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THE AUTO OIL II PROGRAMME

Working Group 5

NON-TECHNICAL MEASURES

Final Report

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Executive summary

Objectives and scope

This report presents the work of Working Group 5 “Non-technical measures” (WG5) in the second European Auto-Oil Programme (AOPII). AOPII was launched in Spring 1997 to develop cost-effective strategies allowing to meet the Community’s air quality targets for the year 2010. The programme is required to include an evaluation of the potential of non-technical measures to contribute to this objective.

WG5 considered a wide range of transport policy and management measures in

- traffic management (including telematics and infrastructure improvement),
- public transport, cycling and walking, as well as intermodality;
- freight transport;
- pricing measures, including road pricing;
- turnover and modernisation of the vehicle park;
- mobility and driver behaviour; and
- land use policies.

The distinguishing feature of non-technical measures is that they are geared towards changing the behaviour of transport users, i.e. the choice to travel or to move goods, and the choice of transport mode, time of travel, driving behaviour, and type of vehicle owned. The reaction of transport users cannot be foreseen exactly, depends usually on local circumstances and may vary over time.

Non-technical transport policy measures are in the competence of different authorities. Especially for measures with a potential to improve urban air quality, competencies are concentrated on the local and regional level. A coherent policy framework at the European level can facilitate the implementation of certain measures in those areas. Transport policy measures at national and Community level provide an additional potential to reduce emissions.

The aims of WG5 are

- to demonstrate that a wide range of non-technical measures is available,
- to promote good practices for the implementation of non-technical measures,
- to show the potential of non-technical measures to influence local air quality,
- to provide quantified information on the impacts and costs of selected non-technical transport policy measures, allowing cost-efficiency estimates, and
- to provide thereby a basis for policy recommendations.

Relevance of non-technical and local measures

The step-by-step tightening of vehicle emission and fuel quality standards has led to impressive reductions in pollution, although technical progress was partially offset by the strong growth in passenger and freight transport, the shift towards road and air transport, the tendency towards larger cars, and a high market share of older, more polluting vehicles in some countries.

Main reasons for these developments are an increase of mobility needs in the society, changes in land-use patterns, inadequate organisational frameworks of some public transport means, declining fuel prices in real terms, and long life cycles for vehicles in some countries.

Efficient transport is an essential service contributing to competitiveness, economic growth, and social cohesion in the European Union. However, an indefinite continuation of current trends in growth of road transport would be unsustainable in relation to the environmental impacts at global, regional and local level. The AOPII basecase shows significantly declining annual growth rates for the next 20 years.

The promotion of sustainable mobility requires an integrated approach, including technical measures to reduce emissions as well as non-technical measures

- to make better use of existing infrastructure,
- to achieve a shift to less environmentally damaging modes of transport, and
- to reduce the need for travel.

Good local and regional transport systems are essential for a sustainable transport system in general and for the improvement of urban air quality in particular. Depending on the geographical scope of air quality problems, local measures might be a cost-efficient response to meet air quality targets.

Data collection and validation

Assessing the impact of non-technical measures on air quality is characterised by a high complexity and uncertainties with regard to data availability, behavioural responses and the comparability and transferability of results. In addition, cumulative effects of different measures and side effects with regard to other policy objectives have to be taken into account.

WG5 decided to concentrate its work on the impact of measures on transport related dimensions, i.e. transport demand, modal choice, vehicle ownership and fleet composition, and driving behaviour. Emission effects would be reported where available, but would be considered as part of the modelling. Special consideration was given to investment and operating costs of measures.

A questionnaire was developed aiming at additional information on practices at urban level and data needed for the cost-effectiveness analysis. More than 40 replies to the questionnaire were received, mainly from city authorities, research organisations, consultants, pressure groups, and public transport operators. The replies indicate that at present the implementation and the discussion of non-technical measures is concentrated on traffic management, public transport, and road pricing. Quantity and quality of the information provided varies considerably. There is much qualitative information on measures and their assessment, while data on quantitative impacts of measures and investment and operating costs are relatively rare.

Data validation included an assessment of figures provided in literature and research projects, together with the case studies resulting from the survey. Criteria are methodological transparency and mutual confirmation between different sources. Validation also had to address local conditions and circumstances, though owing to limited information and resources it was impossible to take full account of these important factors.

Promoting good practice

A wide range of general information and good practice for the implementation of non-technical measures has been collected directly from WG5 members, from studies and reports, and from replies to the questionnaire. The main findings and examples for the impacts of different types of non-technical measures are presented in this report.

Specific information on research findings and descriptions of good practices for the implementation of non-technical measures with the goal to reduce emissions and improve air quality are going to be collected in CANTIQUE, a concerted action within the Transport programme in the 4th RTD Framework Program. CANTIQUE will make use of the work in WG5 and provide its results on the Internet.

Key facts for the assessment of non-technical measures

Emission and pollution levels are one indicator for the quality of transport systems, besides others like regional accessibility, management of traffic flows, safety, quality of public transport, opportunities for non-motorised transport, and stimulation of the regional economy. Local strategies have to deal with synergies and trade-offs between these objectives, taking into account the availability of policy options, the relation between cities and their environs, and the question of public acceptability.

Single (“stand-alone”) measures addressing only one aspect of the transport system tend to be less effective with regard to the above mentioned objectives, than policy packages. Optimal packages of measures in this respect are likely to include physical, pricing and organisational measures which combine a “push & pull“ approach towards motorised road transport and its alternatives.

Possible adverse effects may call for mitigating measures. For example, measures to reduce congestion and increase average speeds encourage additional traffic, while traffic restrictions to central areas may induce development of activities in suburban belts, generating additional traffic flows that are much more difficult to bundle.

In addition to the cost-effectiveness ratio as required for the assessment model, the policy dimension of non-technical measures has to be addressed. This includes especially the public acceptance of measures. Co-ordinated information policy and awareness campaigns can increase the sensitivity towards a topic and the acceptance of measures.

Assessment of selected non-technical measures

Based on a comprehensive inventory of measures, a limited set of measures was chosen to be modelled in Tremove, the AOPII transport and emission model (see AOPII final report and reports of WG7 "Cost-effectiveness"). The selection of measures was based (1) on their expected emission impact and cost-effectiveness, and (2) the possibility to define the relevant modelling inputs with available data. The following measures were tested:

Type of measure		Measure description		Athens 1)	Lyon 1)
Traffic Management	Improving traffic flows	Increase road capacity	capacity +5%	X	
	Improve attractiveness of other modes	Public transport prioritisation	Bus speed +15%	X	
Public Transport	Reduced fares	Bus/Metro	fare -30%	X	
Freight transport	City logistics	Reduce freight mileage	load factor +10%	X	
Road Pricing	Parking charges	Undifferentiated	charge + 3 ECU	X	X
	Urban road pricing	Time differentiated	see text	X	X
		Vehicle differentiated	Package of measures 2)		
Fleet modernisation	Environmental classification	Zoning / restricted access	Package of measures 2)		
	Scrappage scheme	premium	1000 ECU/car	X	

1) Following recommendations from WG1 - Environmental Objectives, the measures were tested for Athens and Lyon.
2) Not included in WG5 report.

For the assessment of non-technical measures with Tremove, the changes to the attributes of transport supply, mainly the generalised price reflecting the total cost of using a transport mode, have to be defined. Measures can change market prices or travel time (speed) directly, or they might have an impact on capacities, average load factors and frequencies of service. The following Table summarises the main results:

Measure	Domain	Social costs: NPV[1)]	Government budget[2)]	Emission impact (2010)		WG7 Code
				NOx	PM	
Road capacity +5%	Athens	-1.68	-11	0.0 %	-0.8 %	NT_4
Bus prioritisation	Athens	0.66	-26	-0.6 %	-0.4 %	NT_5
Public transport fare -30%	Athens	-1.14	-292	+0.4 %	+1.6 %	NT_3
without fixed load factor[3)]				-0.6 %	+0.3 %	--
City logistics (load +10%)	Athens	-9.32	-87	-2.8 %	-5.7 %	NT_6
Parking charge (3 ECU)	Athens	-1.82	+1490	-5.7 %	+1.4 %	NT_1
	Lyon	-1.49	+491	-2.1 %	-8.7 %	NT_1
Time-differentiated road pricing (peak/off peak)	Athens	-1.17	+1630	-5.5 %	-3.8 %	NT_2
	Lyon	-1.40	+491	-2.9 %	-6.2 %	NT_2
Scrappage scheme	Greece[3)]	0.57	-295	+0.1 %	0.0 %	NT_7

1) Net present value (2000-2020) incl. noise and accident costs, bio. ECU. Negative value: cost savings.
2) Budget impact for the year 2010. Positive value: net revenues, negative value: net expenditure.
2) I.e. with increase of bus frequency only during peak.
3) Social cost and budget impact for Greece, relative emission impact for Athens.

It has to be stressed that the modelling results provide strategic information on potential impacts of measures. They will have to be verified by competent local authorities based on specific local information and more detailed (network) models. Therefore the following findings can serve as a general guidance but they can not provide a blueprint for local policies:

- There is a substantial no-regret potential available, i. e. measures that reduce road transport emissions and at the same time total costs to society by making transport more efficient.
- Although the impact of individual non-technical measures on emissions at city level is relatively low, their importance on a more local level can be much higher. Bundling of measures to policy packages can induce a mutual strengthening of individual measures.
- Road capacity increases have usually a limited impact on emissions, as opposite effects outweigh each other.
- The emission impact of measures improving bus transport depends crucially on load factors, emission rates, and cross elasticities to other modes.
- The impacts of public transport prioritisation depend strongly on the effect on road capacity for other users.
- Road pricing measures have a strong potential to achieve cost-efficient emission reductions if they bring user costs closer to the marginal social costs of transport.
- Though more flexible pricing instruments allow for different user reactions, also parking charges can be very effective.

There is a need to improve the knowledge on impacts and costs of non-technical measures and to encourage related research projects. Specific research needs are seen in the area of freight transport, especially urban delivery systems.

1. Introduction

This report presents the work of Working Group 5 "Non-technical measures" (WG5) in the second European Auto-Oil Programme (AOPII).

WG5 was chaired by the Transport Directorate-General of the European Commission[1]. The constructive climate in the discussions and the competence of the members of WG5, representing member states, industries and non-governmental organisations, are appreciated.[2]

Members to WG5 were nominated by Austria, Germany, Greece, Italy, the Netherlands and Sweden; European Automobile Manufacturers Association (ACEA), European Natural Gas Vehicle Association (ENGVA), European Petroleum Industry Association (EUROPIA), International Association of Public Transport (UITP), Intelligent Transport Systems-Europe (ERTICO); Bureau Européen des Unions des Consommateurs (BEUC), European Federation for Transport and Environment (T&E), and EUROCITIES.

This final report has been prepared by the Transport Directorate General[3], based on the discussions within the Working Group.

Chapter 1 of the report presents the framework: The Auto-Oil Programme, the integration of environmental concerns in transport policy in general, and the current trends of transport demand.

Chapter 2 summarises the mandate and the work program of Working Group 5.

Chapter 3 shows the general findings of WG5 with regard to the various types of non-technical measures, their potential to reduce air pollution and issues relevant for the assessment and the implementation of non-technical measures.

Chapter 4 describes the development of a data set for selected measures to be fed into the cost-effectiveness analysis of Auto-Oil II and the respective modelling results.

Chapter 5 draws conclusions and provides an outlook to follow-up work.

1.1 The Auto-Oil Programme

1.1.1 Auto-Oil I

The *first Auto-Oil Programme (AOPI)* was established in 1993 by the Commission in co-operation with the European Automobile and Oil Industries as a technical programme to assist further legislative proposals on road transport emissions. It was intended to provide policy makers with an objective assessment of the most cost-effective measures to reduce emissions from the road transport sector to a level consistent with the attainment of the EU air quality standards. The programme was concentrated on technical measures like vehicle technology and fuel quality, while non-technical measures were not included in the overall assessment framework.

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1 Chairman: Jan-Peter Paul, Head of Unit E1 – Analysis and development of transport policy, Transport DG.

2 We are especially grateful for the very active participation of Stefan Andersson (Sweden), Thomas Glöckel (Austria), Norbert Goriβen and Hedwig Verron (Germany), Cornelis Havenith (Netherlands), Antonio Lioi (Italy), Ivan Cieker and John Price (EUROPIA), Marc Girardot, Lies Goeller and Klaus J. Meyer (UITP), John Hollis, Stefan Larsson and Peter Rogers (ACEA), Frazer Goodwin, Gijs Kuneman and Jose Palma (T&E), Hans van Raak, Oscar Martijn and Anthony van de Ven (EUROCITIES), and Jeffrey Seisler (ENGVA).

3 Rapporteurs: Doris Schröcker (till November 1998) and Stefan Winkelbauer (from December 1998), Unit E1, Transport DG.

In 1996 the Commission presented conclusions[4], followed by proposals for several directives[5]. In 1998 Council and European Parliament reached a political agreement on a package of measures[6], including a tightening of vehicle emission limits for cars to be implemented in 2 steps (2000 and 2005) as well as new specifications for fuels.

1.1.2 Auto-Oil II

The second *Auto-Oil Programme (AOPII)* was launched in 1997 with the additional participation of Member States and non-governmental organisations to develop a package of strategies to meet the Community's air quality targets set out in directives for the year 2010. The programme should enhance the methodology used in AOPI and provide a cost-effectiveness assessment of different policy options and measures.[7]

AOPII was supposed to include legislative proposals on vehicle emission limits and fuel quality standards, confirming or modifying the indicative values for the year 2005 in the Commission's AOPI proposals. Furthermore, the overall assessment process would include non-technical, local and fiscal measures, representing a major innovation compared to AOPI.

As the directives adopted in 1998 include mandatory technical standards for 2005, the scope of AOPII was reduced in this respect. The Commission presented modified terms of reference for AOPII in November 1998, referring to two principal aims. Firstly, the ongoing work should be completed to assess future air quality and to support proposals intended to take effect from the year 2005 (e.g. standards for heavy-duty vehicles and motorcycles, further fuel specifications, or provisions for improved roadworthiness testing). The second principal aim is to provide the methodological foundation for longer term air quality studies covering all sources of emissions.

There was no change to the requirement to evaluate the potential of non-technical and fiscal measures. Furthermore, the Commission may bring forward proposals setting levels of specification for fuels used by captive fleets and for liquid petroleum gas, natural gas and biofuels. All proposals are required to take into account background considerations including an evaluation of the impact of the agreed directives and an estimation of the potential to reduce emissions from all sources.

AOPII involves a wide range of interests and their representatives, the AOPII stakeholders. The programme was managed by an ad hoc inter-service group of Commission services[8]. The group addressed strategic issues and reported progress to a "contact group" bringing together Member States, industry, non-governmental organisations and other experts.

The work programme of AOPII was executed by seven working groups (WG), dealing with environmental objectives (WG1), cost-effectiveness analysis (WG7) and the various policies and measures (WG2: vehicle technology, WG3: fuels, WG4: inspection and maintenance, WG5: non-technical measures, WG6: fiscal instruments).

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4 Communication on a future strategy for the control of atmospheric emissions from road transport taking into account the results from the Auto/Oil Programme COM(96) 248 final of 18.06.1996.

5 "Auto Oil proposals" for directives relating to the quality of petrol and diesel fuels (1996), relating to emission standards for cars (1996), light commercial vehicles (1997), and heavy-duty vehicles (1997), and on the roadside inspection of the roadworthiness of commercial vehicles (1998).

6 Directive 98/69/EC relating to measures to be taken against air pollution by emissions from motor vehicles and directive 98/70/EC relating to the quality of petrol and diesel fuels, both of 13 October 1998.

7 It was specifically intended to satisfy the requirements of articles 3 and 9 of the proposed directives on emissions from motor vehicles and quality of petrol and diesel fuels respectively (96/0163 (COD) and 96/0164 (COD)).

8 The group was chaired in rotation by the DGs for Transport, Energy, Industry and Environment, and included in addition the DGs for Economic affairs, Research, and Taxation. A permanent secretariat was provided by the Environment DG.

To enable the identification of a cost-effective combination of technical and non-technical measures, an advanced scientific/methodological approach has been implemented in Auto-Oil II. The methodological framework includes[9]

- A socio-economic transport model ("Tremove") including modules to forecast transport demand, modal split, vehicle stock and transport emissions, for 10 "model cities" and the remaining urban and non-urban areas in 9 member states;
- Air quality models for the 10 model cities and their vicinity to forecast the concentration of several pollutants (NO_x, CO, NMVOC, Benzene, PM_{10}), subdivided over time and space; and
- An optimisation model ("Leuven II") intended to choose the most cost-efficient package of European, national and local policy measures.

1.1.3 The role of Working Group 5

Working Group 5 "Non-technical measures" (WG5) deals with a wide range of different measures, including traffic management, public transport, road pricing, measures targeting the efficiency of freight transport, measures promoting the modernisation of the vehicle stock, influence on mobility behaviour, as well as land use aspects.

WG 5 is required to collect information on the transport demand and emission reduction impacts of non-technical transport policy measures. As far as possible, these impacts should be provided in quantitative terms. A quantitative description of selected measures including cost estimations had to be delivered to Working Group 7 for the Auto-Oil II cost-effectiveness analysis. Where data availability does not allow data input into modelling, measures should be analysed and best practices presented.

Policy recommendations of WG5 have to consider that the competence for non-technical measures lies at different levels of government with a concentration on the local level. Furthermore, non-technical measures have an impact on transport emissions as well as on important side-effects like efficiency, safety and land-use.

WG 5 held eight meetings[10]. Beside the WG5 members mentioned in the introduction, representatives of the General Directorates responsible for other Working Groups in Auto-Oil II attended the meetings regularly. In this meetings, the work programme was structured, methodological key issues were discussed, an inventory of promising measures has been set up, preliminary conclusions were drawn, and a short list of measures to be delivered to WG7 for the cost-effectiveness analysis was defined. Furthermore, the modelling results for non-technical measures as well as potential policy conclusions were discussed and this final report was developed.

The objectives of WG 5 are

- to demonstrate that a wide range of non-technical measures is available,
- to promote good practices for the implementation of non-technical measures,
- to show the potential of non-technical measures to influence local air quality,
- to provide quantified information on the impacts and costs of selected non-technical transport policy measures, allowing cost-efficiency estimates, and

[9] These models are described in detail in the reports of Working Groups 1 (air quality) and 7 (transport model and assessment).
[10] On 20 March, 9 July, 1 October, 10 December 1997; 26 February and 19 November 1998; 25 January and 7 October 1999.

- to provide thereby a basis for policy recommendations.

1.2 Integrating environmental concerns in transport policy

1.2.1 The Common Transport Policy

Efficient transport is an essential service contributing to competitiveness, economic growth, and social cohesion in the European Union. But the growing demand for transport has led to increasing negative impacts on the environment, too[11].

The Treaty on the European Union (Amsterdam Treaty) emphasises the principle of sustainable development respecting the environment (Art. 2) and sets out objectives for environmental protection (Art. 130r to 130t). Political support for the promotion of sustainability comes from the European Council and the European Parliament.

The Common Transport Policy (CTP)[12] aims to promote efficient and sustainable transport systems that meet the needs of both citizens and business. Environmental considerations are a crucial part of the CTP. The Community strategy to integrate the environmental dimension in an overall approach to sustainable mobility is based on the following main lines of action:

- the completion of a liberalised Internal Market for transport services;
- the development of the Trans-European Transport Networks;
- the promotion of fair and efficient pricing, including environmental costs;
- the enhancement of a shift to efficient, environmentally friendly transport modes, and the development of intermodal transport;
- the promotion of strict environmental and safety standards for vehicles and fuels.

The framework for an integrated European strategic approach to sustainable mobility is represented in a series of policy documents developed over the last years, notably:

- Already the Green Paper on "The Impact of Transport on the Environment"[13] and the White Paper on "The Future Development of the Common Transport Policy"[14] assess the problems of sustainable mobility and put forward guidelines for a strategy to enhance the efficiency and sustainability of the transport system.
- The White Paper on "Fair Payment for Infrastructure Use"[15] proposes a step-wise approach towards a system where all users of transport infrastructure pay for the costs they impose, including environmental impacts, to enhance both the efficiency and the sustainability of the transport system.
- The White Paper "A Strategy for Revitalising the Community's Railways"[16] and several legislative proposals for railways[17] have the objective to improve the competitiveness of rail transport as an environmentally friendly transport mode.
- The Communication on "Intermodality and Intermodal Freight Transport"[18] defines intermodality as a systems approach to transport. Reducing friction costs

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11 See e.g. Joint Environment and Transport Council, June 1998, Conclusions, paragraph 1.
12 See e.g. European Commission, COM (92) 494 final of 02.12.1992 and COM (98) 716 final of 01.12.1998.
13 European Commission, COM (92) 46 final of 20.02.1992.
14 European Commission, COM (92) 494 final of 02.12.1992.
15 European Commission, COM (98) 466 final of 22.07.1998.
16 European Commission, COM (97) 242 final of 29.05.1997.
17 European Commission, COM (98) 480 final of 22.07.1998.
18 European Commission, COM (97) 243 final of 29.05.1997.

of the transfer between modes shall allow to make better use of existing capacities in different modes.

- The Communication on "Transport and CO_2"[19] launches a broadly based package of measures to reduce CO_2 emissions from transport, including technical improvements as well as incentives to influence driver behaviour.
- An approach for the future development of the Common Transport Policy was presented in the Communication "The Common Transport Policy, Sustainable Mobility: Perspectives for the Future".[20]

The Joint Council on Transport and Environment in June 1998 set short to medium term priorities on the integration of environmental concerns in transport policies, stating i.a. that an indefinite continuation of current trends in the growth of road transport is unsustainable in relation to environmental impacts[21]. It adopted also the proposal for a reporting mechanism for transport and environment using an indicators-based approach to monitor the progress towards sustainable transport in the EU.

In October 1999 the Transport Council adopted a report to the European Council of Helsinki on "Transport and Environment"[22]. This report provides a short analysis of the situation, sets objectives, summarises progress achieved and the need for further actions, and states a concrete list of measures to be completed by the Member States and the Commission. On the basis of reports from the Commission, the Council will regularly review the operational parts of this strategy.

Aiming at a better integration of environmental and transport policies, the Commission has set up a joint expert group of transport and environment experts from member states, jointly chaired by the DGs for transport and environment. This collaboration should support the development of consistent policy measures and appropriate monitoring methods. A final report of this group is expected for autumn 1999.

1.2.2 Local and regional policies

Good local and regional transport systems are essential for a sustainable transport system in general and for the improvement of urban air quality in particular. The competence for measures in this area lies primarily with local, regional and national authorities, working together with transport operators. However, as stated in the Communication on "Developing the Citizens Network"[23], also at Community level the right policy framework has to be established and useful tools for authorities, operators and users can be provided.

Goals regarding the environmental impact of transport in national transport policies are addressed usually in a general manner, and do in many cases not refer to measures such as public transport, which are mainly under control of regional and local authorities.[24]

19 European Commission, COM (98) 204 final of 31.03.1998.
20 European Commission, COM (98) 716 final of 01.12.1998.
21 Council Conclusions, Council of the European Union, Doc. 9151/98 TRANS 81 ENV 249, Annex I.
22 Council of the European Union, 11717/99, TRANS197, ENV 335, 11 October 1999.
23 European Commission , COM (98) 431 final of 10.07.1998.
24 A survey of national transport and environmental plans was undertaken in the framework of COST CITAIR, see Action 616, Draft Final Report, Zürich 1998

The importance of urban strategies is underlined by the fact, that in the European Union about three quarters of the population lives in cities[25]. 75% of all passenger movements are below 10 km, 60% of all good movements below 50 km.

Local measures are usually in the competence of local authorities. However, as a consequence of the air quality directive[26], Member States have to ensure that a plan or programme is prepared to achieve the urban air quality targets. This plan shall incorporate also urban transport policy strategies.

1.2.3 Transport and air pollution

One of the most prominent issues of environmental concern over the past decades has been the air pollution caused by the transport sector. With regard to the Community's air quality targets transport plays a substantial role as a polluter. Though current trends show a significant decrease of emission levels, in 1995 transport still amounted to 59 % of overall NO_x emissions (of which road transport 44 %), 64 % of CO emissions (road transport 60 %) and 43 % of NMVOC (non methane volatile organic compounds) emissions (road transport: 37 %) in the European Union.[27]

The step-by-step tightening of vehicle emission and fuel quality standards has led to impressive environmental progress[28]. Major reductions in pollution, especially from new vehicles, have been achieved. Whereas emission levels for certain pollutants were reduced drastically (e.g. lead), other components of air quality targets could not be met. Emissions of the main green house gas CO_2 show an increasing trend.

1.3 The development of transport demand

The technical improvements with regard to the emission of pollutants from road transport have been partially offset by:

- the significant growth in overall passenger and freight transport (about 2.5% and 2.3% p.a., respectively, between 1980 and 1997; see Table 1.1),
- the shift towards road and air transport, both in passenger and freight markets, which has reduced the share of other modes, in some cases even in absolute terms[29],
- the tendency towards larger cars, and
- a high market share of older, more polluting vehicles in some countries.

The main reasons for these developments are[30]:

- Mobility needs in the society increase, notably due to globalisation, changes in logistics systems, the creation of the internal market, higher available incomes, and an increase of leisure time.

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[25] In France urban trips account for roughly 50 % of all passenger kilometres (Charles Raux in: ECMT Round Table 102, Changing daily urban mobility: Less or Differently?, Report of 9/10 May 1996; Paris; p. 89).

[26] Directive 96/62 and daughter directives (adopted for SO_2, NO_2, PM and lead; proposals for Benzene, CO and Ozone).

[27] Source: Auto Oil II Emissions Base Case, June 1999. According to EUROSTAT, transport shares were 2 to 5 % higher.

[28] Road transport emissions decreased by 13% (NO_x) to 19% (NMVOC) from 1990 to 1995, with further reductions of 23% to 35% expected between 1995 and 2000 (Source: Auto Oil II Emissions Base Case, June 1999); see also chapter 4.1.

[29] Rail transport went down from 287 bio. tkm in 1980 to 219 bio. tkm in 1994, followed by an increase to 240 bio. tkm in 1998.

[30] European Commission, Communication on Transport and CO_2, Developing a Community Approach, COM(1998)204; Commission Staff Working Paper, Transport and the Environment – overview of current policy directions, SEC(1998)634.

- Land-use development has increased travel distances and reduced the attraction of public transport. This is primarily a result of increased demand for housing space in "green" areas, diversification of labour and changes in shopping and leisure activities.
- The regulatory frameworks for rail and other forms of public transport tend to be inadequate for these new challenges. While securing system integration, more competitive elements could urge operators to satisfy customer demand and thereby increase the role of these sectors in the transport system.
- Declining fuel prices in real terms have contributed to making transport cheaper.
- Long life cycles, e.g. due to high purchase cost and registration tax, imply a high market share of older, more polluting, vehicles in some countries.

Table 1.1: Development of passenger and freight transport demand in the EU15 between 1980 and 1997, and growth in AOPII basecase till 2010.

		Demand in bio. pkm or tkm			*Annual growth*		*Growth p.a. 2000-10 (AOPII basecase)[1]*
		1980	*1990*	*1997*	*1980-90*	*1990-97*	
Passenger	Passenger cars	2333	3302	3787	3.5 %	2.0 %	1.6 %
transport	Motorcycles	115	112	121[a)]	-0.3 %	1.1 %	1.8 %
(in bio. pkm)	Buses & coaches	347	369	393	0.6 %	0.9 %	1.5 %
	Rail & tram	293	322	323	0.9 %	0.0 %	1.9 %
	Air [b)]	96	204	322	7.8 %	6.7 %	--
	Cycling & walking	232	220	233[a)]	-0.5 %	0.8 %	1.0 %
	Total	*3416*	*4529*	*5179*	2.9 %	1.9 %	*(1.6 %)*
Freight	Road	626	929	1202	4.0 %	3.7 %	2.0 %
transport	Rail	287	255	237	-1.2 %	-1.0 %	2.1 %
(in bio. tkm)	IWW	107	108	119	0.1 %	1.4 %	0.4 %
	Pipelines	93	77	86	-1.9 %	1.6 %	--
	Sea (intra-EU)	778	919	1124	1.7 %	2.9 %	--
	Total	*1891*	*2288*	*2768*	1.9 %	2.8 %	*(1.8 %)*

1) For 9 countries included in Tremove (D, EL, E, F, IRL, I, NL, FIN, UK).
2) 1995.
3) European traffic.
Source: European Commission (DGVII), Transport in Figures, 1999.[31]

An indefinite continuation of current trends in growth for private and commercial road transport and aviation is unsustainable in relation to the environmental impacts at global, regional and local level.[32] The AOPII basecase assumes a significantly reduced road transport growth for the next 10 years and even less after 2010.

The promotion of sustainable mobility requires an integrated approach. This requires technical measures to reduce emissions as well as non-technical measures

- to make better use of existing infrastructure,
- to achieve a shift to less environmentally damaging modes of transport, and
- to reduce the need for travel.[33]

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31 Regularly updated on the Europa internet site at the following URL: <http://europa.eu.int/en/comm/dg07/tif>

32 Council of the European Union, Report to the European Council of Helsinki, October 1999.

33 Joint meeting (Transport and Environment) of the Council, 17 June 1998, Conclusions, Doc. 9151/98 TRANS 81 ENV 249, Annex I.

2. Working program and methodology

2.1 Objectives and scope

Working Group 5 "Non-technical measures" (WG5) deals with a wide range of transport policy and demand management measures. The scope of non-technical measures to be considered was defined in the Terms of Reference and was further developed in the discussions of WG5. Non-technical measures include

- traffic management (including telematics, infrastructure),
- public transport, cycling and walking, as well as intermodality;
- measures to enhance the efficiency of road freight transport and alternatives to road freight transport;
- pricing measures, including road pricing;
- measures to influence the turnover and modernisation of the vehicle park (including scrappage schemes);
- measures targeted at mobility and driver behaviour,
- land use aspects.

Economic instruments are part of the work programmes in Working Groups 5 and 6. It has been agreed that general fiscal measures, i.e. the issues of vehicle purchase, circulation and fuel taxes, are dealt with in WG6. Pricing measures including road pricing and parking charges remain in WG5.

The distinguishing feature of non-technical measures is that they are geared towards changing the behaviour of transport users, i.e. the choice to travel, modal choice, choice of time of travel, driving behaviour, and the type of vehicle owned. The reaction of transport users cannot be foreseen exactly, depends usually on local circumstances and may vary over time.

Non-technical transport policy measures are in the competence of different authorities. Policy conclusions with regard to the implementation of measures will have to regard the principle of subsidiarity. Especially for measures with a potential to improve urban air quality, competencies are concentrated on the local and regional level. A coherent policy framework at European level can facilitate the implementation of certain measures in those areas. In addition, transport policy measures at national and Community level provide an additional potential to reduce emissions.

The aims of this report are

- to demonstrate that a wide range of non-technical measures is available,
- to present good practices for the implementation of non-technical measures,
- to show the potential of non-technical measures to influence local air quality,
- to provide quantified information on the impacts and costs of selected non-technical transport policy measures, allowing cost-efficiency estimates, and
- to provide thereby a basis for policy recommendations.

2.2 Inventory of measures and impacts

WG5 has developed a comprehensive inventory[34] of potential non-technical measures. The objective was to include all measures for which measurable (positive) impacts were indicated in the available literature and to structure them in a pragmatic way.

Many classifications of transport policy measures are available from literature, based on different criteria, e.g. the economic components controlled (price, capacity, market access …)[35], the economic form of state intervention[36], transport impacts, technical characteristics, or fiscal characteristics. WG5 defined a pragmatic structure, which has been used for internal discussion, as an annex to the questionnaire (see below), and to structure the present report.

Table 2.1 provides an overview of this pragmatic structure, while the inventory itself is shown in Annex 2.

Table 2.1: Inventory of non-technical measures: Overview

Traffic management:

traffic control; speed limits; infrastructure investments; infrastructure allocation to specific users; better parking management; zoning - restricted access; Park & Ride, integrated parking systems

Public Transport / intermodality:

extension of services; frequency increase; pricing; comfort; safety; security; information; inter-connected ticketing; marketing, advertising; specific type of service; capacity planning/utilisation; car pooling; car sharing; park & ride; location and design of stations; incentives for walking and cycling; integrated information/reservation/booking/ticketing systems

Efficiency of/ Alternatives to road freight transport:

TEN: infrastructure projects; location of transfer points; integration of modes at service level; introducing/enhancing competition; improved logistics; increased loading capacities

Road Pricing:

Pricing strategies: urban pricing; parking charges; inter-urban road pricing

Price differentiation by: type of vehicle; mileage / access; time (peak-/off-peak); capacity/space; emissions; air quality situation; vehicle occupancy; targeted groups

Promotion of fleet modernisation:

environmental or age classification; subsidies for scrappage; incentives for new cars/new technologies; disincentives of old cars; promote upgrading/ retrofitting; second hand market for clean fuel vehicles

Land use / accessibility:

urban planning; housing patterns; location (working, shopping...); mixing functions in city centres; planning aspects: use of space for transport; infrastructure investments

Influence on mobility behaviour:

targeted awareness activities; pre-trip information; education; fleet management; new technologies of the information society; car-free residence

Source: Working Group 5, own concept.

In order to cope with the complexity of the subject and to maintain a pragmatic approach, a matrix structure was adopted for the variety of measures and their impacts. Four possible dimensions were agreed to classify the type of impact of the

34 See Annex 1.
35 E.g. F. Voigt, Verkehr, Band 1, Berlin 1973.
36 E.g. J.M. Thomson, Modern Transport Economics, Suffolk 1974.

measures. They reflect determinants for the use of motorised vehicles and therefore emissions and air quality:

- transport demand (transport volume),
- modal choice,
- motorization and the composition of the fleet,
- mobility and driver behaviour.

For each dimension a range of parameters was identified which allows to quantify the effects of the different measures and packages of measures. For example, effects on transport demand and modal split could be expressed in passenger-km or ton-km. Alternatively, the mileage of different vehicle categories can be considered. The number of vehicles of different categories will reflect the motorization composition of the fleet, and time and speed factors are able to reflect driver behaviour.

2.3 The assessment framework

2.3.1 Cost-effectiveness assessment model

In the framework of WG 7, their consultants[37] provided guidelines for the data requirements of the TREMOVE model[38], a transport simulation tool that allows to analyse technical and non-technical measures. The policy measures can be designed for one of the 10 model cities[39], the other urban areas of one of the 9 countries considered, or the non-urban areas of a country (or for combinations of these domains).

Model inputs are - for non-technical measures - the changes of transport prices, capacities, average speed or load factors in comparison to the basecase, and the additional investment and operating costs. The model calculates the emission reductions for five pollutants as well as the total cost to the society (i.e. for transport users, service providers and governments).

In addition, the optimisation model LEUVEN II supports the selection of cost-effective packages of measures that allow to satisfy the air quality targets. Both TRENEN and LEUVEN II are intended for a strategic analysis rather than for an investigation of concrete local situations.

While a large number of policy measures can be analysed with TREMOVE, certain promising measures will not be included in the model, either due to methodological doubts or because the link between the measures and specific costs and effects cannot be quantified. For example, land use issues are not covered due to the nature of the model. The main limitations in this respect are:

First, in terms of geographical coverage: In TREMOVE, countries have been divided in three zones - a city (usually defined as the metropolitan area, for example Greater London or the Land of Berlin), the other urban area in the country, and the non-urban areas. Hence, it will often be difficult (though not always impossible) to analyse policy measures aimed at a very local scale.

37 Standard & Poor's DRI and K.U. Leuven.
38 For a detailled description see the Cost-effectiveness study report produced by WG7.
39 Athens, Berlin, Cologne, Dublin, Helsinki, London, Lyon, Madrid, Milan, and Utrecht.

Second, a major assumption of TREMOVE is that the behaviour of transport users is driven by the relative generalised cost (which includes the money cost and the time cost) of each transport mode. Thus, a policy measure that has no effect on the generalised cost of transport will not have any impact on user behaviour in the model. For example, measures affecting the comfort or security of public transport are excluded, because they have no impact on generalised cost. Some of these measures are quite innovative and might become more important in future.

However, policy measures such as improving the frequency of public transport, park and ride or improving the interconnections between modes will have an impact, because they influence the travel time. WG5 noted the importance of including non-motorised modes, in particular cycling and walking in the modal split.

In addition, the model does not take into account behavioural differences with regard to fixed and variable "point of use" costs, although in practice marginal user costs will be decisive for transport user decisions.

Some behavioural issues are covered in the specification of the transport model, depending on the possibility to translate them into relevant parameters. Route choices could be reflected through parameters related to travel time and the type of road (urban / inter-urban roads; geographic aspects would not be considered).

The effects of the measures are expressed in parameters that are related to

- transport volume (mileage) and load factors
- (average) speed and travel time
- the distribution of traffic over time and on specific roads (peak-/off-peak hours, different types of roads).

These parameters are provided for different modes (road, rail) and for specific vehicle categories (classification of passenger cars, motorcycles, buses, and trucks, according to different fuel and propulsion systems and sizes).

The costs of measures include

- costs borne by the users of the transport system (monetary and time costs),
- the costs for investment, administration, operation and maintenance, borne by the institutions responsible for the implementation of the measures, including (for non-technical measures) governments at local and national level (incl. the net effect of any changes in tax revenues), EU funds, transport operators, industry,
- additional costs to the society in form of external effects such as CO_2 emissions, noise, and accidents.

The base case is developed in the framework of WG1 and WG7 for the ten cities and nine countries. The cost-effectiveness analysis will tackle additional measures compared to this business-as-usual scenario.

Packages of technical and non-technical measures are defined in co-operation with other AOPII working groups and tested with the models developed in WG 7.

2.3.2 Important issues for the assessment of non-technical measures

The closer the leverage point of measures is to emissions (e.g. for technical measures), the easier it is to predict effects on pollutant emissions. It is therefore more ambitious to evaluate transport policy measures, which affect the behaviour of people.[40] The analysis of non-technical measures links and tries to compare different instruments and measures to manage different forms of mobility and life styles[41].

For assessment purposes it is necessary to define costs and effects of single measures. However, where possible bundles of measures will be specified which would maximise the emission reduction potential of non-technical measures, including complementary push & pull strategies combining e.g. parking management, pricing and public transport (see chapter 3.10).

Effects should be relevant at city level and medium- to long-term. Measures with positive short-term and limited local effects (street level, specific areas within a city) should be treated as specific, separate strategies in addition to the analysis at city level or in a medium- to long-term time horizon.

Emissions and air quality are not the only assessment factors for urban transport policy. Other objectives include transport quality, efficiency and urban accessibility. In many cases measures to improve the position of public transport and non-motorised modes or to reduce motorised vehicle traffic are linked with complementary objectives such as reducing congestion, increasing safety and quality of life.

Findings of WG5 with regard to assessment issues are summarised in chapter 3.1.

2.4 Data collection and validation

2.4.1 Data availability and uncertainties

Assessing the impact of non-technical measures on air quality is characterised by a high complexity and uncertainties with regard to data availability, behavioural responses and the comparability and transferability of results. In addition, cumulative effects of different measures and side effects with regard to other policy objectives have to be taken into account.

WG 5 follows the guidelines provided by WG 7 on the requirements of the TREMOVE model. The group decided to concentrate its work on the impact of measures on transport related dimensions, i.e. transport demand, modal choice, vehicle ownership and fleet composition, and driving behaviour. Emission effects would be reported where available, but would be considered as part of the modelling. Special considerations would need to be given to the investment and operating costs of measures, while welfare costs owing to behavioural changes would be estimated in the assessment model.

The work started with a systematic collection of information on promising non-technical measures on local, national and European level. This includes studies, reports from members of WG 5, different public and private sources, including governments, international organisations, interest groups as well as EU transport research in the 4th Framework Programme.

The analysis showed that various indications on the impact of certain measures on transport are available. Most of them are based on models and estimations, only few before/after studies are available. References to costs of measures are relatively rare.

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40 COST CITAIR, Action 616, Learning Scheme for the Assessment and Shaping of Environment Oriented Urban Transport Policies, Zürich/Bern 1998

41 ECMT Round Table 102, p. 92

Data are not fully available or inconsistent between cities, notably with regard to urban fleet and traffic volumes of different vehicle categories, freight transport, the impact of measures at an European level, future trends, behaviour, and the full costs of measures.

In assessing the impact of different measures, national, regional, and local framework conditions have to be taken into account that may limit the comparability and transferability of results. The transferability of effects and costs has to be assessed. Current transport research offers starting points to categorise different cities (SESAME), and objectives and measures (CAPTURE, DANTE), in order to allow a better comparison of the situation in different cities.

2.4.2 The questionnaire

A questionnaire has been developed aiming at additional information on practices at urban level and identifying the availability of the specific data needed for the cost-effectiveness analysis (see Annex 3). The well above 200 recipients include the AOP stakeholders, transport and environment ministries of EU-Member States, authorities of selected cities in the European Union, including the members of the City Contact Group for those ten cities that serve as models and case studies throughout the Auto Oil II Programme. In addition transport operators, the vehicle and fuel industry, associations and experts from the fields of transport and traffic planning and science have been included.

More than 40 replies to the questionnaire were received, mainly from city authorities (11), research organisations and consultants (13), pressure groups (5), and public transport operators (4). About 70 % of the replies came from organisations in five member states, namely Germany (8), Austria (6), Italy (5), the United Kingdom (5), and Sweden (3).

The replies to the questionnaire indicate that in practice the implementation and the discussion of non-technical transport policy measures is concentrated on three areas:

- Traffic management (traffic control, infrastructure investment, separate lanes, parking management, zoning – restricted access),
- Public transport (pricing, comfort, car sharing/pooling, park and ride), and
- Road pricing (parking charges, cordon pricing, congestion pricing).

In addition, examples for fleet management (scrappage, incentives), land use planning, and mobility behaviour (targeted awareness activities, and drivers training) were provided.

Quantity and quality of the information provided varies considerably. In general there is much information on the type of measures which have been implemented and much background information (expectations, assessment studies, accompanying measures, rejected measures, and main obstacles for implementation).

On the other hand there is little information on quantitative impacts of measures and on investment and operating costs. This is due to the fact that measures are implemented parallel to other measures, while other circumstances are changing, too. In addition, monitoring of impacts is often not a priority for policy makers.

The available information has been used in chapter 3 (range and potential of non-technical measures) as well as for the definition of modelling inputs in chapter 4 (cost-effectiveness assessment).

2.4.3 Data validation

Data validation included a comparative assessment of the figures provided in literature and research projects, together with the case studies resulting from the survey. Positive criteria are the mutual confirmation between different sources and a methodological transparency.

In co-ordination with WG7, impact levels can be cross-checked with assumptions in the Tremove model. This can be done (1) by comparing Tremove elasticities with elasticities in other studies, especially from the recent transport RTD project TRACE[42], and (2) by comparing Tremove results with the findings of other sources (see chapter 4).

TRACE produced a detailed elasticity handbook and an interactive sketch planning model on CD-ROM, both providing elasticities for a range of typical contexts. These values are the result of a large-scale review of available literature, as well as new runs with national and regional traffic models for many different contexts.

The validation process also had to address local conditions and circumstances. However, owing to limited information and resources it was impossible to take full account of these important factors.

Moreover, data validation had to deal with the variety of definitions and different data, taking into account the different models used in for the air quality studies and the cost-effectiveness analysis as well as the sources for the assessment of non-technical measures (literature, research projects, replies to the questionnaire).

The valuation of modelling results has to take into account the different time-scale of various measures, which may imply a decision-making chain for the implementation of relevant measures. Sensitivity tests for the most promising measures could help to conceive uncertainties.

2.4.4 Promoting good practice

During the work of WG5 a wide range of information on good practice for the implementation of non-technical measures has been collected. Examples were provided directly by WG5 members, obtained from studies and reports, and from replies to the questionnaire. The main findings and examples for the impacts of different types of non-technical measures are presented in chapter 3 of this report.

More detailed descriptions of good practice are provided on the European Local Transport Information Service ELTIS (http://www.eltis.org/). This interactive guide to current transport measures, policies and practices implemented in cities and regions across Europe is jointly funded by the Transport DG of the European Commission and UITP, the International Union of Public Transport. The aim of ELTIS is to support a practical transfer of knowledge and exchange of experience in the field of urban and regional transport in Europe

More specific information on research findings and descriptions of good practices for the implementation of non-technical measures with the goal to reduce emissions and improve air quality are going to be collected in CANTIQUE, a concerted action

42 Hague Consulting Group et al., TRACE, Project funded under the Transport RTD Programme of the 4th Framework Programme, Final report, June 1999.

within the Transport programme in the 4th RTD Framework Program. CANTIQUE will make use of the work in WG5 and provide its results on the Internet.

3. Range and potential of non-technical measures

3.1 Relevant issues in assessing urban transport policy measures

In chapter 3 findings from available reports, studies, policy papers and replies to the WG5 questionnaire, as well as statements based on the experience of WG5 members, are summarised. As set out in the work programme of WG5, the analysis relates to the costs of different measures and their effects with regard to transport demand (passenger-km, ton-km, vehicle-km), modal choice, fleet composition and car ownership, and drivers behaviour.

Prior to the analysis of specific measures in sections 3.3 to 3.9, section 3.1 deals with general issues that are relevant for the assessment of urban transport policy measures and section 3.2 with the issue of public acceptance.

3.1.1 Urban transport strategies

- Strategies to maintain mobility[43] aim at enhancing
  - a more efficient use of available capacities in road transport (including focused infrastructure investments),
  - the market share of alternatives to motorised road transport for passengers and freight (including traffic avoidance),
  - a change in the structure of the vehicle fleet used, aiming at a lower average age and/or less polluting propulsion and fuel technologies,
  - measures to motivate the use of less polluting fuels.

  Different measures are able to address one or more of these objectives.
- As air quality is one among other indicators for the conditions of urban life, emission/pollution levels can be interpreted as a quality indicator for urban transport systems[44]. Other objectives and indicators related to urban transport systems include the accessibility of urban areas, the management of traffic flows, reducing congestion, safety, patronage and quality of public transport, opportunities for non-motorised transport, and stimulation of the urban economy.
- Urban strategies have to deal with synergies and trade-off effects between these objectives and the strategies to achieve them. In addition, the availability of appropriate policy options at local level, the inter-relation between cities and their surrounding catchment areas, and the question of public acceptability play a role.
- The public perception of problems and negative effects seems to play an important role in the design and implementation of appropriate measures. Environmental pressure at local level and in densely urbanised areas increases the feasibility of strategies to reduce emissions stemming from transport[45].

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43 see e.g. different approaches to classify policy instruments in COST CITAIR Programme Action 616 Draft Final Report, Zürich 1998

44 see QUITS Quality indicators for transport systems, research project in the 4th Framework Programme for RTD 1994-98

45 COST CITAIR Action 616, Draft Final Report, Zürich 1998

- A coherent European policy framework can facilitate local measures. Examples are the air quality legislation, fuel tax directives, standardised definitions for EEV, technical specifications of road pricing systems, and provisions for public service obligations. A survey of obstacles and opportunities in the current framework (regulations, directives) could serve as a starting point for improvements.

3.1.2 Covering the whole transport system

- Single ("stand-alone") measures addressing only one aspect of the transport system tend to be less effective with regard to the above mentioned objectives, than policy packages. Optimal packages of measures in this respect are likely to include physical (traffic management), pricing and organisational measures which combine a "push & pull" approach. This implies in general increasing the attractiveness and the capacity of alternatives to motorised road transport and increasing the burden on the latter (see also section 3.10 – packages of measures).
- Measures should target all travel purposes, because commuting to work and education constitute a decreasing proportion of overall transport. Growth rates are mainly due to more leisure trips, longer distances between homes and destinations and a greater dispersion of destinations.
- Particular regard should be given to measures aimed at reducing the amount of motorised short distance trips (about 50% of all trips are below 5 km).
- Measures and incentives oriented toward the use of less polluting fuels and particularly alternative fuels (natural gas, LPG, electricity) can be effective in reducing emissions from traditionally fuelled vehicles. However, the long term advantage in comparison to improved technologies for conventional fuels (Euro IV) is being investigated by Working Group 3.
- The aggregability of local results to national and European level is closely linked with uncertainties regarding the impact of measures and the influence of specific conditions. The impact of measures should be given in ranges, in order to conclude with reliable orders of magnitude on a more aggregated level.

3.1.3 Adverse side effects

- In order to take into account undesired side or long-term effects of measures[46], and trade-offs between different measures within a package,
  - the geographic level of their effects (at street level or in certain areas and at overall city or regional level) and
  - the time horizon of their effects: immediate (up to one year), short term (up to 5 years), medium term (up to 10 years), or long term (more than 10 years)

  have to be analysed. In the Auto Oil II programme, strategies are sought with positive medium to long term effects at city level.
- Possible adverse effects may call for complementary measures to reduce them. For example, measures aiming to reduce congestion and to increase average speeds encourage additional traffic on these roads and increase travel distances. This concerns traffic management measures as well as measures to increase the average speed of public transport, which imply higher travel speeds also for private traffic.

[46] see COST CITAIR Programme Action 616 Draft Final Report, Zürich 1998

> Elasticities for induced road transport related to changes in average speed quoted in literature vary usually between +0.3 and +1.0 (the latter corresponding to a “constant travel time budget”). Actual values depend e.g. on the scale and direction of change, available alternatives, the modal split in the base case, and the observation period (with higher long term elasticities).[47]

- Measures reducing the use of available cars make them available to other family members, inducing additional traffic.
- Traffic restrictions to central areas may induce development of working and shopping sites in suburban belts, if no supportive measures are taken. This can induce more traffic from further away origins, and traffic flows are much more difficult to bundle.

3.1.4 Further assessment issues

- The cost-effectiveness assessment evaluates different measures and strategies (combinations of measures) according to their costs and their effects upon emissions and air quality. Effects are achieved by reducing mileage in motorised road transport, inducing a modal shift, changes in the composition of the vehicle fleet, and changes in driving behaviour.
- Limits to urban transport and emission modelling are related to the importance of acceleration-deceleration cycles and the behaviour in traffic jam situations and congestion, compared to the use of average speed as an indicator.[48]
- Most non-technical measures have an impact not only on air pollution, but also on accidents, CO_2 emissions, noise, or infrastructure costs. These side effects have to be included in the cost and objective functions to achieve sensible results.
- Furthermore, many non-technical measures are continuous measures (e. g. pricing, subsidies, speed limits, and capacity increase), which theoretically may be set at an infinity of different levels with probably different cost-effectiveness results. On the one hand, local non-technical measures should be defined in a wide range for the optimisation procedure in the Auto Oil Programme, to avoid as far as possible the application of global technical measures in cases where only one or few cities fail to achieve air quality targets. On the other hand it is clear, that only a limited number of measures can be included in the AOPII assessment model.

3.2 Public acceptance of non-technical measures

3.2.1 Importance of public acceptance

- In addition to the cost-effectiveness ratio as required for the assessment model, the policy dimension of non-technical measures has to be addressed. This would take regard of available policy instruments, the total costs and distributive effects of the measures, and their public acceptance.
- Non-technical transport policy measures have often direct impacts on the mobility and welfare of people. Therefore the implementation of such measures is

[47] The Transport RTD project TRACE provides elasticity values for a range of typical contexts, disseminated in a detailed handbook and an interactive program on CD-ROM.

[48] COST CITAIR, Action 616, Draft Final Report, Zürich 1998

thoroughly observed by individuals concerned as well as by news media. Political and social acceptability is vital for the success of measures.

3.2.2 Determinants of acceptance

- The acceptance of measures is guided by various influences. Measures passing the cost-effectiveness criterion can be rejected because of distributional impacts, because of limited public awareness of benefits, or because underlying objectives and assumptions are rejected. Public awareness and participation can be decisive for the implementation of measures (see section 3.2.4).
- Sometimes a time gap between the implementation of a measure and the incident of particular consequences hinders people to recognise beneficial effects.
- The efforts for the implementation of a measure should be in line with the expected benefits. Current evaluation methods often do not cover aspects like disadvantages for residents during construction periods.
- The acceptance of certain transport policy measures depends also on economic circumstances. Especially developing regions rely on transport as a precondition to augment welfare and growth. In more developed regions, people's sensitivity towards issues environmental issues becomes more important.
- Furthermore, acceptance might be influenced by location. In the periphery, participation in (international) trade and its positive welfare effects requires transportation to a higher extent. In central regions with a high volume of transit traffic, people might be more sensitive towards the negative impacts of traffic.

3.2.3 Social acceptance versus individual behaviour

- The acceptance of measures can be defined on an individual as well as on a social level:
  - The individual level is revealed through user reactions, through adopting a particular behaviour (e. g. choosing a certain mode).
  - The social attitude towards a policy measure is related to the general awareness of a given problem (e. g. impact of certain activities on the environment).
- In practice, differences between the social attitude and individual behaviour can be observed. The individual acceptance normally is below the social one, revealing a kind of free-rider position. For example, about 70 % of respondents in a survey stated their acceptance of an integrated smart-card system in Florence, while only about 10 to 20 % accepted the system in real life (revealed preferences)[49]. The higher value defines the social attitude towards an item, while the lower value shows the real behaviour.
- The difference between the attitude stated before the implementation and the concrete adoption of the system afterwards might partially be caused by general problems of co-operation under uncertainty as illustrated with the prisoners dilemma in game theory.[50] The socially accepted (optimal) solution is not realised,

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[49] EUROTOLL project, Deliverable R2, 1999, p. 6.

[50] Co-operation is usually analysed in game theory by means of a non-zero-sum game called the "Prisoner's Dilemma". The two players in the game can choose between two moves, either co-operate or defect. The idea is that each player gains when both co-operate, but if only one of them co-operates, the other one, who defects, will gain more. If both defect, both lose, but not as much as the "cheated" co-operator whose co-operation is not returned (see Axelrod, 1984).

because individuals are uncertain about the behaviour of others. The consequence would be that certain measures that are socially accepted still need enforcement by an authority to be adopted by individual behaviour.

3.2.4 Importance of public awareness and participation

- Public awareness and participation before the implementation of measures can help to increase acceptance. The Treaty of Amsterdam[51] gives citizens the right of access to any document produced by the Community Institutions subject to principles and conditions to be defined on grounds of public or private interest.
- The Aarhus Convention[52] seeks to improve public awareness and participation in the environmental field, based on three pillars: access to information, public participation in decision-making, and access to justice.
- Information and communication strategies perform an important part of implementing transport-related measures successfully. The suitability and necessity of a measure, compared to potential alternatives, has to be demonstrated. Transport users should be addressed as customers and provided with comprehensive information.
- At the same time, users should be informed about alternatives, especially public transport services. People sometimes seem to have distorted perceptions of service quality, e.g. overestimating travel time and especially out-of-vehicle components (access, waiting, interchange time). Targeted area-wide public-awareness-campaigns can have significant positive effects (see chapter 3.9).
- Restrictive measures like road pricing will have a higher acceptability, if users are informed about the service they will receive (especially in terms of travel time).

3.2.5 Further elements influencing the acceptance of non-technical measures

- Compensating measures can be implemented to smoothen negative consequences of non-technical measures on single user groups. A set of information-based, compensating and improving strategies can be taken to support the acceptance of measures.
- Higher transport costs and reduced mobility are expected to have negative impacts on employment and economic growth. However, a quantification of these impacts depends on future research.
- Particular transport behaviour is correlated with social and demographic aspects like the income level of households. Lower income classes do react stronger than higher income classes on price increases, i.e. they have to bear more restrictions of their individual mobility c. p. In Germany, the price elasticities of three different types of households with regard to fuel prices have been derived as

  -0.36 for an income per household < 1,000 €/month,
  -0.28 for an income per household between 1,500 and 2,500 €/month and
  -0.20 for an income per household > 2,500 €/month.[53]

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51 Article 255.

52 United Nations convention signed by the Community together with the Member States in June 1998, but not yet ratified.

53 See Baum, H., Esser, K., Analyse der Verkehrsnachfrage, Teilprojekt im NRW-Forschungsverbund Verkehrssimulation und Umweltwirkungen, Köln 1998.

- The decrease of mobility is a question of age and residence, affecting especially elder and disabled people as well as those living in the countryside with usually less public transport services.
- The spreading of less traffic-related activities like tele-working is partly hindered by lack of abilities, a sometimes negative attitude towards these options from employers as well as from employees side, and a lack of technical facilities with acceptable price and sufficient capacity. Improvements for customers have been realised after deregulating telecommunication markets.

3.3 Traffic management

3.3.1 Scope and impact

- Traffic management measures are aiming at (1) improving traffic flows (reducing congestion), or (2) reducing the number of motorised vehicles in specified areas, or (3) increasing the attractiveness and the usage of alternative transport modes.
- Reducing congestion usually increases average speed and reduces road travel times. Positive effects on emission may over time be offset by induced traffic. Statistics show an increase in mileages whilst the average time budget for travelling remains constant.[54]
- Long-term positive effects require that traffic volumes be within the capacity of the network.

> For Bern, Switzerland, it has been calculated that traffic management measures can produce emission reductions of up to 20%, if congestion is avoided by limiting road traffic volume to the capacity of the road network. [55]

- Where public transport and individual transport use the same infrastructure, a correlation between the speed of the two modes can be observed. Whilst e.g. increasing the travel speed in public transport, also travel speeds in road transport increase and may attract additional traffic over time.
- Measures which put restrictions to specific street corridors or parts of a city (e.g. access restrictions and parking/road charges) can have adverse effects on other roads and areas (increased traffic), and thus low/no/adverse effects at city level.

> To estimate the impact of restricting measures upon adjacent areas or other roads, a factor describing the reduction of mileage for different road categories compared to the change in the restricted area might be used. It can amount to 0.25 e.g. for trunk roads with a large amount of long-distance traffic, 0.5 for roads with high local traffic and 1.0 for the restricted area itself. [56]

- In order to achieve a change in modal split through traffic management measures, an appropriate supply of alternative transport services (e.g. cycle paths, public transport, parking facilities, location and design of interchanges) as well as adequate information (awareness activities) must be ensured.

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[54] COST CITAIR, Action 616 Draft Final Report, Zürich 1998
[55] COST CITAIR Action 616 Draft Final Report, Zürich 1998
[56] LfU, 1996.

3.3.2 Telematics and infrastructure provision

- Telematics for traffic management includes urban traffic control (UTC), e.g. traffic signal control and co-ordination, speed control, and variable message signs, but also incidence and emergency management, and individual guidance systems.[57] They can serve to steer traffic flows into city centres in order to improve inner city traffic flows.
- Infrastructure provision comprises measures at very different scales, including e.g. new major bypasses as well as an additional lane to an existing road section. In this context especially measures aiming to remove bottlenecks in the road network and to improve network capacity are being considered.
- Both telematics and infrastructure provision, if aimed at road transport, increase the available capacity, mainly in order to improve traffic flows. Thereby they relieve congestion, increase travel speeds and reduce travel times.

> Advanced traffic responsive urban traffic control systems tested in various EU transport telematic projects showed overall travel time savings of about 10 %. Examples: MOTION in Cologne[58] and PRODYN in Brussels[59].

> Simulations in course of a pilot study in Stuttgart (STORM – Stuttgart Transport Operation by Regional Management) showed average travel time reductions for cars supplied with individual dynamic guidance systems of about 15 %, reaching up to 45 % in case of traffic interruptions. Depending on the ratio of cars supplied, travel time reductions for all cars could reach up to 13 %.[60]

- The effects on energy consumption and emissions quoted in different studies vary considerably. They are likely to be outweighed by medium- to long-term induced traffic if no measures are taken to counterbalance the increased attractiveness of road transport.[61]
- Urban traffic control (UTC) strategies can be targeted towards environmental control by reducing the use of sensitive routes or through restraining traffic from entering sensitive areas (gating).

> Pollution-sensitive traffic re-routing in Athens (APOLLON implementation) showed a reduction of kerbside pollution inside the controlled area of 30 km^2 by 26 % to 30 % for CO, NO_x and HC, while pollution outside the controlled area increased by 13 %. (As pollution levels after re-routing were higher outside than inside the controlled area, pollution peaks were reduced by 8 % to 10 %.)[62]

- An analysis of the potential effects of an inter-urban traffic control system for a 17km motorway section in Germany showed a decrease of the share of stop-and-go

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57 See e.g. European Commission, Socio-economic impacts of telematics applications in transport, 1997.

58 HERMES, High efficiency roads with rerouteing methods and traffic signal control, EU transport telematics RTD.

59 CITIES, Co-operation for integrated traffic management and information exchange systems, 1996.

60 Büro für Technikfolgenabschätzung beim Deutschen Bundestag (TAB), Entwicklung und Analyse von Optionen zur Entlastung des Verkehrsnetzes und zur Verlagerung von Straßenverkehr auf umweltfreundlichere Verkehrsträger, Final report, 1998, p. 63.

61 A concrete example for the use of PRODYN in Brussels states an increase of traffic by 10 % (CITIES, 1996). For a more general discussion on induced transport see SACTRA, 1994.

62 QUARTET, Quadrilateral advanced research on telematics for environment and transport,Final project report, 1995.

traffic from 35 % to 4 %. This was connected with fuel savings of about 20 %, and emission reductions of 4 % (NO_x), 30 % (HC) and 36 % (PM), respectively.[63]

- The implementation of public transport priority is an important application in advanced UTC systems. Trials in London, Turin and Gothenburg indicate savings in journey times between 8 % and 19 %, with insignificant disbenefits to general traffic.[64] (For public transport priority: see also chapter 3.3.6 on dedicated lanes.)
- Simulation results for Gothenburg, Sweden, show fuel and emission savings by 4 % to 5 % due to enhanced UTC including public transport priority.[65]
- New bypasses could produce advantages in case of large volumes of freight transit[66].

3.3.3 Speed limits

- The impact of speed limits depends on the compliance of drivers and the proportion of roads to which they are applied. Effects are immediate. Speed limits on specific roads and road sectors achieve significant effects. Measures are recommended to control transfers to other not affected roads which could reduce the overall effects.
- In the context of the optimisation of speed limits it has to be considered that engines of cars and High Duty Vehicles (HDV) are optimised for certain speeds.
- It is estimated that driving at very low speed in congestion conditions increases the volume of CO_2, CO and particulate emissions by a factor of 3 or 4. NO_x emissions are estimated slightly lower, fuel consumption would increase as well.[67]

Speed limits on motorways and inter-urban roads could reduce NOx emissions by 10 to 13 %[68]. Attention must be paid to possible increases of benzene and particulate emissions. Specific speed limits (60 km/h) for trucks show a reduction potential for NOx of up to 16 %.[69]

It was found in Graz, that a 30 km/h speed limit for secondary urban roads can reduce NOx emissions by 6 to 9 %, benzene by 2-4 %[70]. Total local emissions can be reduced by up to 10 %, but will include transfer of traffic to main roads. Overall effects at city level are less than 1 %, because the secondary network carries only 10% of vehicle-km in Graz.

- Speed limits have also indirect effects on other modes. Due to positive impacts on safety they are able to accomplish other measures to promote cycling and walking.[71]

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63 Metz, N., et al., Positive effects of a traffic control system on fuel consumption, CO2 and exhaust emissions on the German A9, 1996.

64 PROMPT, Priority and information in public transport, 1996.

65 PROMPT, 1996; Hounsell, N.B., et al., 1996.

66 see LfÜ, 1996, p. 29

67 Roux in ECMT Round Table 102, p. 93-94; see also EEA, COPERT, 1996.

68 Speed limit of 100 km/h during the Abgas-Großversuch in Germany 1985 and on a motorway in Austria in 1986 (Rosinak et al., 1987).

69 LfU, 1996, p. 41

70 Pischinger et al., Tempo 30/50 in Graz, 1995.

71 COST CITAIR, Action 616

3.3.4 Availability and management of parking space

- Effects of reducing/increasing available parking space on traffic volumes and modal split can be important in affected areas, especially if they are supported by additional measures to improve alternative modes. Commuter trips can be addressed by reductions in long stay parking spaces.

Reducing public parking spaces and stabilising the number of private spaces can induce a reduction of urban traffic volume of 10 % to 20 %, if public transport alternatives are available [72].

- In case of traffic reductions, attention has to be paid to possible transfers to adjacent areas and additional mileage for searching purposes. Neighbouring areas of areas where parking space has been reduced and areas with new parking facilities are likely to suffer from higher traffic volume and pollution.

Following a reduction of parking space by more than 50 % in central and mainly commercially used areas in Stuttgart, 42 % of affected commuters evaded to adjacent areas, 24 % switched to public and non motorised transport, 7 % used car pooling and 27 % other, not specified re-organisational measures[73].

- Converting long stay into short stay parking spaces may increase turnover from 1-2 to about 5-7 cars per day and can therefore induce traffic.
- Reserving parking spaces to residents can reduce trips to these areas and traffic in search of parking spaces[74].

On-street long term parking has been abolished in 9 inner districts of Vienna (introduced 1993-99), with exceptions for residents and local business (for a fee of 160 Euro/year). Fees for short term parking are about 1 Euro/h. As a consequence, parking space occupancy was reduced by up to 30 %. Overall car traffic was reduced by about 20 % in the central district and by about 12 % in other districts concerned. Commuters and visitors (in 3 investigated districts) are paying for short term parking (33 %), use exceptional permissions (7 %), public transport (25 %), a private parking space (12 %), a parking space outside the affected area (5 %), or changed their destination (7 %).[75]

- A guidance system can prevent additional traffic for search for parking space. Information systems should include/emphasise public transport options (park & ride). Variable message signs (VMS) increased the use of a P & R facility in Munich by 26 % on weekdays[76], and in Cologne by at least 33 %[77].
- A barrier to the effects of reducing public parking spaces is the fact that an important share of parking space is usually not under control of local authorities, but in private non-residential car parks[78]. Local authorities have, however, long-term possibilities to influence the provision of such facilities, e.g. by requiring

[72] LfU, 1996, p. 21
[73] Wermuth, Verkehrsverlagerung: Restriktive Massnahmen im motorisierten Individualverkehr, in: Strassenverkehrstechnik, 1994, no. 5, p. 312-314.
[74] LfU, 1996: Wiesbaden, no data available.
[75] Stadtplanung Wien, Parkraumbewirtschaftung in Wien, 1997.
[76] LLAMD, EU Transport Telematics RTD, 1996.
[77] SCOPE, EU Transport Telematics RTD.
[78] May, A. D., 1994, p.4.

developers of projects above a certain size to subsidise local public transport rather than to provide private parking spaces.

- An analysis of 3 French and 3 Swiss cities identifies the availability of parking spaces in the city centre as a decisive factor for modal choice. The share of public transport on motorised trips to the centre is 68 % in Bern (with 18 parking spaces per 1000 inhabitants), about 30 % in Geneva and Lausanne (about 50 parking spaces), and about 24 % in 3 French cities (60 to 150 parking spaces).[79]
- Parking incentives (i. e. similar to handicapped parking access) for clean vehicles can attract increased awareness and use of these vehicles.

3.3.5 Restricted access

- Access restrictions, either general or differentiated according to vehicle categories (e.g. bans for more polluting vehicles), have high, immediate effects on the restricted areas.
- Access restrictions for specific areas can be applied permanently (e.g. pedestrian areas, residential areas, specific streets), or temporary (e.g. during certain hours of a day or in case of alerts). Restrictions to more polluting types of vehicles induce a change in the fleet used.
- If the restrictions are differentiated according to emission characteristics, they can send a strong message to residents promoting clean fuel vehicles. Support from EU level would be needed, because for cost-efficiency reasons the underlying environmental classifications of vehicles should be standardised across Europe.
- The city of Paris initiated a plan for pollution-alert days limiting petrol and diesel cars on the basis of odd-even license plates for alternative days while permitting natural gas, LPG and electric vehicles at all times.
- Access restrictions are highly and immediately effective with regard to emission reductions within the areas affected (therefore considered in case of alerts), supported by access control[80].

Access of cars and trucks to the city centre of Bologna (about 4.5 km2 with 50000 inhabitants) was reduced through several successive measures between 1985 and 1994. The number of motorised vehicles per day entering this area was reduced from about 180000 in 1982 to 90000 in 1994, while traffic volumes on several parts of the ring road increased.[81]

- Permanent bans in larger areas such as city centres bear potential to reduce NOx and HC[82]. Limited results related to the overall urban area, depending on the extension of the areas affected.

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[79] Bovy, P., 1998.

[80] LfU Baden Württemberg, 1996.

[81] GAUDI project.

[82] Stuttgart: - 10 % Nox, - 17 % HC for Stuttgart; source: LfU Baden Württemberg, 1996.

> Temporary restrictions for more polluting cars can produce a reduction of NOx emissions in the order of more than 40 % in affected areas and times[83]. Around minus 25 % can be achieved with permanent restrictions[84], inducing a change in the structure of the vehicle fleet. Improvements depend on the proportion of clean vehicles in the fleet. Traffic bans for non-residents can lead to reductions of close to 50 % in the affected area, but have almost no impact for the urban area in total[85].

- Changes in the car use depend on the availability of alternatives in public transport.
- Regulatory measures may provoke reactions of effected individuals that can increase mileage. Examples are the deviation traffic around restricted areas or the development of shopping centres outside of cities.
- Limiting access to certain urban areas may lead to changes in the economic structure and activities. E.g. in the context of urban and land use planning the link between restricted traffic in city centres and the generation of business/shopping/leisure centres outside has to be examined with regard to the overall environmental impact.

3.3.6 Dedicated lanes (public transport, other high occupancy vehicles, or alternative fuel vehicles)

- Separating the modes allows to significantly increase speed, and thereby the level of service and reliability of public transport. Dedicated lanes and prioritisation are able to increase the average speed of buses by up to ca. 100%.[86]
- As a consequence of higher speed of buses and tramways, the same service frequency can be provided with less input of labour and vehicles. This results in significant operating cost savings, which can exceed the costs of implementation for priority schemes.[87] Cost elasticities with respect to speed were calculated with -0.39 for buses and -0.12 for tramways.[88]

> A 16 km bus and HOV lane was opened in 1995 in a corridor in the Northwest of Madrid. Between November 1991 and November 1995, the number of passengers (bus and car) increased by 26 %, while the number of vehicles was stable. This was due to two effects: (1) The modal share of buses increased from 24 % to 33 %, and (2) the average occupancy rate of private cars grew from 1.36 to 1.53.[89]

- Bus lanes may also increase the capacity of bus corridors. In Bangkok and Singapore a throughput of up to 19500 persons per hour and lane was recorded.[90]
- Converting an existing lane into an HOV may increase travel time on the remaining lanes around 12 %, depending on capacity usage in the base case.

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83 LfU, 1996, p. 15.

84 LfU, 1996: Restricted access to Stuttgart city center: -25 % NOx, - 25% benzene; trucks not affected; overall effects – 10% NOx, + 1% benzene

85 LfU, 1996: Zürich: minus 47 % of traffic volume

86 APAS, Public transport prioritization, EU Transport research, 1996.

87 See e.g. Schönbäck, W., Kosten und Finanzierung des öffentlichen Personenverkehrs in Wien, 1994, p. 37-41.

88 Wunsch, P., Cost and productivity of major urban transit systems in Europe, 1996

89 Comunidad de Madrid, 1998; Transprice, Deliverable 7.

90 Gardner G. et al., The performance of busway transit in developing cities, 1991.

Adding a dedicated lane implies higher traffic flows on all lanes. Commuters in HOV benefit from reduced travel times of about 6 %[91].

- The opening of HOV lanes to alternative fuelled vehicles can help to make people aware of and to motivate demand for cleaner fuels.[92]

3.4 Public transport, intermodality and non-motorised transport

3.4.1 Potential to reduce air pollution

- Pollutant emissions related to passenger-km are in general comparably lower for public transport than for cars[93]. The actual differences depend however on the type of vehicles used, the fuel used and on vehicle occupancy. The contribution and effect of public transport on air pollution is related to its proportion in total traffic[94].
- Findings from the Auto Oil I Programme indicate that policies designed to increase vehicle occupancy, but that result in increased use of traditional diesel buses actually tend to increase NO_x pollution. Load factors and the age of vehicles are decisive. On the other hand, in general this modal shift would reduce CO_2 emissions. NO_x and VOCs would be further reduced if the increased use of urban buses utilised natural gas or LPG.[95]
- Increases in the use of public transport due to measures improving its attractivity have to be examined in view of the sources of additional passengers. Without specific measures in the road sector only a limited proportion will switch from road transport, the major part of the increase is likely to stem from newly generated trips from captive riders, or from people who used to cycle or to walk before the measure was implemented.[96]
- The efficiency of public transport is linked with the density of land use, population and the dispersion of trip origins and destinations. Public transport is effective where congestion is a severe problem[97]. Therefore, public transport is more beneficial in larger urban areas than in smaller cities. Improvements are most effective when certain corridors (e.g. radial axes to city centres) are affected where at the same time other measures address the overall traffic flow.
- Available capacities can in general be considered as fully used in peak hours, with the possible exception of parallel services with different travel times (high time value of commuters).
- Effects of changes (improvements) in public transport will occur medium to long-term.

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91 The cost-effectiveness and magnitude of potential impact of various congestion management measures, Arizona and US DoT, March 1997, p. 23

92 Provision in U.S. federal legislation, see e.g. in Natural Gas Fuels, 1998, p. 10.

93 LfU/Knörr, COST CITAIR Action 616

94 questioned in the US: The cost-effectiveness and magnitude of potential impact of various congestion management measures, Arizona and US DoT, March 1997, p. 27

95 European Commission, The European Auto-Oil Programme, 1996.

96 APAS, Public transport prioritisation, 1996.

97 The cost-effectiveness and magnitude of potential impact of various congestion management measures, Arizona and US DoT, March 1997, p. 27

3.4.2 Bundling public transport measures

- Increasing the attractiveness of public transport requires a bundle of measures which includes aspects of availability, accessibility, reliability, security of passengers, pricing, comfort.
- Mobility surveys show that the awareness of transport options in public transport (marketing, pre- and on-trip information) play an important role for the actual modal choice of individuals.
- Public transport should actively be integrated in traffic management. This implies prioritisation (e.g. dedicated lanes, prioritisation at intersections, exemptions from access restrictions) which in many cases is already in place (in a survey over 73 important cities, 76 % had bus lanes).[98]
- Recent developments include the (test) application of Urban Traffic Control (UTC) systems, which include traffic control, fleet management in public transport and - in advanced cases - information to users.
- While in the short run capital costs of public transport are fixed, in the long run all costs are variable. Higher demand should lead to higher load factors, higher service frequencies, thus reducing costs per passenger and waiting time.[99]
- In most European cities public transport fares cover only the minor part of the costs of public transport; cost coverage varies from less than 20% to more than 80%. Owing to relatively high fixed costs and low marginal costs, deficits for the provider may be justified by economic efficiency reasons.
- Moreover, low average public transport fares may be chosen to compensate for uncovered external costs of road transport and to encourage a change in modal split, especially in urban areas and at peak times (second best measure).
- An optimal subsidy from a welfare economic point of view implies that marginal private cost for an individual are identical to marginal social cost of travel.
- Adjustment costs for moving from a current equilibrium to a theoretically superior situation increase e.g. „where transport use was charged more in accordance with marginal social costs“, due to a slow adjustment process[100] (e.g. adjustment of vehicle fleet, infrastructure and land-use patterns).

3.4.3 Extension of services: Infrastructure investment or frequency increase

- The use of public transport and therefore the cost-effectiveness of investments depends on local circumstances and factors which are related to car use. Examples in France show that heavy investments are necessary but successful to maintain or increase the share of public transport.[101]
- Establishing new and attractive public transport facilities will not stop growth in road transport. Usually investments in public transport alone cannot increase the share of public transport.[102]

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98 Heunemann, G., Priority for buses serving central zones, 1993.
99 See e.g. Wunsch, P., 1996.
100 APAS, Pricing and financing of urban transport, 1996, p. 24.
101 Raux in ECMT Round Table 102, p.99
102 Raux in ECMT Round Table 102, p. 99-100

- The difficulties connected with infrastructure investments arise from the high financial requirements and the long-term commitment (impossibility of transfer to other places), connected with the need for reliable demand forecasts. (German and Austrian sources indicate investment costs of about 5-12 mio. Euro per km for new tramway lines and 100-160 mio. Euro per km for new underground lines.[103])

> The conversion of two suburban railway lines to a light rail system (Manchester Metrolink) led to an increase of patronage by over 50%.[104] In general, demand elasticities with regard to changes in urban public transport travel times quoted in literature vary usually between -0.2 and -0.7.

- Increased frequencies on existing networks may increase capacity and reduce total travel times (by reducing waiting times), too. Especially if the frequency increase is achieved by means of increased speed (separate lanes, priority at intersections), operating costs can be reduced simultaneously.

> A frequency increase of 30% with the extension of the underground rail in Munich in 1981 was followed by a 18% increase in ridership (elasticity 0.6), reports from other cities show frequency elasticities in a range of 0.3 to 0.5.[105]

3.4.4 Pricing measures: reduced and/or integrated fares

- Fares may be set individually for single operators or an integrated tariff may be determined (either on the basis of legal competence or on the basis of contracts with all companies participating in regional transport co-operations).
- Low average public transport fares may be chosen to compensate for uncovered external costs of road transport and to encourage a change in modal split. Evidence suggests usually quite low cross-price elasticities between public and private transport and therefore a relatively low efficiency of subsidies in this respect.

> Price elasticities in urban public transport are usually between –0.2 and –0.5. Actual values depend on available alternatives, trip purpose, mode, time of day, location of origin and destination, income and absolute fare levels in the base case (share of fare on generalised user costs).[106]
>
> There are indications that after price reductions in public transport an average of about 20 to 40 % of additional passengers were former car users[107].

- Research results provide no clear recommendations on the level of public transport fares. Cross price elasticities between public and private transport are usually relatively low, indicating a low efficiency of subsidies in this respect. On the other hand, research results indicate a wide variation of optimal public transport fares policy. In a recent research project, for certain cities even free public transport is

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[103] Hüttl B., König H., Eine Renaissance der Strassenbahn in München, 1995; Titz, T., Interne Kosten des öffentlichen Verkehrs in Wien, 1994.

[104] Jones P., in ECMT Round Table 102, p. 165.

[105] Ruff T., Selz T., Das ÖPNV-Modell Freiburg – Deutliche Nachfragesteigerungen, in: Internationales Verkehrswesen, 1995/5, p.255-261.

[106] W. Frank, Auswirkungen von Fahrpreisänderungen im Öffentlichen Personennahverkehr, Berlin, 1990; Halcrow Fox et al., Review and specification of model elasticities, London Congestion Charging, HMSO, 1993; Wang G., Skinner H., The impact of fare and gasoline price changes, in: Transportation research 18B, 1984, no.1, p.29-41

[107] APAS, Effectiveness of measures influencing the levels of public transport use in urban areas, 1996; COST CITAIR, Action 616 Learning scheme

regarded as optimal with regard to an objective function concentrated on sustainability goals[108].

- If demand is considered fairly inelastic, the decrease in revenues may be bigger than increases in passenger figures. In addition, the latter will happen in an order of magnitude, which does not promise significant impact on congestion or air pollution.[109]
- Owing to very different demand characteristics and different marginal costs of supply, a distinction between peak and off-peak fares could have considerable economic benefits. At present this distinction is usually applied in a limited form, as certain ticket types are valid only after the morning peak.
- The possibilities as well for integrated fares and revenue sharing as for tariff differentiation over time of day may be considerably increased by using smart cards and other advanced payment systems.

3.4.5 Park & Ride systems

- The effects of Park + Ride facilities depend on the quality of the public transport network and the location of interchanges.
- Demand depends on the differences in travel times and travel costs between a car trip and a combined car - public transport trip.

> Empirical studies in Stuttgart show a share of P+R users of 44% on certain routes, if travel time and costs are the same for a car trip and a P+R trip. If P+R travel time or costs are reduced by 10%, the share could increase up to 64%.[110]

- Benefits increase with the distance to the city centre due to the longer distance of avoided car trips (in Stuttgart „break-even“ at 13 km[111]). For new P+R facilities in German agglomerations a benefit/cost ratio of 2.5 has been calculated.[112]
- Overall effects are limited. However, there may be a perceptible relief in sensible city centres.

> Less than 1 % reduction in mileages and between 1 and 4 % for different pollutants expected, calculated for all German cities with more than 20 000 inhabitants.[113]

- A considerable share of P+R users may have used public transport (bus and rail) before.
- Free parking facilities at the destinations of car trips may hamper the use of public transport.[114]

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108 OPTIMA, Transport research in the 4th Framework Programme (Delivery 2, p.43).

109 The cost-effectiveness and magnitude of potential impact of various congestion management measures, Arizona and US DoT, March 1997, p. 28

110 see function in: Baum H., Rationalisierungspotentiale im Straßenverkehr I, in: FAT Schriftenreihe, Nr. 94, Frankfurt/Main, 1992, p. 40; several WG5 members doubted the very high impact of relatively small time or cost reductions.

111 Baum H., Rationalisierungspotentiale im Straßenverkehr I, in: FAT Schriftenreihe, Nr. 94, Frankfurt/Main, 1992.

112 Baum H., Gesamtwirtschaftliche Bewertung von Rationalisierungspotentialen im Straßenverkehr, in: FAT Schriftenreihe, Nr. 113, Frankfurt/Main, 1994.

113 LfU, 1996.

114 Raux, 1996, p. 99, quoting US experience.

3.4.6 Public transport organisation

- There are strong indications that deregulation in the public transport sector can increase its productive efficiency. Costs per bus-km were reduced by about 30% after local bus deregulation in Great Britain (including impacts of changes in social regulation) and by about 10% in Sweden. Research based on data from 34 European cities also suggests possible unit cost savings in urban bus transport in the order of 15 to 30%[115]. These savings should be linked to a reduction of subsidies or an increase of services for the same level of subsidies.
- However, responsibilities and incentives for transport authorities and operators have to be defined carefully to retain or even increase the quality of public transport services and thereby the attractiveness for users (efficiency in consumption). Deregulation in Great Britain outside London was followed by a decline in ridership of more than 20%, due to lack of co-ordination, instability of service provision, and information deficits. Less radical deregulation (with a common planning authority) in London and Sweden showed better results.[116]
- The direct impacts of changes in public transport organisation can not be included in the transport model. However, based on assumptions with regard to operating costs, ridership and the use of money saved (e.g. an increase of services), indirect effects on modal split and emissions may be estimated.

3.4.7 Cycling and walking

- Estimations for the potential of cycling stress that 50% of car trips in urban areas are under 5 km. They account for 9% of car-km. The potential for walking would be smaller, because the average distance is around one third of cycle trips[117].

> Programmes for the promotion of cycling in German cities increased the share of cycling on all trips from 18% to 27% in Freiburg and from 13% to 25% in Erlangen.[118]

- Policy makers should consider cycling and walking as means of transport. Cultural differences between countries or cities as well as the segmentation of user groups have to be taken into account. Measures should be based on an integrated plan and implemented in packages step by step, single measures have limited effects.[119]
- Information campaigns and the provision of better facilities have to be co-ordinated in a multidisciplinary approach.[120] Cycling and walking should be promoted only, if a minimum of safe infrastructural facilities is available.
- Important issues are the provision of sufficient and safe cycle parking, possibly by employers, shops, and schools, as well as the integration of public transport in the integrated plan.[121]

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115 EU transport research, ISOTOPE, 1998, p. 168.

116 White, P. R., Bus deregulation: A balance sheet, 1990; Nickel, B. E., Deregulierter ÖPNV in Schweden, 1993.

117 LfU, 1996, p.52-55.

118 Kanzlerski, D., Emissionsminderung durch flächenhafte Verkehrsberuhigung, 1991; Apel, D., Erfahrungen mit städtischen Konzepten zur Verkehrsentlastung und Emissionsreduzierung im In- und Ausland, 1991.

119 Adonis, Transport Research, 4th Framework Programme, 1998, p.68.

120 Walcyng, Transport Research, 4th Framework Programme, 1998, p.103.

121 Adonis, Transport Research, 4th Framework Programme, 1998, p.65.

- All road users awareness of each other has to be increased, including measures influencing the speed of vehicles and the provision of crossing facilities that allow good visibility.[122]

3.5 Freight transport

3.5.1 Introduction

- The growth of freight transport illustrated in chapter 1.3 is expected to continue at a lower rate of approximately 2 % per year (2000-2010). The strong performance of road transport increased its market share on land transport to 73 % in 1997 (compared to 49 % in 1970).
- It is estimated that in general, freight transport accounts for about 28 % of the overall energy consumption in transport.[123]
- With regard to long distance freight transport, no detailed evaluations of transport policy or management measures are available quantifying their effects on activities, modal share or environmental criteria.
- On a case study basis, results from the evaluation of projects in the Commission's PACT Programme demonstrate a significant potential to improve combined transport services. For example, the implementation of a multi-modal short-sea/rail block train service between Sweden and Germany achieved an increase of multi-modal through-transports in this relation by 51 % for the period June - December 1998 compared to the same period in 1997 (from 60 mio. to 99 mio. ton-km).[124]
- Calculations with regard to an increase in loading capacity by the use of the modular system for trucks[125], show an increase of the payload per truck by about 50 % and thus a reduction of the number of trucks used for the same amount of freight by about 1/3. The scheme is being applied in Sweden and Finland.[126]

3.5.2 Urban freight transport

- The share of freight transport on total mileage in urban areas varies between below 10 % and about 20%[127], depending inter alia on the size and structure of the city. While an average proportion on mileage of about 15% can be estimated, the share in terms of energy consumption and pollution may account for up to 40%.[128]
- Electronic commerce will replace passenger transport (shopping trips) by freight transport (urban delivery services).
- Measures aiming at the improvement of the environmental performance of truck traffic have to take into account economic and efficiency objectives for the transport sector as well as for the urban economy as a whole.

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122 Adonis, Transport Research, 4th Framework Programme, 1998, p.68.

123 L. Schipper/L. Scholl/, L. Price: Energy use and carbon emissions from freight in 10 industrialized countries: an analysis of trends from 1973 to 1992, July 1996; in: Transport Research, Vol.2 No.1, 1997, p. 58

124 Kombiverkehr et al., Multi-modal short-sea/rail block train service Sweden - Germany, Final report, January 1999.

125 Based on the standards as set out in EC Directive 853.

126 Volvo Press Information; According to further information from ACEA/Volvo, further tests are being conducted in the NL.

127 see: COST 321 Urban goods transport, 1997, Chapters 1.1, p.2 and 3.1. p. 1

128 COST 321 Urban goods transport, 1997, Chapter 1.1, p. 2.

- A survey of about 20 European cities showed that depending on the size and the local structure of a city in average a range of between 35 and 60 HGV (with a total weight of more than 2.8 or 3.5 tons) are registered per 1,000 employees. A comparably larger number can be found in cities with a large proportion of industrial workers, a smaller number in cities dominated by the service sector. The mileage per day in the sample of cities varies between 30 and 70 km/day, which is substantially more (sometimes double) than the average mileage by car.[129]

- In addition to the size and structure of a city and region, and the availability of different modes, the organisational structure of enterprises in the transport sector (their size, the involvement of public or private companies) has considerable impact on the effects of individual measures.

3.5.3 Impacts of measures

- COST 321 identifies a range of promising measures and provides some indications on their average effects, calculated for different cities[130]. The biggest emission reductions would result from fitting HGV up to 7.5 tons with electric propulsion systems: NO_x by an average of 6 to 8 %, PM by up to 20 %.

- The reduction of packing volume could result in average decreases of HGV mileage of 6 % and reduces the flow of HGV in the secondary road network by 8 %. Pollutant emissions would be reduced by about 3 %, particulate emissions by about 7%. Similar effects with regard to fuel consumption and pollutant emissions can be expected from light and flexible goods handling equipment.[131]

- Traffic management measures to speed up traffic on main roads would reduce journey times by 3 % and attract traffic from the secondary network (about –6 %). Distances would though increase by about 1 %.[132]

- Route guidance and information systems would deserve a thorough analysis, as they would induce increases in the traffic flow on the secondary network (in case of accidents, roadworks) by 3 %, though they could reduce fuel consumption by approximately 3 % and NOx by 2 %.[133] Another project noted a reduction of fuel consumption by 4-5 % as a result of using telematics in freight and fleet management.[134]

- Improved driving behaviour could reduce fuel consumption and pollutant emissions by about 6 %, continuous refreshing of the driver training would be necessary to maintain the positive behaviour over a longer period.[135] The direct effect on business profitability provides a strong incentive for this measure.[136]

- Options to reduce emissions and mileage of trucks in particular in urban areas include the bundling of goods for specific areas linked with increased load factors

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[129] COST 321 Urban goods transport, 1997, Chapter 3.5.3, p. 32-37.

[130] These were developed mainly in a two-step procedure: In a first round a number of measures were identified and their effects were estimated by experts, in a second round, numerical simulations were done for about 20 case cities.

[131] COST 321 Urban goods transport, 1997, Chapter 3.5.3, p. 43

[132] COST 321 Urban goods transport, 1997, Chapter 3.5.3, p. 46

[133] COST 321 Urban goods transport, 1997, Chapter 3.5.3, p. 47

[134] METAFORA, 1995.

[135] COST 321 Urban goods transport, 1997, Chapter 3.5.3, p. 45; Martinez de Lizarrondo, El programa de conduccion economica de CEFTRAL.

[136] FTA, Fuel Management Guide: „A 10 % saving in fuel costs will increase profitability by 29 %.“ (p.6).

and optimised routes. Related infrastructure measures include distribution centres at the edge of urban areas, and rail access for new industrial areas. Transit traffic of heavy trucks can be led via by-passes.

- City logistics may help to increase load factors and to cut HGV mileage by about 10 %.[137] The impact of measures depends on the proportion of heavy trucks, the quality of routing and the location of distribution centres. Attention must be paid to the additional traffic volume from smaller but more goods vehicles in order to avoid an increase in emissions.
- Combined transport can make an important contribution to decreasing the growth in road transport on longer distances. The potential for a modal shift in local transport is very limited. Main roads in urban areas will benefit more than smaller roads. [138]

3.6 Pricing measures

3.6.1 Scope

- While tolls for inter-urban motorways as well as for certain urban bridges, tunnels or lanes are used in several countries, urban road pricing for access to certain areas has so far only been implemented in Singapore and Norway. Studies of road pricing schemes have been done in other cities, e.g. Stockholm, London, Oxford and Bristol.
- Internalisation of external costs provides an incentive for transport users to make efficient choices with regard to transport demand in general, modes, routes, time of travel, and type of vehicle. An environmental classification of vehicles takes direct account of the environmental performance of vehicles (examples in Sweden, and for freight transit in Austria[139]).
- Congestion pricing reflects the attempt to internalise external congestion costs, i.e. costs that individual drivers impose on the other road transport users.[140]
- Marginal congestion costs as a basis for urban infrastructure charging differ between cities, for example due to differences in local road networks. Marginal congestion costs in Amsterdam and Brussels are found almost twice as high as in London or Dublin[141] (TRENEN II, p.16).
- From April 1998, an electronic road pricing system has been implemented in Singapore.[142] The system involves an increasing number of expressways leading to the Central Business District. To maintain fair charging and traffic distribution, traffic speeds on various roads are reviewed on a quarterly basis and adjustments to the rates are made accordingly. Where travel speeds are high, the rates are reduced

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[137] COST 321 Urban goods transport, Final report, December 1997, Chapter 3.5.3, p. 42-45.

[138] Figures for Basel from Abay et al., 1990, quoted in LfU, 1996, p.30-31.

[139] In the Austrian System cleaner and quieter HGV need less "Oekopoints" per trip.

[140] Arizona and US DoT, 1997, p. 19, states a cost differential of $1.5 million per morning rush hour in Minnesota.

[141] CERTE/CES/SESO, TRENEN II STRAN: What do the TRENEN II case studies tell us about the reform of European transport pricing?, Document for workshop 25 March 1998, draft

[142] The Area Licensing Scheme (ALS) introduced earlier in the central district charged motorists a flat fee (per day or per month) for using congested roads.

to allow more vehicles to make use of available road capacities. Where travel speeds are low, the rates are raised to ease congestion.[143]

- Distance related inter-urban road pricing has some parallels to an increase of fuel taxes. Advantages are reduced possibilities to avoid the tax by tanking in other countries (tank tourism) and more possibilities to differentiate by road types, time or vehicle categories. Disadvantages are additional implementation costs and the lower acceptability of a new levy.[144]
- In the context of private financing and tolling of new infrastructure, such as new roads / expressways in urban areas, transport demand can be segmented by means of tariff differentiation. A coherent management of the urban network including combined measures addressing public transport and non-motorised modes is recommended.[145]
- Pricing measures will increase welfare if net benefits exceed the costs. This requirement is likely to be met, if current prices paid by travellers are below marginal social costs (incl. environmental and congestion costs).[146]
- A main component of the benefits of pricing schemes are usually the net revenues to the government. The affected area itself will benefit, if those net revenues are spent in the area, and if they are spent wisely, i. e. producing a net welfare gain. The availability of revenues to compensate potential losers is an advantage of pricing over other restrictive measures.[147]

3.6.2 Acceptability

- Crucial are the acceptability of road pricing and the information of people (public relation activities), as well as the use of revenues. A simple structure of the pricing scheme facilitates the acceptability of the measure.
- If new toll-expressways in urban areas are provided, an equivalent portion of the existing road network should be reserved for public transport or non-motorised traffic, in order to address the imbalance between the modes.[148]
- To achieve behavioural changes in road transport via price increases alone might require a level that is politically not feasible. In order to induce changes at lower price levels, a combination with measures which improve alternatives is required.

3.6.3 Impact on demand

- Pricing measures in road transport should be examined with regard to their impact on the use of vehicles (short term) and purchase decisions and mobility patterns, including land use (long term).

> Long term price elasticities in road transport reported in literature vary usually between –0.1 and –1.0, with most values in a range of –0.3 to –0.5.[149]

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[143] See e.g. http://www.asiasignworld.com or http://www.straitstimes.asia1.com.
[144] Schönbäck, W., Kosten und Finanzierung des öffentlichen Verkehrs in Wien, 1994, p. 121.
[145] Roux in, ECMT Round Table 102
[146] SACTRA, Transport and the economy, Appendix E, 1999.
[147] SACTRA, Transport and the economy, Appendix E, 1999.
[148] Raux, Ch., in: ECMT Round Table 102, Changing daily urban mobility – less or differently?, 1996, p.126.

- Elasticities for mandatory trips (work, education) are lower and depend on available alternatives (public transport, car-pooling, possibility to change travel time in case of time differentiated prices). Voluntary trips are more flexible, mainly in their number and time, also depending on available alternatives.
- An analysis of (cross) price elasticities between pricing measures for cars and trucks and public transport showed elasticity ranges as follows[150]:

	(cross) price elasticity of road use	**(cross) price elasticity of public transport use**
Higher parking fees	- 0.1 to - 0.3	+ 0.05 to + 0.15
Road pricing	- 0.1 to - 0.8	+ 0.1 to + 0.4
Higher public transport fares	0 to 0.1	- 0.3 to - 0.4

- The relevance of congestion pricing for air quality depends on the need to reduce peaks, at it has only limited impact on modal shift.
- The impact of road pricing on freight transport should be examined further. First indications (a survey in Germany) show different reactions depending on the size of transport companies. Elasticities depend on availability of alternatives.[151]

3.6.4 Parking charges

- Parking charges are an obvious and easy to implement approach to encourage modal shifts and reduce congestion on urban roads. Implementation costs are usually lower than for road-pricing schemes.
- Eliminating subsidised parking for employees especially in city centres would reduce expenditure for parking facilities, free up land for other uses, and favourably alter the modal split in congested areas.[152]
- Parking charges should be part of a package of management measures related to parking. Aiming at reducing traffic volume, model calculations suggest increases of current charges between 100% (UK) and 400 to 500 % (Stuttgart). These increases have to be accompanied by attractive alternatives in public transport.
- Reduction potential for trips concerned amounts to 15 %, taking into account an increased use of public transport and higher car occupancy. At city level, car traffic will decrease by around 1 to 1.5 %.[153]
- As parking charges are not directly linked to distance travelled or to vehicle characteristics, they are theoretically less efficient than distance or congestion based road pricing schemes. Short distance and long distance trips are not differentiated, and through traffic are not influenced at all. In practice, however, implementation costs and feasibility favour the implementation of parking charges.

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149 Goodwin, P.B., A review of new demand elasticities with special reference to short and long run effects of price charging, 1992; Halwcrow Fox et al., Review and specification of model elasticities, 1993; COST-CITAIR Programme Action 616, Final report, Zurich, 1998; Hague consulting, TRACE, 1999.

150 Halcrow Fox et al., Pricing and financing of urban transport, Transport research APAS, Brussels 1996; summarised in: COST-CITAIR Programme Action 616, Final report, Zurich 1998, p. 28.

151 EUROTOLL, transport research in the 4th Framework Programme

152 Small, K., Urban Transportation Economics, 1992, p. 128.

153 LfU, 1996.

- In public garages, parking charges are usually determined by garage operators in an attempt to maximise profits. Authorities can restrict the amount of new parking space by refusing planning permits for public garages, but they have usually no influence on the pricing policy of existing car parks.
- Reduced charges for clean fuel vehicles can motivate the use of less polluting vehicles and raise public awareness of their availability. The city of Gothenburg, Sweden, initiated a programme allowing clean fuel vehicles to park free at any municipal parking metered space or garage, as well as using spaces restricted to 10 minutes for 2 hours. Consumers have to purchase a window sticker to designate their vehicles as clean fuelled.
- A barrier to comprehensive parking pricing measures that should encourage modal shift away from car traffic, is the fact that an important share of parking space is usually not under control of local authorities, but in private non-residential car. A possibility to include private non-residential car parks in comprehensive parking policies is the implementation of a parking cordon around the city centre, where all cars accessing the city are charged as if they were using a public car park. This measure has been suggested and modelled for the city of Leeds[154]. The proposed charging structure involves no changes for paying short and long time parkers (1.9 and 4.4 Euro, respectively), but imposes the same price for cars parking in private non-residential car parks. Besides, a smaller charge (1.2 Euro) on through traffic (leaving the area within 1 hour), and eight park and ride sites have been suggested. Modelling results suggest only a slight change in modal split (2 % of total morning peak trips), because of improved driving conditions for existing paying parkers. If charges are increased by 50 % to offset this effect, the predicted modal shift rises to 7 % in the morning peak period.

3.6.5 Costs to transport users

- Price structures have to be understood by consumers. If optimal policies can only be achieved using tools with high transaction costs and /or high information requirements on the part of the consumers than these costs may outweigh the benefits of a more efficient pricing system.[155]
- Perception of payment has an impact on behaviour. Costs payable at point-of-use will be more reflected in an individual’s mode choice.[156]
- Public transport users pay a fee at point-of-use or through purchase of travel passes. Car users experience generally low marginal costs, more than 50% of financial costs using a car do not vary by distance travelled. For short distance journeys, additional cost of parking charges might be significant. For company cars, most costs are not paid by trip maker. Car owners are less likely to have public transport passes.[157]

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[154] TRANSPRICE, transport research in the 4th Framework Programme (Delivery 3, p. 67-75)

[155] APAS, Pricing and financing of urban transport, 1996, p. 28

[156] APAS, Pricing and financing of urban transport, 1996.

[157] APAS, Pricing and financing of urban transport, 1996, p. 25; ECMT Round Table 102, p. 96-98.

3.7 Promotion of renewal of the vehicle fleet

- Two main kinds of scrappage schemes can be distinguished: In the first one owners receive a certain bonus for every scrapped car, without further conditions, while in the second kind of schemes the bonus depends on a specific kind of replacement, typically a new car.[158]
- Scrapping schemes result in an earlier replacement of old cars by usually newer and often bigger cars. Some people do not re-acquire a car (if this is not a condition of the scheme), but drive together with others or switch to public transport or non-motorised transport.
- Scrapping schemes are usually seen as a short-term strategy for reducing a part of the air pollution problem in a cost-effective way.[159] The efficiency depends on the design of the scheme and the structure of the (regional or national) vehicle fleet, especially the share of very old cars.

> Actual effects depend on the magnitude of the subsidies offered and the structure of the vehicle fleet: Estimates for the Danish scrappage scheme (1994/95, in average about 800 Euro/car) show reductions in energy consumption and air pollutants from car transport by 0.6% to 1%.[160] On the other hand, a more substantial effect has been calculated for the Greek scrappage scheme (1991-93, in average 3400 Euro/car in form of different tax reductions), showing a decrease in urban emissions of 10% (HC and NOx) to 23% (CO).[161]

- Scrappage schemes are expected to become less effective with time, as even older cars will not be extremely polluting in, e.g., 2010.
- A combination of purchase and annual tax (both depending on emissions) and rewards for retrofitting or scrapping polluting old cars during a defined period of time, should be most effective in improving the vehicle fleet without increasing the total number of cars and without extra-impact to low-income households.[162] The same technique also could be used to increase the use of cleaner fuelled vehicles.
- In AOPII, vehicle taxes are investigated by WG6 - Fiscal measures. Other incentives for clean cars (e.g. environmental zoning , see chapter 3.3.5) might also have an impact on the vehicle fleet.

3.8 Land use/accessibility

- Evidence suggests a close connection between the density of population and jobs in cities on the one hand and modal split between public and car transport on the other hand.[163]
- Urban and regional land use structures can be influenced only over long periods of time. Cities like Los Angeles or Detroit in the U.S. have been transformed from

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[158] CEMT, Group on Transport and the Environment, 1999.

[159] Hahn, R., An economic analysis of scrappage, in: The RAND Journal of Economics, vol.26, no.2, 1995, p.239.

[160] Transportradet, Skrotningspraemien, Rapport no.95.04, 1995, p.7.

[161] ForeMove calculations, quoted in Samaras, Z., Scrappage incentives: The Greek experience, 1995.

[162] COST CITAIR, Action 616, Draft Final Report, Zurich 1998, p. 39

[163] Newman P., Kenworthy J., Transport and urban form in 32 of the world’s principal cities; in: Transport reviews, 1991, no. 3, p.249-272.

being compact rail-oriented cities to extremely dispersed automobile-oriented cities over a 30 to 40 year period.[164]

- Policies promoting higher land-use densities may be in conflict with wishes of the local population. High density combined with certain urban structures also can lead to spatial distortions in property values, with a concentration of jobs in the centre, poorer inhabitants dislodged to peripheral areas, sub-urbanisation and increased distances between home and work.[165]
- A policy of mixed land-use is sometimes seen as a way to reduce commuting distances, reducing the length of car trips as well as their number by encouraging cycling and walking. The chances for a success of such a lifting of zoning control are, however, hindered by differences in property prices, social segregation, the fact that usually more than one person per household is employed, and by institutional barriers (e.g. municipal borders).[166]
- Recent literature results differ: An American study shows only weak evidence for a coherent link between land-use patterns at the neighbourhood level and travel behaviour[167]. On the other hand, a European research project shows a positive correlation between the density of the local urban area and non-motorised transport share, as well as with public transport service levels.[168]
- The location of major transport sources close to attractive public transport services can further a modal change, especially if car traffic is impeded by a shortage of parking spaces.
- To ensure viability of bus services with a grid of 5 km (i.e. still leaving large areas without public transport access) and a frequency of 20 minutes would require a population density of at least 150 people per square-km (under the very optimistic assumption of a 50% modal share). To ensure access from the whole area and increase frequencies to 5 minutes in peak periods would require a population density of at least 1500-2300 people per square-km[169].
- Rail and underground networks are viable (without heavy public subsidies) only in high-density areas and along major corridors.

3.9 Influence on mobility behaviour

3.9.1 Awareness campaigns

- Increasing importance is attached to awareness activities, because individual perception is the filter through which information regarding travel options is processed and evaluated. Perceptions (perceived costs and benefits of alternatives) determine the behaviour of people.[170]

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164 Newman P., Kenworthy J., 1991.

165 Roux, in: ECMT, Round Table 102, 1996, p.122.

166 Roux, in: ECMT, Round Table 102, 1996, p.123.

167 Boarnet, M., Sarmiento, S., Can land-use policy really affect travel behaviour? A study of the link between non-work travel and land-use characteristics, in: Urban Studies, vol.35, no.7, p.1155.

168 SESAME, Transport research in the 4th Framework Programme, Final report, December 1998.

169 D. Frank, C. Storath, J. Sumpf, Mindestsiedlungsdichte für den ÖPNV, in: Internationales Verkehrswesen, vol. 46 (1994), no. 1+2, p. 25-31.

170 OECD, Second workshop on individual travel behaviour: “Culture, choice and technology”, Final report, 1997, p.17.

- Recent EU Transport Research[171] shows more than 120 examples of transport information and marketing campaigns to promote alternatives to the car or to reduce car use. Despite a lack of monitoring for many campaigns, there are several examples of evaluated campaigns showing that awareness programs can lead to changes in peoples attitudes and travel behaviour in favour of cycling, walking and the use of public transport.
- A distinction has to be made between general campaigns and targeted marketing activities. The former may influence general attitudes, but especially the latter can have measurable effects.
- Information is required about the availability of alternative choices as well as about the social and environmental consequences of different decisions.
- Mobility agencies or mobility consultants try to feed users information needs about integrated travel chains, providing door-to-door information. Field trials with in-house mobility consultants at larger enterprises show that 43 % of employees are especially interested in commuting alternatives followed by 35 % in car-sharing.[172]
- Surveys in Germany revealed information gaps about public transport. For instance, 80 % of all travellers did not know where to get information from and about 88 % of public transport users did not know the best connection.[173] Recently, many public transport companies have taken efforts to spread information including new media like the Internet.
- Most effective are measures focusing on individuals and households most open for change. Children and young people may be educated by activities in schools and through daily experience, e.g. by providing a safe environment for non-motorised mobility.
- If people are exposed to conflicting messages about travel decisions, it may be more effective to target governments, mass media and industry rather than individuals.[174]
- "Car-free days" have been organised in many cities in Europe, especially in France, Italy and the United Kingdom. They are intended to encourage car drivers to leave their cars at home voluntarily and try another way of getting to work. This actions are expected to improve also in the long term the awareness of alternatives to car traffic.

3.9.2 Other influences on mobility behaviour

- Time management based on negotiations between city authorities, employers, schools, transport operators is an interesting measure for homogenous medium sized cities.
- The influence of new telecommunication technologies on transport demand is ambiguous. Only a certain type of work can be done at home ("teleworking") and not everyone who can wants to "telecommute". Additionally, the capacity freed

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171 INPHORMM, Transport research in the 4th Framework Programme, Deliverable D2, May 1998, and D3, November 1998

172 Binnenbruck, H.-H., et al., Mobilitätsmanagement im Personen- und Güterverkehr, in: Der Nahverkehr, no. 9, 1998.

173 Hahn, W., Konzept einer Mobilitätsberatung für den Landkreis Marburg-Biedenkopf, in: Verkehr und Technik, vol. 51, no. 8, 1998.

174 OECD, Second workshop on individual travel behaviour: “Culture, choice and technology”, Final report, 1997, p.4.

may be used to realise latent demand for other trips, and telecommunication capabilities themselves may induce additional demand for travel. However, peak-hour traffic may be reduced more strongly.

> The potential reduction of car traffic due to telecommunications has been estimated to be about 1%, the net change (incl. latent and induced demand) between 0.5% and 1%.[175]

- The use of alternative fuel vehicles by public officials can set an example for the general population. In the UK the Queens and the Prime Minister's fleets include cars running on LPG and natural gas. In the USA ministers for energy have been using natural gas vehicles. The Department of Energy also had special contracts with a taxi company operating NGV, requiring staff to use them for trips originating from their offices.[176]

3.10 Packages of non-technical measures

3.10.1 Introduction

- As stated in section 3.1, single ("stand-alone") measures addressing only one aspect of the transport system tend to be less effective than policy packages which address motorised road transport and alternatives in parallel. Therefore, while implementing non-technical measures, priority is usually given to policy packages with crosscutting impacts on different modes. Stand-alone measures have to be seen in the context of the existing policies in order to allocate their effects.[177]
- Optimal packages of measures are likely to include physical (traffic management), pricing, awareness raising and organisational measures which combine a "push & pull" approach. This implies in general increasing the attractiveness and the capacity of alternatives to motorised road transport and increasing the burden on the latter.
- The interdependence of individual measures, as well as of the interests of different groups concerned, requires the development of policy packages. Complementary measures are required to achieve significant improvements ("push and pull") as well as to gain public acceptance.[178]
- Research dealing with non-technical transport policy and demand management measures is usually focused on the implementation of single measures.
- The effects of several single measures combined to bundles will not be additive because of typical user reaction schemes. Even single measures comprise usually more than one reaction parameter.
- Transport users dispose of a set of reaction patterns with regard to a given non-technical measure. Potential reactions take place within as well as outside the transport sphere, taking a short-term or long-term time horizon, directly or indirectly induced. As to an environmental target, these reaction patterns define the

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[175] Mokhtarian, P., The transport impacts of telecommuting, in: Urban Studies, Vol.35, No.2, p.219, 1998.
[176] US Department of Energy, written communication, 1999.
[177] This chapter is to a large part based on input from the CANTIQUE consortium.
[178] COST CITAIR, Action 616, Draft Final Report, Zürich 1998, p. 43.

net result of bundling non-technical measures. These net effects are not necessarily additive. Therefore the configuration of strategies is a deciding factor for success.

Intensifying positive impacts

- Combining different measures can intensify their positive results. Thereby investment or pricing measures may be combined with each other (as known from public transport policy) or with accompanying measures like providing information and raising awareness.
- A combination of awareness raising and information measures alone might show no effect, if necessary infrastructure prerequisites are missing or prices are not attractive. On the other hand, a characteristic of this type of measures is their – when successful – long-lasting impact because they affect opinions and attitudes.

Containing negative impacts

- Complementary measures can help to avoid non-desired side effects. Improving traffic conditions is supposed to improve the environmental situation due to more homogeneous traffic flows. However, improved traffic conditions may induce new traffic at the same time.
- Tele-working and electronic commerce are expected to reduce the corresponding trips. It has to be clarified, whether the savings of disposable time will be spent for other trips instead. Estimations for Switzerland in the late eighties state about 20 % of car kilometres saved to be re-allocated for other purposes (mainly leisure)[179]. Electronic commerce will increase freight transport for urban deliveries.
- Enhancing public transport use might pull off people from walking and cycling. In case of encouraging cycling, the share of public transport on modal split has decreased up to 5 %-points.[180]
- Decision makers should aim at a consolidated strategy across transport modes. A typical conflict is the trade-off between public and individual transport when implementing priority at traffic lights. Especially in case of joint lanes and/or a larger number of intersections, giving priority to public transport requires complementary measures. Otherwise, the beneficial effect in public transport might be exceeded by impairing results for individual road transport.

3.10.2 Examples

- Implementing a comprehensive approach, i. e. a package of non-technical measures, is more complex than the implementation of single, isolated measures. In the decision making process, the following questions need to be solved:
  - Which policy lever should be chosen for a given target or target system, taking into account local circumstances and transport user characteristics? General options comprise pricing, taxes, regulation, infrastructure, operating/service measures, information and public awareness initiatives, voluntary agreements, and institutional frameworks measures.[181]

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179 Rotach, M., Keller, P., Abschlussbericht des Forschungsprojektes MANTO – Wirkungen, Zürich 1987.

180 Bundesminister für Verkehr (ed.), Zusammenfassende Auswertung von Forschungsarbeiten zum Radverkehr in der Stadt, Forschung Stadtverkehr, Heft 17, 1991.

181 See: CANTIQUE – Cleaner Air for Europe: the Role of Non-technical Transport Measures, Briefing paper for the 1st management committee meeting (Brussels, 7 April 1999), Annex 6.

- Which measures are most promising? Operational measures affecting emissions per vehicle-km, strategic measures affecting the amount of vehicle-km driven for a given transport demand, or measures reducing transport demand itself?
- Which complementary and supporting measures can be taken to optimise the results? For example, extending road infrastructure might be efficient due to savings in travel time and vehicle operating costs, and could be combined with pricing measures, telematics, supply extensions in public transport and so on to achieve certain environmental targets.

- In Table 3.1 complementary measures for selected non-technical measures are identified. These combinations are either common practice or based on plausibility.

Table 3.1: Examples for effective bundles of non-technical measures.

basic measures	complementary & supporting measures	restrictions
individual transport / road transport		
Road pricing	*pull-options* • improving/extending transport alternatives • information and telematics • promotion of clean vehicle technology	• Wide range of results due to pricing scheme. • Compensating measures are inevitable because of expected growth and social effects. • Especially urban pricing has to obey capacity restriction in public transport
taxes	*pull-options* • improving/extending transport alternatives • information and telematics • promotion of clean vehicle technology	• effect based on the incidence of taxes referred to (direct/indirect) • Compensating measures are inevitable because of expected growth and social effects.
infrastructure measures	*push-options:* • pricing (externalities, financing) • parking management *pull-options* • intermodal networking measures like P & R facilities and information access • telematics (road)	• complementary measures are critical regarding induced traffic
service measures	*push-options:* • zone access • driving bans • parking fees	• related to information and telematics as supporting tools
rationalisation measures	*pull-options:* • deregulation • promotion of new vehicle technologies • promotion of joint activities • promotion of new media	• final decision in the responsibility of transport participants • deregulating and promoting joint activities might initiate a trade-off
public transport		
extension of services	*pull-options:* • introduction of new vehicles • decreasing travel time	• elements are closely related to each other
tariff policy	*push-options:* • co-ordinated car-related measures (pricing, parking fees, access control, driving bans) *pull-options:* • service and operating improvements • co-operations and integrated time tables • marketing measures	• Decreasing tariffs alone are not effective; customers show a quite rigid behaviour (elasticity about –0.2) • tariff reductions reduce cost coverage • special fares can be more effective than general modifications • potential shift from cycling & walking.
awareness campaigns, marketing and information policy	*push-options:* • pricing policy *pull-options:* • increase of frequency and travel speed • security and service measures • promotion of mobility agencies	• Additional measures, supporting the establishment of positive attitudes towards public transport and reducing information gaps (e.g. in Germany about 5 to 8 % of non-customers do not take public transport due to lack of information[182]).
intermodal strategies		

[182] Dobeschinsky, H., ÖPNV-Komponenten im integrierten Verkehrsmanagement, in: Telematik im Verkehr – Stand und Perspektiven integrierten Verkehrsmanagements, Schriftenreihe der DVWG, vol. 198, 1997, p. 164.

(improvement of) freight interfaces	*pull-options:* • extension of delivery times • extension/improvement of feeder roads	• Traffic conditions and organisational restrictions are decisive.
(improvement of) passenger interfaces	*push-options:* • adjustment of tariff policy (tariff zones and scales) • configuration of feeder lines *pull-options:* • improvement of cycling paths and parking lanes • promotion of stations (service centres, shops etc)	• Apart from general level of public transport services, the location and the capacity of interfaces are deciding. Both have to be in accordance to tariff zones and projected demand.

- In many cases an empirical proof for the contribution of single elements of more comprehensive approaches is missing. Although methodologies to determine the contribution of single influences on a final reaction exist, data availability is poor.
- A Swiss study developed a 3-stage approach to combine parking charges and road pricing:[183]
  - Application of parking charges reflecting the costs of supply and maintenance of parking facilities, an availability surcharge (in particular in peak periods) and a base charge for internalising external costs.
  - An additional simple road-pricing scheme could reflect the external costs, with parking charges related to the costs of supply and availability.
  - In future, advanced electronic systems could combine car park charging and road pricing.

  Complementary measures in public transport, cycling, walking and measures to improve the quality of the city centre are necessary. Adequate use of revenues can include e.g. tax relief, noise-reducing measures, and improving other transport options.
- In the USA a “clean cities programme” including 77 designated cities (in November 1999) has been successfully implementing packages of alternative fuelled vehicle initiatives to reduce vehicle emissions.[184]

4. Cost-effectiveness assessment of selected non-technical measures

4.1 The Auto Oil II base case: emission and air quality results

4.1.1 Emissions from road transport and other sources

The AOPII base case includes a substantial amount of data characterising the transport market and emissions between 1990 and 2020, as well as air quality in 2010.

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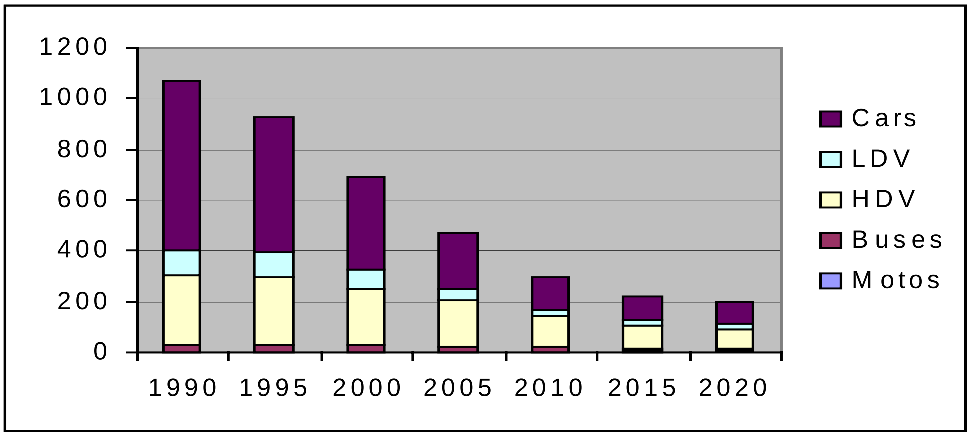
183 COST CITAIR, Action 616, Draft Final Report, Zürich 1998

184 U.S. Department of Energy, Incentives and Laws, 1998, and written communication, 1999; http://www.ccities.doe.gov.

Extensive information can be found in the reports of WG7 and WG1. This chapter summarises the main results with regard to emissions (4.1.1) and air quality (4.1.2).

The AOPII emission base case shows a strong reduction of road transport emissions for most pollutants. Figure 4.1 illustrates this for NO_x emissions. Technical improvements will lead to a distinct reduction of emissions across all vehicle categories (except two-wheelers), with the strongest decrease for cars and LDV.

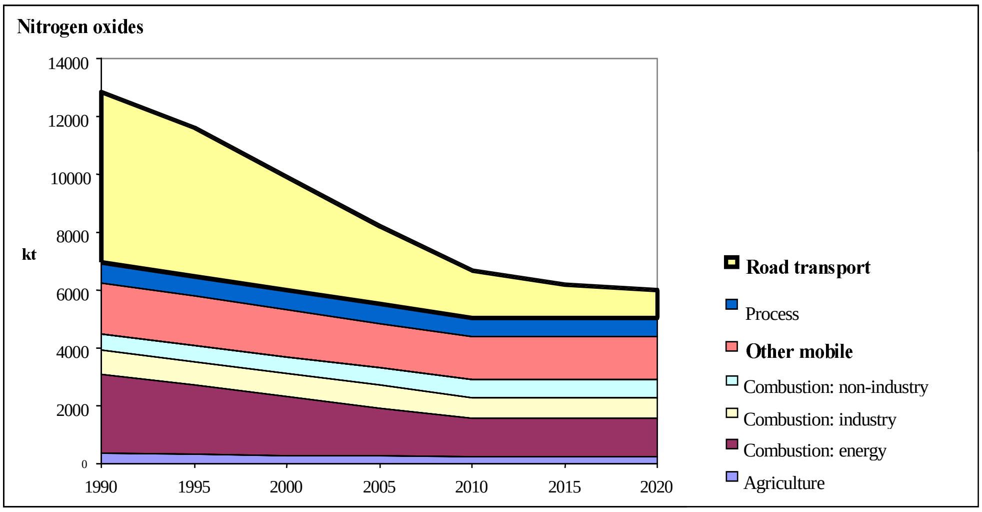
Figure 4.1: NO_x emissions from road vehicles in France, in 1000 tons/year.



Source: Auto Oil II, Transport base case, 1999.

The share of road transport on emissions from all sources will fall significantly. Between 1995 and 2010 it is expected to decrease from 44 % to 24 % for NO_x (see figure 4.2), from 65 % to 21 % for Benzene, and from 60 % to 33 % for CO.

Figure 4.2: NO_x emissions from all sources in the EU15, in 1000 tons/year.



Source: Auto Oil II, Emissions base case, Version 5, 1999.

4.1.2 Air quality results and recommendations from Working Group 1[185]

The air quality objectives for AOPII have been defined on the basis of adopted or proposed directives either in form of ambient air quality standards (NO_2, PM_{10}, CO,

185 The air quality results are preliminary and will be subject to further modifications and refinements in WG1.

and benzene) or in form of emission reduction targets for ozone precursors (for NO_x and VOC).

The emission reductions illustrated in chapter 4.1.1 result in major air quality improvements. Out of the ten cities which have been modelled in detail in AOPII, seven would have exceeded the annual NO_2 and/or the benzene standard at background levels in 1995, but only two are expected to exceed in 2010. All three cities exceeding the CO standard in 1995 would comply in 2010.

For Athens, widespread exceedence of the NO_2 annual mean objective is predicted (98 % of the city area), with the highest background levels reaching 66 $\mu g/m^3$. Exceedence of the benzene standard is much more limited.

For Lyon, limited exceedence of the NO_2 in the city centre (9 % of the city; up to 46 $\mu g/m^3$) and benzene are expected.

Exceedences for PM_{10} are expected in four to five cities, though results are judged to be not very robust.

It can be expected, that in busy street canyons exceedences will occur also in cities where all targets are met on the level of background concentrations.

The expected improvements in tropospheric ozone will not be enough to meet the EU objectives.[186] However, as shown in chapter 4.1.1, the share of road transport on total emissions and therefore its contribution to regional-scale air quality problems is expected to decline strongly. In 2010, the share of road transport on NO_x and NMVOC emissions is predicted to be 24% and 11 %, respectively.

On the other hand, in central urban areas with air quality problems relating to NO_2 and benzene, the contribution of road transport to the concentration of pollutants will still be in the order of 40 % to 80 %[187]. For exceedances of the objectives in street canyons, road transport will be the dominant source.

WG1 summarises the remaining challenges for achieving the AOPII objectives:

- Closing the gap between base case emissions and the proposed national emission ceilings for NO_x and VOCs,
- Meeting the PM_{10} objectives for 2010 in many cities, and
- Tackling the exceedences of NO_2 objectives in some cities (Athens and Lyon in the AOPII sample).

4.1.3 The potential of local measures

The remaining NO_2 and benzene problems in 2010 are expected to be limited to a relatively small number of cities, indicating that local measures might be an efficient way to tackle these problems. This expectation will have to be tested with the cost-effectiveness models of WG7.

Based on the air quality modelling results, WG1 suggested to investigate local measures for Athens and for Lyon. For the latter, measures focussed on the city centre could be considered, though their effectiveness will depend on the balance between local and transit traffic.

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186 See for example the explanatory memorandum to the proposals for national emission ceilings (COM (99)125 final of 9.6.1999).

187 See the source attribution tables based on air quality models which were produced for WG1. A more exact contribution is ambiguous due to the non-linearity of the relation between emissions and air quality.

For PM the methodology and the empirical data base will have to be improved, leading to a longer term strategy beyond AOPII. Nevertheless, WG1 suggested to consider some local measures to contend PM_{10} exceedences. Non-technical measures will in most cases influence all pollutants, though to a different extent if certain vehicle categories are targeted or speed and other driving patterns are altered.

4.2 Specific characteristics of transport demand and supply

4.2.1 Cost concept and other important features of the transport model

After a short summary of main developments, this chapter will describe some additional features (incl. AOPII cost concepts) that are important for the assessment of non-technical measures. Detailed information on the transport model Tremove, the AOPII cost concept and the transport base can be found in the reports of WG7.

The increase of transport demand (see chapter 1.3) is expected to continue, though at a slower pace. The average growth of vehicle-km between 1995 and 2010 reaches about 1.5 % to 2 % p. a. in most of the nine countries studied in detail, only for Spain and Ireland a rate of about 2.5 % is expected. Growth rates are lower within cities due to the limited infrastructure available. The dominance of road in passenger and freight transport is predicted to increase further in several countries.

The main attribute of transport supply is the generalised price reflecting the total cost of using a transport mode. It is calculated as the sum of resource costs (including net vehicle purchase, maintenance, insurance and fuel costs), taxes or subsidies, and travel time costs. In the AOPII basecase, average lifetime driving costs are expected to decrease slightly, mainly owing to improved fuel efficiency. However, this decrease of monetary costs might be offset by the increase of congestion and travel time, especially in cities.

Non-technical measures are usually changing the monetary costs of transport and/or travel time. In Tremove, all changes are translated to changes in the average generalised price per vehicle-km, i.e. no distinction is made between distance related, trip related or vehicle-related ("fixed") costs. The strengths of the model are distinctions by vehicle-categories (also according to environmental criteria), by time of day (peak/off peak) and between inhabitants and commuters.

An important relationship is the speed-flow function, which shows the relation between travel time and traffic volume, i.e. the influence of congestion. It links the different transport types (passenger cars, buses and trucks) because speed on the road is a function of the total traffic flow.

In Tremove, the speed/flow relationship is assumed to be exponential:

$$1/Speed_r = a + b * \exp(c * PCU_r)$$

where

$Speed_r$ is the speed on road class r (in km per minute)

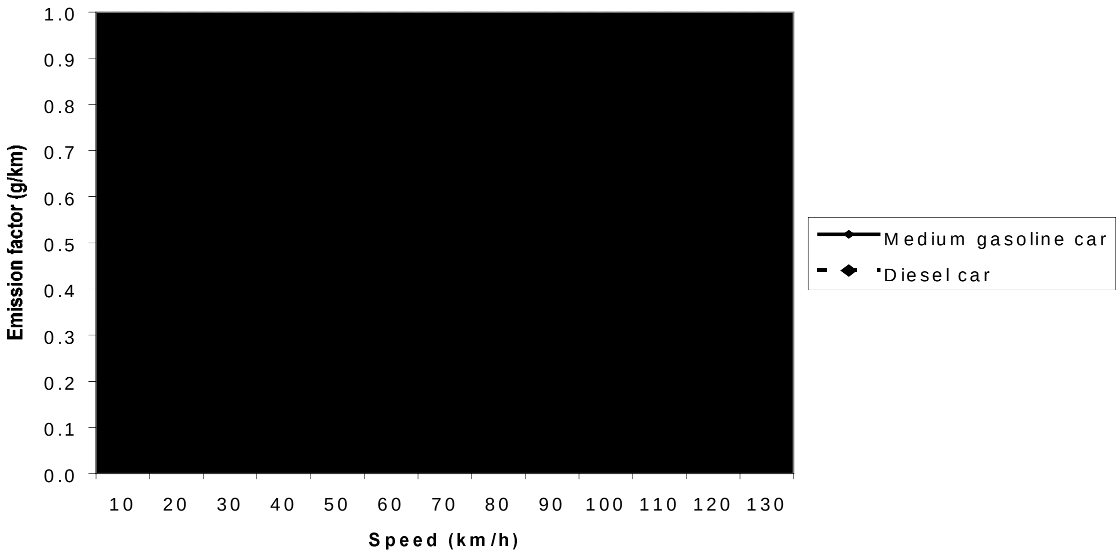
a, b, c are coefficients that have to be estimated for each equation

PCU_r is number of passenger car units per hour. A car corresponds to 1 PCU, buses and trucks to 2 PCU.

Speed is also an important driving factor of emission rates in the model. Figure 4.3 shows two examples for the speed-emission relationships used (based on

COPERT[188]). Average speed in this relation represents typical traffic conditions rather than a constant speed, i.e. lower speed corresponds to an increase in congestion.[189] However, due the use of average speeds for a city the reduction of stop-and-go traffic in specific locations is not modelled.

Figure 4.3: Hot emission factors, Euro I cars: NOx.



Source: Tremove, 1999, based on EEA, COPERT, 1996.

Modelling results should be regarded as a useful strategic guidance. Due to the lack of spatial disaggregation (as shown for the speed-flow function and the speed-emission function), they will have to be verified by competent local or national authorities with locally specified (network) models, before implementing measures. (Moreover, the relative importance of various policy objectives will differ between cities.)

The welfare cost of a non-technical measure affecting only car users can be separated into three components:[190]

- increased money cost of remaining car users,
- the gain in time costs of the remaining car users, and
- the lost welfare of the diverted car users.

The relative size of these components depends on the type of measure (monetary cost versus time cost) and the relative change in demand (the last component).

Besides the costs borne by the users of the transport system (monetary and time costs, as described above) the costs of measures include

- the costs for investment, operation and maintenance, borne by governments or transport operators, and
- additional costs to the society in form of external effects such as CO_2 emissions, noise, and accidents.

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188 COPERT II is a software enabling the calculation of road traffic emissions. See: European Environment Agency, 1997.

189 Therefore emissions are much higher e.g. at 10 km/h than at 40 km/h: +60% for the gasoline and +100% for the diesel car (and for HDV<16 t, which are not shown in the figure, even +180%).

190 More complicated cases considering several transport markets as well as the impacts of taxes (marginal cost of public funds) are outlined in the report of WG7.

While investment costs for non-technical measures have to be defined by WG5, operating costs are partially available from the transport basecase (e.g. costs per bus-km). As a default assumption, Tremove uses linear cost functions.

Tremove includes a simple calculation of the external costs of accidents and noise in an alternative cost function to test the sensitivity of the cost-effectiveness calculations. These values are distance related and distinguish between vehicle categories, while other parameters like average speed are not taken into account. The values were taken from previous TRENEN studies[191]. For example, marginal external accident costs in urban areas are about 33 Euro per 1000 car-km, marginal noise costs 1.9 Euro/car-km in peak and 7.3 Euro/car-km in off-peak. The corresponding values per truck-km are about 3 times higher for accidents and 10 times higher for noise.

The following description of important additional features of the base case is concentrated on the model cities where non-technical measures have been tested, i.e. Athens, and Lyon.

4.2.2 Athens

The domain of Athens, as defined in the Auto Oil II transport basecase[192], has about 3.5 million inhabitants. Traffic demand in 1995 included 9.1 bio. car-, 2.2 bio. LGV-, 0.96 bio. HGV-, 0.12 bio. bus-, and 2.1 bio. motorcycle-km. In the same year, the modal split in passenger-km was cars and motorcycles 62 %, public transport 37 %, and non-motorised 1 %.

Athens encounters severe congestion and pollution problems. The road infrastructure in the urban area did not change much over years due to lack of land and funding. The public transport system consists of a very limited rail system (one metro line and some suburban services) and an extensive, but slow, unreliable and crowded bus system (diesel buses and electrically powered trolley buses). Tariffs were increased strongly during the 1990's, but are still quite low (single 0.3 Euro, monthly travelcard 16 Euro).

Since about 15 years traffic to the city centre is restricted for private cars on alternate working days according to the (odd or even) last digit on the number plate ("Daktylios" system). The efficiency of this system deteriorated over the last years due to several reasons, e.g. induced traffic on allowed days, double car ownership, violations, and the fact that motorcycles and taxis are allowed to drive every day[193].

Other measures introduced during the 1990's are a traffic-free zone in the historical core (about 1-2 km^2), the introduction of wide-scale parking control and improvements to the bus system (some 10 km bus lanes and restructuring of the network). Shortly after 2000, two metro lines will start to operate.

Figure 4.4 shows the relation between traffic volume (in mio. pcu-km per hour) and average speed in the Athens road network[194]. In 1995, with a traffic flow of 3.9 mio. pcu-km/h, average speed during peak was 24.5 km/h. With an expected increase to 5.0 mio. pcu-km in 2010, average peak speed would decrease to 22 km/h. Off-peak speed would change less, because the traffic volumes of 2.4 and 3.0 mio. pcu-km/h,

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191 TRENEN II STRAN, Final report, 1999; De Borger et al., Alternative transport pricing and regulation policies, 1997.

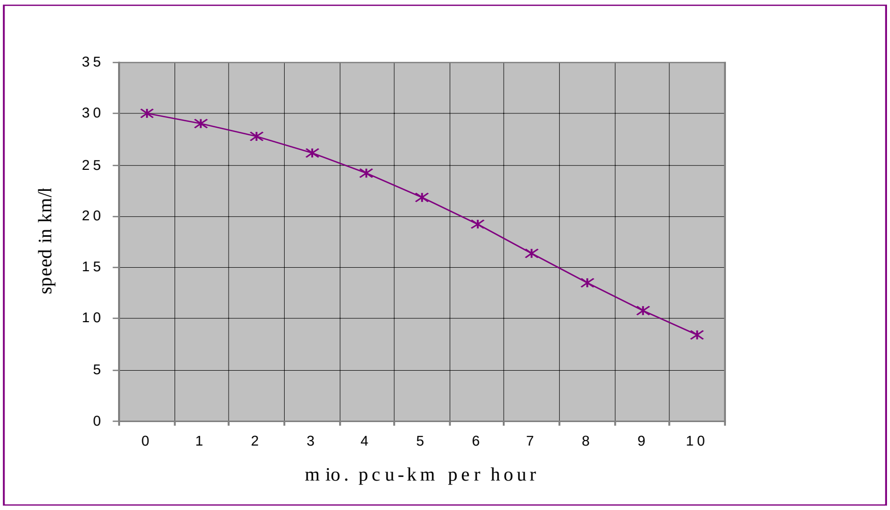
192 As traffic data for Greece was relatively scarce, the basecase includes a range of plausible assumptions, using data from previous case studies and from other regions.

193 TransPrice, research project in the Transport Programme of the 4th Framework Programme for RTD 1994-98.

194 Parameters for the Athens speed-flow function: a = 1.847, b = 0.153, c = 3.536.

respectively, are situated closer to the flat part of the congestion function. Free flow speed would be only 30 km/h.

Figure 4.4: Speed flow-function for Athens.



Source : parameters from Tremove ; own graph.

The car fleet in Greece is characterised by a low diesel segment (diesel cars are banned in Athens), a high share of small cars (about 80 %) and most particular a very high share of old cars (in 1995 about 29 % of cars were older than 13 years). Similarly, about 15 % of trucks were older than 13 years. This might be seen as an argument in favour of a well targeted scrappage scheme (the last scheme in Greece run between 1991 and 1993). However, the basecase forecasts anticipate a rapid reduction of the share of cars older than 13 years to 14 % in 2000 and 11 % in 2005.

4.2.3 Lyon

The domain of Lyon, as defined in the Auto Oil II transport basecase, has about 1.3 million inhabitants. Traffic demand in 1995 included 3.37 bio. car-, 656 mio. LGV-, 81 mio. HGV-, 259 mio. bus-, and 221 mio. motorcycle-km. In the same year, the modal split in passenger-km was cars 49 %, public transport 47 %, and non-motorised transport 3 %.

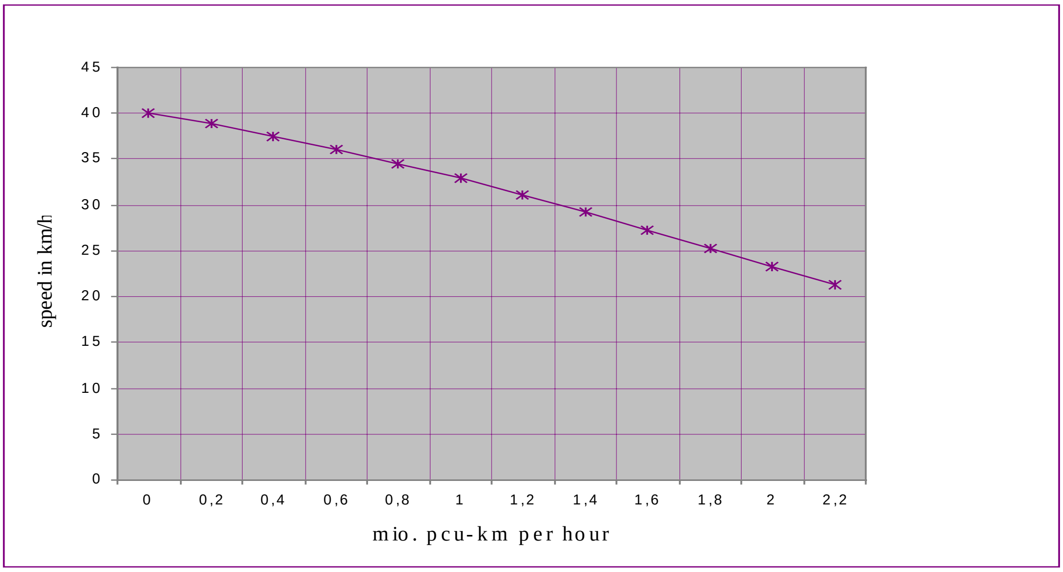
The central area of Lyon is very accessible for cars. The motorway linking Paris and the South of France leads through the centre, several other motorways and a very dense road network are available or under construction. Public parking is not strongly restricted, and 68 % of employees have free parking at their working place.

The public transport system consists of regional express trains operated by SNCF (TER), a modern metro (30 km) and a bus and trolley bus system (about 1300 km). However, only 70 km of buses have reserved lanes and priority regulation at traffic lights is just starting. The single fare is 1.2 Euro, a monthly travelcard costs 43 Euro.

To improve the public transport system, 2 tramway lines and several priority trolley bus lines will be built over the next few years. Characteristics will be high frequency, real priority, information on arrival times, and use of new technologies). Further measures foreseen include, e.g., improvements to other bus and railway services, as well as for cycling and walking. More extensive use of parking charges and speed limits should complement this strategy. An urban road pricing scheme on the main roads (motorways and inner ring including the new TEO, Trans Est Ouest) is foreseen.

Figure 4.5 shows the relation between traffic volume (in mio. pcu-km per hour) and average speed in the Greater Lyon road network[195]. In 1995, with a traffic flow of 1.1 mio. pcu-km/h, average speed during peak was 32 km/h. With an expected increase to 1.4 mio. pcu-km in 2010, average peak speed would decrease to 29 km/h. Off-peak speed would change less, because the traffic volumes of 0.6 and 0.8 mio. pcu-km/h, respectively, are situated closer to the flat part of the congestion function. Free flow speed would be 40 km/h.

Figure 4.5: Speed flow-function for Lyon.



Source : parameters from Tremove ; own graph.

The car fleet in France is characterised by a very high diesel segment (28 % in 1995) and a balanced distribution between small and medium sized cars. In 1995 about 7 % of cars were older than 13 years, with an expected increase of this share to 10 % in 2010. In 1995, about 18 % of trucks were older than 13 years.

Air quality is a major concern in Lyon due to geographical and meteorological conditions, strong traffic growth, and also the high share of diesel cars.

4.3 Description of non-technical measures (Tremove input)

4.3.1 Selection of measures

The basis for the selection of measures is the WG5 “Inventory of measures” (see Annex 1). In a first step, a draft long list of scenarios was defined that still included measures from each of the seven main policy areas defined in WG5, though with an emphasis on traffic management, public transport and road pricing. For several measures, more than one level of intensity was defined to increase the chance of including efficient levels of intensity.

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195 Parameters for the Lyon speed-flow function: a = 1.252, b = 0.248, c = 0.837.

From this long list a limited set of measures was chosen to be modelled in Tremove, mainly considering the criteria data availability and model feasibility. Table 4.1 provides an overview of the selected measures and the domains where they will be assessed.

Table 4.1: Selected measures to be modelled with Tremove[196].

Type of measure		Measure description		Athens	Lyon	Further domain
Traffic Management	Improving traffic flows	Increase road capacity	capacity +5%	X		Test[1)]
		Non urban speed limit	100/120 km/h			
	Reduce traffic in specified areas	Parking restrictions	mileage -10%			
		Zoning/restr. access	mileage -10%			
	Improve the attractiveness of other modes	PT prioritisation	PT speed +15%	X		
		Promote cycling and walking	car mileage -2% to -6%			
Public Transport	Extension of services	Urban bus and/or rail	frequency +30%			Test[1)]
	Reduced fares	Bus/Metro	fare -30%	X		Test[1)]
Freight transport	Combined transport	Interchanges				
	City logistics	Reduce freight mileage	mileage -10%	X		
Road Pricing	Parking charges	Undifferentiated	charge + 3 ECU	X	X	
	Urban road pricing	Time differentiated	see text	X	X	
		Vehicle differentiated	with WG 2 + 3			
	Non-urban road pricing	Distance based				
Fleet modernisation	Environmental classification	Zoning / restricted access	with WG 2 + 3			
	Scrappage	premium	1000 ECU/car	X		Test[1)]
Land use	Density, location of activities					
Mobility behaviour	Targeted awareness activities		mileage -10 %			

1) Test scenarios were run for Berlin and Cologne, resp. Germany (scrappage).[197]

4.3.2 Traffic management measures

Improving traffic flows by increasing road capacity

The purpose of this type of measures is to improve urban road traffic flows, i.e. reducing inefficient and polluting stop-and-go traffic. This should be achieved using telematics, e.g. route guidance and synchronisation of signalling, and variable message signs, and/or by improving infrastructure at bottlenecks, e.g. additional lanes and better design of crossings.[198]

The main impacts expected are on the one hand shorter travel times, increased safety and reduced emissions (as a consequence of smoothed traffic). On the other hand, the reduction in emissions could (partially) be offset by traffic generation due to shorter travel times[199]. In principle, both impacts can be investigated with Tremove, though the simplified relation between average speed and emission factors in the model will

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196 In chapters 4.3 and 4.4 we use ECU rather than Euro, because Tremove uses 1998 prices in ECU.

197 See AOPII Cost-effectiveness Study, Preliminary Draft Report, Part IV, August 1999.

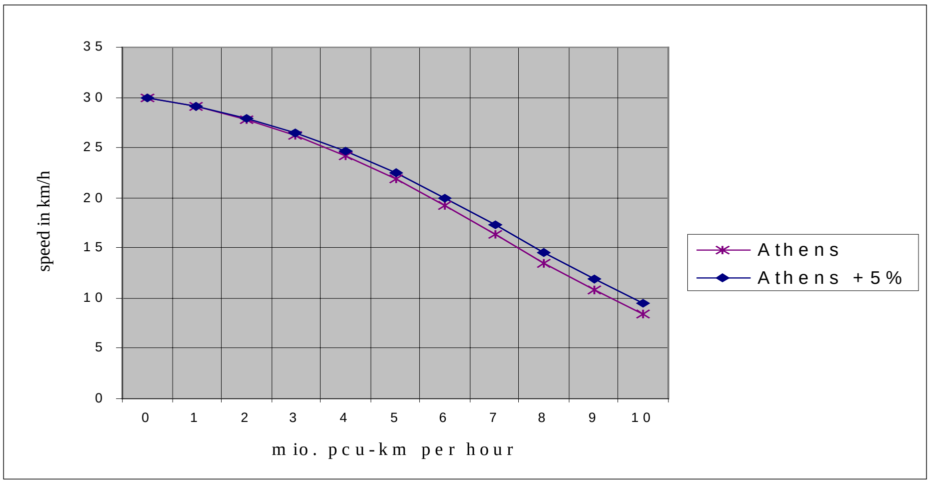
198 See also chapter 3.2.2 for a general discussion of this type of measures.

199 For a discussion of traffic generation due to increased road capacity see e.g. SACTRA, 1994.

have to be considered when interpreting the modelling results. While average speed in this relation (based on COPERT) represents typical traffic conditions rather than constant speeds (and therefore traffic congestion), the reduction of stop-and-go traffic at specific locations can not be modelled due to a lack of local disaggregation.

In Tremove, this measure is simulated by a change of one parameter in the speed-flow function, as shown in figure 4.6. The impact of the capacity change is stronger during peak (5.0 mio. pcu-km/h) than in off-peak (3.0 mio. pcu-km/h).

Figure 4.6: Simulating an increase of road capacity in Athens by a modification of the speed flow-function.



Especially the impacts of removing bottlenecks are very site dependent. A proper assessment requires the use of network models and has to take account of local circumstances. The translation of improvements on certain links into changes of average speed in the city might cause a significant aggregation error.

Nevertheless, it is expected that Tremove can provide useful results for a more general assessment. After incorporating the impacts, the model will find the new equilibrium taking into account primary effects of increased speed as well as further effects of demand changes for road and alternative modes.

Investment and operating costs could vary considerably between infrastructure and telematics investments at different levels. This scenario is interpreted as a package of relatively cheap traffic management and transport telematics measures, possibly including minor construction measures to remove bottlenecks, and affecting a major part of the main road network.

The following cost estimations are mainly based on assumptions in the Transport RTD project OPTIMA[200] and empirical evidence collected for the UK air quality strategy[201]. These sources offer a relatively wide range of cost estimates. In addition, costs in the area of telematics are changing quickly (generally decreasing).

The scale and sophistication of traffic management measures can vary substantially. An important tool to increase the capacity of an existing network is a modern urban

200 ITS Leeds et al., Optimisation of policies for transport integration in metropolitan areas, Project funded by the European Commission under the transport programme of the 4th framework programme, September 1997.

201 WS Atkins, Evaluation of transport measures to meet NAQS objectives, Technical note 1: Implementation costs of local transport measures, December 1998.

traffic control (UTC) system that responds automatically to traffic fluctuations[202]. Several studies showed a reduction of average delays by 12 to 20 % compared to fixed-time systems. The installation of inductive loops to upgrade from fixed time to variable time costs about 8000 to 15000 ECU per junction, the costs of signalising an individual junction from scratch are about 60000 to 75000 ECU. Examples for the costs of other traffic management measures are junction improvements (varying from 50000 to 700000 ECU) and Red Route type controls (up to 700000 ECU per km).[203]

In the OPTIMA project, consultants and research teams from five countries estimated the costs for an increase of road capacity by 5 % in 5 major cities, i.e. Helsinki, Merseyside, Oslo, Torino and Vienna, ranging from 11 mio. to 53 mio. ECU. Standardised by the number of registered cars, costs range from 31 ECU in Torino to 114 ECU in Oslo, with Merseyside (113) and Vienna (108) very close to the value for Oslo. Due to the scarcity of urban space, a relatively high value of 110 ECU seems to be appropriate to calculate the implementation costs of this measure in Athens, too. Annual operating costs are estimated with 5 % of the implementation costs.

Model input for Athens (from 2005):
Increase capacity by 5%: reduce parameter “c” in speed-flow function to 3.368
Implementation costs: 80 mio. ECU
Operating costs: 4 mio. ECU per year

Non-urban speed limit

Speed-limits are intended to improve inter-urban road traffic flows. The main impacts expected are increased travel times, improved traffic safety, reduced vehicle operating costs, and reduced emissions (pollutants and CO_2). This is primarily achieved by smoothing road traffic flows, a second effect is an incentive to shift to alternative modes or reduce travel distances due to the increase in general costs of road transport. The main cost element for governments are the enforcement costs.

The impacts of speed-limits have been studied extensively in literature[204]. A significant potential to reduce NO_x emissions by 10 to 15 % was identified. As this is achieved mainly outside urban areas, it was decided not to model this scenario in Tremove. Nevertheless, in some countries this measure could have a strong potential to contribute to achieving the National Emission Ceilings.

Reduce traffic in specified areas: Parking and access restrictions/zoning

This type of measures has the goal to reduce road traffic in specified urban areas by means of parking restrictions other than pricing. Theoretically, the impact of this measure could be modelled either by increasing searching time for a parking space or by limiting the number of road commuters to the number of private parking spaces, depending on the design of the system.

It was decided not to test this scenario with Tremove, as it was felt that model structure and input data availability would not be adequate. Moreover, in an economic model like Tremove restrictions will never be more efficient than (optimal) parking charges. Instead, WG5 defined two plausible levels of rigidity, i.e. a reduction of

202 A prominent example is SCOOT (split cycle offset optimisation technique) developed in the UK by the Transport Research Laboratory and traffic systems suppliers and used in more than 170 cities in several countries.

203 All costs in this paragraph are quoted from WS Atkins, see above.

204 See also chapter 3.3.3.

urban car mileage by 5 % and 15 %, respectively[205]. The higher value could be valid for a targeted central area, the lower value for an entire city - though this depends strongly on the size of the restricted area and its share of the total city area.

Another way to reduce road traffic in specified urban areas are access restrictions, which can be total, temporal, and/or with certain exceptions. A differentiation according to an environmental classification of vehicles ("environmental zoning") will be discussed in section 4.3.6 and might be defined in modelling terms in co-operation with WG2 and WG3.

Theoretically, the impact could be modelled via a limitation of the number of road commuters. It was decided not to test this scenario with Tremove because of the limited potential to model the relevant reaction mechanisms. Based on an assessment of the sources quoted in chapter 3.3.5, WG5 defined a plausible range of rigidity instead, i.e. a potential to reduce urban car mileage by 5 % to 10 %.

Improve attractiveness of other modes: Public transport prioritisation

This measure is meant to increase public transport speed and reliability by dedicating lanes for buses and priority for public transport at signals. Main impacts expected are an increased speed for buses and, if space and capacity for other modes have to be reduced, a lower average speed for cars. Consequently, a modal shift from other modes to public transport is expected. The reduction in emissions could (partially) be offset by increased congestion. It was decided, that this measure should be tested for Athens using Tremove.

Several sources state a potential increase of bus and tramway speeds of 10 % to 20 % and an even higher increase in service reliability due to prioritisation.[206] In the case of London, this should be achieved with a network of about 1270 km of bus lanes (510 km red routes, 860 km additional bus lanes). The Athens region has a considerably smaller bus-network than London (46 % in terms of routes, 37 % in terms of bus-km, and 30 % in terms of buses). Based on the share of bus-km, there would be a need for bus lanes with 470 km in Athens, i.e. 460 km more than the existing 10 km.

Main costs for the operator or the government are implementation and enforcement costs. The following cost estimations are mainly based on Transport RTD projects and empirical evidence collected for the UK air quality strategy[207]. The latter offers a relatively wide range of cost estimates for bus lanes, stating 0.15 mio. ECU as an average value and more than 1 mio. ECU per km for very sophisticated demonstration projects. The APAS project (EU-Transport RTD) on Public transport prioritisation[208] states the cost for 6 km bus lanes in Athens with 80000 ECU per km for 1988. Taking into account inflation and the fact that probably lanes on simpler locations have been realised first, implementation costs are assumed to be 0.15 mio. ECU per km of bus lane. This gives for Athens implementation costs of about 70 mio. ECU.

This measure has also a significant potential for additional revenues (modal shift) and for cost savings due to shorter travel times (less labour input and less rolling stock for a given service frequency). The latter impact has to be introduced exogenously into

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205 These values are slightly lower than the figures indicated in the case studies quoted in chapter 3.3.4.

206 London Transport Buses, The London Bus Priority Network, 1997; DITS, TTR, Public transport prioritization, Transport Research APAS, Urban Transport, vol. 25, Luxembourg 1996.

207 WS Atkins, Evaluation of transport measures to meet NAQS objectives, Technical note 1: Implementation costs of local transport measures, December 1998.

208 DITS, TTR, Public transport prioritization, Transport Research APAS, Urban Transport, vol. 25, Luxembourg 1996.

Tremove, where constant operating costs per vehicle-km are assumed. Several studies show that savings in operating costs (due to higher speed the same frequency of services can be produced with less input of labour and buses) can outweigh or even exceed the costs of implementation. A detailed estimation for a bus and tramway prioritisation scheme in Vienna[209] shows annual savings in operating costs amounting to 13 % of the original costs of implementation. For Athens this would result in annual savings of 9 mio. ECU.

The indirect effect on the congestion of other road vehicles (cars, trucks) is very site dependent. Taking road space as a proxy for capacity[210], it can be estimated roughly on the example of London. If roads (network length in London is 13400 km) have in average 2.5 lanes, the projected bus lanes correspond to 4 % of road space.[211] This value could be an overestimation, because drivers can still choose other routes, or an underestimation, if bus lanes are concentrated in areas where also most congestion occurs. Locally the impact might be much higher and cause traffic jams in central areas with already poor air quality.

Model input for Athens:
Increase speed of buses by 15 % (bus lanes, priority at junctions).
Indirect effect: Reduced road capacity for cars by 4 % (i.e. increase parameter "c" in speed-flow function from 3.536 to 3.677, but only for cars, LDV and HGV, and not for buses).
Implementation costs: 70 mio. ECU
Operating costs: savings of 9 mio. ECU/year

Improve attractiveness of other modes: Promote cycling and walking

The purpose of this type of measures is to increase the speed, safety, and comfort of cycling and walking by means of dedicated lanes for cyclists and further supportive measures[212]. The higher attractiveness should lead to a modal shift from motorised to non-motorised modes.

Theoretically it would be possible to model this measure via an increase of the average speed for cyclists, and possibly reduced speed for cars (reduced capacity and/or loss of parking spaces). However, it was felt that this would not properly take account of the incentives set by such a policy, which would affect the subjective perception of safety and comfort for cyclists. Therefore WG5 decided not to assess this measure in Tremove, but to define a plausible range for the potential of this measure to reduce urban car traffic. Based on an assessment of the sources quoted in section 3.4.7, this range was defined with 2 to 6 %[213].

4.3.3 Public Transport measures

Extension of services

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209 Schönbäck, W., Kosten und Finanzierung des öffentlichen Personenverkehrs in Wien, 1994, p. 37-41.

210 This might underestimate or overestimate the actual impact on road capacity: While bus lanes would be concentrated on critical links of the road network, careful planning and the use of bus lanes by taxis and/or bicycles, could reduce pressure on the remaining lanes.

211 This figure corresponds roughly to the result of another approach: According to Arizona et al. (1997) speed on remaining lanes on effected streets (here about 5 %, however with a higher but unknown share on traffic) could decrease by 12 %.

212 See chapter 3.3.9 for a general discussion of measures in support of cycling and walking.

213 While the share of cycling on urban trips in European cities reaches up to 30 %, these trips are concentrated on shorter distances (50 % of all urban car trips are below 5 km, they account for 9 % of car-km: see 3.4.7).

An increase of public transport supply can be implemented either in form of extended or new lines (i.e. reduced access walking times) or in form of increased frequencies (i.e. reduced waiting times). The main impacts are reduced travel times for public transport users, and a small increase of all road transport due to improved vehicle flows. Additional operating costs (including amortisation of rolling stock) are calculated within Tremove, based on linear cost functions.

A distinction between extending bus services and metro/rail services should be made, as they have very different emission factors. Moreover, as the positive impact of additional conventional buses on air quality is questionable, this measure could be combined with the use of alternative fuel buses. An adequate package of measures can be defined in co-operation with WG2 and WG3.

As the extension of public transport services is a very common policy, it was suggested to test one scenario for Athens with an increase of bus frequency using traditional buses. As occupancy rates are exogenous in Tremove, it will be necessary to calculate the expected decrease in an iterative way. The result can be compared with empirical frequency elasticities of demand.

Model input for Athens (from 2005):
Increase bus frequency by 30%: reduce waiting time by 1/1.3, i.e. about 23%.
Occupancy rate: reduce in iterative process using Tremove.
Costs: According to Tremove (linear cost function).

Reduced public transport fares

This measure assumes a reduction of public transport fares, financed by an increase of the subsidy from the government to the transport operator. The expected impacts are an increase of public transport ridership and a reduction of car traffic as well as non-motorised transport. In addition, Tremove will calculate the costs of the subsidy with an assumption on the marginal costs of public funds.

Depending on the amount of additional public transport demand, an increase of frequencies might be necessary. Tremove assumes a fixed occupancy rate, i.e. an increase proportional to the increase of demand. This assumption will have to be considered when discussing the modelling results, it is questionable especially for off-peak trips. (Therefore it could be useful to test time-differentiated fares.)

Model input for Athens:
Reduce the average fare as well for bus as for metro services by 30%.
Costs: Model will calculate increase in government subsidies.

4.3.4 Freight transport

Intermodal/combined transport

This measure would include the provision of interchange facilities, especially for combined rail transport.

Results from the evaluation of projects are available on a case study basis, e.g. from the Commission's PACT Programme. These case studies demonstrate a significant potential to improve combined transport services (see section 3.5.1).

Because combined transport uses alternatives to road freight transport mainly outside urban areas, this measure is expected to have a relatively low impact on urban air quality. Therefore it was decided not to model this scenario in Tremove.

Improved city logistics

Freight transport causes an important part of emissions in some cities. According to the AOPII basecase, in Athens the share of freight transport on NOx emissions in 2010 is expected to be 49% (cars 39%, buses 10%, two-wheelers 2%). Therefore it was decided, to model this measure for Athens despite the very rare cost information available.

Several studies indicate a potential to increase load factors in urban freight transport, while other sources stress the fact that private operators already have a strong incentive to optimise usage, as it is decisive for their competitiveness. However, based on the studies quoted in chapter 3.5, it is assumed that it would be possible to increase the average load factor by 10 %, with a corresponding reduction of HGV- and LGV-mileage.

The only detailed cost-estimation found for a city-logistics concept was made for Cologne[214]. As the authors stress, there is a set of parameters that are not directly transferable to other cities (e.g. land prices, sectoral structure, and wages). Nevertheless, the study indicates the elements of an overall strategy to improve urban freight transport.

For the definition of the modelling inputs, the following elements of the study for Cologne have been taken into account: implementation of freight distribution centres, an improvement of supply and delivery conditions, co-operations in urban delivery traffic, and the installation of city terminals.

The cost estimations for Cologne include investment and operating costs for the freight distribution centre, labour and equipment costs to enable less restrictive delivery times, communication and information costs for better co-operation, and investment costs for terminals. Several elements include rough estimates, not least because of rapidly changing costs for information technologies. Therefore the cost estimates should be seen as indicative. To obtain cost estimations for Athens, all costs have been increased in proportion to freight transport mileage in the two study areas.

Indirect effects of the measure due to the higher attractiveness of car traffic (less congestion) are modelled in Tremove.

Model input for Athens:
Increase load factors for HGV and LGV in Athens by 10% (with corresponding reduction of HGV- and LGV-km).
Implementation costs: 66 mio. ECU
Operating costs: 50 mio. ECU/year

4.3.5 Road Pricing (incl. parking charges)

Parking charges: undifferentiated

214 Baum H. et al., City-Logistik Köln, Gesamtwirtschaftliche Bewertung mit Nutzen-Kosten-Analysen, Köln 1996.

This measure comprises an additional parking charge of 3 ECU (average value that might be varied over the city area) for inhabitants and commuters at the urban destination of each trip (i.e. not at the home based trip end). The main impact is an increase of the costs for the use of cars.

Enforcement cost is the main cost component for the government. Figures stated in literature include 0.4 mio. ECU[215] for Winchester in the UK and 1.6 mio. ECU for Graz in Austria[216]. Taking into account the size of the cities and average wages, the expected costs would be about 8 mio. ECU for Athens and 4 mio. ECU for Lyon. However, additional implementation and operating costs are relatively low, if the measure implicates only an increase of existing parking charges that had to be administrated in the basecase, too. In Athens, wide-scale parking control was introduced in 1996[217], while in Lyon public parking is not strongly restricted.[218]

Secondary effects include the partial compensation for increased monetary road transport costs by higher speed (relief of congestion). This will be calculated by Tremove, although the reduced search time for parking will not be taken into account.

Based on the assumption that buses are fully used, Tremove will also calculate additional operating costs for public transport due to modal shifts. The additional revenues for the government will be calculated, too.

Model input for Athens and Lyon:

Increase parking costs by 3 ECU by trip, i.e. by 0.214 ECU/veh.-km for inhabitants and by 0.115 ECU/veh.-km for commuters, both in peak and off-peak. (Assumption, that inhabitants drive 2x7 km and commuters 2x13 km (source: TRENENII)).

Costs for Athens:

Implementation costs: 2 mio. ECU. Operating and enforcement costs: 3 mio. ECU per year. Revenues from penalties: 3 mio. ECU per year. TREMOVE will calculate welfare costs.

Costs for Lyon:

Implementation costs: 1 mio. ECU. Operating and enforcement costs: 2 mio. ECU per year. Revenues from penalties: 1 mio. ECU per year. TREMOVE will calculate welfare costs.

Urban road pricing - time differentiated

This measure involves the introduction of a time-differentiated toll for commuters as well as for inhabitants, either through adequate cordons within the city area or distance based. The main impact is an increase of the travel costs for car transport users, especially during peak (when external congestion and emission costs are high, too). Implementation and operating costs are considerable, but additional revenues for the government are expected to be much higher. Secondary effects due to the lower traffic volume will be calculated by Tremove. They include additional operating costs for public transport and the fact that higher speed compensates partially for the increase in monetary road transport costs.

Tremove does not distinguish between an increase by a fixed amount (cordon charging) or proportionally to trip distance. It would be possible in the model to define cordon pricing as effecting outsiders (“commuters”) only, but this would imply

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215 WS Atkins, Evaluation of transport measures to meet NAQS objectives, Technical note 1: Implementation costs of local transport measures, December 1998.

216 Klamer, M., Maßnahmen zur Beschränkung des motorisierten Individualverkehrs in Städten, Wien, 1996.

217 TransPrice, Research project in the Transport programme of the 4th Framework Programme, Deliverable 4.

218 Communaute urbaine de Lyon, Departement developpement urbain, Written response to the WG5 questionnaire, 1998.

a cordon at the outer border of the city, while in most larger cities cordon pricing is discussed for a central or inner area only.

Several studies provide estimates for implementation and operating costs of road pricing schemes. The most detailed descriptions were found in the London congestion charging research programme.[219] Other sources for Stockholm, Lyon, Oslo and other cities provide total estimates in the same order of magnitude (per vehicle).

A main part of the costs arise for the in-vehicle-units (IVU) (in London about 50 %), and administration and enforcement costs (in London about 45 %) dependent on traffic volume. Roadside equipment accounts for a relatively small share (in London only 5 %). Therefore it is rational to define costs in relation to the number of vehicles involved. Implementation costs are, based on the data for London, 82 ECU per vehicle, and annual operating costs amount to 24 ECU per vehicle[220]. It is assumed that one quarter of the operating costs are intended for enforcement and will be covered by fines for violations. The number of vehicles to be equipped with IVUs is assumed to be 20 % above the number of cars registered in the study area (i.e. 1.144 mio. in 2005).

Model input for Athens:

Introduce a toll for commuters as well as for inhabitants, starting from 2005.

Toll level: Peak: 0.3 ECU/veh.-km for cars and LGV, 0.6 ECU/veh.-km for HGV; off-peak: 0.05 ECU/veh.-km for cars and LGV, 0.1 ECU/veh.-km for HGV.

Costs: Implementation costs (total): 94 mio. ECU; Operating costs (total): 27 mio. ECU/year (including enforcement costs of 7 mio.). Additional revenues from fines: 7 mio. ECU/year.

Urban road pricing - vehicle differentiated

Increase of the travel costs for road transport users, differentiated between vehicles with different emission levels. The main impact would be changes in transport demand and modal split (depending on the average level of the charge) and in the composition of the vehicle stock (depending on the degree of differentiation of the charge). The impacts for the government would again include revenues from charges, and investment and operating costs. Secondary effects would be similar to the other road pricing scenarios.

This measure would have to be defined in co-operation with WG2 and WG3.

Non-urban road pricing – undifferentiated

This includes again an increase of the travel costs for road transport users, in this case outside urban areas. Usually only motorways are affected, but all other roads could be included, too (see e.g. the new HGV-charge in Switzerland). Impacts on government and secondary effects would be similar to the other road pricing scenarios.

It was decided not to model this measure with Tremove, because it is expected to have a relatively low impact on urban air pollution and the impacts would be similar to an increase of fuel taxes investigated by WG6.

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[219] MVA Consultancy, The London Congestion Charging Research Programme, Final Report, 3 volumes, London 1995.

[220] These are the costs for a system based on transponder and electronic cash. Total annual costs for other systems (read-write tag, transponder/smart card, and a hybrid system) are stated to be 34% to 47% higher (MVA, vol. 2, p. 12.2 and 12.3).

4.3.6 Incentives for fleet modernisation

Environmental classification - zoning/restricted access

In environmental zones the access to specified urban areas is restricted to vehicles fulfilling certain environmental standards. The restriction can be total, temporal, and/or with certain exceptions. The major cost element for government will be for enforcement.

This measure would have to be defined in co-operation with WG2 and WG3.

Scrappage schemes

Scrapping schemes provide owners with a bonus for every scrapped car, sometimes depending on replacement by a new car. The main effect is an earlier replacement of old cars. The efficiency of scrappage depends on the design of the scheme and the structure of the vehicle fleet, especially the share of very old cars (see chapter 3.7).

> This measure should be tested for Athens, where due to slow replacement the car fleet is relatively old. The proposed bonus is 1000 ECU per car, to be offered between 2005 and 2010 for the scrappage of cars older than 10 years.

4.3.7 Land use

Density, location of activities

Higher density of land use and an adequate location of transport generating activities are expected to reduce trip distances for commuting, shopping, and certain leisure activities. Moreover, the efficiency of public transport is higher in more densely populated areas (see chapter 3.8).

Due to model and data limitations it was decided not to assess land use policies with Tremove.

4.3.8 Influence on mobility behaviour

Targeted awareness activities

It was decided not to test this awareness increasing measures (see chapter 3.9) with Tremove, as it was felt that model structure and input data availability would not be adequate. WG5 defined a plausible level of impact with a reduction of urban car mileage by up to 10 %.

4.4 TREMOVE results and validation

4.4.1 Introduction

Chapter 4.4 shows the main results for non-technical measures of the AOPII transport and emissions model Tremove, as provided by the consultants of WG7. In principle, a vast amount of information would be available for each model run: Impacts on prices, speed, generalised prices, transport demand by mode and vehicle categories, vehicle stock characteristics, fuel consumption, emissions for nine pollutants, costs to consumers, freight transport and government, and total social costs. Each of these categories can be shown for each individual year till 2020, in absolute values or percentage changes to the basecase, referring to an individual city, the country or the EU-level.

Therefore it is important to choose the most relevant tables and diagrams for the interpretation of results. They are presented in a summary table and selected diagrams providing relevant information for WG5. All results are as of end October 1999.

4.4.2 Traffic management

Improving traffic flows by increasing road capacity

A description of this measure, which involves an increase of road capacity by 5 %, can be found in chapter 4.3.2. The higher capacity leads in Athens (in 2010) to a slight decrease of generalised prices (incl. monetary and time costs) for cars by 0.5 %, for buses by 0.2 % and for trucks by 0.6 %. Table 4.2 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

Table 4.2: Improving traffic flows by increasing road capacity in Athens by 5 % - main results (%changes for Athens)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	0.6 %	0.7 %	0.8 %	1.0 %
Big cars	0.5 %	0.6 %	0.7 %	0.9 %
Mopeds & motorcycles	0.4 %	0.4 %	0.5 %	0.6 %
Buses	-0.2 %	-0.3 %	-0.4 %	-0.5 %
Metro	-0.4 %	-0.5 %	-0.6 %	-0.7 %
Non-motorised transport	0.0 %	0.0 %	0.1 %	0.1 %
Total passenger-km	*0.3 %*	*0.3 %*	*0.4 %*	*0.4 %*
Light trucks	0.2 %	0.2 %	0.2 %	0.3 %
Heavy trucks	0.1 %	0.2 %	0.2 %	0.2 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	1.1 %	1.3 %	1.4 %	1.6 %
Impact on emissions, changes from base case				
	2005	2010	2015	2020
NOx	-0.1%	0.0%	0.0%	0.1%
PM	-0.7%	-0.8%	-0.8%	-0.9%
CO	0.2%	0.5%	0.7%	0.5%
VOC	-0.1%	0.0%	0.1%	0.1%
CO2	-0.2%	-0.1%	-0.1%	-0.1%
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	-107	-159	-224	-320
Side-effects				
Impact on noise cost	0	0	1	1
Impact on accident cost	2	3	4	6
Total with side-effects	-104	-156	-219	-313
Net present value:	-1720	**with noise&accidents:**	-1682	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	-7	-11	-10	-8

Source: Tremove, September 1999.

The impacts of this measure on emissions are limited, as opposite trends (transport demand, speed) compensate each other. Only reductions of PM last beyond 2010 (see figure 4.7). A test run with Tremove for the same measure in Berlin and Cologne (see Part IV of WG7's preliminary draft report) resulted in a slight increase of NOx emissions already from 2005, and a smaller decline for PM. The difference could be caused by the lower base case speed in Athens.

The negative costs to society indicate cost savings due to reduced congestion, as well for freight as for passenger transport (see figure 4.8). The increase of benefits over time is caused by the strong growth of transport demand in Greece, which leads in the basecase to an increase of congestion over time. Additional tax revenues cover the annualised costs for the government (14 mio. ECU) only partially.

Figure 4.7: Increase of road capacity by 5% in Athens - Total road transport emissions in Athens, %-change from base case.

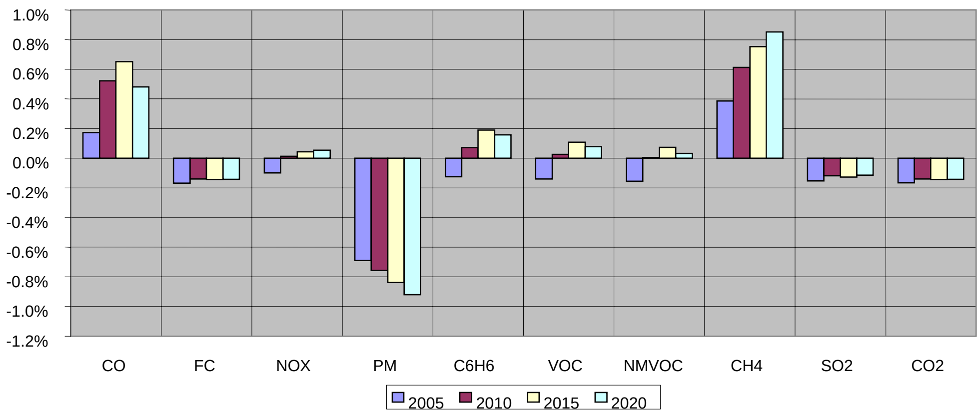
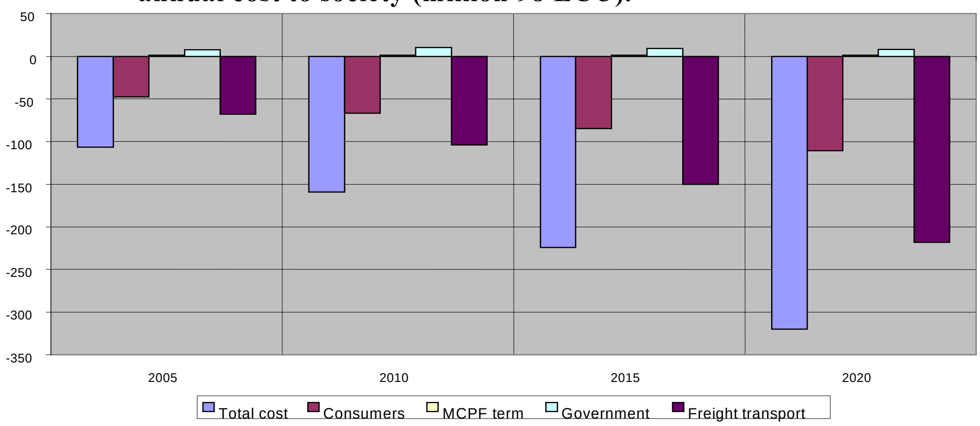


Figure 4.8: Increase of road capacity by 5% in Athens - Decomposition of total annual cost to society (million 98 ECU).



Public transport priority

A description of this measure, which involves an increase of average bus speed by 15 %, can be found in chapter 4.3.2. This leads in Athens (in 2010) to a decrease of generalised prices for buses by 2.5 %, while generalised prices for cars increase by 0.4 % and for trucks by 0.5 %. Table 4.3 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

The impacts of this measure on emissions are limited, as opposite trends (transport demand, speed) partially outweigh each other (figure 4.9). NO_x emissions decrease by about 0.6 %.

The costs to society indicate increased congestion (see figure 4.10). While this is overcompensated for passenger transport by the gains for public transport users, the net costs for freight transport are decisive for the increase of total social cots. The increase over time is due to the increase of congestion already in the basecase. Despite the assumption of savings for current bus services, the government has to cover the net costs for additional services (which are overestimated due to the Tremove assumption of fixed load factors also in off-peak).

Table 4.3: Public transport priority: increase of average bus speed in Athens by 15 % - main results (%changes for Athens)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	-1.2 %	-1.3 %	-1.4 %	-1.6 %
Big cars	-1.1 %	-1.2 %	-1.3 %	-1.5 %
Mopeds & motorcycles	0.0 %	-0.1 %	-0.1 %	-0.2 %
Buses	5.1 %	5.3 %	5.5 %	5.7 %
Metro	2.7 %	2.9 %	3.0 %	3.2 %
Non-motorised	0.2 %	0.2 %	0.2 %	0.2 %
Total passenger-km	*0.3 %*	*0.2 %*	*0.2 %*	*0.2 %*
Light trucks	-0.1 %	-0.2 %	-0.2 %	-0.2 %
Heavy trucks	-0.1 %	-0.1 %	-0.1 %	-0.2 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	-0.9 %	-1.0 %	-1.1 %	-1.2 %
Impact on emissions, changes from base case				
	2005	2010	2015	2020
NOx	-0.5 %	-0.6 %	-0.6 %	-0.6 %
PM	-0.4 %	-0.4 %	-0.4 %	-0.3 %
CO	-0.4 %	-0.7 %	-0.9 %	-0.7 %
VOC	-0.0 %	-0.2 %	-0.2 %	-0.1 %
CO2	-0.3 %	-0.3 %	-0.3 %	-0.3 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	17	43	78	132
Side-effects				
Impact on noise cost	0	0	0	-1
Impact on accident cost	-3	-5	-6	-9
Total with side-effects	13	38	72	122
Net present value:	541	**with noise&accidents:**	487	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	-10	-8	-9	-10

Source: Tremove, October 1999.

Figure 4.9: Prioritisation of public transport in Athens - Total road transport emissions in Athens, %-change from base case.

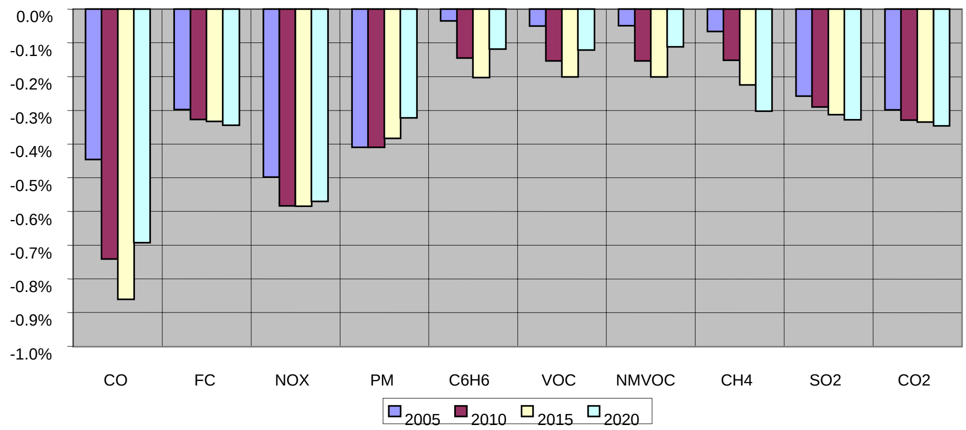
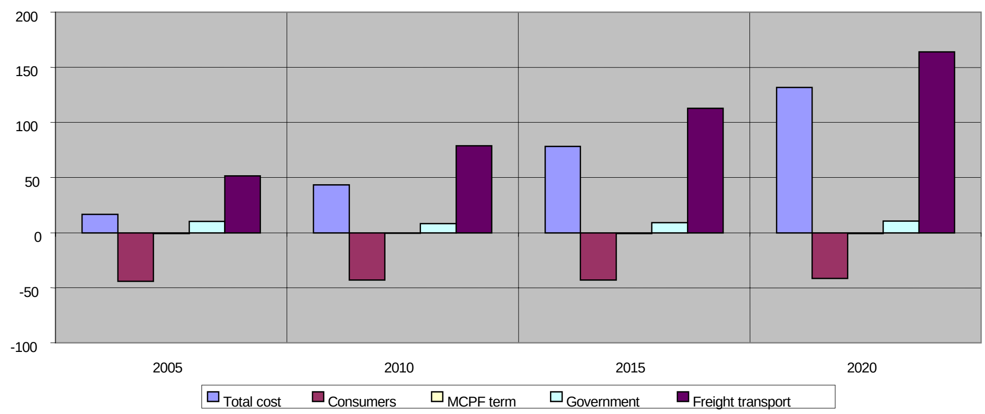


Figure 4.10: Prioritisation of public transport in Athens - Decomposition of total annual cost to society (million 98 ECU).



4.4.3 Public transport measures

Reducing public transport fares

Table 4.4: Reducing public transport fares in Athens by 30 % - main results (%changes for Athens), with constant load factors [1)]

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	-3.0 %	-2.9 %	-2.7 %	-2.6 %
Big cars	-3.0 %	-2.9 %	-2.7 %	-2.6 %
Mopeds & motorcycles	0.8 %	0.8 %	0.8 %	0.8 %
Buses	15.3 %	14.6 %	14.0 %	13.4 %
Metro	13.2 %	12.7 %	12.2 %	11.6 %
Non-motorised	0.7 %	0.7 %	0.6 %	0.6 %
Total passenger-km	*2.1 %*	*2.1 %*	*2.0 %*	*2.0 %*
Light trucks	0.1 %	0.1 %	0.1 %	0.1 %
Heavy trucks	0.0 %	0.1 %	0.1 %	0.1 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	0.3 %	0.3 %	0.4 %	0.4 %

Impact on emissions, changes from base case				
	2005	2010	2015	2020
NOx	0.5 %	0.4 %	0.5 %	0.5 %
PM	1.2 %	1.6 %	1.7 %	1.6 %
CO	-0.6 %	-1.0 %	-1.2 %	-1.0 %
VOC	-0.1 %	0.0 %	0.2 %	0.3 %
CO2	-1.2 %	-1.1 %	-1.1 %	-1.0 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	-84	-105	-128	-159
Side-effects				
Impact on noise cost	0	0	0	-1
Impact on accident cost	-8	-9	-11	-13
Total with side-effects	-92	-114	-140	-172
Net present value:	-1049	**With noise&accidents:**	-1143	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	-274	-292	-309	-329

1) See sensitivity test with regard to critical load factor assumption.

Source: Tremove, October 1999.

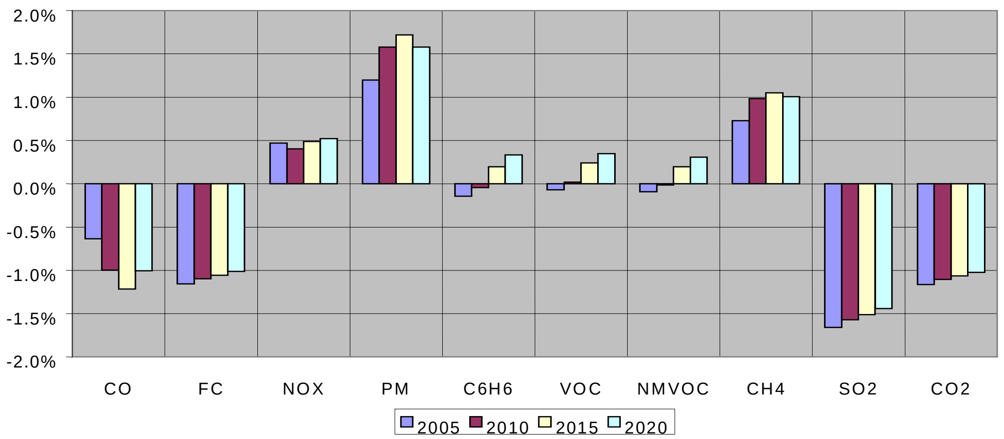
The reduction of public transport fares by 30 % leads in Athens (in 2010) to a decrease of generalised prices by 5 % for buses and by 3.5 % for metro. Due to a decrease of congestion, the generalised prices for cars and trucks decrease by 0.1 % and 0.2 %, respectively. Table 4.4 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

According to the modelling results for 2010, the increase of bus-km by 15 % outweighs the reduction of car-km by 3 % with regard to the majority of pollutants (figure 4.11). However, these results depend crucially on the assumption of fixed load factors, i.e. an increase of bus frequencies parallel to demand. If this assumption is relaxed for off-peak, NO_x emissions in 2010 would decrease by 0.6 % and PM emissions would increase by 0.3 % only. A simple sensitivity test for NO_x in 2010 shows the following results:

NO_x emissions in Athens, 2010	*Cars*	*Buses*	*Others*	*Total*
Base case emissions (in tons)	3795	961	4919	9675
Change of emissions due to decrease of public transport fares:				
with fixed load factors	- 2.9 %	+ 14.6 %	+ 0.1 %	+ 0.4%
without frequency increase in off-peak	- 2.9 %	+ 5.5 %	+ 0.1 %	- 0.6%

NB: This sensitivity test ignores the impact of speed on emissions. The increase of average speed by 0.3 % would correspond to a decrease of emission rates by 0.1 to 0.2 %.

Figure 4.11: Reduce public transport fares (-30%) - Total road transport emissions in Athens, % change from base case (with constant load factors).

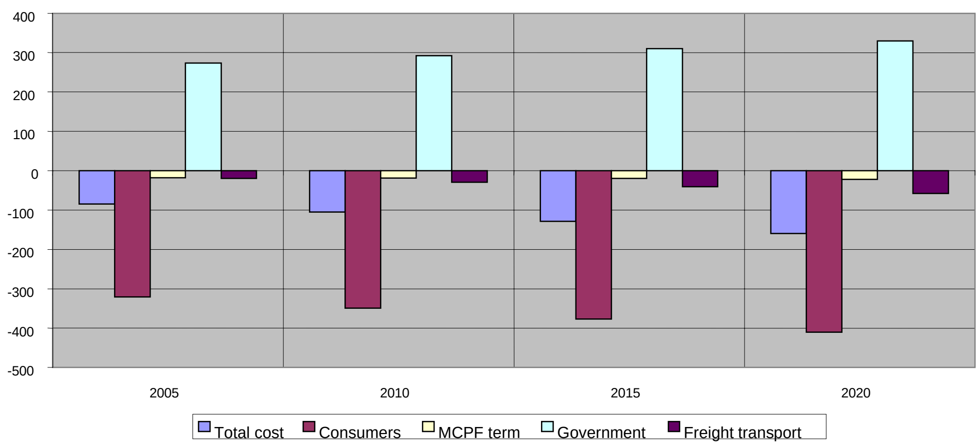


The high increase of PM emissions is specific for Athens, where private diesel cars are banned. Therefore the increase of emissions from buses is dominant (although Tremove uses national vehicle stock distributions).

Furthermore, it would be useful to test the impact of this and other measures increasing the attractiveness of bus transport in combination with alternative or clean fuel buses. This involves a "package of measures" and is foreseen to be included in the WG7 reports.

Benefits to consumers (and also to freight transport due to relieve of congestion) surpass the required increase in government subsidies, so that the total costs to society of this measure are negative (see figure 4.12). An increase of public transport frequencies only during peak will further reduce costs, though not proportional to the vehicle-km saved as additional services during peak hours are more expensive.

Figure 4.12: Reduce public transport fares (-30%) in Athens - Decomposition of total annual cost to society (mio. 98 ECU), with constant load factors.



4.4.4 Freight transport

City logistics

A description of this measure, which involves an increase of average load factors for HGV and LGV by 10 %, can be found in chapter 4.3.4. This leads in Athens (in 2010) to a decrease of generalised prices for trucks by 5 %, and due to less congestion for cars by 0.3 % and for buses by 0.1 %. Table 4.5 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

The impacts of this measure on freight transport are an increase of ton-km by about 2 % (due to the reduced generalised price) but a decrease of vehicle-km by about 7 % (higher load factor). Road passenger transport increases slightly, too.

Road transport emissions are reduced by almost 6 % for PM and 3 % for NO_x. The cost savings for the society express primarily efficiency gains for freight transport.

The results for this measure should be interpreted with special care because of poor data availability (e.g. cost estimate based on one source only) and inadequate model design (e.g. no distinction by type of good). There are different opinions in literature on the possibilities to increase the load factor (see chapter 4.3.4).

Figure 4.13: Improved city logistics in Athens - Total road transport emissions in Athens, %-change from base case.

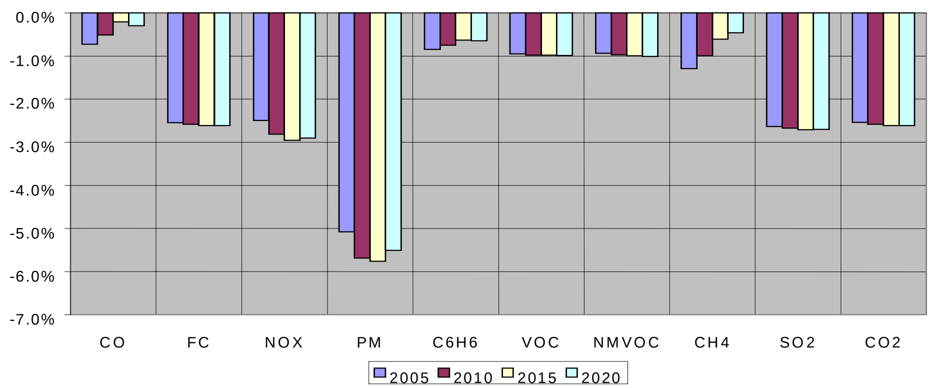


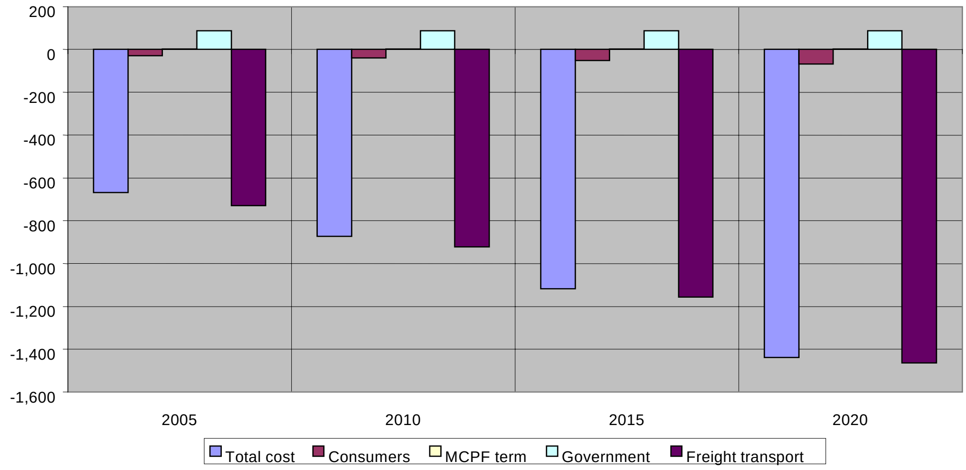
Table 4.5: Improved city logistics: Increase of average load factors by 10 % - main results (%changes for Athens)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	0.3 %	0.4 %	0.5 %	0.6 %
Big cars	0.3 %	0.4 %	0.4 %	0.5 %
Mopeds & motorcycles	0.2 %	0.2 %	0.3 %	0.3 %
Buses	-0.2 %	-0.2 %	-0.2 %	-0.3 %
Metro	-0.3 %	-0.3 %	-0.4 %	-0.4 %
Light trucks (veh-km)	-7.3 %	-7.3 %	-7.2 %	-7.2 %
Heavy trucks (veh-km)	-7.3 %	-7.4 %	-7.3 %	-7.3 %
Light trucks (tkm)	2.0 %	2.0 %	2.0 %	2.0 %
Heavy trucks (tkm)	2.0 %	1.9 %	1.9 %	1.9 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	0.7 %	0.8 %	0.9 %	1.0 %
Impact on emissions, changes from base case				
	2005	2010	2015	2020
NOx	-2.5 %	-2.8 %	-3.0 %	-2.9 %
PM	-5.1 %	-5.7 %	-5.8 %	-5.5 %
CO	-0.7 %	-0.5 %	-0.2 %	-0.3 %
VOC	-1.0 %	-1.0 %	-1.0 %	-1.0 %

CO2	-2.5 %	-2.6 %	-2.6 %	-2.6 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	-668	-873	-1117	-1438
Side-effects				
Impact on noise cost	-12	-15	-18	-22
Impact on accident cost	-20	-24	-30	-36
Total with side-effects	-699	-912	-1164	-1497
Net present value:	-8931	**with noise&accidents:**	-9320	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	-88	-87	-88	-88

Source: Tremove, October 1999.

Figure 4.14: Improved city logistics in Athens - Decomposition of total annual cost to society (million 98 ECU).



4.4.5 Road pricing

Parking charges

The increase of average parking charges by 3 ECU per trip leads in Athens (in 2010) to an increase of generalised prices (incl. monetary and time costs) for small cars by 15 % and for big cars by 14 %. The generalised prices for buses decrease by 3 % and those for trucks by 2 %, due to reduced congestion. Table 4.6 shows the impacts of these changes in attractiveness of different modes on transport demand, speed, and emissions, as well as the total social costs of this measure.

Table 4.6: Increasing average parking charges in Athens by 3 ECU - main results (%changes for Athens)

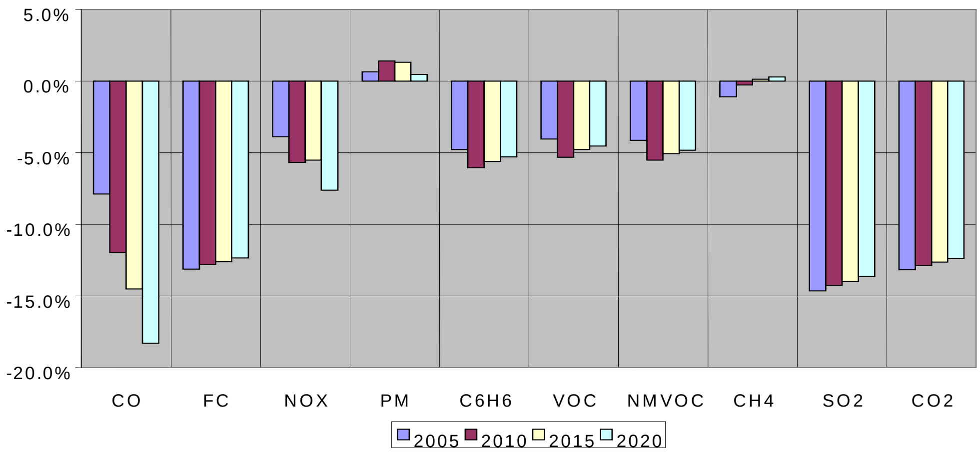
Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	-27.0 %	-26.5 %	-26.0 %	-25.2 %
Big cars	-23.8 %	-23.3 %	-22.9 %	-22.3 %
Mopeds & motorcycles	-3.1 %	-2.9 %	-2.7 %	-2.4 %
Buses	39.6 %	38.5 %	37.4 %	36.1 %
Metro	37.7 %	36.6 %	35.4 %	34.0 %
Non-motorised	-4.1 %	-4.0 %	-3.9 %	-3.9 %
Total passenger-km	*-3.5 %*	*-3.4 %*	*-3.3 %*	*-3.2 %*
Light trucks	0.5 %	0.6 %	0.7 %	0.8 %
Heavy trucks	0.4 %	0.5 %	0.6 %	0.7 %
Changes on average speed				

	2005	2010	2015	2020
Urban roads	3.1 %	3.5 %	4.0 %	4.4 %
Impact on emissions, changes from base case				
	2005	2010	2015	2020
NOx	-3.9 %	-5.7 %	-5.5 %	-7.6 %
PM	0.6 %	1.4 %	1.3 %	0.5 %
CO	-7.9 %	-12.0 %	-14.5 %	-18.3 %
VOC	-4.0 %	-5.3 %	-4.8 %	-4.5 %
CO2	-13.2 %	-12.9 %	-12.6 %	-12.4 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	96	-26	-185	-416
Side-effects				
Impact on noise cost	-10	-12	-15	-18
Impact on accident cost	-68	-84	-100	-121
Total with side-effects	18	-122	-300	-555
Net present value	-868	**with noise&accidents:**	-1818	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	1358	1489	1624	1784

Source: Tremove, September 1999.

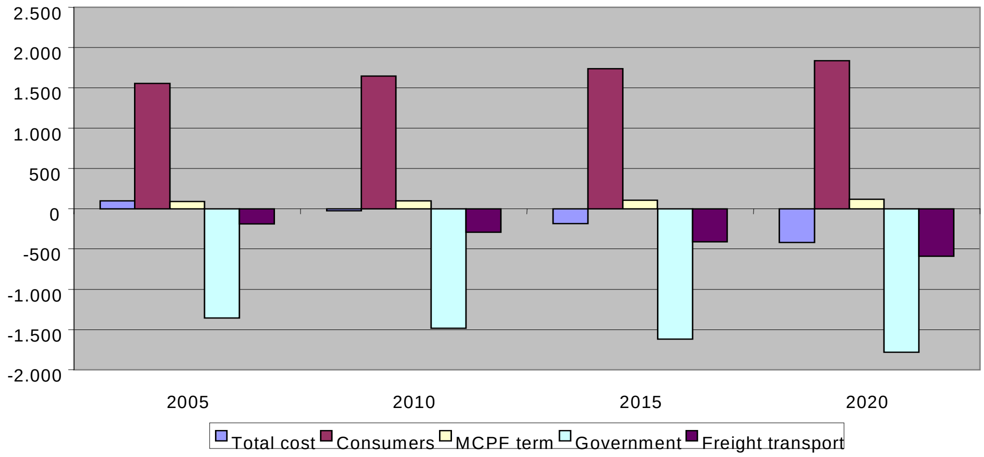
This measure shows a very strong impact on modal split (around -22 % for cars, +38 % for public transport). Most pollutants show considerable reductions, e.g. NOx in 2010 by 6 %. Because there are almost no diesel cars in Athens, the additional PM emissions from buses and HGV exceed reductions from car traffic.

Figure 4.15: Parking charges in Athens - Total road transport emissions, change from base case (in % of emissions in Athens).



Annual costs to consumers (in 2010 1656 mio. ECU) exceed the benefits for the government (in 2010 1489 mio. ECU). Mainly due to increasing time savings for freight transport due to relieve of congestion, the total annual cost savings to society are positive from 2010 onwards.

Figure 4.16: Parking charges in Athens - Decomposition of total annual cost to society (in million 98 ECU).



In *Lyon*, the increase of average parking charges by 3 ECU leads (in 2010) to an increase of generalised prices for small cars by 8 % and for big cars by 11 % (this difference is, at first sight, unexpected). The generalised prices for buses and for trucks decrease by 2 %, due to reduced congestion. Table 4.7 shows the impacts of these changes in attractiveness of different modes on transport demand, speed, and emissions, as well as the total social costs of this measure.

Also for Lyon this measure shows a very strong impact on modal split, though slightly lower than in Athens. Almost all pollutants are lower than in the base case, i.e. the decrease of car-km is not outweighed by the increase of bus-km and truck-km (e.g. in 2010 PM by 9 % and NOx by 2 %; see figure 4.17).

In Lyon, annual costs to consumers (in 2010 393 mio. ECU) are lower than the benefits for the government (in 2010 481 mio. ECU). Combined with time savings for freight transport, this results in substantial annual cost savings to society.

Table 4.7: Increasing average parking charges in Lyon by 3 ECU - main results (%changes for Lyon)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	-21.4 %	-21.0 %	-20.8 %	-20.5 %
Big cars	-24.5 %	-24.3 %	-24.2 %	-24.0 %
Mopeds & motorcycles	-0.5 %	-0.1 %	0.1 %	0.4 %
Buses	13.8 %	12.9 %	12.1 %	11.3 %
Metro	16.1 %	14.8 %	13.7 %	12.6 %
Non-motorised	-1.6 %	-1.5 %	-1.4 %	-1.3 %
Total passenger-km	*-4.5 %*	*-4.2 %*	*-3.9 %*	*-3.5 %*
Light trucks	0.5 %	0.6 %	0.6 %	0.7 %
Heavy trucks	0.3 %	0.5 %	0.6 %	0.6 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	3.4 %	3.7 %	4.1 %	4.4 %
Impact on emissions, %changes from base case				
	2005	2010	2015	2020
NOx	-3.0 %	-2.1 %	-2.5 %	-3.3 %
PM	-7.8 %	-8.7 %	-10.8 %	-11.7 %
CO	-18.7 %	-17.7 %	-16.7 %	-15.8 %
VOC	-9.3 %	-9.2 %	-7.0 %	-6.2 %

CO_2	-11.1 %	-10.8 %	-10.6 %	-10.4 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	-65	-112	-170	-245
Side-effects				
Impact on noise cost	-1	-2	-2	-2
Impact on accident cost	-20	-24	-27	-30
Total with side-effects	-87	-138	-199	-277
Net present value:	-1245	**with noise & accidents:**	-1488	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	448	491	527	566

Source: Tremove, September 1999.

Figure 4.17: Parking charges in Lyon - Total road transport emissions in Lyon, %-change from base case.

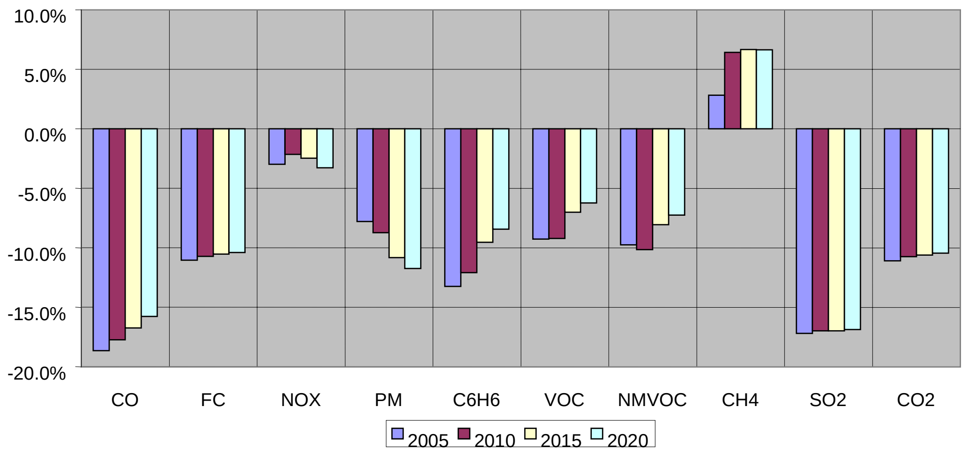
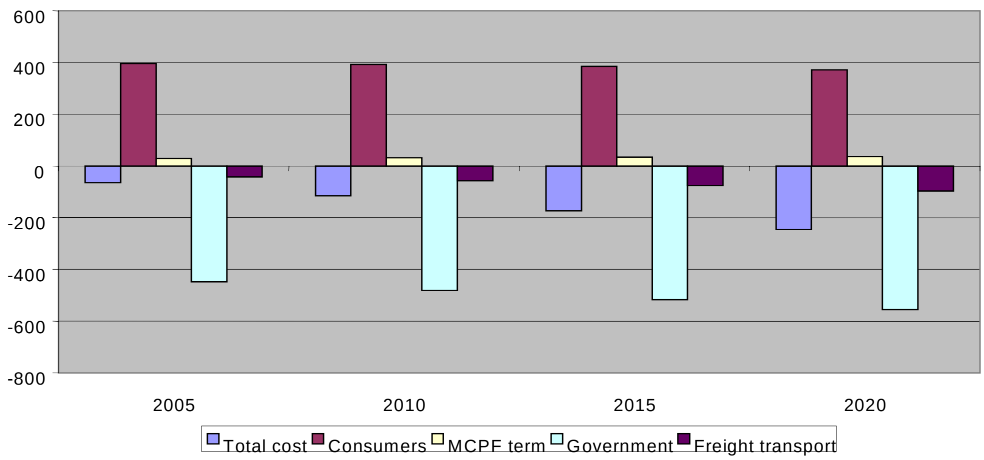


Figure 4.18: Parking charges in Lyons - Decomposition of total annual cost to society (in million 98 ECU).



Time differentiated road pricing

Table 4.8: Introducing time-differentiated road pricing in Athens - main results (%changes for Athens)

Transport demand (%change from basecase)

	2005	2010	2015	2020
Small cars	-15.3 %	-15.0 %	-14.7 %	-14.2 %
Big cars	-13.1 %	-12.8 %	-12.6 %	-12.2 %
Mopeds & motorcycles	-0.6 %	-0.5 %	-0.4 %	-0.3 %
Buses	15.7 %	15.3 %	14.9 %	14.3 %
Metro	14.9 %	14.4 %	13.9 %	13.2 %
Non-motorised	-1.3 %	-1.3 %	-1.3 %	-1.3 %
Total passenger-km	*-1.4 %*	*-1.4 %*	*-1.3 %*	*-1.2 %*
Light trucks	0.9 %	0.9 %	0.9 %	0.9 %
Heavy trucks	-4.5 %	-3.9 %	-3.5 %	-3.0 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	2.7 %	3.1 %	3.4 %	3.8 %
Impact on emissions, %changes from base case				
	2005	2010	2015	2020
NOx	-4.2 %	-5.5 %	-5.5 %	-4.9 %
PM	-4.1 %	-3.9 %	-3.8 %	-3.8 %
CO	-4.1 %	-6.3 %	-7.8 %	-7.4 %
VOC	-2.4 %	-3.0 %	-2.7 %	-2.3 %
CO_2	-8.7 %	-8.5 %	-8.4 %	-8.1 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	88	-13	-147	-341
Side-effects				
Impact on noise cost	-1	-2	-4	-5
Impact on accident cost	-41	-50	-60	-71
Total with side-effects	45	-65	-210	-418
Net present value:	-649	**with noise&accidents:**	-1168	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	1478	1630	1782	1957

Source: Tremove, September 1999.

A description of this measure, which involves a road charge of 0.3 ECU in peak and 0.05 ECU in off-peak per car-km (HGV 0.6 and 0.1 ECU, resp.), can be found in chapter 4.3.5. In Athens this measure leads (in 2010) to an increase of generalised prices for small cars by 16 %, for big cars by 14 %, for LGV by 2 %, and for HGV by 6 %. The generalised prices for buses decrease by 2 %, due to reduced congestion. Table 4.8 shows the impacts of these changes in attractiveness of different modes on transport demand, speed, and emissions, as well as the total social costs of this measure.

This scenario has also a very strong impact on modal split for passenger transport, though smaller than in the parking charge scenario. In contrast to parking charges in Athens, also PM is reduced (-4 %), because of the additional reduction of truck mileage. The smaller reduction of overall passenger transport (1 % compared to 3 % for the parking charge scenario) is partly due to the shift from peak to off-peak.

Figure 4.19: Road pricing (time differentiated) in Athens - Total road transport emissions in Athens, 2010, %-change from base case.

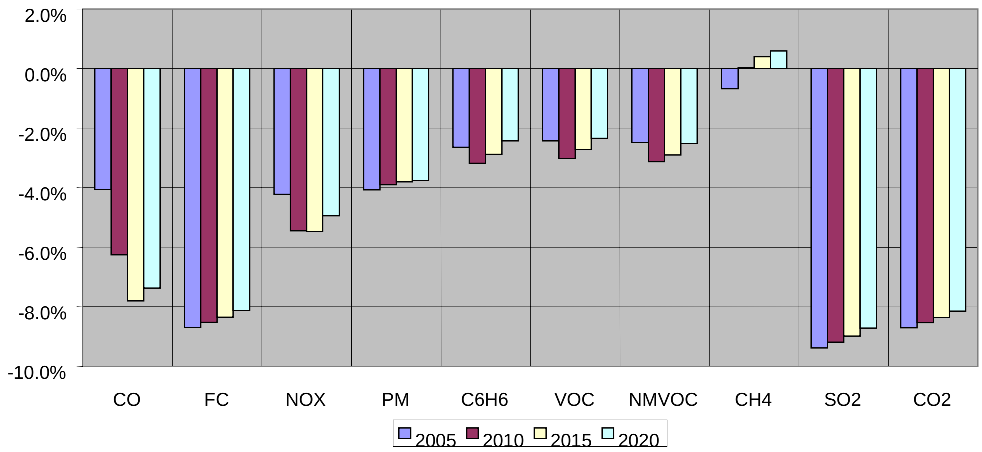
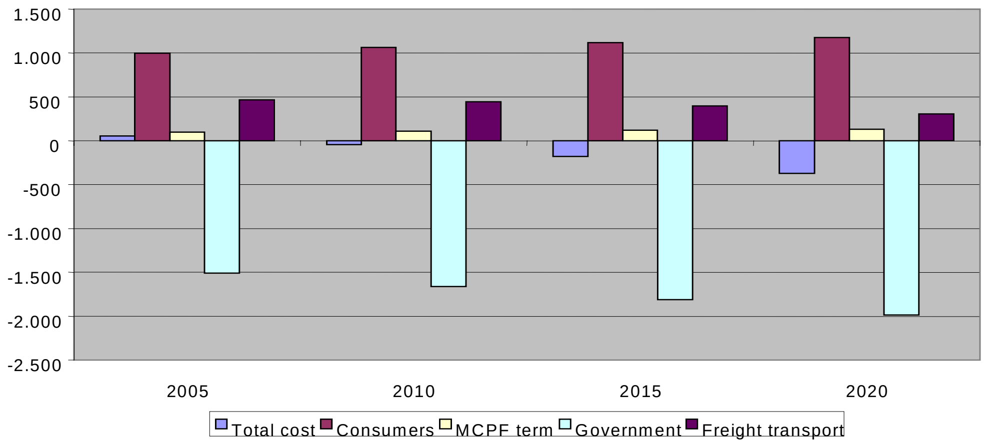


Figure 4.20: Road pricing (time differentiated) in Athens - Decomposition of total annual cost to society (million 98 ECU).



In 2010, annual costs to consumers and freight transport (1506 mio. ECU) are lower than the additional revenues for the government (1660 mio. ECU). Annual cost savings to society are increasingly positive from 2010 onwards, although lower than in the parking charges scenario, mainly owing to the implementation and operating costs of a road pricing scheme. The net revenues for the government are, however, even higher than with the parking charges investigated above.

In Lyon, this measure results (in 2010) in an increase of generalised prices for small and big cars by 11 %, for LGV by 2 %, and for HGV by 6 %. The generalised price for buses decreases by 1.5 %, due to reduced congestion. Table 4.9 shows the impacts of these changes in attractiveness of different modes on transport demand, speed, and emissions, as well as the total social costs of this measure.

Table 4.9: Introducing time-differentiated road pricing in Lyon - main results (%changes for Lyon)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	-14.7 %	-14.6 %	-14.4 %	-14.1 %
Big cars	-13.7 %	-13.7 %	-13.6 %	-13.4 %
Mopeds & motorcycles	0.4 %	0.6 %	0.8 %	1.0 %
Buses	6.4 %	6.1 %	5.7 %	5.5 %

Metro	6.0 %	5.6 %	5.1 %	4.7 %
Non-motorised	-0.6 %	-0.5 %	-0.5 %	-0.4 %
Total passenger-km	*-2.0 %*	*-1.8 %*	*-1.5 %*	*-1.3 %*
Light trucks	0.0 %	0.0 %	0.1 %	0.1 %
Heavy trucks	-5.5 %	-5.0 %	-4.6 %	-4.2 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	3.6 %	4.0 %	4.4 %	4.7 %
Impact on emissions, %changes from base case				
	2005	2010	2015	2020
NOx	-3.4 %	-2.9 %	-2.9 %	-3.2 %
PM	-5.7 %	-6.2 %	-7.3 %	-7.7 %
CO	-12.2 %	-11.5 %	-10.9 %	-10.2 %
VOC	-6.3 %	-6.4 %	-4.9 %	-4.3 %
CO_2	-7.9 %	-7.7 %	-7.6 %	-7.4 %
Total cost to society (million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	-67	-113	-170	-245
Side-effects				
Impact on noise cost	0	0	0	-1
Impact on accident cost	-13	-15	-17	-19
Total with side-effects	-80	-128	-187	-264
Net present value:	-1252	**with noise & accidents:**	-1398	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	448	491	529	570

Source: Tremove, September 1999.

The changes in modal split and traffic patterns bring about a reduction of almost all pollutants, including PM. Total cost savings to society are substantial, and here almost identical to the parking charges scenario. The same is valid for the net revenues for the government.

Figure 4.21: Road pricing (time differentiated) in Lyon - Total road transport emissions in Lyon, %-change from base case.

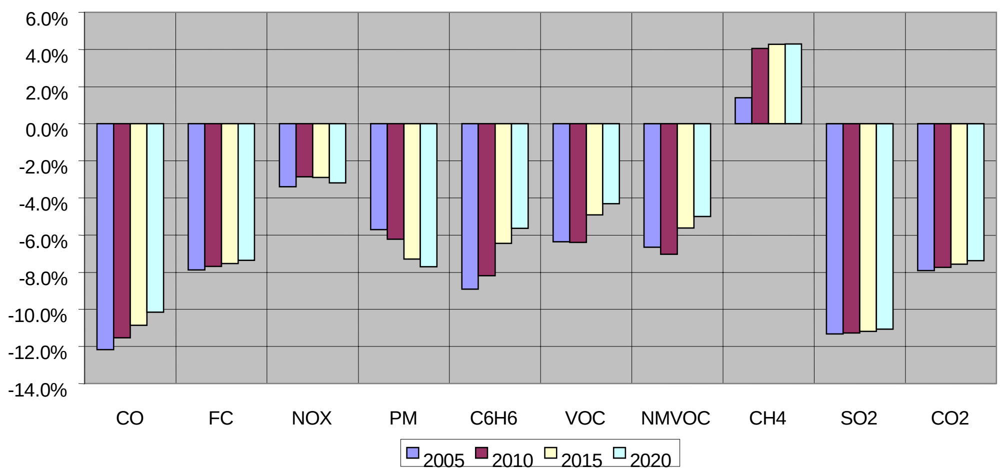
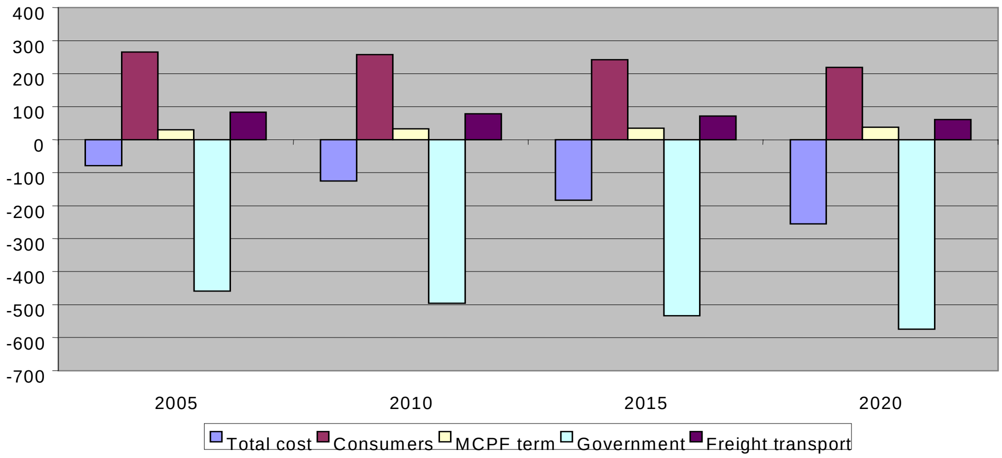


Figure 4.22: Road pricing (time differentiated) in Lyons - Decomposition of total annual cost to society (in million 98 ECU).



4.4.3 Incentives for fleet modernisation

Scrappage scheme

A description of this measure, which involves a 1000 ECU subsidy in Greece for the scrappage of cars older than 10 years between 2005 and 2010, can be found in chapter 4.3.6. In Athens this measure leads (in 2010) to a decrease of generalised prices for cars by 0.7 %, and to an increase for other road vehicles by 0.1 % to 0.2 %, due to congestion. Table 4.10 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

The impacts of this measure on transport demand are clearly below 1 %, emission impacts are negligible. Additional social costs mainly are borne by the government.

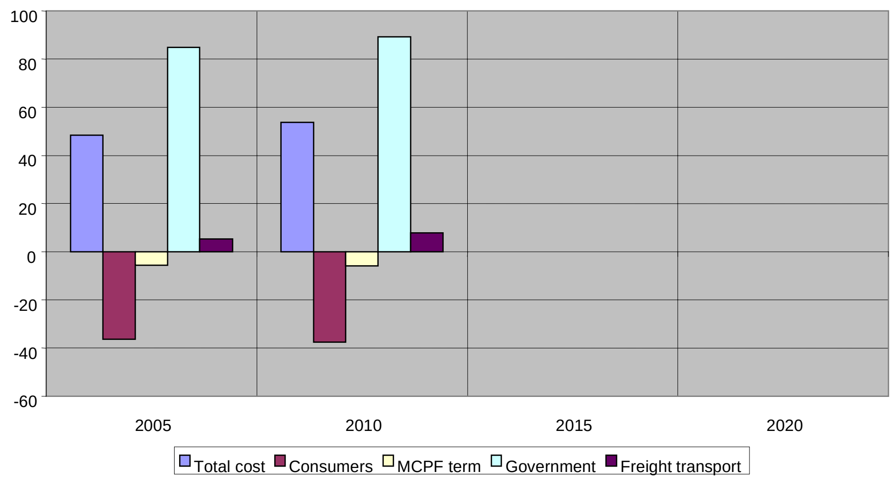
Table 4.10: Scrappage scheme in Greece - main results (%changes for Athens; social cost and government cost for Greece)

Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	0.9 %	0.8 %	0.0 %	0.0 %
Big cars	0.4 %	0.4 %	0.0 %	0.0 %
Buses	-0.9 %	-0.8 %	0.0 %	0.0 %
Metro	-0.9 %	-0.8 %	0.0 %	0.0 %
Light and heavy trucks	0.0 %	0.0 %	0.0 %	0.0 %
Changes on average speed				
	2005	2010	2015	2020
Urban roads	-0.1 %	-0.1 %	0.0 %	0.0 %
Impact on emissions, %changes from base case				
	2005	2010	2015	2020
NO_x	-0.1%	0.1%	0.1%	0.0%
PM	0.1%	0.0%	-0.1%	-0.1%
CO	-0.2%	0.3%	0.3%	0.1%
VOC	-0.1%	0.1%	0.1%	0.0%
CO_2	0.4%	0.3%	0.0%	0.0%

Total cost to society (for Greece, in million 1998 ECU)				
	2005	2010	2015	2020
Total cost to society	118	135	0	0
Side-effects				
Impact on noise cost	0	0	0	0
Impact on accident cost	8	10	0	0
Total with side-effects	126	145	0	0
Net present value:	533	**with noise&accidents:**	571	
Impact on government budget (1998 million ECU)				
	2005	2010	2015	2020
Budget impact	-274	-295	0	0

Source: Tremove, October 1999.

Figure 4.23: Scrappage scheme in Greece - Decomposition of total annual cost to society (in mio. 98 ECU p.a.)



4.5 Summary of cost-effectiveness assessment

4.5.1 Modelling results

The AOPII basecase shows a substantial reduction of road transport emissions over the next 20 years. The air quality predictions for the ten AOPII model cities indicate that local measures might have a significant potential to contribute in a cost-effective way to the achievement of air quality objectives in Athens and Lyon (and possibly in some other cities for PM).

WG7 invited WG5 to deliver inputs for the transport model Tremove for a limited number of non-technical measures. Table 4.10 summarises the main results of the measures tested.

Table 4.11: Social costs and main emission impacts of non-technical measures.

Measure	Domain	Social costs (NPV in mio. ECU)	Government budget (2010)	Emission impact (2010)	AOPII WG7 Codes

		NPV1[1)]	NPV2[1)]		NOx	PM	
Road capacity +5%	Athens	-1720	-1682	-11	0.0 %	-0.8 %	NT_4
Bus prioritisation	Athens	718	664	-26	-0.6 %	-0.4 %	NT_5
Public transport fare -30%	Athens	-1049	-1143	-292	+0.4 %	+1.6 %	NT_3
without fixed load factor[2)]					-0.6 %	+0.3 %	--
City logistics (load +10%)	Athens	-8931	-9320	-87	-2.8 %	-5.7 %	NT_6
Parking charge (3 ECU)	Athens	-868	-1818	+1489	-5.7 %	+1.4 %	NT_1
Parking charge (3 ECU)	Lyon	-1245	-1488	+491	-2.1 %	-8.7 %	NT_1
Time-diff. road pricing	Athens	-649	-1168	+1630	-5.5 %	-3.8 %	NT_2
Time-diff. road pricing	Lyon	-1252	-1399	+491	-2.9 %	-6.2 %	NT_2
Scrappage scheme	Greece[3)]	533	571	-295	+0.1 %	0.0 %	NT_7

1) Net present value excluding (NPV1) and including (NPV2) noise and accident costs.
2) I.e. with increase of bus frequency only during peak.
3) Costs and budget impact for Greece, relative emission impact for Athens.
Source: Tremove results, September 1999.

Generally, the impact of individual non-technical measures on emissions at city level is relatively low: modelling results show for important pollutants reductions of about 2-6 % for the road pricing measures and for city logistics, and less than 1 % (or even an increase) for the other measures tested. However, the importance of these measures on a more local level (city centres, street canyons, specific bottlenecks) can be much higher, and the bundling of adequate non-technical (and technical) measures to policy packages will increase the impact on emissions.

While the increase of road capacity and the reduction of public transport fares have to be financed by government, the costs of road pricing are paid for by transport users. The results indicate a substantial no-regret (or win-win) potential, i.e. the availability of measures that reduce road transport emissions and at the same time total costs to society by making transport more efficient and reducing congestion. As most measures cause cost savings to society, it is not meaningful to calculate cost-effectiveness ratios.

It has to be stressed that the modelling results should be regarded as a strategic guidance showing the potential of non-technical measures. Before implementation, competent local or national authorities would have to verify the results for specific local conditions and based on local information and more adequate (network) models.

4.5.2 Comparison of modelling results and other findings

The modelling results provide preliminary findings that can be compared with the findings of other projects described in chapter 3 and 4.3 of this report:

- Road capacity changes might have only limited impacts on emissions, as opposite effects (less congestion, but higher mileage) outweigh each other.

This result is in line with calls for caution quoted in chapter 3.3.2 and 4.3.2. The actual result might be very site-dependant.

- The emission impact of measures improving the attractiveness of bus transport depends crucially on load factors and emission rates.

This result is in line with findings quoted in chapter 3.4.1. The present load factor is decisive for the potential need to increase bus frequencies. The use of alternative fuel buses can improve results, too.

- The impacts of bus prioritisation depend strongly on the impact on road capacity for other users.

While several sources quoted in chapter 3.3.6 demonstrate emission gains for buses and due to modal shift, only few analyse the impact of increasing congestion for other road transport on social costs and emissions.

- Pricing measures have a strong potential to achieve cost-efficient emission reductions.

The decrease of social costs due to pricing measures indicates that in the basecase marginal social costs (especially costs of congestion) are higher than costs to transport users (see sources quoted in chapter 3.6).

- Although more flexible instruments (e. g. with differentiation by time of day or by environmental characteristics of vehicles) allow for different user reactions, parking charges also can be very effective.

Providing users with a wider choice of reactions (to travel off-peak, to acquire clean vehicles) will increase cost-efficiency, if implementation costs are not higher than the additional benefit (see also studies quoted in chapters 3.6 and 4.3.5). This has to be balanced against the easier implementation of parking charges.

- Local conditions determine the optimal choice and design of measures: The impact of parking charges and time differentiated road pricing on different pollutants differs considerably between Athens and Lyon.

This result shows that Tremove takes into account important basecase differences between cities (e. g. modal share of public transport, age of the vehicle fleet, share of diesel cars, importance of urban freight transport, average speed, relation between peak and off-peak). On the other hand, this result confirms the importance of local factors, that might also differ between areas within one city.

5. Conclusions

5.1 General findings

- A wide range of non-technical transport policy measures with a potential to reduce road transport emissions is available and has been realised in Europe. Chapter 3 of this report provides a structured though clearly not comprehensive overview of case studies, describing key features, transport and emission impacts of measures, and other assessment issues.
- The competence for the implementation of these measures lies at different levels of government. Especially for measures with a potential to improve urban air quality, competencies are concentrated on the local and regional level.
- Nevertheless there is an important task at Community level in promoting good practice for the implementation of non-technical measures. WG5 encourages the use of the Internet and other adequate media for this purpose and welcomes related activities of the Commission in course of ELTIS[221] and CANTIQUE[222].
- Moreover, a coherent policy framework at the European level can facilitate the implementation of non-technical measures.
- The distinguishing feature of non-technical measures is that they are geared towards changing the behaviour of transport users. Their reaction depends on local circumstances, may vary over time, and cannot be foreseen exactly. Due to a lack of systematic monitoring and the parallel realisation of various measures, relatively little empirical evidence on the impacts and costs of specific measures is available.
- Non-technical measures affect not only the emission of pollutants, but also other objectives like safety, noise, emission of greenhouse gases, management of traffic flows, quality of public and non-motorised transport, regional accessibility, and the regional economy. Policy strategies have to deal with synergies and trade-offs between these objectives.
- Single (“stand-alone”) measures addressing only one aspect of the transport system tend to be less effective with regard to the above mentioned objectives, than policy packages. Optimal packages of measures in this respect are likely to include physical, pricing, awareness raising and organisational measures which combine a “push & pull“ approach towards motorised road transport and its alternatives.
- Awareness of alternative fuel vehicles (AFVs) and their expanded use can be motivated through non-technical measures at the local and national level, by extending incentives (e.g. use of bus lanes) to AFVs, or providing exemptions from restrictive non-technical measures (e.g. access or parking restrictions).
- In addition to the cost-effectiveness ratio as required for the AOPII assessment model, the policy dimension of non-technical measures has to be addressed. This includes especially the availability of policy options at different levels of government, and the public acceptability of measures. Co-ordinated information and awareness campaigns can increase acceptance.

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221 European Local Transport Information Service (http://www.eltis.org/), jointly funded by the Transport DG of the European Commission and the International Union of Public Transport (UITP).

222 Concerted Action on Non-technical Measures and their Impact on Air Quality and Emissions, in the Transport Programme of the 4th RTD Framework Program.

- The actual impact of transport policy measures depends also on the degree of enforcement, i.e. the probability of being caught and the level of the fine.
- Possible adverse effects may call for mitigating measures. For example, it might be necessary to control traffic induced by measures that reduce congestion and increase average speeds. On the other hand, traffic restrictions in central areas can divert traffic to other areas and encourage development of activities in suburban belts, generating additional traffic flows that are much more difficult to bundle.

5.2 Findings with regard to specific non-technical measures

- Local conditions determine the optimal choice and design of measures. Important parameters include the average speed in the basecase, the composition of the vehicle fleet, the shares of internal and external traffic, and the relative importance of freight transport. While these factors are considered in the AOPII modelling framework, others would require more detailed information and (network) models. Also the relative importance of different policy goals differs between cities. Therefore the following findings might serve as a general guidance but they can not provide a blueprint for local policies.
- Although the impact of individual non-technical measures on emissions at city level is relatively low (modelling results show for most pollutants reductions of less than 5%), their importance on a more local level (city centres, street canyons, specific bottlenecks) can be much higher.
- Moreover, the bundling of adequate non-technical (and technical) measures to policy packages increases the impact on emissions.
- Case studies in chapter 3 as well as AOPII modelling results reported in chapter 4 indicate a substantial no-regret (or win-win) potential, i.e. the availability of measures that reduce road transport emissions and at the same time total costs to society by making transport more efficient and reducing congestion.
- Road capacity increases have generally a limited impact on emissions, as opposite effects (less congestion, but induced transport demand) outweigh each other. They might however be able to divert traffic from areas with poor air quality.
- Measures inducing a modal shift from cars to public transport and non-motorised transport have a potential to reduce transport emissions depending on the cross elasticities between modes.
- The emission impact of measures improving the attractiveness of bus transport depends crucially on load factors and emission rates. If bus frequencies are increased in parallel to demand, this increase is achieved with conventional buses, and only a low share of new passengers is shifting from cars, such measures can even cause an increase of emissions. With increasing load factors, low emission buses and/or many of the new passengers being former car users, emission impacts will be more positive.
- The impacts of public transport prioritisation depend strongly on the impact on road capacity for other users. Increasing congestion partially outweighs emission gains and causes social costs for car users and freight transport.

- Parking charges and other road pricing measures have a strong potential to achieve cost-efficient emission reductions if they bring user costs closer to the marginal social costs of transport.
- Although more flexible pricing instruments (e.g. with a differentiation between peak and off-peak or between vehicle categories with different environmental characteristics) allow for different user reactions and show therefore more positive effects, parking charges also can be very effective.
- The design of parking policies includes important elements besides the average price. Limits to the number of available parking spaces and regulations for their use by inhabitants and other transport users have shown a significant impact on modal split in different cities.
- Freight transport has an increasing share on urban road transport emissions. The lack of information with regard to urban delivery transport did not allow a comparative analysis of different measures. However, technical measures (electric propulsion) and non technical measures (city logistics, traffic management, drivers training) have a high potential to reduce urban freight transport emissions.
- In future scrappage schemes will have limited effects, because even older cars will have much lower average emission rates.
- As transport is a derived demand, land use policies can support a sustainable urban transport system in the long term.

5.3 Future activities

- There is a need to improve the knowledge on impacts and costs of non-technical measures and to encourage related research projects. Specific research needs are seen in the area of freight transport, especially urban delivery systems.
- In the short run, but beyond the time horizon of AOPII, work will be supported by CANTIQUE[223]. WG5 welcomes the fact that additional relevant research results will be collected. However, it will be important to consolidate different results based on very different assumptions and methodologies. WG5 proposes to use AOPII (basecase assumptions, modelling framework and results, WG5 report) as a starting point with which the various results investigated by CANTIQUE could be compared. This would be the most promising way to improve the knowledge developed during AOP with the participation of member states, industries and non-governmental organisations.
- A coherent European policy framework can facilitate certain local measures. A survey of obstacles and opportunities in the current framework (regulations, directives) could serve as a starting point for improvements.
- Transport policy measures at national and Community level provide an additional potential to reduce emissions. The report on Transport and Environment from the Transport Council to the European Council of Helsinki[224] provides the basis for the development of such a framework.

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[223] Concerted Action on Non-technical Measures and their Impact on Air Quality and Emissions, in the Transport Programme of the 4th RTD Framework Program.

[224] Council of the European Union, 11717/99, TRANS197, ENV 335, 11 October 1999.

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