Auto-Oil II Cost-effectiveness Study

Part IV

Simulation and integrated assessment of policy measures

Annex 4
Non-Technical Measures

Draft Final Report
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1. Summary

The AOPII base case showed a substantial reduction of road transport emissions over the next 20 years. In addition, the air quality predictions for the ten AOPII model cities indicated 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).

In order to obtain a quantitative assessment of the strategic potential of the non-technical measures, WG7 invited WG5 to deliver a number of scenario inputs for the TREMOVE model. Table 1 summarises the tested measures and the main results for selected parameters.

TABLE 1: 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

Source: Tremove results, September 1999.

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.

Generally, the impact of individual non-technical measures on emissions at AOP-II 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. These relatively modest results can be explained because of the strategic questions that model is supporting and, hence, the relative size of the AOP-II city modelling domain (usually greater urban area rather than city centre) and the level of detail with which city networks are modelled (e.g. average speed functions per road category rather than detailed road newtork).

However, whereas general results point at a positive potential, 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.

The modelling results provide general findings that can be compared with the findings of other projects described in chapter 3 and 4.3 of the WG5 report, i.e.:

- **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 of WG5. 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 of WG5. 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 of WG5 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 base case marginal social costs (especially costs of congestion) are higher than costs to transport users (see sources quoted in chapter 3.6 of WG5).

- **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 of WG5). 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 base case 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.

2. Introduction

The basis for the selection of measures is the WG5 “Inventory of measures” (see WG5 report, annex 1). From this "long list" a limited set of measures was chosen to be modelled in TREMOVE, mainly considering the availability of input data and the characteristics of the TREMOVE model. An overview of the selected measures and the domains to which they have been applied to date is given in the table below:

TABLE 2: SELECTED NON-TECHNICAL MEASURES MODELLED WITH TREMOVE

Type of measure		Measure description		Athens	Lyon	Further domain
Traffic Management	Improving traffic flows	Increase road capacity	capacity +5%	X		Test1)
		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%			Test1)
	Reduced fares	Bus/Metro	fare -30%	X		Test1)
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		Test1)
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).[1]

Chapter 4.4 of the WG5 report shows the main results for non-technical measures of the AOPII transport and emissions model TREMOVE, as provided by the consultants of WG7. For each scenario a vast amount of information is 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

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[1] See AOPII Cost-effectiveness Study, Preliminary Draft Report, Part IV, August 1999.

be shown for each individual year till 2020, in absolute values or percentage changes to the base case, 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.

3. Improving traffic flows by increasing road capacity (NT4)

3.1. Scenario description

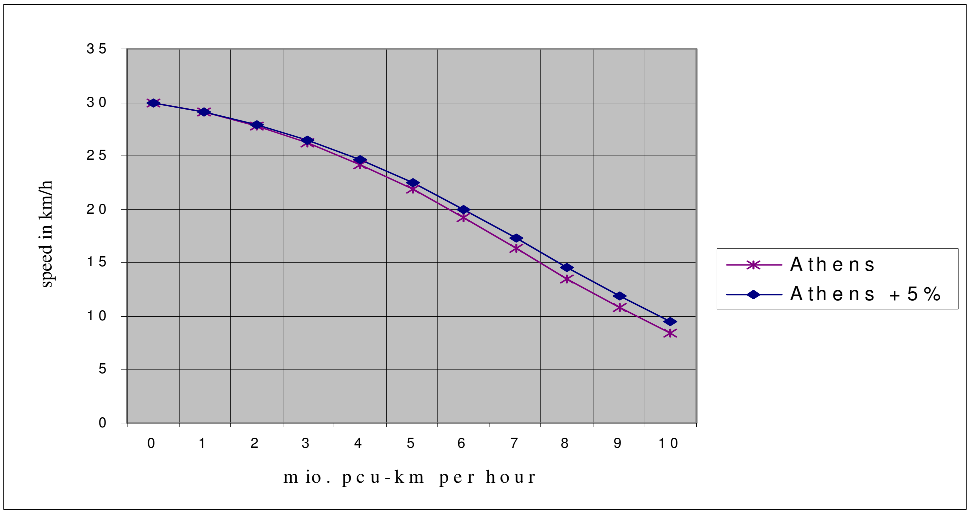
The purpose of this type of measures is to improve urban road traffic flows, i.e. reducing inefficient and polluting stop-and-go traffic. This could be achieved using telematics (e.g. route guidance and synchronisation of signalling, and variable message signs), and/or by improving infrastructure at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

The main impacts expected are 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.

In principle, both impacts can be investigated with TREMOVE, though the simplified relation between average speed and emission factors in the model will have to be considered when interpreting the modelling results. This relation is based on COPERT, and average speed represents typical traffic conditions rather than a constant speed, and therefore for low speeds traffic congestion. However, 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 of the parameters in the speed-flow function, as shown in Figure 1 below. 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 1: SIMULATING INCREASED ROAD CAPACITY IN ATHENS BY MODIFYING 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, 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[2] and empirical evidence collected for the UK air

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[2] 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.

quality strategy[3]. 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 traffic control (UTC) system that responds automatically to traffic fluctuations[4]. 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 60.000 to 75.000 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).[5] 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.

3.2. Summary of TREMOVE input data

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

3.3. TREMOVE results and validation

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

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

[4] 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.

[5] All costs in this paragraph are quoted from WS Atkins, see above.

for trucks by 0.6 %. Table 3 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

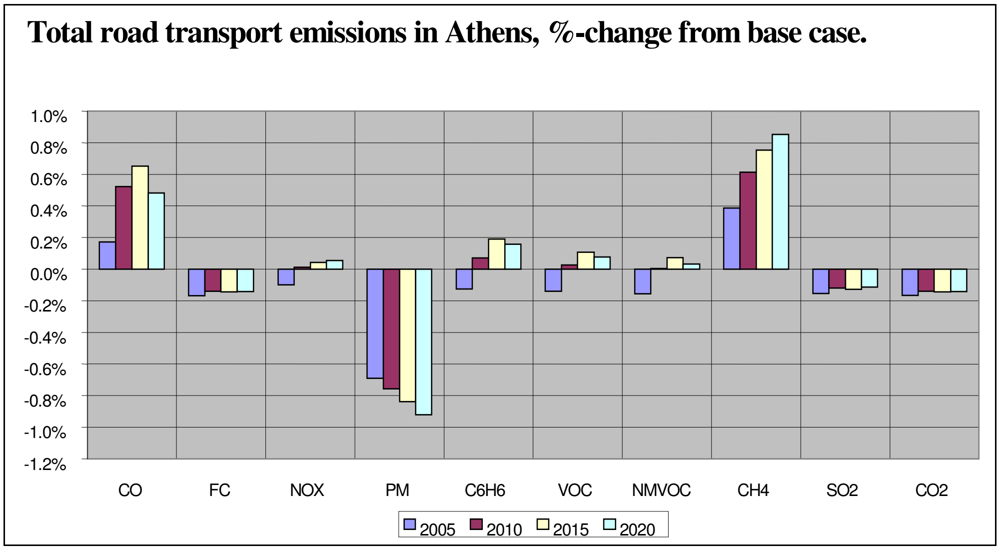
TABLE 3: IMPROVING TRAFFIC FLOWS BY INCREASING ROAD CAPACITY IN ATHENS BY 5 % (%CHANGES FOR ATHENS)

Transport demand (%change from base case)				
	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.

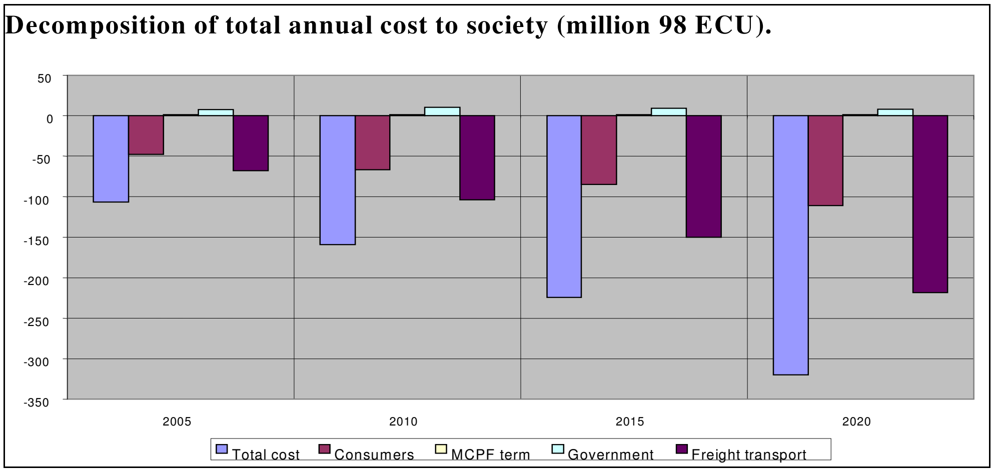
The impacts of this measure on emissions are limited, as opposite trends (transport demand, speed) compensate each other. Only reductions of PM last beyond 2010 (see Figure 2). A test run with TREMOVE for the same measure in Berlin and Cologne (see Part IV of WG7's preliminary draft report) resulted 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.

FIGURE 2: INCREASED ROAD CAPACITY IN ATHENS - EMISSION EFFECTS



The negative costs to society indicate cost savings due to reduced congestion, as well for freight as for passenger transport (see Figure 3). The increase of benefits over time is caused by the strong growth of transport demand in Greece, which leads in the base case to an increase of congestion over time. Additional tax revenues cover the annualised costs for the government (14 mio. ECU) only partially.

FIGURE 3: INCREASED ROAD CAPACITY IN ATHENS - COSTS TO SOCIETY



4. Improve attractiveness of other modes: Public transport prioritization (NT5)

4.1. Scenario description

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.[6] 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[7]. 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[8] 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,

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

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

[8] DITS, TTR, Public transport prioritization, Transport Research APAS, Urban Transport, vol. 25, Luxembourg 1996.

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 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[9] 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[10], 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.[11] 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.

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

[10] 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.

[11] 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 %.

4.2. TREMOVE input data

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

4.3. TREMOVE results and validation

This measure 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 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

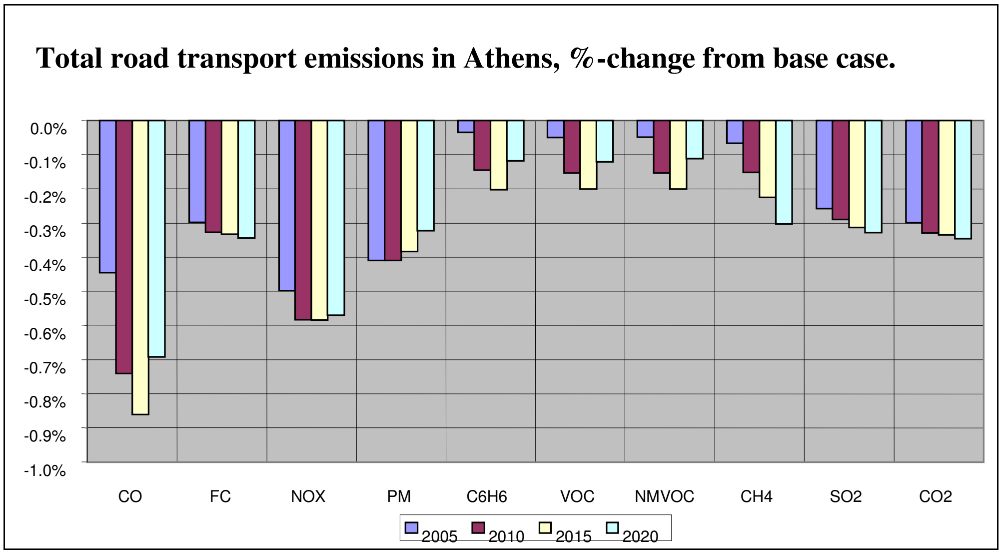
TABLE 4: **PUBLIC TRANSPORT PRIORITY: INCREASE OF AVERAGE BUS SPEED IN ATHENS BY 15 %** (%CHANGES FOR ATHENS)

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.

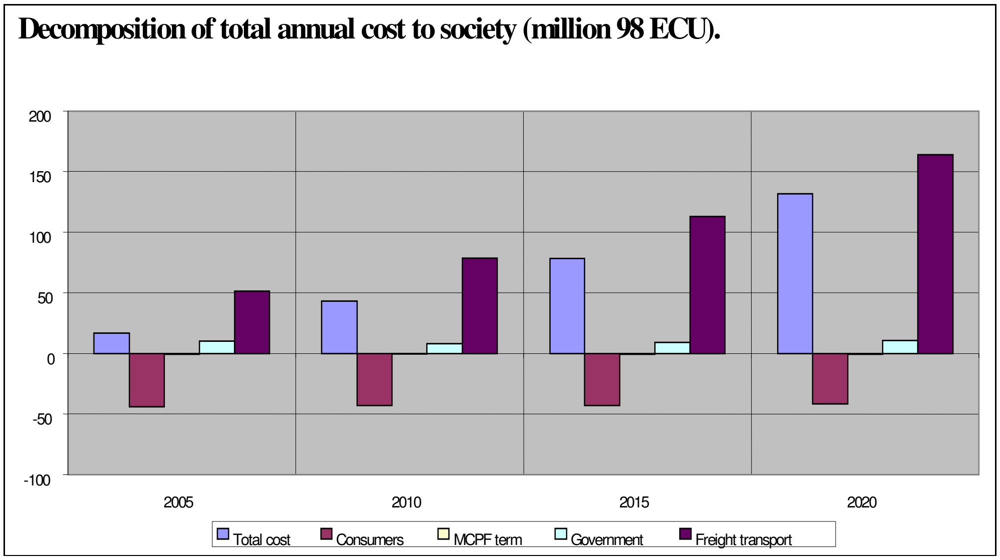
The impacts of this measure on emissions are limited, as opposite trends (transport demand, speed) partially outweigh each other (see Figure 4). NO_x emissions decrease by about 0.6 %.

FIGURE 4: **PUBLIC TRANSPORT PRIORITY: INCREASE OF AVERAGE BUS SPEED IN ATHENS BY 15 %** - EMISSION EFFECTS



The costs to society indicate increased congestion (see Figure 5). 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 base case. 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).

FIGURE 5: **PUBLIC TRANSPORT PRIORITY: INCREASE OF AVERAGE BUS SPEED IN ATHENS BY 15 %** - COSTS TO SOCIETY



5. Reduced public transport fares (NT3)

5.1. Scenario description

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 calculates 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, as it is questionable especially for off-peak trips. (Therefore it could be useful to test time-differentiated fares.)

5.2. TREMOVE input data

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.

5.3. TREMOVE results and validation

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 5 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

TABLE 5: **REDUCING PUBLIC TRANSPORT FARES IN ATHENS BY 30 % -WITH CONSTANT LOAD FACTORS**[12] - MAIN RESULTS (%CHANGES FOR ATHENS)

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

Source: TREMOVE, October 1999.

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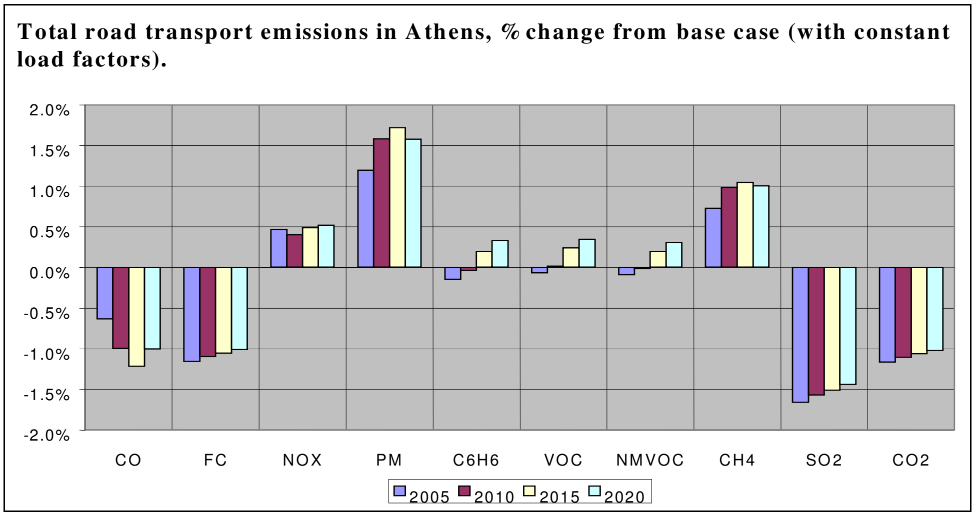
[12] See sensitivity test with regard to critical load factor assumption.

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 6). 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).

FIGURE 6: **REDUCING PUBLIC TRANSPORT FARES IN ATHENS BY 30 %** - EMISSION EFFECTS



The results shown in Table 5 and Figure 6 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 presented in Table 6.

TABLE 6: **REDUCING PUBLIC TRANSPORT FARES IN ATHENS BY 30 % - SENSITIVITY TEST AROUND FIXED LOAD FACTOR ASSUMPTION**

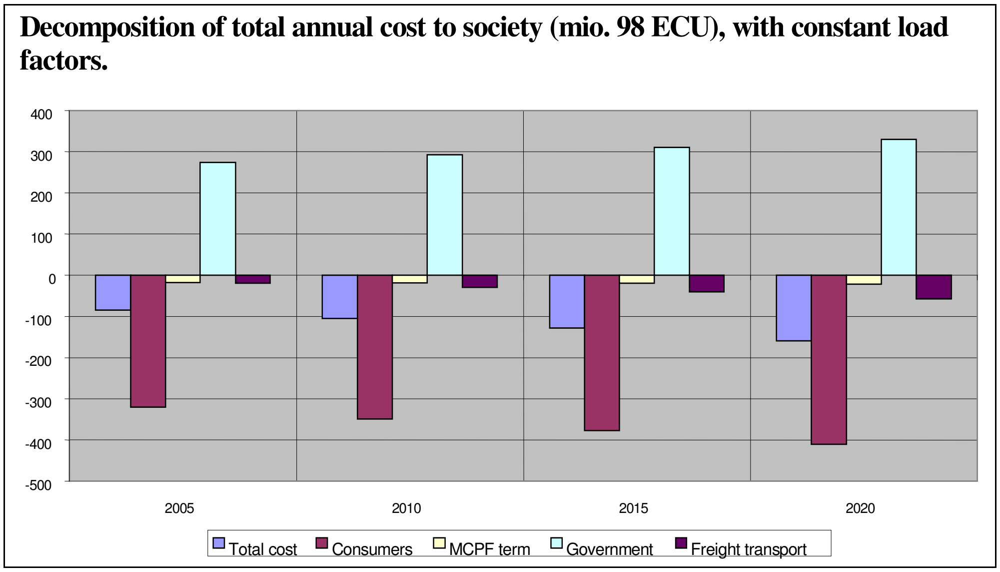
NO_x emissions in Athens, 2010	*Cars*	*Buses*	*Others*	*Total*
Base case emissions (in tons)	3795	961	4919	9675
Change of emissions due to decrease of public transport fares:				
with fixed load factors	- 2.9 %	+ 14.6 %	+ 0.1 %	+ 0.4%
without frequency increase in off-peak	- 2.9 %	+ 5.5 %	+ 0.1 %	- 0.6%

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 %.

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 7). 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 7: **REDUCING PUBLIC TRANSPORT FARES IN ATHENS BY 30 %** - COSTS TO SOCIETY



6. Freight transport : Improved city logistics (NT6)

6.1. Scenario description

Freight transport causes an important part of emissions in some cities. According to the AOPII base case, in Athens the share of freight transport on road transport 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 of the WG5 report, 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[13]. 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.

6.2. TREMOVE input data

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

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

6.3. TREMOVE results and validation

This measure, which involves an increase of average load factors for HGV and LGV by 10 %, 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 7 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

TABLE 7: IMPROVED CITY LOGISTICS - MAIN RESULTS (%CHANGES FOR ATHENS)

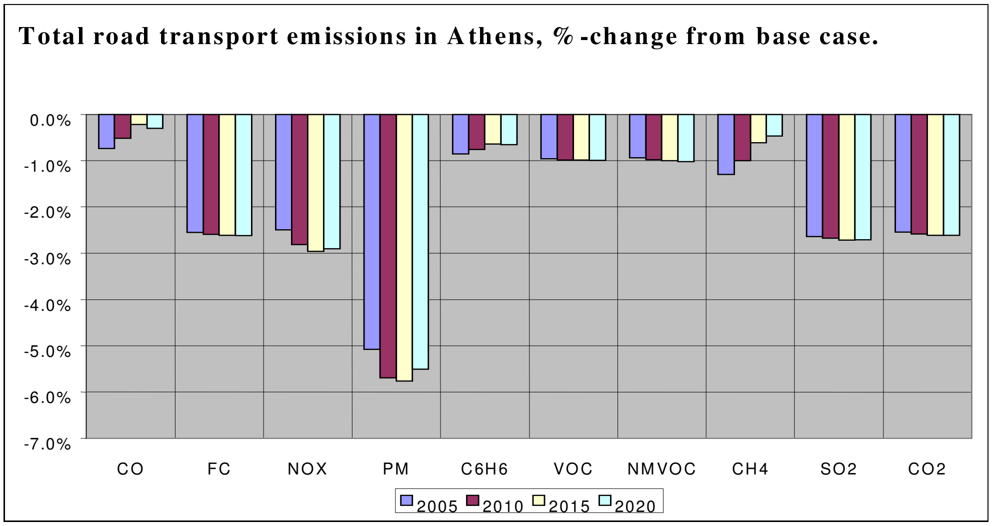
Transport demand (%change from basecase)				
	2005	2010	2015	2020
Small cars	0.3 %	0.4 %	0.5 %	0.6 %
Big cars	0.3 %	0.4 %	0.4 %	0.5 %
Mopeds & motorcycles	0.2 %	0.2 %	0.3 %	0.3 %
Buses	-0.2 %	-0.2 %	-0.2 %	-0.3 %
Metro	-0.3 %	-0.3 %	-0.4 %	-0.4 %
Light trucks (veh-km)	-7.3 %	-7.3 %	-7.2 %	-7.2 %
Heavy 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.

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.

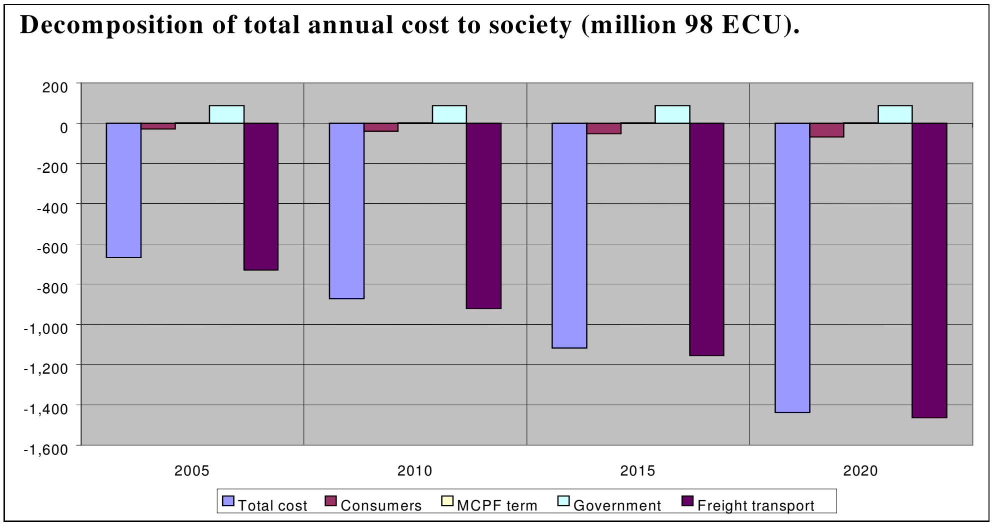
As can be seen in Figure 8, road-transport emissions are reduced by almost 6 % for PM and 3 % for NO_x.

FIGURE 8: IMPROVED CITY LOGISTICS - EMISSION EFFECTS



The cost savings for the society express primarily efficiency gains for freight transport (Figure 9).

FIGURE 9: IMPROVED CITY LOGISTICS - COSTS TO SOCIETY



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 the acknowledged limitation of the data and modelling tool (e.g. no distinction by type of good). Also, there are different opinions in literature on the possibilities to increase the load factor (see chapter 4.3.4 of WG5).

7. Undifferentiated parking charges (NT1)

7.1. Scenario description

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[14] for Winchester in the UK and 1.6 mio. ECU for Graz in Austria[15]. 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[16], while in Lyon public parking is not strongly restricted.[17]

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.

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

[15] Klamer, M., Maßnahmen zur Beschränkung des motorisierten Individualverkehrs in Städten, Wien, 1996.

[16] TransPrice, Research project in the Transport programme of the 4th Framework Programme, Deliverable 4.

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

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.

7.2. TREMOVE input data

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.

7.3. TREMOVE results and validation

7.3.1. The Athens case

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 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.

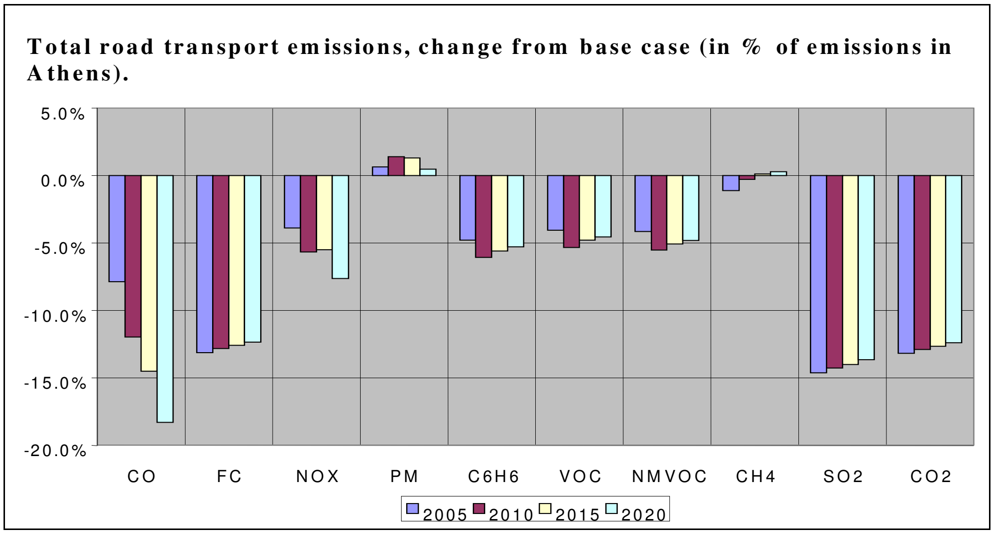
TABLE 8: PARKING CHARGES - MAIN RESULTS (%CHANGES FOR ATHENS)

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.

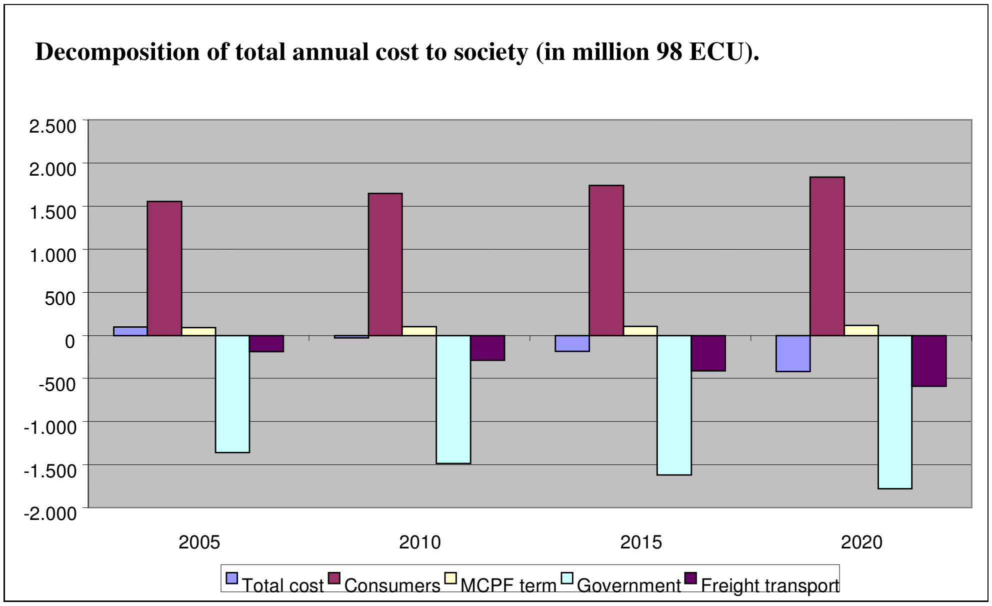
This measure shows a very strong impact on modal split (around -22 % for cars, +38 % for public transport). As can be seen from Figure 10 most pollutants show considerable reductions, e.g. NOx in 2010 by 6 %. Because there are almost no diesel cars in Athens, the additional PM emissions from buses and HGV exceed reductions from car traffic.

FIGURE 10: PARKING CHARGES IN ATHENS - EMISSION EFFECTS



Annual costs to consumers (in 2010 1656 mio. ECU) shown in Figure 11 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 11: PARKING CHARGES IN ATHENS - COSTS TO SOCIETY



7.3.2. The Lyons case

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 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.

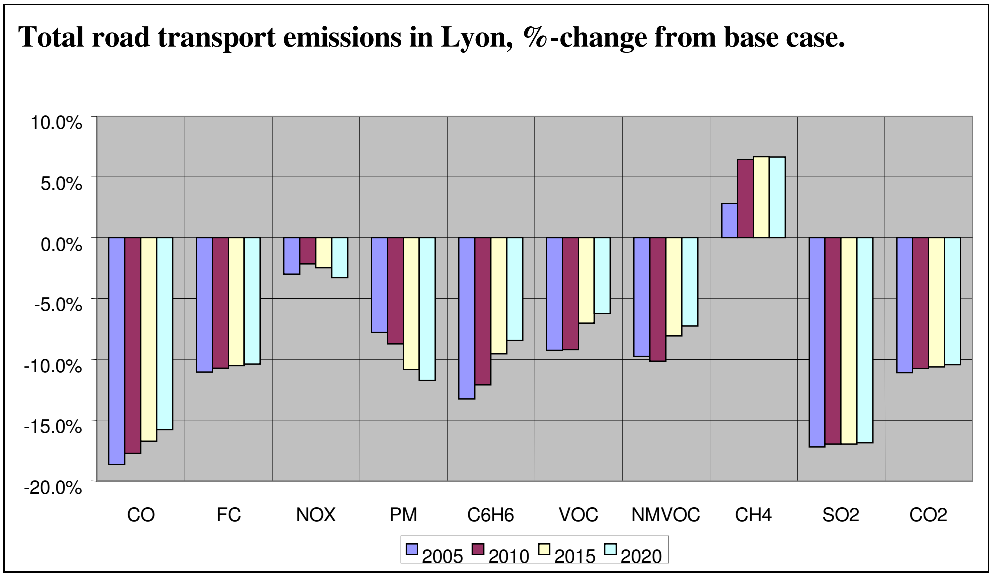
TABLE 9: PARKING CHARGES - MAIN RESULTS (%CHANGES FOR LYONS)

Transport demand (%change from base case)				
	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.

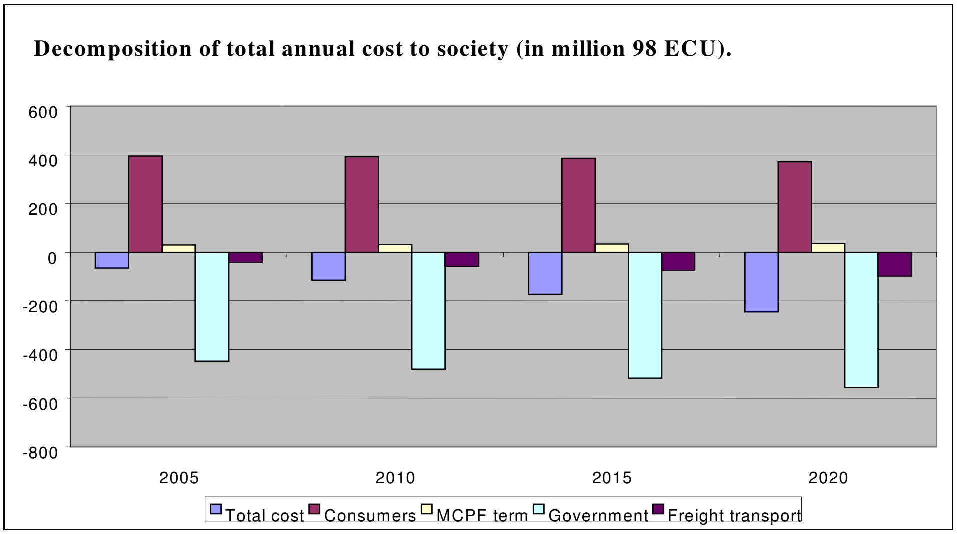
Also for Lyon this measure shows a very strong impact on modal split, though slightly lower than in Athens. Almost all pollutants are lower than in the base case, i.e. the decrease of car-km is not outweighed by the increase of bus-km and truck-km (e.g. in 2010 PM by 9 % and NOx by 2 %).

FIGURE 12: PARKING CHARGES IN LYONS - EMISSION EFFECTS



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.

FIGURE 13: PARKING CHARGES IN ATHENS - COSTS TO SOCIETY



8. Time differentiated urban road pricing (NT2)

8.1. Scenario description

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 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.[18] 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[19]. It is assumed that one quarter of the operating costs are intended

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

[19] 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).

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).

8.2. TREMOVE input data

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.

8.3. TREMOVE results and validation

8.3.1. The Athens case

In Athens 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.), 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 10 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.

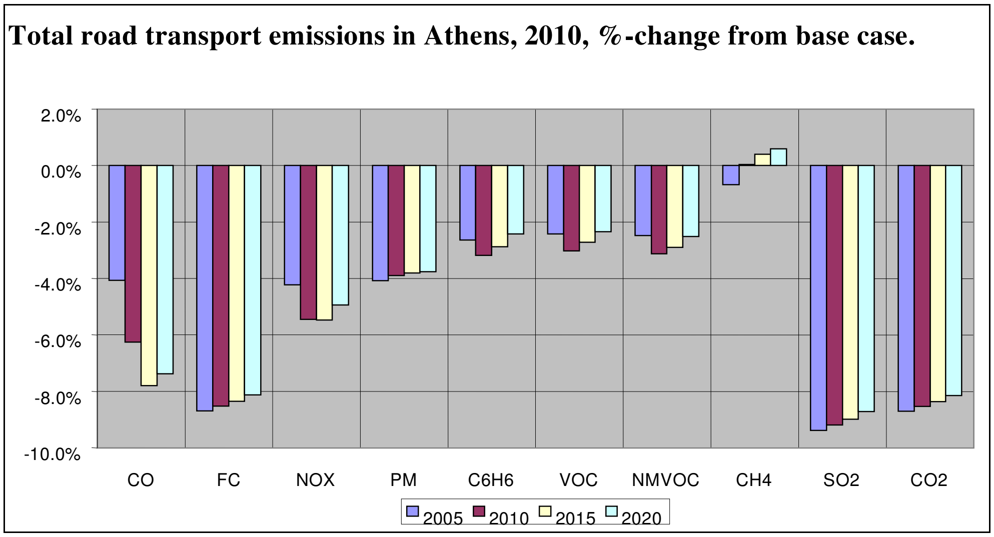
TABLE 10: ROAD PRICING IN ATHENS - MAIN RESULTS (%CHANGES FOR ATHENS)

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.

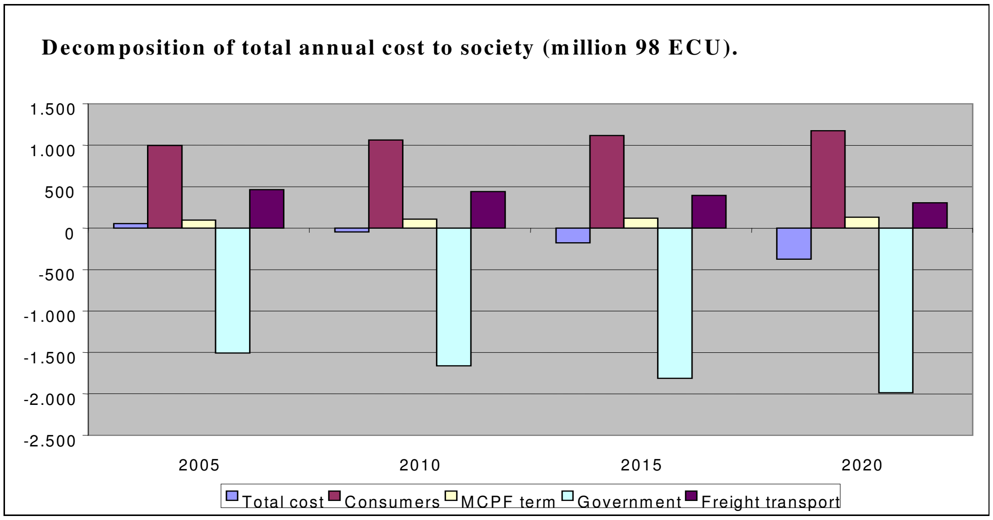
This scenario has also a very strong impact on modal split for passenger transport, though smaller than in the parking charge scenario. In contrast to parking charges in Athens, also PM is reduced (-4 %), because of the additional reduction of truck mileage. The smaller reduction of overall passenger transport (1 % compared to 3 % for the parking charge scenario) is partly due to the shift from peak to off-peak. Overall emission effects are shown in Figure 14.

FIGURE 14: ROAD PRICING IN ATHENS- EMISSION EFFECTS



In 2010, annual costs (Figure 15) 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.

FIGURE 15: ROAD PRICING IN ATHENS - COSTS TO SOCIETY



8.3.2. The Lyons case

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 11 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.

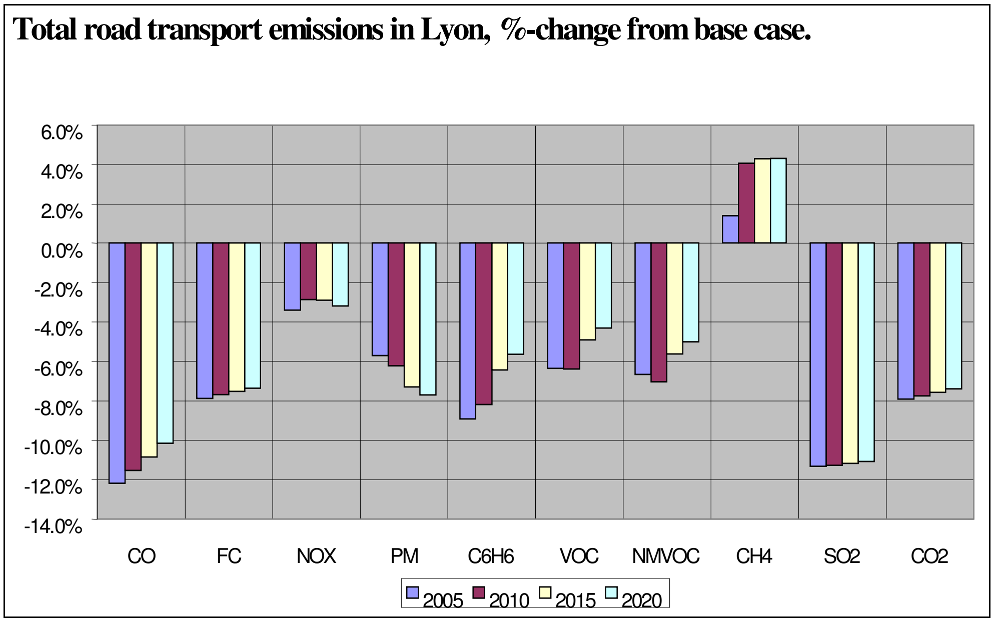
TABLE 11: ROAD PRICING IN LYONS - (%CHANGES COMPARED TO BASE CASE)

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.

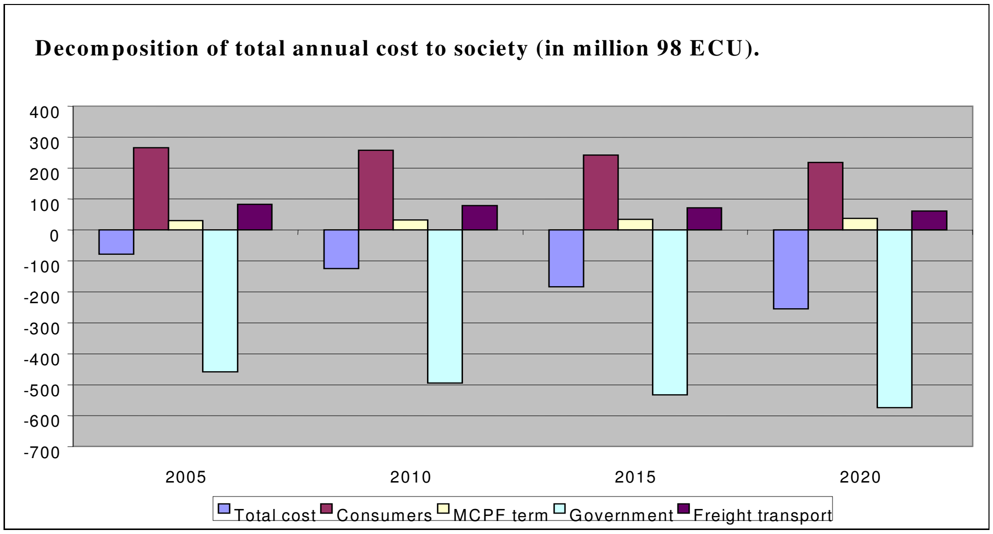
The changes in modal split and traffic patterns bring about a reduction of almost all pollutants, including PM (Figure 16).

FIGURE 16: ROAD PRICING IN LYONS - EMISSION EFFECTS



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 (see Figure 17).

FIGURE 17: ROAD PRICING IN LYONS - COSTS TO SOCIETY



9. Scrappage schemes (NT7)

9.1. Scenario description

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 of WG5 report).

9.2. TREMOVE input data

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.

9.3. TREMOVE results and validation

In Athens this measure, which involves a 1000 ECU subsidy in Greece for the scrappage of cars older than 10 years between 2005 and 2010, 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 12 shows the impacts of these changes on transport demand, speed, and emissions, as well as the total social costs of this measure.

Table 12: National scrappage scheme - main results (%changes for Athens)

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.

The impacts of this measure on transport demand are clearly below 1 %, emission impacts are negligible (Figure 18). Additional social costs are mainly borne by the government (Figure 19).

FIGURE 18: NATIONAL SCRAPPAGE SCHEME - EMISSION EFFECTS

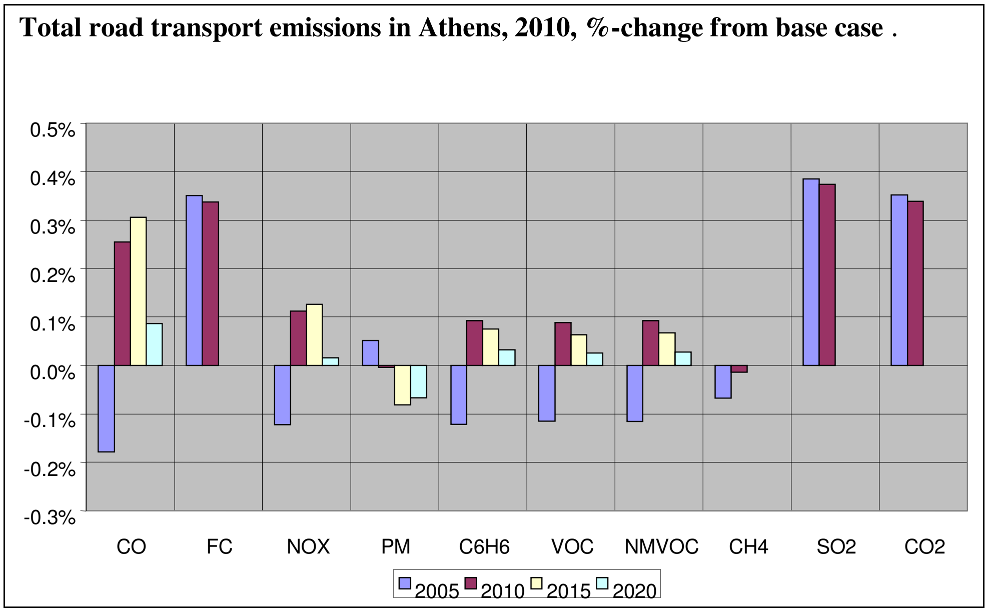
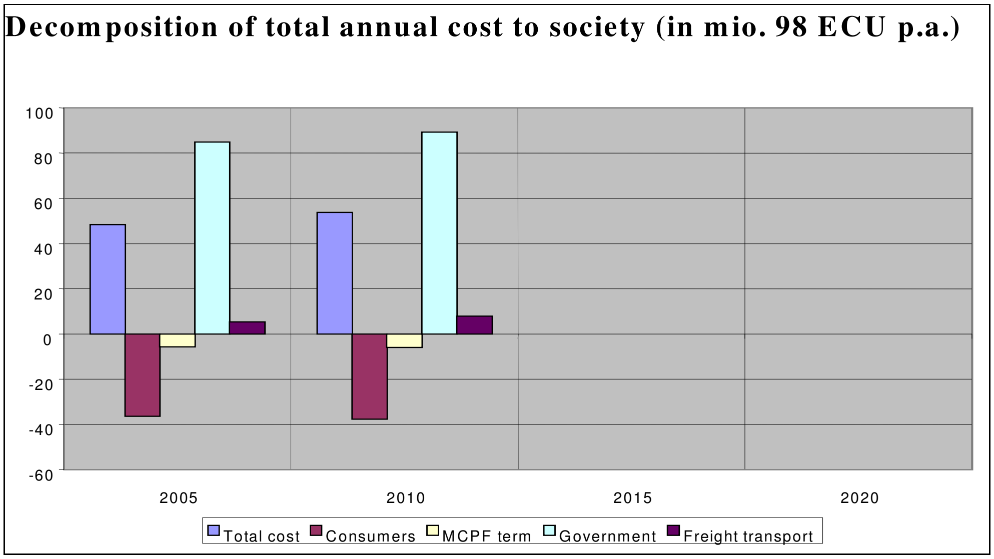


FIGURE 19: NATIONAL SCRAPPAGE SCHEME - COSTS TO SOCIETY



10. Conclusions

Table 13 summarises the tested measures and the main results.

TABLE 13: 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

Source: TREMOVE results, September 1999.

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.

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.

The modelling results provide general findings that can be compared with the findings of other projects described in chapter 3 and 4.3 of the WG5 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 in the WG5 report. 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 of the WG5 report. 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 of WG5 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 base case marginal social costs (especially costs of congestion) are higher than costs to transport users (see sources quoted in chapter 3.6 of WG5).

- **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 of WG5). 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 base case 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.

11. Recommendation for future studies

The development of the integrated assessment tool "TREMOVE" has generally been welcomed by many experts to allow them to compare technical and "non-technical" measures on an equal footing whilst also allowing a comparison of the cost-effectiveness of local versus national and/or EU wide measures.

TREMOVE was useful to assess non-technical measures and/or local measures at the strategic level based on a number of generalized traffic data and flow characteristics. Whilst its limitations were recognized, e.g. network models are capable of analysing in more detail the effects of measures on the local network including the impact of infrastructure, it was also agreed that useful insights were created at a broader assessment level and that the results were generally plausible.

Throughout the discussions in WG7 and WG5, a number of recommendations were made related to the future update requirements of the AOP-II/WG7 tools and data bases. Some suggestions are listed below in random order:

- A better definition, preferably in geographical terms of the city domains would help achieving a better alignment with air quality models and would also allow a better data collection process related to specific stocks and usage data in a given domain (e.g. for captive fleets);
- Updates and fine-tuning exercises are recommended in particular related to parameters such as the value of time, travel times, load factors, and the marginal cost of public funds and to the speed flow functions; a more detailed approach for public transport, in particular (freight) rail transport and barges may enhance the plausibility of certain scenarios aiming at modal shifts;
- Continued and more intense collaboration with local experts could enhance the general buy-in of the cost-effectiveness of certain local measures and the general improvement of the model and the data; A continued collaboration would also allow local authorities to demonstrate their experience to a European wide panel of experts based on a shared analytical platform whilst progress could be more easily demonstrated to European and other authorities where appropriate;

- A further integration with air quality modeling and links with transport planning experts could increase the economies of scale for coming to cost-effective solutions.