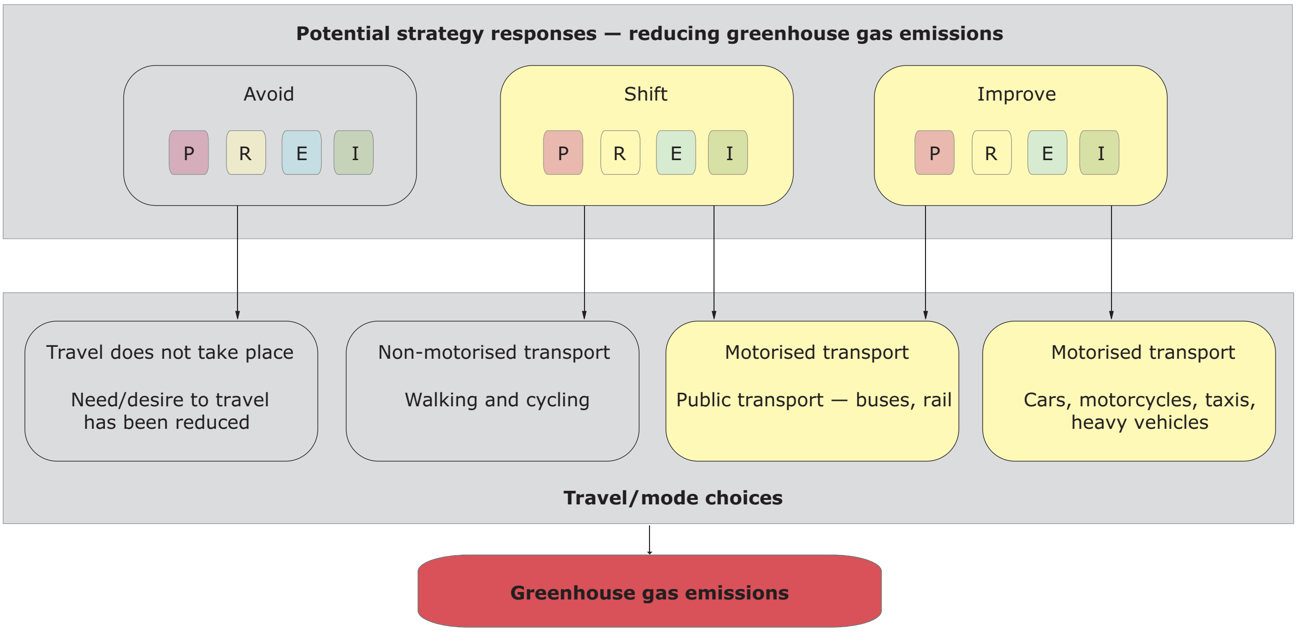
- There has been extensive research into the setting of the zone entry charge. This will be different depending on the city and largely dependent on local conditions. It is therefore recommended that full consideration be given to local conditions, willingness to pay, and the likely impact of selected charges on traffic (for example, high charges will be effective in reducing traffic, but lower charges will not deter enough traffic to make a significant difference). The charge set will also influence the amount of revenue made by the authority.

7 Environmental zone — Prague

Measure	Environmental zone
Implementation level	Local/city
Target group	Freight (road) [private, public transport] *
Type of measure	Regulation
Strategy impact	Improve (shift)
Effectiveness of measure — key benefits	50 % compliance with the scheme, resulting in a shift in vehicle composition from heavy goods vehicles. Traffic directed to more appropriate routes
Greenhouse gases emission reduction	CO_2 emission decreased by 1 650 tonnes a year
Ancillary benefits	Decrease in emission of NO_x and PM_{10}; noise and energy consumption decreases, increased attractiveness of the city centre and shift towards more environmentally friendly vehicles

Note: * Elements in square brackets are not part of this example, but could relate to the measure when implemented elsewhere.

Figure 9 Prague — Environmental zone



7.1 Overview

Prague has recently experienced a massive rise in registered vehicles as well as increased volumes of car traffic. The number of registered vehicles almost doubled between 1990 and 2003, and traffic volumes more than doubled in the same period.

Simultaneously, neighbouring countries like Germany and Austria imposed fees for heavy goods vehicles, which had a knock-on effect of increasing freight transport in the Czech Republic, which have had negative impacts on the environment, traffic flow and road safety.

Prague already had an access restriction zone in the inner city centre for heavy vehicles and buses over 3.5 tonnes. Surrounding this area is a larger zone where access is restricted for vehicles over 6 tonnes, see Map 3. With the aid of the Trendsetter project ([5]), Prague aimed to curb negative impacts of traffic on the environment by almost doubling this larger 6 tonne limit zone (maintaining the 3.5 tonne limit zone within the city centre area). The differentiation in weight limits between zones was introduced to ensure widespread support for scheme implementation. More stringent controls across the entire zone would affect more drivers and companies.

A proportion of the traffic that used to cross the zone was expected to move outside the restricted area to other roads that have larger capacity and are more capable of reducing the adverse effects of traffic. Additionally, it was expected that implementing this measure would increase pressure on fleet operators to gradually renew their fleet to modern, light and medium-weight goods vehicles that produce less hazardous emissions, are not as noisy and have less effect on other urban traffic.

The scheme operates via a permit system for access to the city centre. Those wishing to carry out goods delivery or building works within the zone area can apply for permits, which are issued on the basis of vehicle weight and legitimacy of access to the controlled zone. Non-compliance results in penalty charges being levied by patrolling police, where vehicles heavier than the stated zone entry weights are found to be within area of the environmental zone.

Specific objectives for the environmental zone in Prague were to:

- enlarge and optimise the access restriction zones for heavy vehicles over 6 tonnes;
- decreased emissions and noise in the city;
- reduce energy consumption due to a shift of vehicle fleets towards cleaner and more efficient vehicles;
- increase acceptance for clean vehicles; and
- promote a more attractive city centre.

7.2 Responsibilities of key stakeholders in implementation

Key stakeholders involved in the implementation and operation of Prague's environmental zone were the Institute of Transportation Engineering of the City of Prague, the police, local residents and fleet operators.

The implementation of other environmental zones has shown that they generally have high support and acceptance from local residents affected by the negative impacts of transport, but lower acceptance from transport companies. However, through successful design and implementation of such a scheme, transport operators become more supportive. This scheme adopted a participatory approach, which allowed members of the local population to express their opinions and potentially influence the project.

The police are responsible for enforcement within the zone; they carry out random checks for infringement of entry and award fines to those who do not comply with entry requirements.

The press and media were involved in informing the local public and organisations about the introduction and expansion of the environmental zone. The areas in which it operates are indicated by traffic signs at entry roads.

7.3 Effectiveness of the measure — key benefits

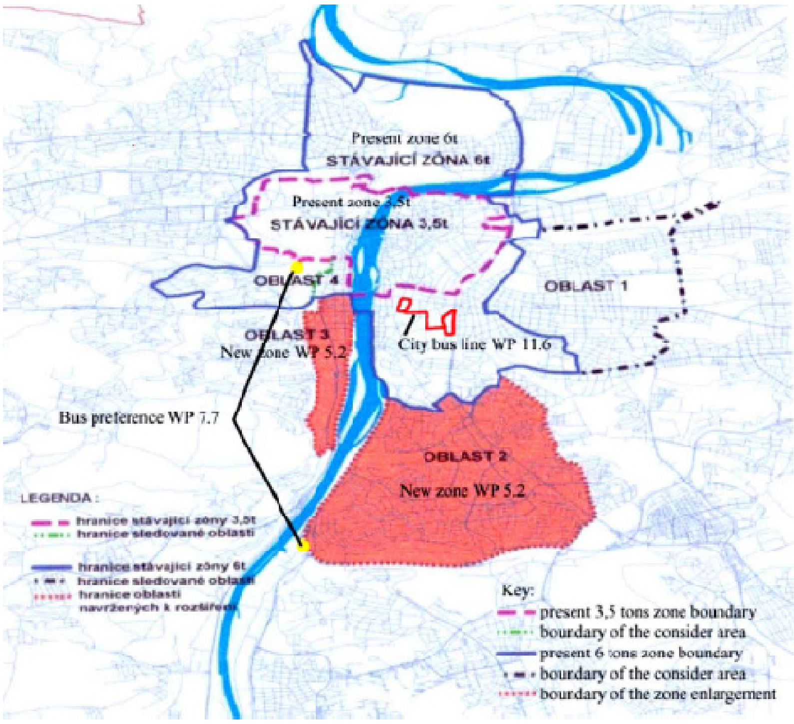
Compliance levels in the new part of the environmental zone were estimated at roughly 50 %. A shift in heavy goods traffic was seen, with associated reductions in vehicle emission in the zone. The measure was successful in reducing heavy vehicle traffic by up to 85 % on the busiest routes. Most of this traffic was redirected to more appropriate routes, including parts of the city ring road (at the southern border of central Prague). However, the volume of heavy-vehicle traffic increased on sections of the ring road by approximately 30 to 50 % (Trendsetter, 2003).

7.3.1 Greenhouse gas emission

The reduction in CO_2 per year as a result of the environmental zone implementation is shown in

([5]) Part of the EC Civitas Initiative: http://www.civitas-initiative.org/main.phtml?lan=en.

Map 3 Outline of the environmental zone in Prague



Source: Trendsetter, 2005.

Table 14. It is not known whether the measure resulted in a shift in vehicle movement to the zone periphery, thereby offsetting reductions seen in the zone.

The reduction in CO_2 emission was calculated by initially undertaking a traffic survey to identify the number of vehicle kilometres before and after the extension of the environmental zone. Emission factors for the various vehicle categories were then used to identify by how much emission of CO_2 had been reduced (Trendsetter, 2005).

As CO_2 emission was only estimated at a local level, it is not possible to gain a clear picture of the overall benefit in terms of CO_2 emission. However, the project has been presented as a success story.

7.3.2 *Ancillary benefits*

The Trendsetter (2005) evaluation report described various ancillary benefits achieved by the extended environmental zone in Prague, including:

- decrease in greenhouse gas emission;
- decrease in noise;

Table 14 Shift in heavy goods traffic composition — CO_2

Results	
Energy use	– 12.2 TJ */year
Emission of fossil fuels (CO_2)	– 1 650 tonnes/year

Note: * TJ = terajoule, a unit of energy expended.

Source: Trendsetter, 2005.

- reduction in energy consumption;
- increase in the attractiveness of the city centre; and
- shift towards more environmentally friendly vehicles.

Table 15 shows the results of a shift in heavy goods traffic composition on air pollutant emission for NO_X and PM_{10}.

7.3.3 *Economic efficiency*

Although the economic efficiency of the measure has not been calculated, potential costs that may be incurred in the implementation and operation of the environmental zone include:

- administrative costs for issuing the permits;
- enforcing the permits with patrolling police;
- permit material;
- change in traffic signals and signs; and
- loss of the existing business.

Unlike measures such as congestion charging, no significant revenue is expected from the environmental zone scheme apart from revenue from fines.

7.4 Conditions affecting the success of the measure and lessons learnt

7.4.1 *Public acceptance*

Public acceptance was not really a problem in Prague, particularly for residents affected by the negative effects of traffic. However, there was initially less support from transport companies operating heavy vehicles within the city. However, Prague overcame this by adopting a participatory approach to the design and implementation of the scheme.

Heavy haulage operators with businesses located within the zone respected the regulations and in many cases sought solutions by using lighter, compliant vehicles, one of the key objectives of the scheme.

7.4.2 *Implementation and operation*

Clear, strong transport policies at national, regional and local levels facilitate individual demand management measures and their acceptance. As anticipated by the local authorities, administration work and associated costs increased as a result of the environmental zone implementation/expansion as they now have to issue access permits for vehicles to enter the zone, for example to obtain necessary supplies and visit construction sites.

The Prague environmental zone was successful in reducing heavy-vehicle traffic flow, and managed to achieve a shift to lighter, less-polluting vehicles. However, fleet renewal can often take time and it is therefore important that zone rules are set at an appropriate level, for example if the rules are too lenient, there may not be enough pressure on operators; if too stringent, operators may be driven out of business.

A 50 % compliance rate has been reported for the Prague environmental zone. The compliance rate, and effectiveness of the measure, could be increased through the use of more stringent enforcement methods (such as cameras). However, this would increase the operating costs.

Table 15 Shift in heavy goods traffic composition — air quality

Results	
Emission of NO_X	– 43.5 tonnes/year
Emission of PM_{10}	– 3 tonnes/year

Note: * TJ = terajoule, a unit of energy expended.

Source: Trendsetter, 2005.

7.5 Transferability

Environmental zones, or low-emission zones/clear zones, have been implemented in a range of European cities. Sweden was one of the early adopters and implemented low-emission zones, primarily aimed at heavy vehicles, in Stockholm, Malmo and Gothenburg. As in Prague, the zones were enforced through a permit system with manual inspection. At the moment, schemes are being considered in Berlin and London.

Box 5 Transferability considerations — environmental zones

Geographic scale

- Prior to deciding upon the final area for the extension to the Prague environmental zone, four areas within the city were considered to ensure that the final area selected would have a satisfactory effect on the heavy vehicles passing through it, and that the existing road network arrangements were appropriate. Therefore, traffic patterns and conditions must be carefully monitored to generate information about the traffic share along with vehicle origin and destination data relating to the zone.

- Traffic not permitted to enter the Prague environmental zone has to use alternative orbital routes that are more suited to heavy-vehicles. When implementing environmental zones, it is important to consider routes that displaced traffic will take so that negative effects are not experienced on the zone periphery.

- Targeting urban areas and larger cities is considered more cost effective than implementing restrictions on motorways, or even nationally. Implementing such schemes in small areas will probably not be cost effective.

Technology

- Little technology has been used in the Prague environmental zone. Drivers apply for permits for their vehicles, and the scheme is enforced by patrolling police. An automated approach to enforcement is being considered for the forthcoming London low-emission zone, which requires more resources and will be more expensive.

Resources

- The resources required to implement an environmental zone depend on the scheme area, and the enforcement system used. However, additional administration workload and costs should be considered prior to implementation.

Legislation

- There might be a need to address legal issues prior to scheme implementation. Such issues need to be investigated at an early stage and any constraints resolved before implementation to ensure smooth running of the scheme.

- Camera-based enforcement may require prior legislation.

Awareness and acceptance

- Communication with target groups (for example, haulage companies in the Prague case study) is important from an early stage in project planning, possibly by forming a reference group or setting up stakeholder workshops. Involving affected groups in the design and implementation of the scheme will lead to greater acceptance once it is operational.

Box 5 Transferability considerations — environmental zones (contd)

Operating features

- The Prague environmental zone, like others in Sweden and the proposed low-emission zone in London, focuses on heavy goods vehicles. This is because heavy vehicles were contributing to the majority of problems and there were many passing through the zone before implementation. If the measure is implemented in areas where the proportion of heavy vehicles is considerably lower, then the effectiveness of the scheme may be reduced.

- Enforcement of the Prague zone is via a permit scheme and manual inspection. However, higher levels of compliance may be possible if camera-based enforcement is used. If heavy-vehicle drivers do not adhere to the entry requirements, and the requirements are not strictly enforced, the measure will not achieve original objectives and effectiveness will be reduced. Camera enforcement could also support enforcement for foreign drivers, in which case enforcing authorities will need to gain access to EU driver databases.

- Authorities should bear in mind possible future European Community (EC) harmonisation when choosing specific vehicle restrictions. Co-operation may be required between cities, particularly in reducing confusion between target groups if entry requirements differ between zones.

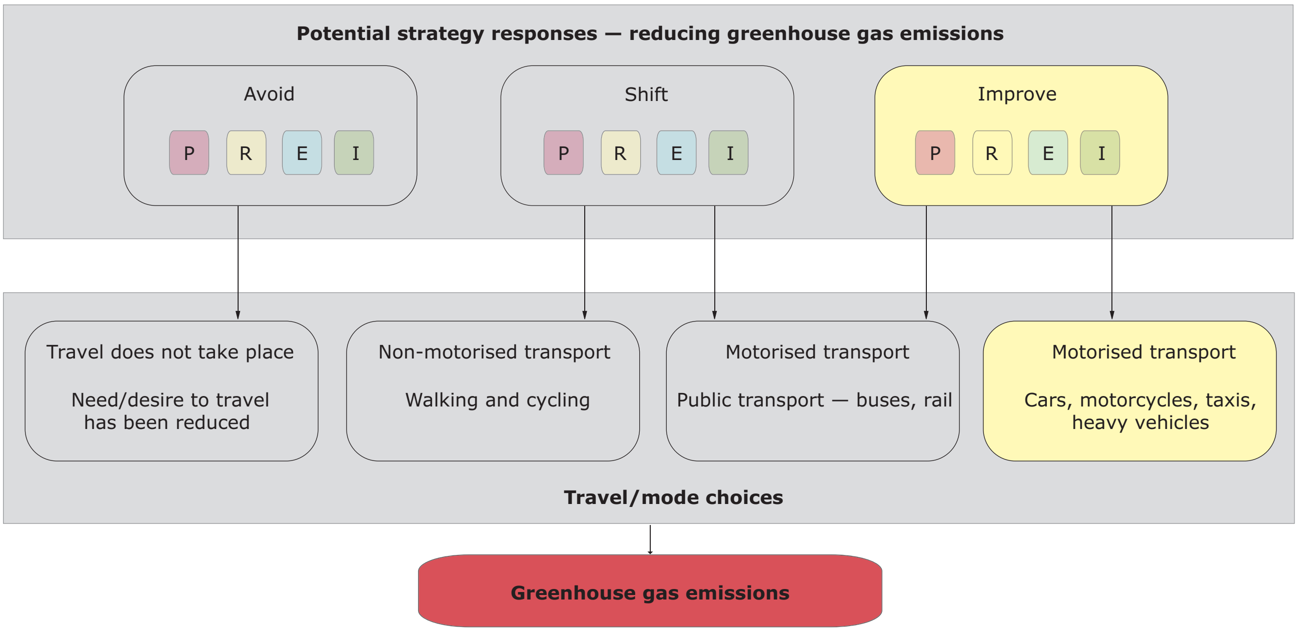
- The timing of implementation should also be considered as an issue for transferability. One of the aims of the Prague scheme was to encourage fleet owners and operators to gradually upgrade their heavy-vehicle fleets to meet tighter emission regulations (higher Euro Standards). Therefore, the

8 Freight Construction Consolidation Centre — London

Measure	Consolidation centre
Implementation level	Local/city, business/organisation
Target group	Freight (road)
Type of measure	Planning
Strategy impact	Improve
Greenhouse gases emission reduction	CO_2 emission reduced by 75 %
Ancillary benefits	Reduced packaging, reduced landfill waste and increased fuel efficiency

Note: Elements in square brackets are not part of this example, but could relate to the measure when implemented elsewhere.

Figure 10 London — Freight Construction Consolidation Centre



8.1 Overview

The key aim of an urban freight consolidation centre is to 'reduce the number of separate deliveries to one place by providing facilities where deliveries can be collected together and then a high load vehicle can make one large delivery into the target area' (WLFQP, 2006). In the United Kingdom there are various examples of this measure, and objectives include making the supply of goods more efficient, reducing congestion, improving air quality and waste recycling.

In London, freight consolidation centres are part of the wider London Freight Plan, which was drawn up to support the sustainable development of the region. This plan provides guidance and support for the Mayor of London's Transport Strategy and will help combine increased economic performance with the environmental and social impacts of freight transport for London. With data collection during the implementation, it will also provide better understanding of freight operations and how freight business impacts on London's economy.

The main objective of freight consolidation centres is to minimise the operational freight impacts of construction traffic for building and developments. The centres provide on-time deliveries of construction materials and reduce the number of deliveries to the construction site, meaning there are fewer freight trucks on the road and lower emission. Furthermore, the vehicles used are certified to Euro III emission standards and the centre is planning to introduce vehicles fuelled by biodiesel.

The London Construction Consolidation Centre (LCCC) was set up in October 2005 as a pilot study for a period of two years — ending in October 2007). It is in South Bermondsey, outside the congestion charge zone. The pilot cost GBP 3.2 million (EUR 4.7 million), and the partnership comprised Stanhope PLC, Bovis Lend Lease, Wilson James and Transport for London.

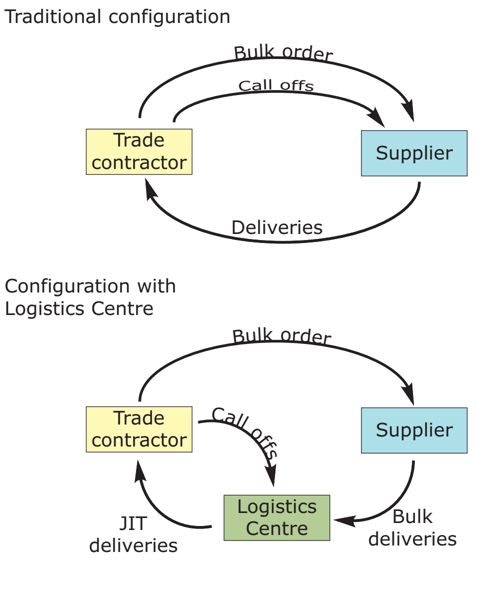
8.2 Responsibilities of key stakeholders in implementation

A range of stakeholders were involved in setting up the Construction Consolidation Centre. Key stakeholders responsible for implementation are the logistics companies and Transport for London. Other stakeholders include:

- local government/parastatals in facilitating planning authorisation, agreeing vehicle access in otherwise time-restricted areas;
- external funding for start-up (for example, EC Vivaldi, Transport for London);
- (potential) consolidation centre operators;
- trade associations;
- logistics companies; and
- local retailers/beneficiary companies (for example, developers).

Strong stakeholder partnership has been identified as a key feature in facilitating a successful consolidation centre for freight operations.

Figure 11 Consolidation centre supply chain configuration



Source: TfL, 2007.

8.3 Effectiveness of the measure — key benefits

8.3.1 *Greenhouse gas emission*

The LCCC has been successful in reducing the number of construction vehicles entering the City of London, and in reducing the number of vehicles delivering to other sites served by the LCCC. It is thought that the number of vehicles has been reduced by 68 %. On average, supplier journey times have been reduced by two hours (including loading and unloading at the LCCC). Due to the reduction in vehicle travel, CO_2 emission has been reduced by about 75 % (TfL, 2007c).

A category B office redevelopment managed to reduce CO_2 emission by 19.3 tonnes, 73 % less than the estimated emission had deliveries been made in the traditional way (TfL, 2007c).

Figure 12 shows estimates of CO_2 emission for traditional delivery methods versus LCCC delivery vehicles for the first eight months of operation. Without the scheme, it is estimated that about 22 tonnes would have been emitted, but the LCCC is estimated to emit about 5 tonnes — a saving of 17 tonnes.

8.3.2 *Ancillary benefits*

Other environmental benefits were:

- reduction in packaging;
- reduced landfill waste; and
- better fuel efficiency.

Since the beginning of the pilot, there have been no reportable accident incidents. Ongoing impacts on safety are not known but the reduction in traffic is thought to have had a positive impact.

Additional environmental benefits of all consolidation schemes include the provision of recycling services, resulting in reduced waste at construction sites and retail outlets. This has had a knock-on effect as the LCCC has reported fewer on-site injuries because there is less excess material lying around on-site.

8.3.3 *Economic efficiency*

Not enough specific details or comparative data were available on the economic efficiency of the measure to make a comment

8.4 Conditions affecting the success of the measure and lessons learnt

8.4.1 *Public acceptance and stakeholder engagement*

Strong stakeholder involvement throughout the setting up of the pilot measures has been cited as key in the success of the LCCC. The private sector, Transport for London and construction centres have worked together to design and implement the scheme to ensure maximum efficiency and the highest levels of environmental benefits.

8.4.2 *Implementation and operation considerations*

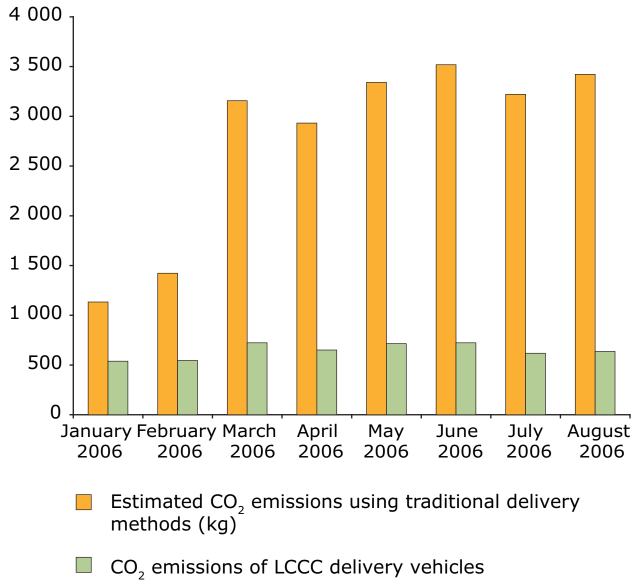
The location of the LCCC in relation to the strategic road network and target businesses has contributed to its success, ensuring that users achieve logistics efficiencies when compared to traditional freight delivery methods.

8.5 Transferability

Freight consolidation centres have been implemented extensively throughout Europe, including in Germany, Spain, Sweden, the Netherlands, France and the United Kingdom.

In addition to consolidation centres for construction, others focus on retail within a city area. For this alternative market, there may be differing transferability considerations. To ensure a scheme is successful, it requires buy-in from a large proportion of retailers within a city area. This will not only have economic efficiency implications, but also yield a greater environmental benefit in terms of reducing greenhouse gas emission. The Bristol (the United Kingdom) city retail consolidation centre scheme was set up in May 2004 and now serves 56 retailers within the city centre. The main aims of the consolidation centre were to reduce pollution and congestion in Bristol by streamlining deliveries and cutting the number of delivery vehicles. Since the scheme became operational, delivery vehicle movements to the 56 retailers have been reduced by 77 % (62 120 lorry kilometres, resulting in an 8 tonne reduction in CO_2 emission; NO_X emission has been reduced by 1.23 kg and PM_{10} by 16.56 kg) (START, 2007). To increase the effectiveness of such schemes, deliveries should be restricted to certain times of the day. Also, the centres need to attract larger retailers (that currently have their own delivering schedules and practices) by ensuring that the consolidation centre is cost effective for businesses.

Figure 12 Emission of CO_2 — estimates of traditional delivery methods versus emission of LCCC delivery vehicles (kg)



Source: Adapted from CESW, 2006.

Box 6 Transferability considerations — consolidation centres

Geographic scale

- The area served by a consolidation centre should not be too large or efficiencies in centralised distribution may be lost.

Location

- Linked to geographical scale, the location of the consolidation centre in relation to businesses or retail outlets that are to be targeted and the strategic road network will be important in determining the effectiveness of the centre. The LCCC was considered to have good links to the strategic road network and located at an optimum distance from the target area.

- To implement a consolidation centre, there must be a number of businesses (for example, retailers and construction companies) willing to join the scheme. Therefore, market research should be undertaken to identify potentially interested business and the likely costs/benefits that could be achieved before implementing the measure.

Resources

- It has been identified that cost is the biggest factor in making the switch to a consolidation centre. Personnel running such a centre need to understand which areas of construction can be influenced so that real savings can be achieved, especially in two key areas: environmental gains and the minimisation of process and waste.

Supporting measures

- Identifying or forming partnerships early on with key sectors, clients, industry and suppliers will be important in promoting awareness of the centre's goals.

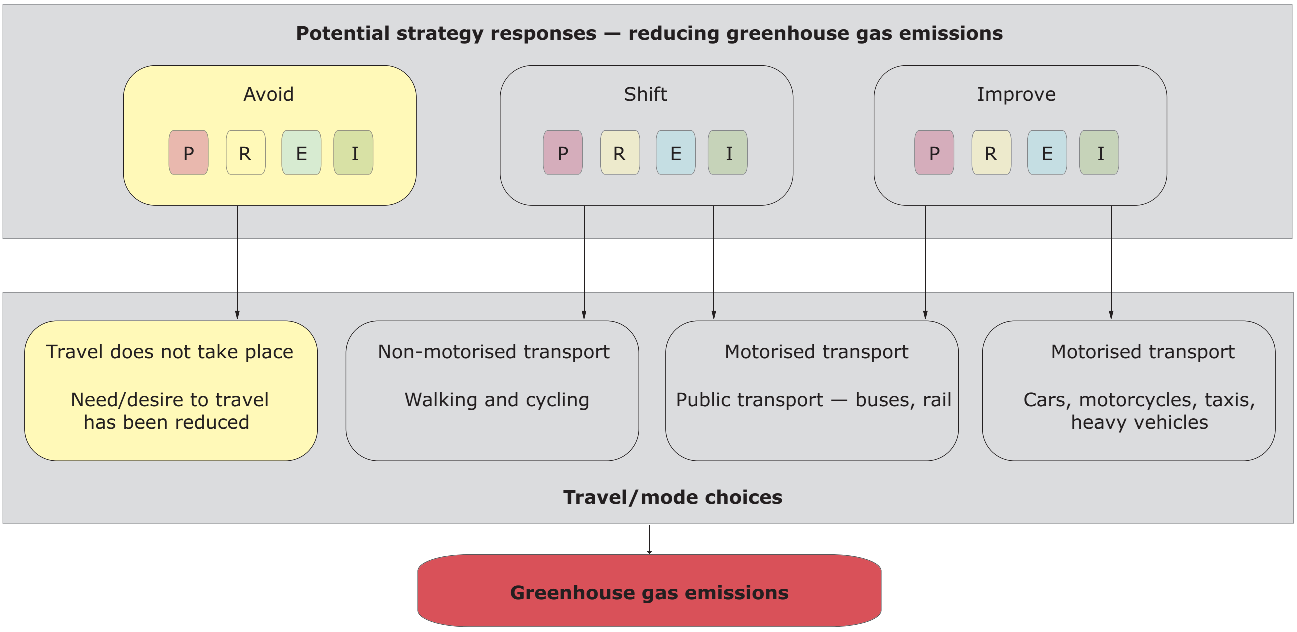
- Raising awareness about the consolidation centre and the benefits to potential users is important in increasing the number of businesses using the service, which in turn makes operations more cost effective and increases environmental benefits.

- To attract users, schemes need to be cost efficient and time efficient and must provide an equal or better service than traditional freight delivery methods.

9 Teleconferencing (ICT) — the United Kingdom

Measure	Teleconferencing
Implementation level	Business/organisation
Target group	Private, public (bus/rail/air)
Type of measure	Regulation (technology measure)
Strategy impact	Avoid
Effectiveness of measure — key benefits	The total amount of business travel undertaken by employees has been reduced
Greenhouse gas emission reduction	CO_2 emission reduced by 97 628 tonnes in 2006
Ancillary benefits	Reduced costs, reduced transport-related emissions and increased productivity

Figure 13 The United Kingdom — Teleconferencing (ICT)



9.1 Overview

Teleconferencing is the substitution of physical meetings by electronic ones through the use of audioconferencing, videoconferencing and web conferencing. This reduces dead time in transport, reduces the uncertainty of potential travel disruption and addresses security concerns. British Telecom (BT) in the United Kingdom uses four key means of conferencing:

- centrally booked conferences: a call is booked in advance centrally and participants are then either dialled, or dial in themselves;
- MeetMe conferences: a personal code is used to dial in to conferences;
- web conferences: the internet is used to exchange diagrams, notes etc at the same time as audioconferencing; and
- video conferences: also known as SeeMe.

In February 2007, the University of Bradford and SustainIT carried out a survey that focused on the economic, environmental and social impact of teleconferencing facilities and their use at BT and to what extent teleconferencing replaced face-to-face meetings (and the associated travel) within the company in 2000.

The survey asked 6 032 BT employees (representing 6 % of the total workforce, including managers and non-managers from a range of business units considered to be representative of BT as a whole) about their use of teleconferencing. 15.1 % (911) of respondents filled in their survey forms to a reasonable level, and of these 72 % (655) of respondents said they had used conferencing facilities in the past four weeks.

Of these 655 respondents, 42 % believed that their conference definitely replaced a face-to-face meeting (86 % of these would have been in the United Kingdom and 31 % in London). The baseline for calculating the difference in usage of conference calling was the study from the previous year. For example: 'The volume of conference calls initiated by BT employees was 2 047 105 in 2006–2007 (the period of the survey), more than double the 2005–2006 figure used in the previous survey' (James, 2007). These results also show year-on-year decreases. Actual trips avoided in the study are the ones that would have been face-to-face meetings in the client's office (not in the BT building).

Decreases in greenhouse gas emission were not expressly part of original project objectives, although this has clearly become a rationale for continued promotion of this technology/approach.

9.2 Responsibilities of key stakeholders in implementation

Measures have been promoted since the 1980s (audio), 1990s (video, web). For BT, development of technology, infrastructure and awareness around these measures was both for internal use and as a series of products, so for key stakeholders was business/sales driven as much as for efficiency and productivity. It is not clear from the BT survey, what kind of incentives were used to promote teleconferencing, The decisions made by and influence of BT management on employees to support teleconferencing is also unknown. However, teleconferencing is closely linked to the business interests of the company, and therefore would be easy to promote within daily working practice.

9.3 Effectiveness of the measure — key benefits

This year-on-year survey has shown that conferencing has been successful in reducing the total amount of business travel undertaken by BT employees.

Table 16 provides an overview, by mode, of the key travel savings, including mileage, avoided and avoided CO_2.

9.3.1 Greenhouse gas emission reduction

A snapshot survey undertaken with employees indicated that the last conference call made by each respondent resulted in 400 km of avoided travel and

Table 16 Avoided mileage, costs and CO_2 emission for all BT staff

Mode of travel	Number of responses	Mean mileage avoided	Total mileage avoided	Total CO_2 avoided (kg)	CO_2 avoided per trip (kg)	Total cost avoided in GBP (EUR)	Cost avoided per trip in GBP (EUR)
All modes	225	247	55 564	15 660	70	21 343 (31 619)	95 (140)
All modes excluding air	204	142	28 934	9 242	45	10 576 (15 668)	52 (77)
Petrol car	69	145	9 977	3 243	47	3,120 (4 622)	56 (82)
Diesel car	37	136	5 044	1 513	41	1 060 (1 570)	35 (51)
Van/LGV	18	106	1 905	619	34	623 (922)	57 (84)
Train	79	145	11 433	3 716	47	5 219 (7 731)	61 (90)
Air	21	1 268	26 630	6 418	306	10 767 (15 951)	468 (693)
Taxi	15	11	164	53	4	341 (505)	18 (26)
Tram/tube	13	23	303	98	8	131 (194)	11 (16)
Other (all other)	16	7	108	n/a	n/a	82 (121)	10 (14)

Note: Figures in brackets are in EUR.

Source: James, 2000.

each conference call is estimated to have saved a minimum of 40 kg of travel-related CO_2 emission.

However, conferencing is not completely carbon neutral. The James (2007) study calculates that CO_2 emission caused by electricity use could offset the benefits described above. The results are shown in Table 18. It is important to note that full life-cycle emissions have not been taken into consideration in this calculation (for example, the manufacture and disposal of required equipment).

herefore, all conferencing calls replacing face-to-face meetings are creating a net saving of at least 97 628 tonnes of CO_2 (James, 2007).

The survey results also show that respondents felt that the effects of increased use of conferencing, such as increased connectivity, has sometimes led to additional face-to-face meetings and associated travel. However, these are far outweighed by the avoided travel. A small minority of respondents also thought that too many calls were being set up or poorly managed due to the ease and flexibility of using the conferencing facilities (across the three surveys there was a gradual reduction in the number of respondents who stated that conferencing is contributing to improved work performance). This could also reflect the way in which conference calls have become routine within the organisation, which could make it difficult to assess the effects in isolation from other/external factors (James, 2007).

9.3.2 Ancillary benefits

Additional benefits identified in the course of project implementation are reduced costs, reduced transport-related emissions, increased productivity, better work–life balance and potential for reduced transport congestion. The BT website states that 'conferencing' increases business efficiency, helps gain competitive edge and helps people work together more effectively.

The elimination of 859 784 face-to-face meetings a year as a result of conferencing (where results are extended to BT as a whole) could, potentially, generate a variety of environmental benefits.

- The last conference call avoided travel of 247 miles for each respondent;

Table 17 Reduced travel and greenhouse gas emission due to teleconferencing at BT, 2006/2007

Volume of conference calls initiated by BT employees 2006/2007	2 047 105
Number of conference calls replacing a face-to-face meeting	42 % (estimate — 42 % of survey respondents stated that their last conference call definitely replaced a face-to-face meeting at a client office)
Number of avoided meetings	859 784
Number of avoided return trips per meeting	3 (mean number of locations participating in a conference call is 5.64)
Number of avoided return journeys	2 579 352
Average saving of CO_2 per journey	40 kg CO_2
Total avoided CO_2 attributed to teleconferencing at BT	**103 174 tonnes for 2006/2007 (2005/2006 figure: 54 177 tonnes)**

Source: Adapted from James, 2007.

Table 18 Greenhouse gas emission due to electricity usage during teleconferencing at BT

Electricity for broadband usage	0.005 kHz
CO_2 emission per kHz of grid electricity	0.43 kg
CO_2 emission per single conference call per participant per hour	0.00215 kg
Average length of call	1 hour
Emission due to electricity usage in conferencing	**5 546 tonnes**
Impacts of conference calls as a percentage of the generated travel-related savings	**5.4 %**

Source: Adapted from James, 2007.

- Air travel trips accounted for 48 % of avoided miles, but only 8 % of avoided trips;
- Most avoided trips would have been undertaken at congested travel times, thereby freeing up road space and seats on public transport;
- 31 % of definitely avoided meetings would have been held in London; and
- Each conference call is saving a minimum 40 kg of travel-related CO_2 emission and all conferencing calls are creating a net saving of at least 97 628 tonnes of CO_2' (James, 2007).

In relation to set objectives, a study of the BT teleconferencing project in 2006 found that each conference call avoided travel and subsistence costs of at least GBP 178 (EUR 263), and freed up management time worth GBP 120 (EUR 177). In 2006 this equated to a benefit of GBP 238 million (EUR 352 million) for BT as a whole — GBP 135 million (EUR 200 million) in avoided travel and subsistence costs, and the equivalent of GBP 103 million (EUR 152 million) in total time saved. Savings to BT were at least 10–15 times greater than the costs of providing the teleconferencing services, suggesting not cost-effectiveness, i.e. net savings from the use of these technologies/approaches.

In the 2007 survey, 19 % of respondents said they would have stayed overnight had they attended the meeting in person. Many of these stays would have been in expensive parts of London, where the average cost of an overnight stay is over GBP 100 (EUR 148), in contrast to the GBP 30 (EUR 44) average cost per conference meeting.

Table 19 shows how teleconferencing has benefited BT financially. BT saved travel and subsistence costs of GBP 109 million (EUR 161 million) and GBP 103 million (EUR 152 million) of time saving for BT as a whole.

9.3.3 *Economic efficiency*

Not enough specific details were available on the economic efficiency of the measure to make a comment — the economic benefits of the scheme have been identified (cost savings related to time, travel and subsistence), but not the costs to implement the scheme.

9.4 Conditions affecting the success of the measure and lessons learnt

9.4.1 *Public acceptance*

Success or failure of the teleconferencing measure is not affected by any specific public acceptance issues.

9.4.2 *Implementation and operation*

In addition to environmental benefits, the extensive implementation and integration of the measure within daily business activities quickly led to a range of financial benefits for BT, including reduced travel and time costs. Savings like these act as an incentive to a business, encouraging further use, hence sustaining the benefits.

9.4.3 *Business objectives*

The fact that greenhouse gas emission reduction objectives coincided with business objectives on productivity and cost savings to the business helped make the measure a success. However, the point has been raised that without specific objectives on travel or reduction in greenhouse gas emissions, the measure may not have been as successful in delivering such reductions. This lack of specific objectives on reduction of emissions may hamper success in this sense.

9.5 Transferability

As long as the technology is in place, virtual meetings using teleconferencing should be a relatively simple measure to transfer.

Table 19 Financial value to BT of avoided meetings resulting from teleconferencing

	Value per meeting in GBP (EUR)	Total value for BT in GBP (EUR)
Time (opportunity)	120 (177)	103 174 092 (152 850 506)
Travel (profit and loss)	148 (219)	109 788 379 (162 649 450)
Overnights (profit and loss)	30 (44)	25 793 523 (38 212 626)
Total value	298 (441)	238 745 994 (353 697 768)

Note: Figures in brackets are in EUR.

Source: James, 2007.

Box 7 Transferability considerations — teleconferencing

Geographic scale

- As long as the right technology is used, teleconferencing can be used on a variety of scales, from a small businesses hoping to cut down on travel client meetings, to a multinational organisation using teleconferencing not only for meetings with clients, but also for meetings with colleagues in different office locations.

Geographic location

- Eastern European countries may be presented with transferability issues whilst introducing a new way method of communication. The main reasons for this link to the older technology which is currently used within businesses. Further more, business ethics in Eastern Europe still consider face to face meeting very important and many businessman are more comfortable to meet clients in person rather than via technology.

Technology

- The BT case study used a variety of technology methods, including telephone, web-based and video conferencing. Depending on the capabilities of the organisation considering using teleconferencing, low tech solutions could be implemented.

Resources

- The resources required depend on the teleconferencing method used.

Legislation

- It is unlikely that this measure will generate any legislation implications.

Awareness and acceptance

- Not all business/organisation meetings will be suited to teleconferencing, so businesses should recognise that not all travel can be replaced in this way. Employees and clients/customers will still appreciate the value of face-to-face meetings and businesses should not expect to eliminate all such meetings.

Supporting measures

- Organisations may want to gain wider travel-reducing benefits through the use of technology and not restrict them to business travel. This many include the introduction of workplace travel plans, flexible working hours, working from home/remote working and hot-desking.

10 Discussion and recommendations

This report has focused on a limited number of measures (six) aimed at improving the environment and which have all reduced the emission of greenhouse gases from the road transport sector. The measures selected covered a range of implementation levels (local/city and business/organisation), mode groups (car, bus, freight) and the use of different policy instruments (planning, regulatory, economic and information).

10.1 Level of implementation and target groups

The majority of measures discussed within this report can be implemented at the local (city) level, or targeted at businesses or organisations (see Table 20). It was identified in Chapter 3 that there are a wide variety of measures being implemented at the national level that are expected to contribute to the reduction of CO_2 emission from the transport sector until the end of the decade (ECCP, 2006; ECMT, 2006; EEA, 2007). However, at this stage according to our research all predictions relate to the potential contribution of such measures, rather than an evaluation of their success to date. It is important that measures are implemented with support at the national as well as the local level. This may be in terms of political will, financial aid, awareness raising and achieving public acceptance. Authorities at the national and local level also have the responsibility to influence changes in businesses and organisations through encouragement and support for the uptake/implementation of measures that will reduce greenhouse gas emission.

The primary objectives of the examples discussed in this report did not include reduction of greenhouse gas emission, but this has nevertheless been achieved within a range of groups, including private, public and freight transport, as shown in Table 20. There are opportunities for the reduction of CO_2 emission within each of the groups. Measures that target private transport could concentrate on reducing the need to travel by these modes and encourage a shift to more environmentally friendly modes. Public transport could focus on improving or implementing existing infrastructure and services, possibly expanding coverage and generally increasing the attractiveness of public transport as an alternative to private transport. As a basis, efforts should be made to develop and use the cleanest and most fuel-efficient technology feasible. Finally, when focusing on freight, efforts should be made to ensure that the least-polluting freight modes are used where possible, and that the efficiency of freight operations is increased.

10.2 Roles of stakeholders and others in implementation

In each of the studies discussed, a range of stakeholders involved in either the design and

Table 20 Level of implementation and mode

Studies	Level of implementation			Target groups		
	National	Local/city	Business/ organisation	Private	Public	Freight (road)
Ecodrive programme (Netherlands)	✓	✓			✓	✓
Speed control (Rotterdam)		✓		✓	✓	✓
Congestion charging (London)		✓		✓		✓
Environmental zone (Prague)		✓				✓
Freight Consolidation Centre (London)		✓	✓			✓
Teleconferencing (United Kingdom)			✓	✓		

implementation of measures or the operational stages were identified. Table 21 provides an overview of relevant stakeholders for each of the studies. The review of key conditions for the success of measures identified that stakeholder involvement and participation was extremely important for a variety of reasons, including holding particular knowledge about a market or sector, ability to bring funding or resources to a scheme, providing support and championing schemes.

The table shows that non-governmental organisations (NGOs) were not necessarily instrumental in the implementation or operation of any of the examples discussed in this report. However, stakeholder involvement is only illustrative of the included studies. In general, NGOs will have a role to play in other examples not discussed here.

The importance of local authorities as stakeholders is stressed, as well as the involvement of public relations, the press and media.

10.3 Reductions in greenhouse gas emission

As discussed in Chapter 2, one of the initial barriers identified during the case study selection period was the lack of implemented measures citing specific objectives or targets related to reducing greenhouse gas emission. The instruments implemented tended to focus on local issues, such as air quality, noise, accessibility and congestion.

Despite these difficulties, the reports on the six measures selected included a degree of evaluation of the effect of implementation on greenhouse gas emission. Table 22 provides an overview of the reduction in CO_2 emission as a result of measure implementation. These figures are expressed as they appear in the reports — either as a percentage reduction or in tonnes.

Although the measures discussed here have been successful in achieving a reduction in CO_2 emission, the long- term effectiveness of such measures should be considered, particularly as technological advances are made. Certain measures, such as the Prague environmental zone, rely on the exclusion of higher-polluting vehicles from a particular zone or area. As technological changes take place and vehicle fleets are renewed, emissions will be reduced gradually over time, reducing the effectiveness of the measure itself.

10.4 Ancillary or co-benefits

Criteria in the case study selection process included ancillary benefits that could be achieved through measure implementation. In the majority of cases, set targets related to achievement of these ancillary benefits, particularly in terms of improved

Table 21 Relevant stakeholders in the implementation and operation

Studies	Relevant stakeholders (implementation and operation)								
	National ministry (transport, environment, planning etc.)	Regional or local authority	Public relations, press and media	Enforcement authorities (police, others)	Non-governmental organisations	Private sector (industry/ commercial)	Private sector — public transport operators	Private sector — employers	Public, residents
Ecodrive programme (Netherlands)	✓	✓	✓			✓	✓		
Speed control (Rotterdam)		✓	✓	✓					✓
Congestion charging (London)		✓	✓	✓		✓			✓
Environmental zone (Prague)		✓	✓	✓					
Freight Consolidation Centre (London)		✓	✓			✓			
Teleconferencing (United Kingdom)			✓			✓		✓	

Table 22 Greenhouse gas emission reduction benefits of measures

Studies	Demonstrated a reduction in CO_2	CO_2 reduction (%)	CO_2 reduction (tonnes)	Description	Impact level	Comments
Ecodrive programme (Netherlands)	✓		– 97 000 to – 222 000 tonnes	Low-range and high-range assumptions	High	Although ecodriving programmes could have a high impact on greenhouse emission reduction, it is expected that renewed training and promotion will be required to maintain a high level of reduced fuel consumption. To instil the ecodriving principles at an early stage, they should be incorporated in new driver tests.
Speed control (Rotterdam)	✓	– 15 %	– 1 000 tonnes		Medium	This measure has proved successful in reducing emissions in a targeted area (i.e. 3.5 km stretch of motorway). However, more widespread controls on speed are required if the effects of reduced CO_2 emission are to be experienced on a larger scale.
Congestion charging (London)	✓	– 16.4 %		Between 2002 and 2003	High	The congestion charging scheme in London has been extremely successful in terms of discouraging private car use in favour of more environmentally friendly modes. As a result, implementation has achieved a reduction in CO_2 emission compared to the previous year, and continues to do so.
Environmental zone (Prague)	✓		– 1 650 tonnes/ year		Medium	The environmental zone in Prague has been successful in reducing emissions from heavy vehicles entering the city centre area. The measure has encouraged the use of more suitable routes for heavy vehicles, the purchasing/upgrading of fleets to comply with more stringent emission standards or application for permits to enter the city.
Freight Consolidation Centre (London)	✓	– 75 %		Compared to trips previously made	High	The Freight Consolidation Centre has successfully minimised the number of larger or half-empty freight vehicles servicing construction centres in the London area by consolidating deliveries and using the 'just in time' delivery principle.
Tele-conferencing (United Kingdom)	✓		– 97 628 tonnes	Based on 2006 survey	High	The use of teleconferencing enabled BT to reduce the CO_2 impact of its business-related travel, both within the United Kingdom and internationally. However, it will not replace all business travel within the company and may not be suitable for other businesses where face-to-face meetings are a necessity. In those circumstances, more sustainable transport modes should be used instead.

air quality, reduced noise from traffic, reduced congestion and improvements in safety.

The majority of local/city level measures can also be implemented in the pursuit of achieving mobility and access objectives, including elements of congestion management and increasing access to public transport for the purpose of social inclusion (ECMT, 2007). Measures and policies that are likely to achieve these ancillary benefits could therefore be prioritised whilst ensuring that the economic efficiency of the measure remains a priority element.

10.5 Economic efficiency

Whilst local authorities or governments are able to implement a range of measures aimed at reducing CO_2 emission from transport, the measures selected may not be economically efficient. Only three of the studies explored in this report considered the economic efficiency of the measures. Reports for both ECMT (2007) and ECCP (2006) stress the importance of cost effectiveness of measures when aiming to reduce CO_2 emission.

ECMT (2007) discusses the cost effectiveness of various types of measures and concludes that those involving technical adaptations (engine/vehicle design) generally generate net costs whereas measures involving behavioural changes tend to generate net benefits. In addition, measures that promote efficient vehicle components are also expected to generate net benefits.

Over time, technological improvements in vehicles may reduce the effectiveness of mitigation measures. It is therefore important that costs and benefits (including where these have an impact on the environment, society and the economy) are considered carefully prior to scheme implementation. This is particularly the case for measures such as environmental zones, as the aim is often to encourage fleet owners and operators to gradually upgrade their heavy-vehicle fleets to higher Euro Standards. Therefore, environmental zones will become less effective over time as the vehicle fleet is upgraded.

10.6 Success factors

The review of the case studies revealed a range of factors that contributed to the success of implementation and in achieving desired results. Some of the key success factors are reviewed here.

10.6.1 Implementation of accompanying measures

Although the measures included within this report have largely been discussed in isolation, they are often only successful when implemented as part of a wider strategy or package of measures. A range of 'sticks and carrots' are required to ensure that measures are successful in achieving their objectives and targets. These supporting measures or policy instruments may be in the form of additional or alternative public transport services, increases in parking restrictions or prices, access restrictions for certain types of vehicles, introduction of other fees and taxes, and awareness campaigns (see below). In the London congestion charging scheme example, extensive public transport service improvements (buses) were implemented from the first day of scheme operation. This provided alternative means of travel for people still requiring access to the zone.

10.6.2 Strong leadership

All measures that initially may seem controversial, particularly if they result in travel restrictions, will require strong leadership and support in order

Table 23 Ancillary benefits

Studies	Traffic reduction	Air quality (NO_2/NO_X)	Air quality (PM_{10})	Noise	Accidents	Economic
Ecodrive programme (Netherlands)		✓			✓	✓
Speed control (Rotterdam)		✓	✓	✓	✓	
Congestion charging (London)	✓	✓	✓		✓	
Environmental zone (Prague)		✓	✓	✓	✓	
Freight Consolidation Centre (London)	✓					✓
Teleconferencing (United Kingdom)	✓					✓

to aid implementation. This was the case in the London congestion charge example, which was pushed through by the Mayor despite initial strong opposition to the scheme. In many cases, initial resistance has been shown to turn into support when the measures have been implemented and the expected benefits become apparent.

10.6.3 Awareness raising

Awareness raising about the implementation of a measure or the potential benefits, either in terms of greenhouse gas emission reduction or the ancillary benefits that are likely to be achieved, is essential and likely to contribute to the success of a measure.

Awareness raising may be targeted at the public, which can initially help to gain acceptance for a measure prior to implementation. Various media can be used to reach the intended audience, including print and television campaigns, focus groups and consultation. The public can be informed about the proposed measure, have the opportunity to influence the design and implementation, and learn about the potential benefits or consequences that may affect them. Subsequently, awareness raising can affect the uptake of or compliance with a measure once implemented, particularly in terms of highlighting any restrictions or rules and alternative options.

Awareness raising can also be targeted at other groups, such as the private sector, transport operators, retail, government departments and other stakeholders. Through targeting wider stakeholders in awareness raising, measures are likely to gain increased support and assistance during the design, implementation and operation stages.

Awareness raising was particularly important in ensuring the success of the London congestion charging scheme. It was important that the public was well informed about the changes that were taking place, how to enter the zone by car and available alternatives, and why the scheme was being implemented..

10.7 Transferability

This report has attempted to address some of the issues related to the transferability of instruments in terms of their implementation in other Member States. There are many variations that could affect the success of measures, such as differences in geography, population density, cultural aspects and affluence (ECCP, 2006). Key transferability issues that should be taken into consideration include the geographic scale, technological and resource requirements, potential legislation, awareness and acceptance issues and operating features.

10.8 Outlook

10.8.1 Considering the future role of monitoring and evaluation of scheme implementation on reduction of greenhouse gas emission

The process of identifying projects for this report has shown that there are limited examples currently available of measures that have been implemented and evaluated within the Member States that have:

a) targets that include reducing greenhouse gas emission; and

b) detailed and standardised evaluations following measure implementation, including of greenhouse gas emission reductions.

It is important that detailed monitoring and evaluation is undertaken. Where best practice is available in terms of reducing greenhouse gas emission from projects aimed at road transport, it should be shared. There are many such programmes that are being implemented now or are in the planning stages across European Member States

10.8.2 Evaluating the cost effectiveness of measures

Cost effectiveness has been mentioned at various stages throughout this report. It is acknowledged that cost-effective measures need to be investigated and subsequently taken into account when addressing the impact of the transport sector on climate change, (in the context of the EU's attempts to reduce greenhouse gas emission across all sectors). A range of factors should be considered when assessing the cost effectiveness of measures, including:

- investment costs (for example, equipment, infrastructure, labour);
- operation and maintenance costs;
- administration costs — government (for example, monitoring and executing policies/measures);
- administration costs — users (for example, enforcement);

- intangible consumer benefits (non-financial) (for example, comfort levels raised/lowered as a result of measure implementation);
- indirect dynamic costs (for example, long-term welfare benefits such as employment); and
- energy savings (CE Delft, 2006).

As this report has shown, very few fully encompassing cost-effectiveness evaluations (ex-post or ex-ante) are undertaken for the examples studied, although cost effectiveness should be an important issue in the decision-making process related to mitigation.

When comparing the cost effectiveness of CO_2 mitigation in transport to that in other sectors, there is no clear answer as to which is more effective. A review of *ex-ante* and *ex-post* studies by CE Delft (2006) revealed that efficiency measures in the transport sectors can be more cost effective than some measures in other sectors, particularly if measures altering consumer behaviour are included. Whilst behavioural changes are cost effective, they may be difficult to enforce or achieve through environmental policies. A variety of cheap technological solutions are also available, but their scope in terms of mitigation is limited (CE Delft, 2006).

10.8.3 Consideration of CO_2 in earlier stages of planning

There are existing tools that are perhaps not being used to their full capacity in terms of recognising the potential of plans, programmes and strategies in reducing greenhouse gas emission from road transport. Strategic Environmental Assessment and sustainability appraisal are often required for a variety of plans, policies and programmes, particularly those related to transport and spatial planning/development. Both strategic environmental assessment and sustainability appraisal assess plans, policies and programmes in terms of their potential effects on climate change, and climate change objectives set by the administration responsible for the plans, policies and programmes.

It is therefore important to use Strategic Environmental Assessment, Sustainability Appraisal and other planning tools/assessments at an early stage within the planning process when making decisions regarding transport, land use and development to more effectively address future impacts on climate change and other environmental issues. This may include the siting and approval of housing, employment and other land uses and their proximity to one another and the potential to use more sustainable modes of transport.

10.8.4 Importance of formulation of a strategy of measures, including accompanying measures

In reality, measures are rarely implemented in isolation. Therefore a strategy, including a range of supporting measures needs to be developed to deliver the best results in terms of reducing CO_2 emission.

One of the success factors identified in the London congestion charging example was the large-scale investment in public transport services to facilitate alternative methods of travel into and within the city alongside the restrictions placed on private vehicles.

Further research and consideration therefore needs to be given to the elements or supporting measures that will deliver the most effective results in achieving and sustaining a reduction in greenhouse gas emission from the transport sector. Supporting measures may include public transport infrastructure or services, walking and cycling improvements, public awareness and publicity campaigns, restricting regulatory measures and fiscal penalties However, it is anticipated that strategies will need to be flexible to adapt to local situations and will therefore not be fully transferable, making it difficult to recommend or promote any particular strategies. Good practice should be shared where available.

10.8.5 Impacts of locally implemented schemes/ measures on CO_2 emission reduction at a national leve

As identified earlier in this report, the majority of measures considered are implemented at the local or city level. If a better understanding of the impacts of such measurements or programmes was gained, there may be incentives for local level administrations to use climate change and reductions in greenhouse gas emission as a driver in scheme development and implementation. There are synergies with the previous point related to the elements that contribute to a successful strategy, and which combination of measures can be implemented at the local level to make the greatest contribution to greenhouse gas emission reductions. If possible, the contribution that such measures make to reducing greenhouse gas emission nationally should be identified.

In addition to identifying the impacts of locally implemented policies and measures on reducing CO_2 emission, an inventory of these policies and measures could be compiled. Such an inventory could be used by local and regional administrations aiming to become more responsible in terms of contributing to reducing CO_2 emission. The inventory could be similar to those created at a national/international level, including details on measures that have been implemented at the local level, projected CO_2 emission reductions, cost effectiveness of measures and any identified transferability considerations.

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Abbreviations

CO_2	carbon dioxide
CO	carbon monoxide
EC	European Commission
ECCP	European Climate Change Programme
EEA	European Environment Agency
EU	European Union
ICT	information communication technology
LCCC	London Construction Consolidation Centre
NGO	non-governmental organisation
NO_X	oxides of nitrogen
MS	Member States
PAM	Policies and Measures
PM (PM_{10})	Particulates (particles measuring 10µm or less)
UNFCCC	United Nations Framework Convention on Climate Change

Annex A Measure selection criteria

The first task was to develop criteria for the selection of measures. A three-stage approach was developed: basic selection of measures, followed by categorisation, then ranking and prioritisation. Figure 14 provides an overview of the selection criteria, which is described in more detail below.

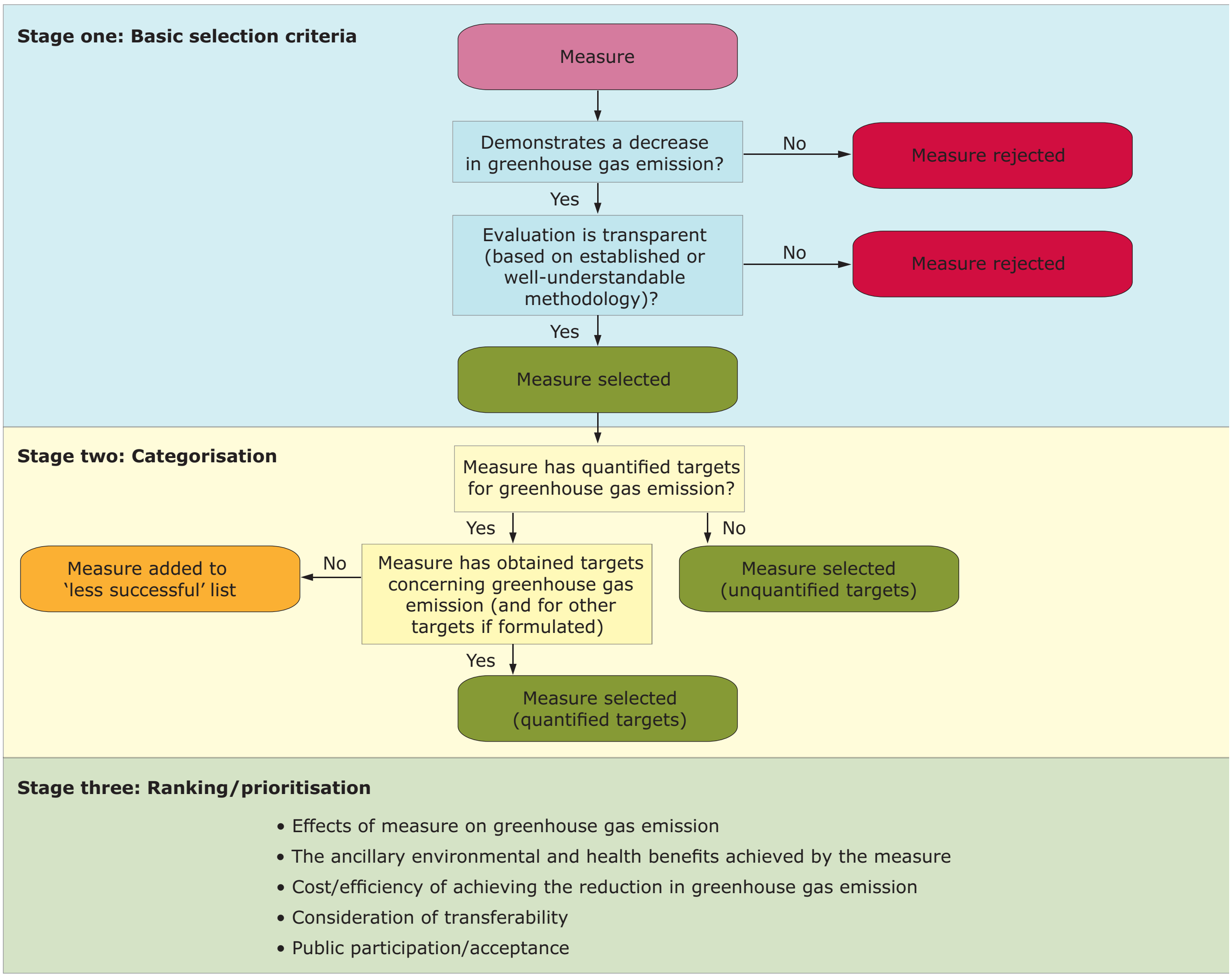
A1: Stage one: Basic selection

Measures selected for the report should demonstrate a decrease in GHG emissions (short and long term). In the cases of a less successful project, measures can be selected if they fail to achieve a projected decrease of emissions of GHGs. Any cases not fulfilling this basic criterion are disqualified. (Note: The terminology 'GHG emissions' is used even if only most likely are covered in different road transport projects).

Short-term savings as well as long term savings should be reflected.

All other benefits should be regarded as ancillary. Those can be divided into environmental and non-environmental benefits.

Figure 14 Measure selection criteria



During the selection of measures, the monitoring methodology used in reports should be evaluated. Only case studies where the evaluation is transparent and based on established or well understandable methodology should be accepted. Those projects that do not meet these criteria will be disqualified. It is difficult to talk about 'independent' evaluations but cases where it is obvious that the report is presented to only back up for instance a political opinion and where it might be obvious that the results obtained are not scientifically linked to the implemented measures should not be qualified.

A2 Stage two: Categorising projects

At this point, a list of measures would have been selected based on the initial selection criteria. Stage two of the process looks at categorising and prioritising the measures.

Measures can basically be divided into two groups — those for which quantified targets were formulated when deciding on the measure and those where this was not the case.

Measures will be split into three initial categories:

- Those setting and meeting quantified targets for GHG emissions ('successful' project, quantified targets);
- Those demonstrating a decrease in GHG emissions but did not have quantified targets ('successful' project, un-quantified targets); and
- Those which had quantified targets for GHG emissions, demonstrated a decrease in emissions, but did not meet the projected decrease ('less successful' project)

A2.1 Measures with quantified targets (1 and 3)

Those measures should at least have quantified targets for GHG emission reductions to be qualified (otherwise the fall into category b). They might in addition have other aspects discussed but not necessarily having quantified targets for all of those aspects.

To be categorised as a 'success', the measure should at least have obtained the targets concerning GHG emissions. It should also basically have achieved targets for other aspects if such ones were formulated.

A2.2 Measures without quantified targets (2)

It has been determined in Stage One of the selection criteria that measures selected so far will have demonstrated a decrease in GHG emissions. These measures are then categorised as those demonstrating a decrease in GHG emissions but did not have quantified targets (Selected un-quantified). When making a comparison between measures and to take into account the situation in different countries/regions, this improvement in the GHG situation may be judged against a BAU situation or a 'basic alternative'.

A3 Stage three: Ranking/prioritising measures

There are a number of factors that will affect the ranking or prioritisation of measures within the three groups of selected projects. The complexity of the issue and the limited size of this project will make it difficult to come up with exact guidelines about cutting points. In addition a lot of necessary information to make detailed analyses is most likely missing from the reports. This therefore has to be a kind of a subjective judgement. The following factors and guidelines may be used to rank measures:

A3.1 Priority Group 1

Effects of project on GHGs:

- total decrease in emissions from the BAU case, including lifecycle aspects;
- total decrease in non- GHG emissions (CH_4, N_2O), including lifecycle aspects;
- proven modal shift to lower carbon modes (as a proxy for GHG reductions).

Cost/efficiency of achieving the improvements concerning GHG emissions:

- the cheaper per tonne of reduced GHG emissions the higher ranked;
- cost per tonne of saved (using different economic lifetimes and discount factors, best to establish discount rates in advance — low or high rate if long term for CO_2);
- reduction in user costs (e.g. fuel costs as part of O&M costs).

The ancillary environmental and health benefits achieved by the project:

- any noise and vibration benefits (human population, building fabric);
- intrusion in sensitive biotopes;
- improvement in air quality;
- improved safety.

Possibilities to transfer to other places, e.g. higher chance of success when no changes in legislation required, hence easier to transfer to other locations.

Public participation/acceptance.

A3.2 Priority Group 2

(Only to be used if Priority Group 1 is not enough to separate projects)

The ancillary non-environmental benefits achieved by the project:

- increased accessibility;
- improved operational efficiency of the transport system, e.g. less congestion (while not raising);
- health benefits due to increased physical activity, e.g. through regular walking/cycling;
- wider economic benefits, i.e. beyond cost-benefit analysis. E.g. economic development around transport projects;
- effect on quality of life (open space, security and safety etc.);
- reduction in demand for travel (discounting any rebound effects);
- improved awareness of the population about climate change issues from this project (is partly covered by the point in Group 1);
- partnerships built as a result of the project that could lead to further win-win situations and projects (e.g. London congestion charge).

Other considerations:

- best technology available has been used;
- project fits with surroundings/culture;
- project is participatory;
- fit with other policy areas. were there synergies or policy clashes?;
- project design and implementation including communication strategy;
- are individual policies parts of a wider package of measures?;
- political leadership — but measured how? Yes or no? (Thinking of London congestion charging and Livingstone's success in pushing things through without loosing the vote);
- political deliverability and public acceptability. there ought to be a measure here of the involvement of the public — participatory processes are very important to get acceptance and behaviour to match with expectations etc.;
- improved planning regime;
- level of enforcement;
- increase in revenue with potential to hypothecate for other low carbon projects (not necessarily limited to transport).

Through identification of the factors in Priority Group 1, measures will be able to be further categorised, and a range of different types of measures selected (to avoid many similar projects being reviewed in Task 3). If necessary, one or more of the factors in Priority Group 2 can be used to separate possible candidate projects.

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