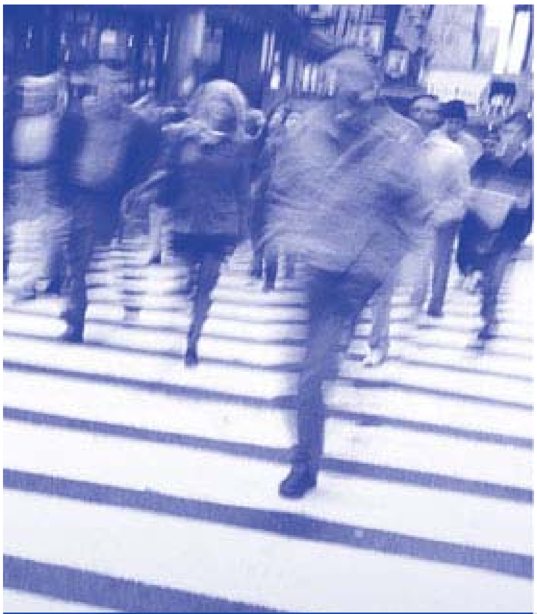

CIVITAS
Cleaner and better transport in cities

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COST BENEFIT ANALYSIS REPORT

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THE CIVITAS INITIATIVE IS CO-FINANCED BY THE EUROPEAN UNION

Contract no:	TREN/O4/FP6EN/S07.39318/513559
Start date	1st January 2005
Duration:	61 months
Version:	Final
Date:	January 2010

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EXECUTIVE SUMMARY

The cost benefit analyses described in this report have been carried out using the impact evaluation results and cost data provided by the cities. The main objective of the study has been to assess the financially viablity of the CIVITAS measures for which adequate data is available and to identify key issues for implementation in terms of costs and benefits of the measures.

The main indicator used has been Net Present Value (NPV) which is defined as the total present value of all future benefits less the discounted sum of all future costs over the appraisal period. It measures the excess or shortfall of monetised resource, in present value terms.

A major input to the CBA analysis comes from the Measure Template documents which describe how the measures were implemented and evaluated as well as the impacts. Cost data sheets for the measures provided additional information about costs relating to the measure (e.g. local price of emissions).

For the measures studied, most of the NPV's are positive and benefit cost ratio (BCR) are larger than 1.0 which means that the investment (or extra investment) can be justified within the evaluation period. For some CIVITAS measures, the capital costs were much higher than those of existing measures. For example in Toulouse, a CNG bus was 24% more expensive than a diesel bus and substantial additional cost were required to build CNG stations. The costs of such investment may never be recovered through revenue. However, such measures bring benefits in terms of reductions in pollutant/GHG (greenhouse gas) emissions and congestion and therefore, may justify some form of subsidy from the local authority. Savings from reductions in pollutant and GHG emissions depend on the nature of the measure and the scale of applications. For example, the benefits of Soot Filters mainly come from reductions of particulate emissions, whilst using clean fuels such as CNG and bio-gas have great potential to reduce a wide range of pollutant and GHG emissions.

Savings in fuel consumption costs are one of the major benefits of the CIVITAS measures, particularly for measures involving clean vehicles and alternative fuels. Some measures benefit from lower prices of the alternative fuels (e.g. LPG in Suceava), and others benefit from improved fuel efficiency of the vehicles (e.g. EEV buses in La Rochelle). In CIVITAS II, two types of alternative car use were demonstrated: sharing a car journey, known as 'car-pooling' and car rental or car clubs, known as 'car-sharing'. NPV calculations show that 'car pooling' is more financially beneficial than 'car-sharing'. For example, the BCR for the 'car pooling' measure in SMILE/Norwich 11.4 is estimated to be 4.26, compared to 1.54 for the 'car sharing' measure in CARAVEL/Genoa 9.4.

It was possible to carry out detailed CBA analyses for only 9 measures. For many measures, the impact evaluation results were not good enough to show the difference in impacts between CIVITAS measure and a reference scenario. The main reasons include: (1) no clear reference cases defined, (2) impact measurements were made only for the 'after' scenario, (3) inconsistency in impact measurements between the CIVITAS measure and the reference case (e.g. time scale, measurements methods).

For future CIVITAS CBA analysis, it is recommended that: (1) a common template should be used for data collection of costs and benefits of the measure studied; (2) impacts of a measure should be measured over the whole project period (not just "After"). (3) impacts in the period beyond the project should be estimated (e.g. lifetime of the measure).

1 INTRODUCTION

1.1 Background and Objectives

In CIVITAS II, 208 new measures were implemented to demonstrate their potential singly and in combination to address urban sustainability issues. The cost-benefit analysis described in this report was carried out based on impact evaluation results and cost data provided by the cities. The main objective of the study was to assess the costs and benefits of introducing the measure.

This study is part of the work of the GUARD project which was established as the Specific Support Action for efficiently and professionally planning, realising, managing and controlling the CIVITAS activities. It was a n additional report based on the opportunity provided by the data available for a small number of measures.

1.2 CIVITAS Measures within cities and projects

In CIVITAS II, there were 17 European cities participating from 12 European countries. These cities are grouped to demonstrate the measures within 4 projects: CARAVEL, MOBILIS, SMILE and SUCCESS. Overall, 208 measures were demonstrated by the cities which are categorised into the following 8 areas:

- Clean vehicles and alternative fuels
- Access management
- Integrated pricing strategies
- Stimulation of public transport modes
- New forms of vehicle use and ownership
- New concepts for goods distribution
- Innovative soft measures
- Telematics

The numbers of measures demonstrated in the 4 projects and 17 cities is given in Table 1.1 by the main Work Package (6-12) The table also shows the distribution of cost benefit analyses that were possible.

The nine measures evaluated were selected on the basis of the information available, and it is very probable that other measures would have returned substantial economic benefits had the data been available.

Table 1.1: Distribution of measures in the cities

	CARAVEL				MOBILIS					SMILE					SUCCESS			TOTAL
	Genoa	Burgos	Krakow	Stuttgart	Toulouse	Debrecen	Ljubljana	Venice	Odense	Malmo	Norwich	Potenza	Suceava	Tallinn	La Rochelle	Preston	Ploiesti	
WP5: Clean vehicles and alternative fuels	1	1	1	0	2	1	1	2	0	4	1	1	2	0	4	1	1	**23**
WP6: Access management	0	2	2	1	4	2	0	4	1	1	2	0	1	0	2	2	1	**25**
WP7: Integrated pricing strategies	1	0	0	0	1	0	0	0	0	1	1	0	0	0	2	2	0	**8**
WP8: Stimulation of PT modes	2	3	5	1	4	1	0	1	1	3	3	1	2	0	5	4	1	**37**
WP9: New forms of vehicle use & ownership	1	2	3	1	2	1	0	1	1	1	1	1	0	0	2	1	0	**18**
WP10: New concepts for goods distribution	1	1	1	0	1	0	0	1	0	3	4	0	0	0	3	2	1	**18**
WP11: Innovative soft measures	6	6	4	1	4	2	2	1	3	4	3	1	1	0	3	4	2	**47**
WP12: Telematics	2	2	2	1	3	1	0	2	0	5	2	0	0	2	4	4	2	**32**
Total measures	**14**	**17**	**18**	**5**	**21**	**8**	**3**	**12**	**6**	**22**	**17**	**4**	**6**	**2**	**25**	**20**	**8**	**208**
Cost Benefit Analyses	**1**				**3**					**1**	**1**		**2**		**1**			**9**

1.3 Structure of this report

The deliverable includes the following sections:

Section 1: Introduction

Section 2: Methodology

Section 3: Data collection

Section 4: Economic evaluation

Section 5: Summary and conclusions

2 METHODOLOGY

2.1 Scope of CBA

In this study, the CBA analysis has been based on measured impacts which related to economy, traffic, safety, energy, pollutants and GHG emissions. Other impacts such as those relating to landscape, water quality, heritage, and biodiversity have not been included due to difficulties in measurement and/or monetization. Thus these CBA's provide an important contribution to understanding the effect of the measures, but need to be considered in a broader context.

The CBA is focused on a sub-set of the quantitative indicators identified in D2.1 (McDonald et al, 2006). These are listed in Table 2.1. The impacts were taken from Table 3.1 of D2.1 (and indicated by ✓). Impacts that were not indicated by Table 3.1 but should be considered are denoted by *. Some other missing indicators include parking costs (could be incorporated into operating revenue) and access/egress time (typically walk time) for public transport.

It should be noted that in most cases the measures are assumed to affect either the passenger sector (WP5, 7, 8, 9, 11, 12) or the freight sector (WP10). Only one set of measures is assumed to affect both sectors (WP6). WP5 assumes no impact on demand, whilst WP6, 7, 9, 11 and 12 assume no changes in public transport service frequencies (in other words any modal shift can be accommodated by existing spare capacity).

With respect to the environment, it is assumed that the emphasis will be placed on emissions except for WP6 where air quality should also be considered.

The key indicators include measures of:

- Capital costs
- Changes in operating and maintenance costs.
- Changes in transport demand (measured in terms of final outputs (passenger km, freight tonne km) or intermediate outputs (vehicle km)).
- Changes in transport costs (fares for public transport, operating costs and parking costs for private transport).
- Changes in transport journey times (including out of vehicle time, in-vehicle time and delay time).
- Changes in vehicle emissions.
- Changes in transport related accidents.

Table 2.1: CBA Indicators

	WP 5 Clean Vehicles & Alternative Fuels	WP 6 Access Management	WP7 Integrated Pricing Strategies	WP8 Stimulation of Public Transport	WP9 New Forms of Vehicle Use & Ownership	WP10 New Concepts for the Distribution of Goods	WP11 Innovative Soft Measures	WP12 Telematics
Operating revenues			*	*	✓	✓ (profitability)	✓ (profitability)	
Operating Costs	✓	*	*	✓	✓	✓	✓	
Maintenance Costs	✓	*	*	*	✓	✓	✓	✓
Investment Costs	✓	*	*	*	✓	✓	✓	✓
Fuel Consumption	✓	✓	✓	✓	✓	✓	✓	
Emissions	✓	✓	✓	✓		✓	✓	✓
Air Quality		✓						
Noise		✓	✓			✓	✓	
Transport safety		✓	*	✓	✓	✓	✓	✓
Passenger movements		✓	✓	✓	✓		✓	✓
Freight movements		✓				✓		
Modal split		✓		✓	✓	✓	✓	✓
Traffic levels				✓	✓	✓	✓	✓ (Congestion)
Journey times		✓	✓	✓				✓
Waiting times							✓	
Service frequency				✓				
Service reliability						✓ (Waiting time)		✓
Vehicle occupancy				✓	✓			
Vehicle Speed		✓	✓ (Congestion)		✓ (Congestion)	✓ (Congestion)	✓ (Congestion)	✓ (Congestion)
Parking demand		✓	✓	✓				

2.2 Form of Analysis

This is based on a standard social cost benefit analysis of the following form (Preston 2006):

$$NPV = \sum_{a} \sum_{i=0} \frac{(R_{ia} + UB_{ia} + NUB_{ia} + E_{ia} - OC_{ia} - K_{ia})}{(1 + r)^{i}}$$

where,

NPV = Net present value summed over all agents

R_{ia} = Revenue in year i to agent a,

UB_{ia} = User transport benefits in year i accruing to agents a,

NUB_{ia} = Non user transport benefits in year i accruing to agents a,

E_{ia} = External benefits in year i accruing to agents a,

OC_{ia} = Operating (and maintenance) costs in year i to agent a

K_{ia} = Capital costs accruing to agent an in year i (with the usual assumption being that capital costs begin to be incurred in year 0).

r = Discount rate

Generally, five agent groups were considered: transport operators, authorities, users of the measure, other transport users and households. This requires impacts to be disaggregated by these groups. Particular attention should be paid to tax streams, particularly where there are transfers from highly taxed car to low taxed (and subsidised) public transport and vice versa. Information is required on transport tax rates in each partner city. It should be noted that in this study we have used market prices. This will not distort our cost benefit calculations as these are transfer. However, analysis of tax streams is needed if changes in public expenditure are to be explained.

The evaluation period of the CBA study varied from measure to measure (based on either the technical, market or economic life of the technologies being introduced). National interest rates in the study period have been used in the CBA analysis, as well as a rate determined by the European Commission (currently 4%) at the time of the analyses.

2.3 Reference case for CBA analysis

In GUARD, three scenarios were defined for impact evaluation: baseline, business-as-usual, after situations (McDonald et al, 2006). In this cost-benefit analysis, selection of appraisal and reference cases followed what were defined in the evaluation result sheets of the measure.

In this cost benefit analysis, the NPV calculation is based on changes in cost/benefit between a CIVITAS measure and a reference measure. In the GUARD evaluation result sheets, many impacts of a measure were measured in terms of relative changes to that of the reference case (e.g. CO2 emissions are reduced by 10%). It is impossible to know the absolute impacts of the measure if no information is given about the impact of the reference case. In such cases, relative cost/benefits (cost/benefit of CIVITAS measure less those of the reference measure) were used in the NPV calculation. If the calculated result is positive, it means the NPV of the CIVITAS measure outweighs that of reference measure.

3 DATA COLLECTION

3.1 Evaluation results sheets

For measures demonstrated in CIVITAS II, results of impact measurements and evaluation were provided in the evaluation results sheets using the template provided by GUARD (Annex B). The evaluation result sheets include details of the measure implementation and evaluation including:

- Objective and functions of the measure
- Situation before CIVITAS
- Actual implementation of the measure and deviations from the original plan
- Baseline and business-as-usual scenarios
- Evaluation indicators and measurement results
- Lessons learned

In this study, evaluation result sheets were used to understand how the measures were implemented and evaluated. Most importantly, the impact measurement results formed the basis on which the cost and benefits of the measure are monetised.

3.2 Cost data sheets

Of the 17 cities in CIVITAS II projects, 15 cites agreed to provide cost data for 43 measures. TRG reviewed the data provided from the perspective of a cost/benefit analysis. The data provided varied substantially in terms of quality and coverage. Some cities provided detailed records of costs/benefits in each year of the project, others could only provide limited data which was not in adequate to carry out cost-benefit analysis.

In the SMILE and SUCCESS projects, cost data were provided using a template of their own which included setting-up costs and operating costs in each year of the project period. Such data provided a record of total cost for the measure demonstrated and were useful for those who are interested in understanding the budget required for implementing similar measures in their cities. The setting-up, operating cost and total cost during the project period are summarised in Table 3.1 (see Annex A for more details). These data were used by the SMILE and SUCCESS projects for cost effectiveness analyses.

Table 3.1 Summary of set-up and operating cost of measures in SMILE and SUCCESS projects (in Euros)

Measure	Set-up cost	Operating cost	Total cost
SMILE/Malmo 5.1: Clean municipal fleets	933,488	45,981	979,468
SMILE/Malmo 5.2: Biogas on the net	314,095	12,857	326,952

Measure	Set-up cost	Operating cost	Total cost
SMILE/Malmo 5.3: Clean heavy vehicles with CO2	81,505	1,012,946	1,094,451
SMILE/Malmo 6.1: Low emission zone	0	67,602	67,602
SMILE/Norwich 6.2: Introduction of low emission zone	598,400	13,200	611,600
SMILE/Suceava 6.4: Extension of low emission zone	8,290	4,862	13,152
SMILE/Malmo 7.1: Marketing of clean vehicles by subsidized parking	7,143	21,905	29,048
SMILE/Malmo 8.1: Marketing of New Bus Route	8,599	364,678	373,277
SMILE/Malmo 8.2: Improved Security/Safety on Buses	8,599	364,678	373,277
SMILE/Malmo 8.3: Integrating of cycling with PT	824,095	20,476	844,571
SMILE/Norwich 8.4: Rail Station Interchange	625,920	18,717	644,636
SMILE/Norwich 8.5: On street ticket vending machine with real time information	254,079	180,489	434,568
SMILE/Norwich 8.6: Linking individual passenger transport information with healthcare appointments	0	11,068	11,068
SMILE/Suceava 8.8: Bus priority measures	48,378	6,424	54,801
SMILE/Suceava 8.9: PT information	74,267	8,179	82,447
SMILE/Malmo 10.1: Freight driver support	4,838	294,302	299,140

Measure	Set-up cost	Operating cost	Total cost
SMILE/Malmo 10.2: Satellite based traffic management for SME's	59,048	92,857	151,905
SMILE/Norwich 10.4: Priority Access For Goods Vehicles	45,848	2,970	48,818
SMILE/Norwich 10.6: Goods delivery to park & ride sites	0	183,359	183,359
SMILE/Malmo 11.1: Managing Mobility Needs of Private Persons and Business Sector	0	2,018,569	2,018,569
SMILE/Malmo 11.2: Eco-Driving for municipal employees	245,742	37,373	283,115
SMILE/Norwich 11.3: Travel planning	149,169	210,606	359,775
SMILE/Norwich 11.4: Car pooling	31,742	68,606	100,348
SMILE/Norwich 11.5: Individual travel advice	127,210	99,296	226,505
SMILE/Suceava 11.7: General information and awareness raising	46,025	3,776	49,801
SMILE/Malmo 11.8: EcoDriving för Hospital Employees	2,629	19,810	22,438
SMILE/Malmo 11.9: Heavy Eco-driving	1,441	133,471	134,912
SMILE/Malmo 12.1: Use of real time applications for travellers	823	975,562	976,385
SMILE/Malmo 12.3: Mobile internet services in connection to bus information	566	1,168,920	1,169,486
SMILE/Malmo 12.4: Internet tool for traffic planning	0	87,048	87,048
SMILE/Tallinn 12.5-12.6: PT priority system and automatic call & information signs in bus	4,431,397	62,492	4,493,889

Measure	Set-up cost	Operating cost	Total cost
SMILE/Norwich 12.8: Traffic and Travel Information for Freight Operators	37,400	3,300	40,700
SMILE/Norwich 12.9: Real Time Passenger Information	0	780,802	780,802
SUCCESS/Preston 5.6: Hybrids/Biodiesel	85,605	82,063	167,669
SUCCESS/Preston 8.7: Creation of and 'Overground' network for PT services	68,253	3,125	71,378
SUCCESS/Preston 8.8: Demand responsive and feeder services	61,443	56,378	117,821

(Exchange rate used: Euro 1=0.91 British Pound, Euro 1=10.5 Swedish krona, Euro 1 = 4.32 Romanian New Leu, Euro 1 = 16.65 Estonian Kroon)

3.3 Summary

From the evaluation result sheets and cost data sheets provided, it is clear that substantial efforts had been made by cities to collect and provide data for cost-benefit analysis. However based on the review, some measure results were of too poor of quality and coverage to be good enough for sound cost-benefit analyses in terms of quality and coverage of data provided:

Based on the review, the measures were ranked according to the quality and coverage of the data provided. For those identified as having high potential for cost-benefit analysis, further contacts were made with the project/cities to try to obtain key information missing from the data provided. Based on quality and coverage of the final data provided, it was decided to carry out detailed cost-benefit analysis for the following 9 measures:

1. MOBILIS/Toulouse 5.1: Large scale operation of clean bus fleet
2. MOBILIS/Toulouse 5.2-1: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Equipping diesel buses with soot filters)
3. MOBILIS/Toulouse 5.2-2: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Buses using bio-diesel)
4. SMILE/Suceava 5.6: Alternative Fuel Bus Fleet
5. SMILE/Suceava 5.7: Marketing for alternative fuels in the public and private sector
6. SUCCESS/La Rochelle 5.2: Introduction of new clean buses
7. SMILE/Malmo 9.1: Car sharing for business and private persons
8. SMILE/Norwich 11.4: Car pooling (sharing)
9. CARAVEL/Genoa 9.4: Car sharing service in Genoa

The detailed analyses of each of these are described in the following Chapters.

4 ECONOMIC EVALUATION

4.1 MOBILIS/Toulouse 5.1: Large scale operation of clean bus fleet

4.1.1 Description of the measure

The main aim of this measure was to renew the bus fleet with CNG powered buses. These new buses give an improved image of the surface public transport for users and non-users alike. The specific objectives of the large scale implementation of CNG vehicle fleets were:

- To build a second CNG filling station located in the new depot (opened in the beginning of 2008)
- To acquire new CNG buses that are mainly being operated in priority areas like High Quality Corridors and city centre bus lines
- To improve the operation of CNG engines together with the natural gas quality, and
- To develop training and extend associated competencies in the CNG engine domain.

The demonstration activities used within the CBA analysis were dealing with two main tasks:

- The acquisition of 68 new CNG buses and their use / exploitation on high quality bus lines, especially the lines that used the High Quality Corridors which had been developed to connect peripheral areas to the subway network.
- The building of a new CNG filling station, located in the new bus depot that has been opened at the beginning of 2008. It has permitted the expansion of the CNG fleet which had suffered previously from the lack of depot space with a temporary provisions resulting from the AZF factory explosion (September 2001) which also destroyed the bus depot.

The measure was implemented in the following stages:

Step 1: Procurement of 28 CNG buses (February 2005) – At the start of the CIVITAS MOBILIS project, Tisséo-SMTC (the public transport authority) purchased 28 new CNG buses at the beginning of 2005, bringing the fleet of CNG buses to a total of 128.

Step 2: Opening of a second CNG filling station (January 2008) – In the frame of the inauguration of the new bus depot of Langlade (destroyed in 2001 in the explosion of the nearby AZF factory), Tisséo has opened a second CNG filling station permitting some further developments of the CNG fleet (capacity was limited to the filling capacity of the only existing filling station (125 buses)).

Step 3: Procurement of 40 new CNG buses (October 2008) – Tisséo ordered 40 new CNG buses in the frame of the CIVITAS MOBILIS project however because of fabrication delays, these buses will not be delivered within the MOBILIS timeframe (the 40 buses should be delivered in summer 2009).

More details about the measure implementation and evaluation can be found in the evaluation results sheets of MOBILIS/Toulouse 5.1: Large scale operation of clean bus fleet

4.1.2 Monetised cost of the measure

According to the evaluation results sheets and cost data sheets provided, the extra costs in vehicle investment, fuel stations, vehicle operating costs and maintenance, compared with the equivalent diesel buses, were as follows:

Capital costs

- Vehicle investment: The investment cost for a CNG bus was €275,470 compared to €222,140 for a diesel bus. In Toulouse 5.1, 28 CNG buses were purchased and evaluated in the project period
- During the project, a natural gas filling station was constructed at a total cost of €2,011,152. Its depreciation cost per kilometre of operation is calculated over a 30 years period with a capacity of the filling station of 125 buses per night.

Operating costs

In this study, only fuel consumption cost has been considered in the operating costs, as it is assumed the other costs stay the same. Based on the mileages and fuel consumption costs provided, average fuel consumption costs per 100km operation are shown in Table 4.1-1.

Table 4.1-1 Fuel consumption cost

	CNG bus (€ / 100 km)	**Diesel bus** (€ / 100 km)
2005	21.22	40.37
2006	24.48	36.40
2007	21.59	42.61
2008	21.48	43.61

Maintenance costs

Maintenance costs included labour and parts costs. Based on the mileges run by the vehicles, average maintenance costs per 100km operation are shown in Table 4.1-2:

Table 4.1-2 Extra maintenance cost for using CNG buses

	CNG bus (€ / 100 km)	**Diesel bus** (€ / 100 km)
2005	19.55	18.57
2006	26.95	21.80
2007	40.97	26.26
2008	44.61	23.61

4.1.3 Monetised benefits of the measure

According to the impact evaluation results provided, using CNG buses reduces pollutant emissions and greenhouse gas (GHG) emissions compared to those with diesel buses. No changes in revenues were reported for applications of CNG buses.

Savings from pollutant reductions

According to the Toulouse 5.1 Evaluation Result Sheets, pollutant emission rates and costs of emissions for CO, NOx, HC and PM10 are shown in Table 4.1-3 and Table 4.1-4

Table 4.1-3 Pollutant emission rate (Source: Toulouse 5.1 Evaluation Result Sheet)

	g / 1000km of operation	
	CNG	Diesel
Nitrogen oxides (NOx)	53,403.756	52,910.798
Carbon monoxide (CO)	5,516.432	22,222.535
Hydrocarbons (HC)	2,687.793	6,984.225
Particulates	46.948	529.108

Values recommended by Plassat (2005) and IMPACT (2008) were based to monetise the savings in reducing pollutant emission. In the project period, the savings from reduction of pollutant was estimated to be €360,790.

Table 4.1-4 Price of pollutant reductions

	Price (€ / tonne)	**Source**
CO	4	Plassat (2005)
HC	2,000	Plassat (2005)
Nox	7,700	IMPACT (2008)
Particulates	156,900	IMPACT (2008)

Based on the mileages provided, reductions of pollutant emissions and the cost are shown in Table 4.1-5 and Table 4.1-6.

Table 4.1-5 Pollutant emissions of CNG and Diesel buses

	annual mileages (km)	Emissions (tones)			
		Pollutant	CNG	Diesel	Reductions
2005	721021	Nitrogen oxides (Nox)	38.51	38.15	0.36
		Carbon monoxide (CO)	3.98	16.02	-12.05

		Hydrocarbons (HC)	1.94	5.04	-3.10
		Particulates	0.03	0.38	-0.35
2006	964428	Nitrogen oxides (Nox)	51.504	51.029	-0.475
		Carbon monoxide (CO)	5.320	21.432	16.112
		Hydrocarbons (HC)	2.592	6.736	4.144
		Particulates	0.045	0.510	0.465
2007	988320	Nitrogen oxides (Nox)	52.780	52.293	-0.487
		Carbon monoxide (CO)	5.452	21.963	16.511
		Hydrocarbons (HC)	2.656	6.903	4.246
		Particulates	0.046	0.523	0.477
2008	1136590	Nitrogen oxides (Nox)	60.698	60.138	-0.560
		Carbon monoxide (CO)	6.270	25.258	18.988
		Hydrocarbons (HC)	3.055	7.938	4.883
		Particulates	0.053	0.601	0.548

Table 4.1-6 Savings from reductions of pollutant emissions (€)

	2005	**2006**	**2007**	**2008**
Nitrogen oxides (Nox)	2736.8	3660.8	3751.4	4314.2
Carbon monoxide (CO)	-48.2	-64.4	-66.0	-76.0
Hydrocarbons (HC)	-6195.6	-8287.2	-8492.5	-9766.6
Particulates	-54545.8	-72959.8	-74767.2	-85984.0
Total	-58052.8	-77650.7	-79574.3	-91512.3

Savings from greenhouse gas reductions

Measurements of greenhouse gas emissions were not provided by the city. In this study, GHG emissions were estimated based on vehicle mileages and fuel consumption of the 28 CNG buses. Three GHG have been considered: CO2, CH4 and N2O. With CNG, emission factors of the GHG considered were based on those recommended by IPCC (2006).

Table 4.1-7 Greenhouse gas emission rates per 10^6km

	Diesel bus (tones)	**CNG bus** (tones)	**Note**

CO_2	4514.1	4242.4	Annex C
CH_4	0.175	0.900	
N_2O	0.00300	0.10100	

Table 4.1-8 Greenhouse gas emissions

	annual mileages (km)	GHG	GHG Emission (tones)	
			CNG	Diesel
2005	721021	CO_2	3058.859	3254.761
		CH_4	0.649	0.126
		N_2O	0.073	0.002
2006	964428	CO_2	4091.489	4353.524
		CH_4	0.868	0.169
		N_2O	0.097	0.003
2007	988320	CO_2	4192.849	4461.375
		CH_4	0.889	0.173
		N_2O	0.100	0.003
2008	1136590	CO_2	4821.869	5130.681
		CH_4	1.023	0.199
		N_2O	0.115	0.003

Table 4.1-9 Global warming potential in CO_2e

	Global warming potential	**Note**
CO_2	1	Source: [1] Tom Beer, Tim Grant, Geoff Morgan, Jack Lapszewicz, Peter Anyon, Jim Edwards, Peter Nelson, Harry Watson & David Williams. Comparison of transport fuels final report (ev45a/2/f3c) to the Australian greenhouse office http://www.environment.gov.au/settlements/transport/comparison/index.html
CH_4	21	
N_2O	310	

		[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Table 4.1-10 Greenhouse gas emission in CO2e (tones)

	Greenhouse gas	**CNG**	**Diesel**
2005	CO2	3058.86	3254.76
	CH4	13.63	2.65
	N2O	22.58	0.05
2006	CO2	4091.49	4353.52
	CH4	18.23	3.54
	N2O	2.05	0.06
2007	CO2	4192.85	4461.38
	CH4	18.68	3.63
	N2O	30.94	0.92
2008	CO2	4821.87	5130.68
	CH4	21.48	4.18
	N2O	35.59	1.06

In IMPACT (2008), the cost of CO2 emisson was estimated to be €25/tonne in 2010, €40/tonne in 2020. These values were based to monetize the savings in GHG reduction in the project period. In the project period, the savings from reducing GHG emissions are estimated to be €24,566.

Table 4.1-11 Savings from greenhouse gas reductions

	CNG (tones)	**Diesel (tones)**	**Difference (tones)**
2005	3095	3257	162
2006	4112	4357	245
2007	4242	4466	223
2008	4879	5136	257

Revenue

No changes in revenue were reported between CNG and diesel buses.

4.1.4 NPV in the lifetime of CNG buses

Evaluation period: 2005-2019

Test case and reference case: 28 CNG buses v.s. 28 diesel buses

Assumptions

- Diesel and CNG buses have equal lifetime (15 years)
- Discount rate: 3.5% (as used by SMILE and SUCCESS measures)
- Introduction of the CNG buses do not result in additional revenues
- Annual mileages beyond the project time (i.e. 2009-2019) is equal to the average of that in 2005-2008
- The differences in fuel consumption and maintenance cost between a CNG and a diesel bus remain unchanged in the study period
- The gas in pollutant emissions and greenhouse gas emissions remain unchanged in the study period.
- No residual values remain at the end of the evaluation period

NPV in the lifetime of CNG buses

Detailed results of costs and benefits are shown in Table 4.1.11.

- Over the whole evaluation period, the net present value of using CNG buses (instead of using diesel buses) is estimated to be €225k
- The present value of extra cost is estimated to be €3,607k. Of the total extra cost, investment in the CNG buses, investment in the filling station accounts for 41% and 12% respectively. The maintenance costs accounts for 47%.
- The present value of extra benefits is estimated to be €3,831k. Of the total extra benefits, savings from fuel costs contribute 71%, reduction of pollutant emissions 21%, and reductions of greenhouse gas emissions 2%

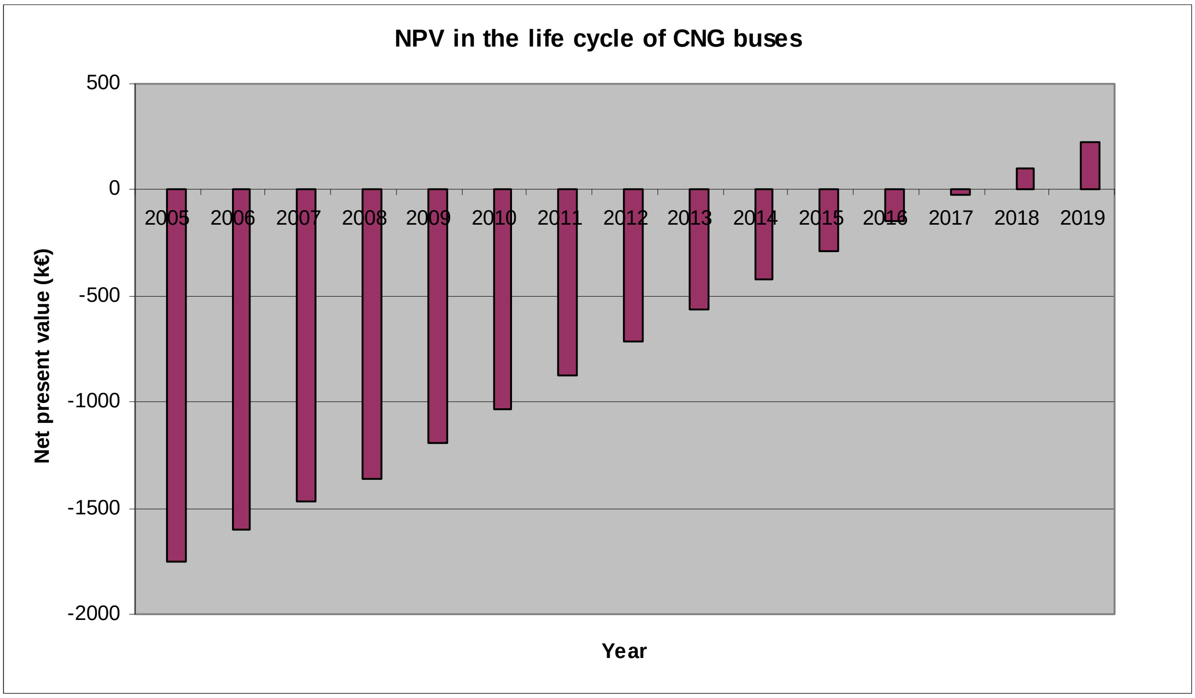

Figure 4.1-1 NPV of extra benefits less the extra cost in the evaluation period

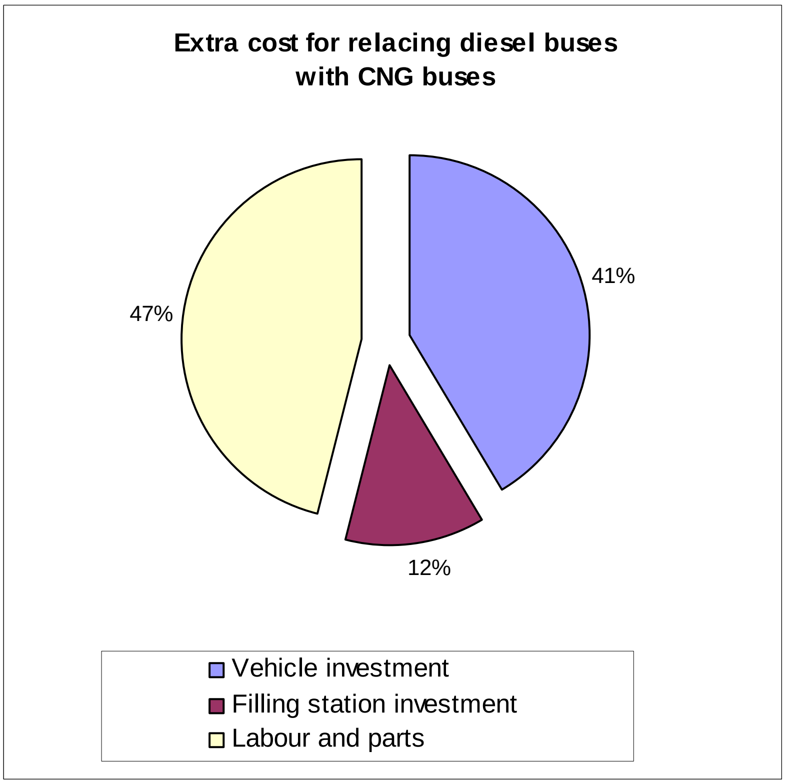

Figure 4.1-2 Distribution of extra cost

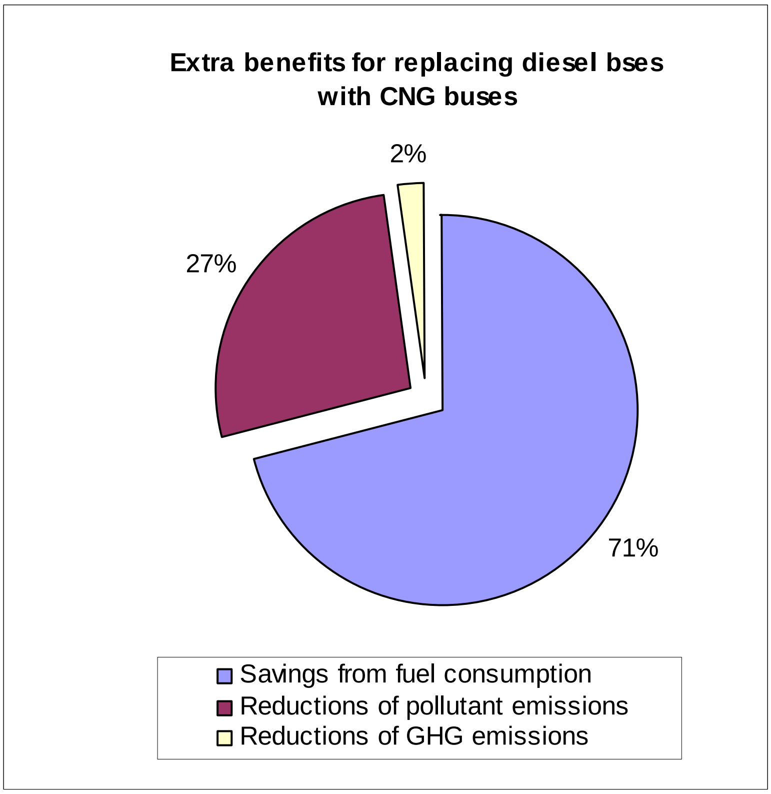

Figure 4.1-3 Distribution of extra benefit

During the project, maintenance costs for CNG buses were found to have been 60% more expensive than those of diesel buses. Such a difference in maintenance cost is expected to reduce with the increase of CNG applications. To understand how changes in maintenance cost would impact on NPV, several scenarios of the gaps are investigated:

- The difference in maintenance cost remain unchanged during the period of 2009-2019 (i.e. beyond the project)
- The difference in maintenance cost reduces by 25% in the period of 2009-2014, and remains constant after then
- The difference in maintenance cost reduces by 50% in the period of 2009-2014, and remains constant after then
- The difference in maintenance cost reduces by 75% in the period of 2009-2014, and remains constant after then
- The difference in maintenance cost reduces by 100% (i.e. equal maintenance cost with diesel buses) in the period of 2009-2014 (linearly), and remain constant after then

As expected, the NPV increases as the difference in maintenance cost reduces (Figure 4.1-4). If the difference reduces by 50%, the NPV would become positive from 2015. If the difference reduces by 100% (i.e. equal maintenance cost), the NPV would become positive after 2014 and increase to €1,470kK by 2019.

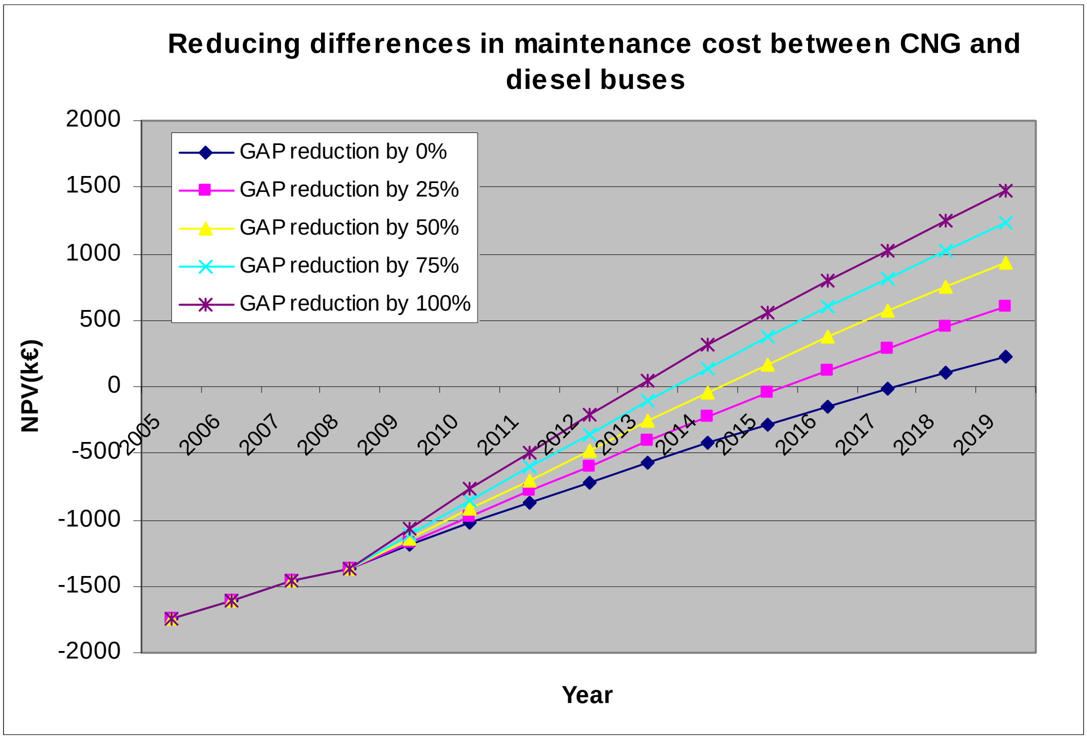

Figure 4.1-4 NPV with reduced gap in maintenance cost

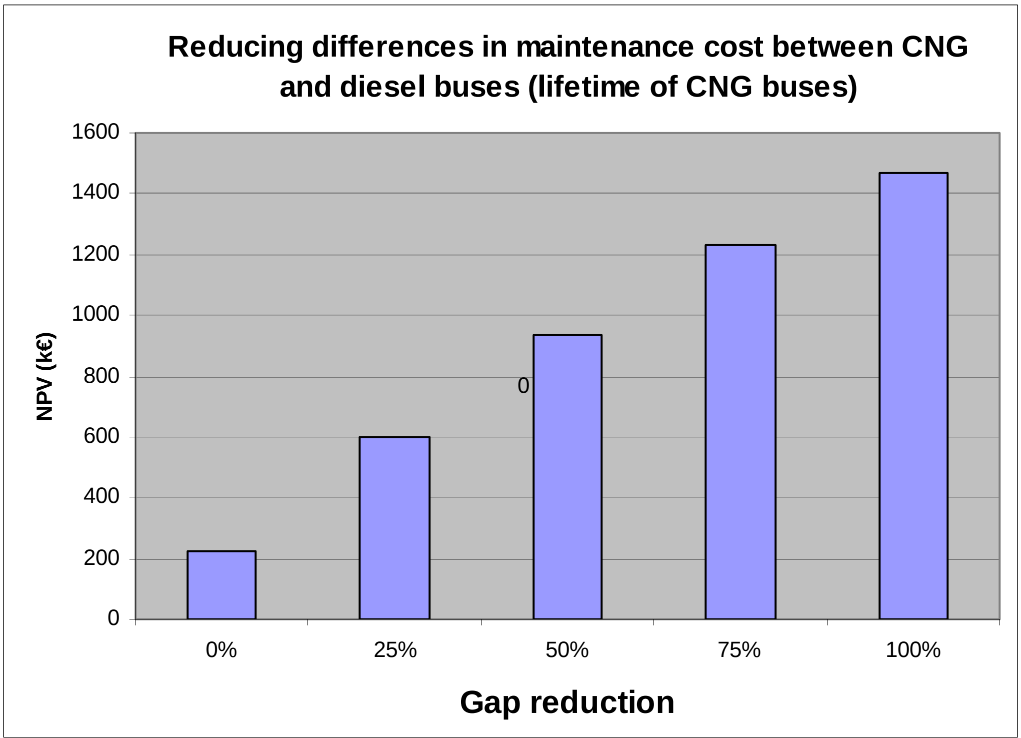

Figure 4.1-5 NPV with reduced gap in maintenance cost in the whole evaluation period

Table 4.1.1 NPV of replacing diesel buses with CNG buses (in 2005 price)

Year		Extra capital cost		Extra operating/maintenance cost		Extra revenue	Extra non-user benefits				Total extra cost	Total extra benefits	NPV
		Vehicle (Euro)	Filling stations (Euro)	Fuel (Euro)	Labour and parts (Euro)	(Euro)	JT savings (Euro)	Accident reduction (Euro)	Emission reduction (Euro)	Greenhouse gas reductions (Euro)	(Euro)	(Euro)	(Euro)
1	2005	1493240	450498	-138082	7044	0	0	0	47446	6542	1,950,782	192069	-1,758,712
2	2006	0	0	-111120	48008	0	0	0	61317	6606	48,008	179043	-1,627,677
3	2007	0	0	-193952	135702	0	0	0	60711	7485	135,702	262148	-1,501,231
4	2008	0	0	-226863	215251	0	0	0	67458	5923	215,251	300244	-1,416,238
5	2009	0	0	-219192	134895	0	0	0	65177	6987	134,895	291355	-1,259,779
6	2010	0	0	-211779	130334	0	0	0	62973	6751	130,334	281502	-1,108,610
7	2011	0	0	-204618	125926	0	0	0	60843	6522	125,926	271983	-962,553
8	2012	0	0	-197698	121668	0	0	0	58786	6302	121,668	262786	-821,435
9	2013	0	0	-191013	117554	0	0	0	56798	6089	117,554	253899	-685,090
10	2014	0	0	-184553	113578	0	0	0	54877	5883	113,578	245313	-553,355
11	2015	0	0	-178312	109737	0	0	0	53021	5684	109,737	237018	-426,075
12	2016	0	0	-172283	106027	0	0	0	51228	5492	106,027	229002	-303,099
13	2017	0	0	-166457	102441	0	0	0	49496	5306	102,441	221258	-184,282
14	2018	0	0	-160828	98977	0	0	0	47822	5127	98,977	213776	-69,482
15	2019	0	0	-155389	95630	0	0	0	46205	4953	95,630	206547	41,435
Total		1,493,240	402,230	-2,060,803	1,981,326	0	0	0	787,091	787,091	1,815,993	866,966	

4.1.5 Summary

In MOBILIS/Toulouse, 28 new CNG buses were purchased, operated and evaluated. In this study, cost benefit analysis was carried out based on the cost data and impact evaluation results provided and compared with the costs for corresponding diesel buses.

- Larger initial investment in CNG buses is one of the main reasons for the negative NPV. In the Toulouse case, CNG buses were 24% more expensive than diesel buses, which contributes to 41% of the present value of extra cost.
- One of the main benefits of using CNG buses is the reduced fuel cost compared to that of using diesel buses. In terms of cost per 100km operation, fuel consumption cost of CNG buses is 58% of that of diesel buses. In the lifetime of the CNG buses, savings from reduction of fuel cost contribute 71% of the total benefits of using CNG buses (€2061k).
- In terms of environmental benefits, the major savings come from reductions of pollutant emissions which account for 21% of the total benefits, compared to 2% for greenhouse gas emissions.
- During the demonstration of the measure, maintenance costs for CNG buses were 60% more expensive than that of diesel buses, and this contributes to 47% of the total extra cost for replacing diesel buses with CNG buses. If the difference remains unchanged, the NPV was estimated to be €225k in the lifetime of the CNG buses.
- If the maintenance costs reduced to the level of diesel buses, the extra cost for replacing diesel buses with CNG buses would be recovered in year 9 (2013), and the NPV of using CNG buses would increase to €1,470K. Specific maintenance training and development of a specific CNG bus maintenance plan could help to bring these costs down.

In addition, if the lower cost of LPG compared with diesel is partly due to lower tax, then there will also be a cost to government, which has not been taken into account in the analysis.

Application of CNG buses may also contribute to a reduction in noise levels in urban area, even if this could be reduced by the characteristic short large difference in noise levels. Generally natural gas engines are far quieter than diesel engines, and they are the ideal choice for buses to run in noise-sensitive routes. However no measurements were provided about impacts on noise, so such benefits were not counted in the CBA analysis.

Thus, whilst the economic case for CNG buses appear poor on the basis of the demonstration data, it is likely that in the longer run, reduction in the differences in purchase and maintenance costs and the inclusion of additional benefits such as noise will lead to a more positive economic outcome. From Figure 4.1.5, it is evident a 35/40% reduction in the current difference in maintenance costs would lead to a positive Net Present Value.

4.2 MOBILIS/Toulouse 5.2-1: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Equipping diesel buses with soot filters)

4.2.1 Description of the measure

In the MOBILIS/Toulouse 5.2 measure, equipping diesel buses with soot filters (SF) was one of the two measures demonstrated for reducing pollutant emissions. In Toulouse, a new generation of soot filters was tested with diesel buses (Heuliez – GX 317). Actual implementation of the measure was as follows:

Stage 1: Acquisition of diesel buses fitted with particle filters (January 2006 – December 2007) – All through this period, Tisséo-SMTC acquired 101 diesel buses fitted with particle filters (96 buses were assigned to the urban network and 5 buses were assigned to run on a specific line to the airport).

Stage 2: Ordering and installation of particle filters on the diesel buses already being used (December 2006 - July 2007) – Tisséo-SMTC ordered and acquired 28 particle filters which were installed on the diesel buses of the existing fleet.

According to the evaluation results sheets provided, no baseline is available for performing a relevant comparison and evaluation for the buses purchased with a soot filter. Soot filter impact evaluation was focused on the 27 buses which were equipped with SF by the local public transport company.

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of MOBILIS/Toulouse 5.2: Solutions for alternative fuels in Toulouse (Equipping diesel buses with soot filters)

4.2.2 Monetised cost of the measure

SF investment costs

Investment cost for a soot filter was €7200 in 2007. For the 27 Heuliez – GX 317 buses evaluated, the total cost was €194,400.

The SF buses were used from 2008 with total annul mileage being estimated to be 1,195,690km.

Operation costs

No changes in fuel consumption costs were reported between buses with and without SF.

Maintenance costs

No changes in vehicle maintenance cost were reported between buses with and without SF.

4.2.3 Monetised benefits of the measure

Revenue

No changes were reported in revenue between buses with and without SF.

Savings from reductions of pollutant emissions

According to evaluation result sheets provided, the impacts of SF on emissions of nitrogen oxides, carbon monoxide, hydrocarbons, and particulates are shown in Table 4.2-1.

Table 4.2-1 Pollutant emission in 2008 (in tonnes)

	without SF	SF	gain
Hydrocarbons (HC)	14.5	16.2	-1.7
Particulates (PM10)	7.2	0.7	6.6

Values recommended by Plassat (2005) and IMPACT (2008) were based to monetise the savings in reducing pollutant and GHG emission.

Table 4.2-2 Costs of emission reductions (Plassat 2005)

	Price (€ / tonne)	**Source**
HC	2,000	Plassat (2005)
Particulates	156,900	IMPACT (2008)

In the project period, the total savings from reductions of pollutant emissions is calculated to be €1,093,534

<u>Savings from reductions of GHG emissions</u>

No changes were reported in GHG emissions between buses with and without SF.

4.2.4 NPV in the lifetime of SF

Test case and reference case: 27 diesel buses with and without Soot Filters

Evaluation period: 2007-2021

<u>Assumptions</u>

- Buses with and without using SF have equal lifetime (15 years)
- Discount rate: 3.5%
- Applications of SF do not result in additional demand for bus services and no changes in operating revenue
- Buses with and without SF have same impacts on accident rates and traffic congestion
- Buses with and without SF have equal mileages, and the annual mileages remain unchanged in the evaluation period
- Rates of pollutant emissions and greenhouse gas emissions remain unchanged in the evaluation period.
- No residual values remain at the end of the evaluation period

NPV in evaluation period

The details of extra costs, extra benefits, and their net present values are shown in Table 4.2-3.

- NPV are positive except for the first year in operation
- In the evaluation period, the NPV for the 27 SF buses is estimated to be €12,166k (in 2007 prices).
- In using SF buses, the main benefit is the reduction of pollutant emissions which was estimated to be €12,360k (in 2007 prices)

Application of SF may have some impacts on greenhouse gas emissions. No results were provided about such impacts in the evaluation report. In this study, such impacts are not included in the NPV calculation.

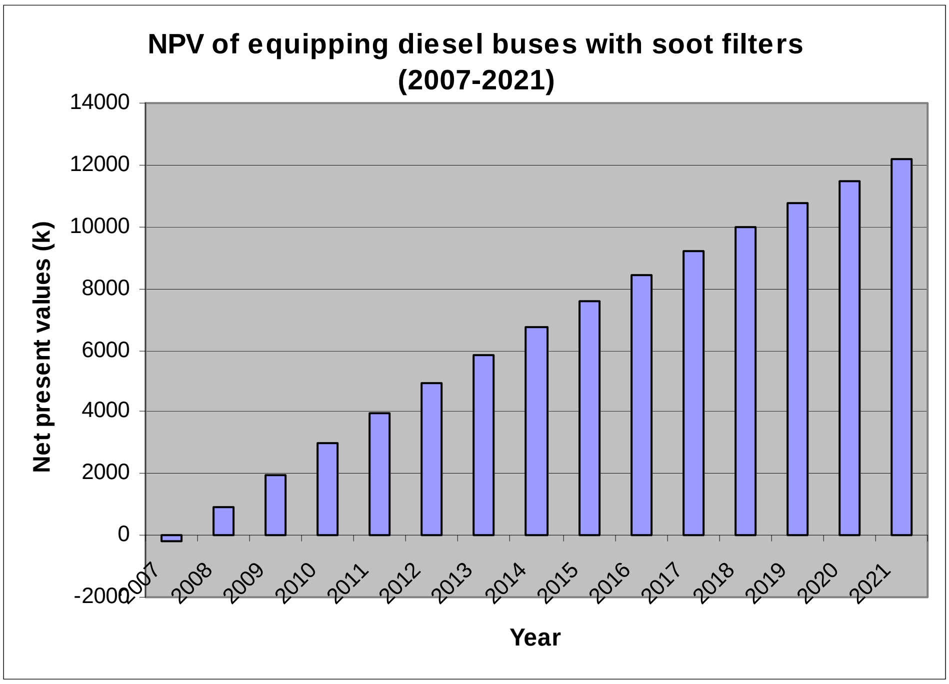

Figure 4.2-1 NPV of using soot filters with diesel buses

Table 4.2-3 Cost, benefit and NPV (in 2007 prices)

Year		Extra capital cost	Extra operating/maintenance cost			Extra non-user benefits				Total extra cost	Total extra benefits	NPV
		Soot Filter Investment (Euro)	Fuel (Euro)	Labour and parts (Euro)	Extra revenue (Euro)	JT savings (Euro)	Accident reduction (Euro)	Emission reduction (Euro)	Greenhouse gas reductions (Euro)	(Euro)	(Euro)	(Euro)
1	2007	194,400	0	0	0	0	0	0	0	194,400	-194,400	-194,400
2	2008	0	0	0	0	0	0	1,093,534	0	0	1,093,534	899,134
3	2009	0	0	0	0	0	0	1,056,554	0	0	1,056,554	1,955,689
4	2010	0	0	0	0	0	0	1,020,826	0	0	1,020,826	2,976,515
5	2011	0	0	0	0	0	0	986,305	0	0	986,305	3,962,820
6	2012	0	0	0	0	0	0	952,952	0	0	952,952	4,915,772
7	2013	0	0	0	0	0	0	920,726	0	0	920,726	5,836,499
8	2014	0	0	0	0	0	0	889,590	0	0	889,590	6,726,090
9	2015	0	0	0	0	0	0	859,508	0	0	859,508	7,585,598
10	2016	0	0	0	0	0	0	830,442	0	0	830,442	8,416,040
11	2017	0	0	0	0	0	0	802,360	0	0	802,360	9,218,400
12	2018	0	0	0	0	0	0	775,227	0	0	775,227	9,993,628
13	2019	0	0	0	0	0	0	749,011	0	0	749,011	10,742,639
14	2020	0	0	0	0	0	0	723,682	0	0	723,682	11,466,322
15	2021	0	0	0	0	0	0	699,210	0	0	699,210	12,165,532
Total		194,400	0	0	0	0	0	12,359,932	0	194,400	12,165,532	

4.2.5 Summary

In MOBILIS/Toulouse 5.2, a total of 27 Heuliez GX 317 buses were equipped with soot filters (SF) to demonstrate their impact on reducing pollutant emissions. Based on the cost data and impact evaluation results provided, the following conclusions can be drawn about the cost and benefits of the SF bus application:

- Except for the first year of the evaluation period (2007), NPV were positive from 2008 when SF buses started to be used. In the evaluation period, the NPV for the 27 SF buses was estimated to be €12,165k (in 2007 prices).
- Equipping diesel buses with soot filters reduces pollutant emissions particularly particulates, compared to the situation without SF. This is the main benefit considered in the cost-benefit analysis.
- A cost of €7,200 is required to equip a bus with a SF in 2007. This is the only extra cost reported in the project. With the increased applications of SF, the SF price may be reduced in the future, and this will result in an increased NPV.

The major impacts of SF is to reduce pollutant emissions particularly PM10 emissions. SF may have some impacts on greenhouse gas emissions. However in the current evaluation results provided, no data were provided about such impacts.

Application of SF may have some impacts on fuel consumption and maintenance costs. However in the current report, no results were provided about such impacts.

Recent evidence has indicated that PM10 may pose a much lower health risk than previously thought, and that smaller particles are more problematic. This may reduce the economic benefits.

4.3 MOBILIS/Toulouse 5.2-2: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Buses using bio-diesel)

4.3.1 Description of the measure

During the project, 81 bio-diesel fuelled GX107 and GX317 buses were tested (starting from January 2008). The buses tested used a fuel mix with 30 percent bio diesel (the other 70% is normal fossil diesel) which was is the maximum allowed percentage of biofuel legally allowed in France.

Stage 1: Feasibility study and recommendations for the use of biodiesel by the fleet of Tisséo buses (January 2006 – November 2006). In collaboration with the School of Agronomy in Toulouse, Tisséo-SMTC undertook a study into the feasibility of changing part of its diesel fleet to biodiesel.

Stage 2: In connection with the opening of the new bus depot of Langlade, Tisséo-SMTC started an experiment in which 81 diesel buses were run on biodiesel fuel during the year 2008 (biodiesel at 30%). The buses running on biodiesel were the oldest in the fleet.

More details on the implementation and evaluation of the measure can be found in the evaluation results sheets of MOBILIS/Toulouse 5.2: Solutions for alternative fuels in Toulouse (Bio-diesel buses)

4.3.2 Monetised cost of the measure

In Toulouse 5.2, a total of 81 bio-diesel buses were tested and evaluated. The bio-diesel buses test started from 2008 and covered a total mileage of 4,572,956km.

Extra investment cost

As an alternative to traditional diesel, bio-diesel mixed to a level of 30% to normal diesel can be directly used in traditional diesel engines, therefore no extra investment cost was incurred.

Extra fuel cost

It was reported that fuel cost an extra €1.21 per 100 km of bus operation compared to traditional diesel buses. Based on the annual mileages run, the total extra fuel cost for the 81 buses was calculated to be €55,333.

Extra maintenance cost

In this study, only parts and labour costs have been considered. According to results provided in the evaluation result sheet, an extra €0.45 parts cost and an extra €0.9 of labour cost were required for 100 km of bus operation compared to traditional diesel buses. This is mainly due to a necessary doubling of the oil change and initial filter cleansing. For the 81 buses tested, the extra maintenance cost was calculated to be €61,735 (assuming equal annual mileages with the bio-diesel and traditional diesel buses)

4.3.3 Monetised benefits of the measure

Savings from reductions of pollutant emissions

Based on emission rates and vehicle mileages reported in the evaluation result sheets, total emissions of CO and PM10 in 2008 are shown in Table 4.3-1.

Table 4.3-1 Emissions in 2008 (in tons)

	Diesel buses	Bio-diesel	Gain

		buses	
Carbon monoxide (CO)	246.1	196.2	49.9
Particulates (PM10)	27.9	22.6	5.3

Economic values recommended in Plassat (2005) and IMPACT (2008) were based to monetizing the reductions in pollutant emissions.

Table 4.3-2 Costs of emission reductions

	€ / ton	Source
CO	4	Plassat (2005)
particulates	156,900	IMPACT (2008)

From results above, the total savings from reductions of emissions in 2008 is estimated to be €832k. The main savings are in particulates.

<u>Savings from reductions of GHG emissions</u>

No changes were reported in GHG emissions between petrol-diesel and bio-diesel buses. However, significant benefits could be achieved, depending on the bio-diesel sources.

4.3.4 NPV in the lifetime of bio-diesel buses

In this study, the costs and benefits of using bio-diesel buses were evaluated for the period of 2008-2022 (against petrol-diesel buses)

<u>Assumptions</u>

- Lifetime of buses: 15 years
- Buses with and without using bio-diesel have equal lifetime
- Discount rate: 3.5%
- Applications of bio-diesel do not result in additional demand and revenues for bus services
- Buses with and without using bio-diesel have equal mileages, and the annual mileages remain unchanged in the evaluation period
- For both petrol-diesel and bio-diesel buses, pollutant emissions and greenhouse gas emission rates remain unchanged in the evaluation period.
- No residual values remain at the end of the evaluation period

<u>NPV in the lifetime of bio-diesel buses</u>

Detailed results of extra costs, benefits and NPV are shown in Table 4.3-3

- As can be seen, the NPV are positive for the whole evaluation period, i.e. the extra benefit outweighs the extra cost. By the end of the evaluation period, and net present value of extra benefit less cost is estimated to be €8,520k

— The present value of extra cost is estimated to be €1,396k. Of the total extra cost, fuel cost and maintenance cost account for 53% and 47% respectively.

— Compared to conventional diesel, bio-diesel can reduce emissions of carbon monoxide and particulates. For the 81 buses tested, the savings from reductions of pollutant emissions are estimated to be €9,915k.

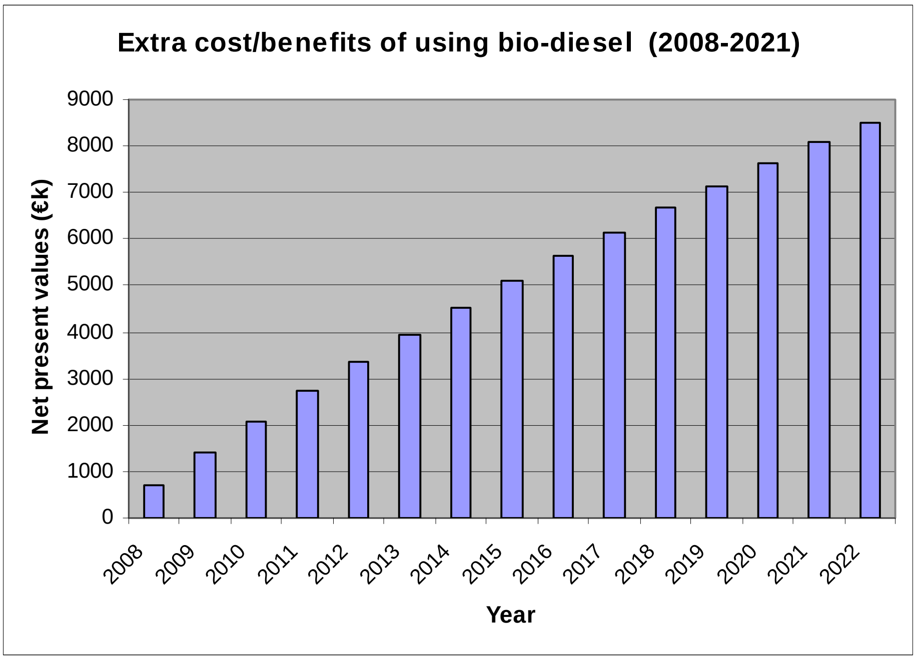

Figure 4.3-1 NPV in the period of 2008-2022

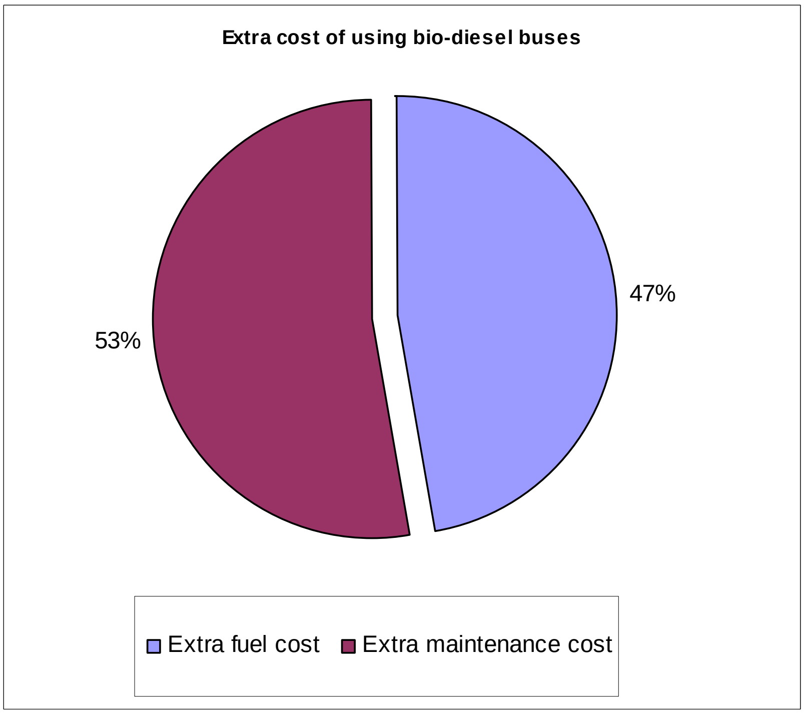

Figure 4.3-2 Extra cost of using bio-diesel buses

Table 4.3-3 Extra cost, benefits and NPV of using bio-diesel buses (in 2008 price)

Year		Extra capital cost		Extra operating/maintenance cost		Extra Revenue	Extra non-user benefits				Total extra Cost	Total extra benefits	NPV
		Vehicle (Euro)	Filling stations (Euro)	Fuel (Euro)	Labour and parts (Euro)	(Euro)	JT savings (Euro)	Accident Reduction (Euro)	Emission reduction (Euro)	Greenhouse gas reductions (Euro)	(Euro)	(Euro)	(Euro)
1	2008	0	0	55,333	61,735	0	0	0	831,769	0	117,068	831,769	714,702
2	2009	0	0	53,462	59,647	0	0	0	803,642	0	113,109	803,642	1,405,235
3	2010	0	0	51,654	57,630	0	0	0	776,466	0	109,284	776,466	2,072,416
4	2011	0	0	49,907	55,681	0	0	0	750,208	0	105,588	750,208	2,717,036
5	2012	0	0	48,219	53,798	0	0	0	724,839	0	102,018	724,839	3,339,857
6	2013	0	0	46,589	51,979	0	0	0	700,328	0	98,568	700,328	3,941,617
7	2014	0	0	45,013	50,221	0	0	0	676,645	0	952,,35	676,645	4,523,027
8	2015	0	0	43,491	48,523	0	0	0	653,763	0	92,014	653,763	5,084,776
9	2016	0	0	42,020	46,882	0	0	0	631,655	0	88,903	631,655	5,627,529
10	2017	0	0	40,599	45,297	0	0	0	610,295	0	85,896	610,295	6,151,928
11	2018	0	0	39,226	43,765	0	0	0	589,657	0	82,992	589,657	6,658,593
12	2019	0	0	37,900	42,285	0	0	0	569,717	0	80,185	569,717	7,148,125
13	2020	0	0	36,618	40,855	0	0	0	550,451	0	77,473	550,451	7,621,102
14	2021	0	0	35,380	39,474	0	0	0	531,837	0	74,854	531,837	8,078,086
15	2022	0	0	34,184	38,139	0	0	0	513,852	0	72,322	513,852	8,519,615
Total		0	0	659,595	735,913	0	0	0	9,915,124	0	1,395,509	9,915,124	

4.3.5 Summary

During the CIVITAS/MOBILIS project, 81 buses (HEULIEZ GX107 and GX317) were tested with bio-diesel. In this study, cost benefit analysis of using bio-diesel was carried out based on cost data and impact evaluation results provided by Toulouse. Based on the analysis results, the following conclusions can be drawn:

- The NPV would be positive from year 1 which means that the extra cost can be recovered for implementing bio-diesel buses. (this is an area which requires further detailed considerations as bio-diesel has a much higher freezing point and its use may be problematic in could weather. Also, the percentage of bio-diesel in the fuel mix will effect maintenance costs, particularly seals and filters. At present, the quality standards are not as adequate as those for standard diesel.)
- One of the advantages of using bio-diesel at 30% is that no in-vehicle capital investment is required, as bio-diesel can be directly used with current petrol-diesel engines.
- The main disadvantages of using bio-diesel buses are that fuel cost and maintenance costs are higher than those for traditional petrol diesel.

In the study, construction costs of bio-diesel filling stations have not been considered. If bio-diesel is not available at public stations, and a bus company wants their own supply, then the costs must be considered in the economic analysis.

Using bio-diesel will have some impacts on greenhouse gas emissions depending on the bio-diesel source. However, no results were provided about such impacts, and therefore, no costs/benefits relating to such impacts were included in this CBA study.

The most important selling argument of using bio-diesel was reductions in Greenhouse (CO2) emission, as the plants that are used to produce the bio-diesel first capture the CO2 out of the air. However, it is not clear what the overall greenhouse gas effects at this stage. In this cost/benefit study, GHG effects of using bio-diesel was not considered (no measurement results were provided in the evaluation report).

4.4 SMILE/Suceava 5.6: Alternative fuel bus fleet

4.4.1 Description of the measure

One major objective is to increase the number of public transport vehicles using clean and renewable fuels, thus reducing the use of diesel and leading the way to a sustainable transport system. Suceava Municipality together with the public transport company initiated the implementation of a new public transport plan which included the introduction of 15 new Euro 3 buses. This provided a good opportunity to reduce public transport pollution by starting the implementation of alternative fuel equipment on the buses. Fuels such as biogas and LPG offer the additional benefit of potentially reducing noise by 50 % and this is very important for the quality of life in the city. Implementation involved the following stages:

- The project implementation team developed a market survey to identify manufacturers and suppliers of buses.
- Preparing tendering documentation and organising the tendering procedure for acquisition of 15 new buses (less polluted).
- Receipt of the first set of 15 PT buses and making them operational - These buses were produced by IRISBUS-IVECO in France and they are equipped with Euro3 engines and have a capacity of 107 people. They have modern passengers' security systems, facilities for disabled people and electronic panels for providing variable message information, making them more comfortable and attractive for passengers. The old bus fleet was partly disposed of and replaced with these new buses and the trolleybus fleet was totally put off duty. The fleet consisted at that time of: the 15 new procured vehicles and 10 old Euro 0 vehicles, in total 25 buses.
- The LPG powered vehicles - The designated company, after completing the procurement procedure, delivered 15 buses in March 2006, initially with the standard fuelling - diesel, because the technology for LPG fuelling was not present in the production process, at the factory in France. This shortcoming was eliminated in a subsequent process, as, during the year 2007, after making operational the second set of new buses (other 15 buses have been procured), 14 buses from the first set were converted to LPG functioning by the manufacturer, and the 15th bus was equipped with a LPG converter system prototype, in collaboration with a Romanian company, designated within a public procurement process. From October 2007 on, all 15 buses received in the first set were entirely transformed into LPG fuelling.

The evaluation result sheet provided by Suceava was based on combined measures of Suceava 5.6, 8.8 and 8.9. Table 4.4-1 shows the main indicators of bus operation including revenue, cost, number of passengers and mileages (quarterly).

Table 4.4-1 Economy indicators (April 2006-June 2008)

	Q2 2006	**Q3 2006**	**Q4 2006**	**Q1 2007**	**Q2 2007**	**Q3 2007**	**Q4 2007**	**Q1 2008**	**Q2 2008**
Revenue – (Euro)	252,356	395,031	537,519	608,146	590,132	549,013	610,738	673,786	685,096
Cost – (Euro)	149,098	203,987	285,131	395,566	395,768	413,325	439,985	409,168	443,973

No. of passengers	1,016,755	1,511,952	1,414,357	1,686,977	1,805,483	1,871,099	1,946,313	1,833,429	1,947,437
Distance (km/month /vehicle	8,135	8,135	8,060	8,250	8,300	8,350	8,250	8,250	8,300
Operating revenue (Euro/pkm)	0.06	0.093	0.128	0.084	0.081	0.075	0.084	0.082	0.083
Operating cost (Euro/pkm)	0.035	0.048	0.068	0.054	0.054	0.056	0.06	0.05	0.054

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of SMILE/Suceava 5.6, 8.8 and 8.9: Alternative Fuel Bus Fleet & Support Measures.

4.4.2 Monetised cost of the measure

Investment for LPG buses

An extra €63,500 EURO was required to purchase a LPG bus over the cost of an equivalent diesel bus. During the Suceava 5.6 measure activity, 15 LPG buses were purchased with a total extra cost of €902,500.

According to the results provided by Suceava, the number of vehicles in the bus fleet is shown in Table 4.4-2. As can be seen, LPG buses started to be used from the second quarter of 2007.

Table 4.4-2 Number of LPG buses in operation (April 2006-June 2008)

	Q2 2006	**Q3 2006**	**Q4 2006**	**Q1 2007**	**Q2 2007**	**Q3 2007**	**Q4 2007**	**Q1 2008**	**Q2 2008**
New Irisbus-Iveco diesel	15	15	15	30	22	16	15	15	15
New Irisbus-Iveco LPG	0	0	0	0	6	12	15	15	15
Old UD 112, temporary replacement	10	10	10	0	2	2	0	0	0

Investment for LPG stations

No cost was reported for LPG stations in the project period.

Fuel consumption cost

Based on the average mileages of buses, the total mileages of LPG buses (quarterly) were estimated to be as shown in Table 4.4-3

Table 4.4-3 Number of LPG buses in operation (April 2006-June 2008)

	Q2 2006	**Q3 2006**	**Q4 2006**	**Q1 2007**	**Q2 2007**	**Q3 2007**	**Q4 2007**	**Q1 2008**	**Q2 2008**
New Irisbus-Iveco LPG	0	0	0	0	6	12	15	15	15
Mileages (km)	0	0	0	0	149,400	300,600	371,250	371,250	373,500

According to the test results, average fuel consumption for diesel buses was 45.5 l/100km. Compared to diesel buses, the LPG buses were less fuel efficient, with 16.5% more fuel being consumed per 100km bus operation. However, LPG was much cheaper than diesel in Suceava, and the average price of diesel was €0.88/l, compared to €0.42/l for LPG.

In Suceava, LPG buses started to use from the second quarter of 2007. Table 4.4-4 shows estimated fuel consumption costs from 2007 to 2008 (assuming diesel buses and LPG buses run equal mileages per quarter)

Table 4.4-4 Cost of fuel consumption

	Q1-2007	Q2-2007	Q3-2007	Q4-2007	Q1-2008	Q2-2008
Fuel consumption cost of diesel buses (€)	0	59,820	120,360	148,649	148,649	149,549
Fuel consumption cost of LPG buses (€)	0	33,256	66,914	82,640	82,640	83,141

Maintenance costs

In Suceava 5.6, maintenance costs of LPG buses were cheaper than for diesel buses. The maintenance cost of LPG buses was €50/100km, compared to €74/100km for diesel buses. Based on mileages and maintenance cost rates reported, maintenance cost for LPG buses and diesel buses are calculated as shown in Table 4.4-5

Table 4.4-5 Quarterly maintenance cost 2007/2008

	Q1-2007	Q2-2007	Q3-2007	Q4-2007	Q1-2008	Q2-2008
Diesel buses (€)	0	110556	222444	274725	274725	276390
LPG buses (€)	0	74700	150300	185625	185625	186750

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4.4.3 Monetised benefits of the measure

Savings from reductions of pollutant emissions

Based on the evaluation result sheets provided, CO, NOx and PM_{10} emission rates of diesel buses and LPG buses are shown in Table 4.4-6.

Table 4.4-6 Pollution emissions with diesel and LPG buses

	CO (g/km)	NOx (g/km)	PM_{10} (g/km)
Diesel buses	3.70	13.60	0.27
LPG buses	3.50	9.45	0.01

Based on the mileages provided, pollutant emissions in 2007 and 2008 are calculated as follows (quarterly):

Table 4.4-7 Pollutant emission (Q1-2007 to Q2-2008)

		Q1-2007	Q2-2007	Q3-2007	Q4-2007	Q1-2008	Q2-2008
Diesel buses	CO (kg)	0.0	553.3	1,113.3	1,375.0	1,375.0	1,383.3
	NOx (kg)	0.0	2,031.4	4,087.3	5,047.9	5,047.9	5,078.5
	PM10 (kg)	0.0	40.4	81.2	100.3	100.3	100.9
LPG buses	CO (kg)	0.0	522.9	1,052.1	1,299.4	1,299.4	1,307.3
	NOx (kg)	0.0	1,411.8	2,840.7	3,508.3	3,508.3	3,529.6
	PM10 (kg)	0.0	1.5	3.0	3.7	3.7	3.7

Savings from reduction of GHG emissions

Regarding greenhouse gas emissions, only CO2 emissions were measured in Suceava 5.6. For LPG buses, CO2 emission rate was 0.93kg/km, compare to 1.18kg/km for diesel buses. Based on the vehicle mileages recorded, CO2 emissions are calculated as shown in Table 4.4-8

Table 4.4-8 CO2 emissions

	Q1-2007	Q2-2007	Q3-2007	Q4-2007	Q1-2008	Q2-2008
Diesel buses (kg)	0	176,292	354,708	438,075	438,075	440,730
LPG buses (kg)	0	138,942	279,558	345,263	345,263	347,355

The costs used for monetizing the reductions of air pollutant and GHG emissions are shown in Table 4.5-9.

Table 4.5-9 Monetised values of pollutant emissions

	€/tonne	Source

CO	4	Plassat 2005
NOx	2,200	HEATCO 2006
PM10	3,800	HEATCO 2006
CO2	25	HEATCO 2006

4.4.4 Economic evaluations

In this study, costs and benefits analysis of using LPG buses is carried out over the time period of 2007-2021. The NPV calculation is based on changes in costs and benefits between LPG buses and traditional diesel buses.

Assumptions

- Lifetime of buses: 15 years
- Buses with and without using LPG have equal lifetime
- Discount rate: 3.5%
- Applications of LPG do not result in additional demand and revenues for the bus services
- Buses with and without using LPG have equal mileages, and the annual mileages remain unchanged in the evaluation period
- For both diesel and LPG buses, pollutant emissions and greenhouse gas emission rates remain unchanged in the evaluation period.
- The same price difference remains between LPG and normal Diesel
- LPG is taken at public LPG station, and therefore no additional costs are taken into account for an LPG filling station
- No additional costs for security and safety measures are taken into account
- No additional staff costs for bus filling at the public station are taken into account.
- No residual values remain at the end of the evaluation period

NPV in the lifetime of LPG buses

Detailed results of costs, benefits and NPV of using LPG buses are shown in Table 4.4-10:

- In the first year of operation, the NPV was calculated to be negative mainly because of the extra investment cost for LPG buses. After that, the NPV becomes positive which means that the extra benefits outweigh the extra costs of using LPG buses. Over the whole evaluation period, the net present value of extra benefit less the extra cost is estimated to be €8,734k

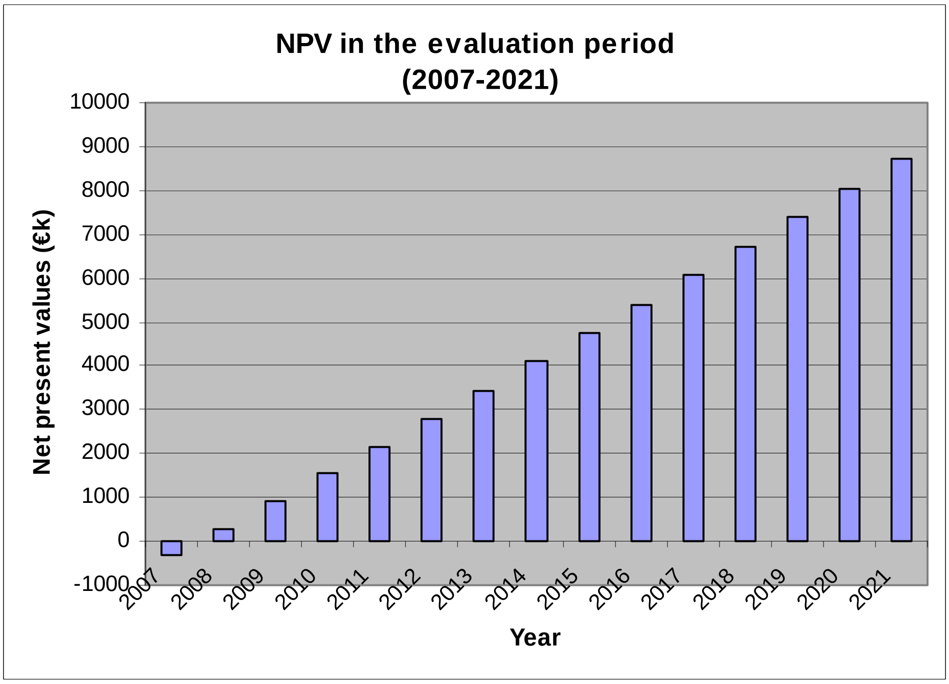


Figure 4.4-1 NPV in lifetime of LPG buses

- As LPG buses have lower fuel consumption and maintenance costs than diesel buses, the only true cost of using LPG buses is the extra expenses in investment of LPG buses.
- The benefits of using LPG buses are contributed to by savings of fuel consumption costs, savings of maintenance costs, and savings from reductions of pollutants and GHG emissions. Of the total benefit, savings maintenance cost accounts for 53%, savings of fuel costs 44%, savings from reductions of pollutant emissions 2%, and savings from reductions of GHG emissions 1%.
- Although LPG buses consumed 17% more fuel than that of diesel buses, applications of LPG in buses would reduce fuel consumption cost, because of the lower price of LPG in Suceava (47% of diesel price)

In the case of SMILE/Suceava 5.6, maintenance costs of LPG buses were found to be 32% lower than that of diesel buses. In order to understand how sensitive the NPV to the variations of maintenance cost, a series of sensitivity tests of the difference in maintenance cost between LPG buses and diesel buses were undertaken. Results are shown in Figure 4.4-3. If the maintenance cost of LPG buses increased from the current 68% to 100% of diesel buses (i.e. to levels of diesel buses), the NPV would reduce from €8,734k to €-358k.

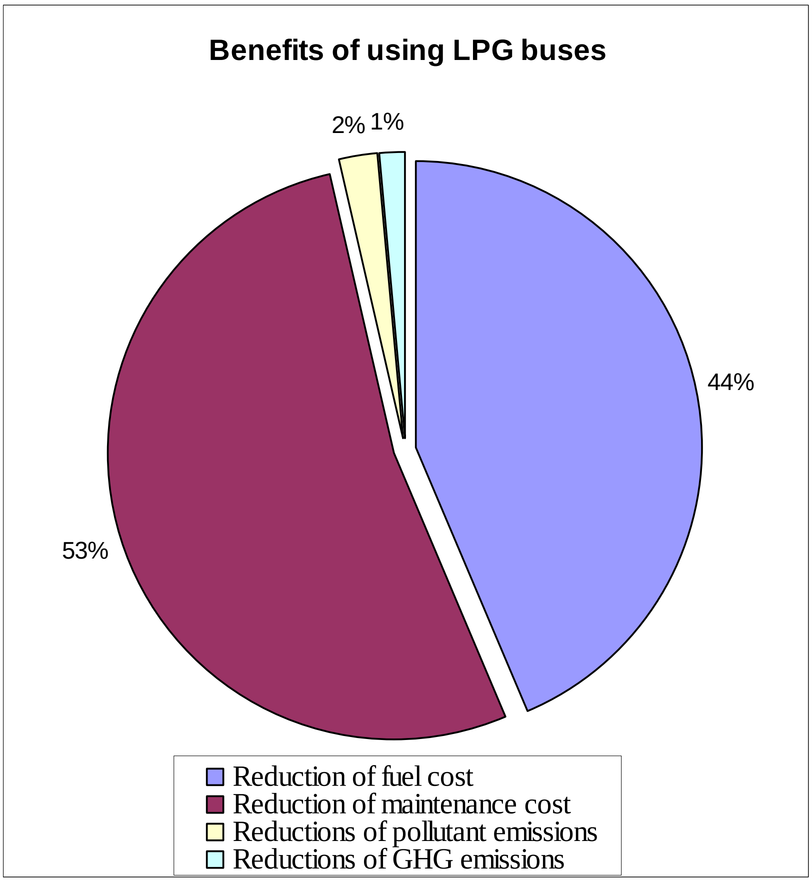


Figure 4.4-2 Distribution of the benefits from using LPG buses

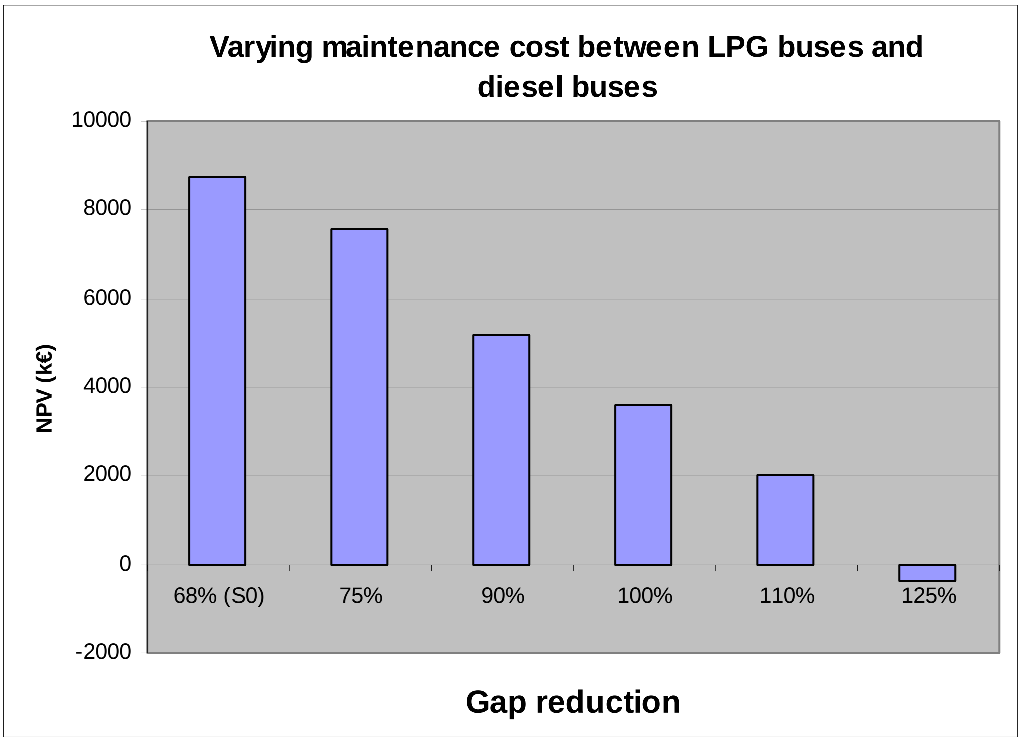


Figure 4.4-3 NPV with different gaps in maintence cost between LPG and diesel buses

Table 4.4-10 Cost and benefits of replacing diesel buses with LPG buses (in 2007 price)

Year		Extra capital cost		Extra operating/maintenance cost		Extra user benefits	Extra non-user benefits				Total extra cost	Total extra benefits	NPV
		Vehicle (Euro)	Filling stations (Euro)	Fuel (Euro)	Labour and parts (Euro)	revenue (Euro)	JT savings (Euro)	Accident reduction (Euro)	Emission reduction (Euro)	Greenhouse gas reductions (Euro)	(Euro)	(Euro)	(Euro)
1	2007	952,500	0	-251,871	-339,984	0	0	0	15,058	9,775	360,645	24,833	-335,812
2	2008	0	0	-255,765	-340,312	0	0	0	14,839	9,634	-596,078	24,473	284,739
3	2009	0	0	-259,719	-340,641	0	0	0	14,624	9,494	-600,360	24,118	909,218
4	2010	0	0	-263,734	-340,970	0	0	0	14,412	9,356	-604,704	23,769	1,537,691
5	2011	0	0	-267,811	-341,300	0	0	0	14,203	9,221	-609,111	23,424	2,170,226
6	2012	0	0	-271,951	-341,630	0	0	0	13,998	9,087	-613,581	23,085	2,806,891
7	2013	0	0	-276,155	-341,960	0	0	0	13,795	8,955	-618,115	22,750	3,447,756
8	2014	0	0	-280,424	-342,290	0	0	0	13,595	8,826	-622,714	22,421	4,092,891
9	2015	0	0	-284,759	-342,621	0	0	0	13,398	8,698	-627,380	22,096	4,742,367
10	2016	0	0	-289,161	-342,952	0	0	0	13,204	8,572	-632,113	21,775	5,396,256
11	2017	0	0	-293,632	-343,283	0	0	0	13,012	8,447	-636,915	21,460	6,054,630
12	2018	0	0	-298,171	-343,615	0	0	0	12,824	8,325	-641,786	21,149	6,717,564
13	2019	0	0	-302,780	-343,947	0	0	0	12,638	8,204	-646,727	20,842	7,385,134
14	2020	0	0	-307,461	-344,279	0	0	0	12,455	8,085	-651,740	20,540	8,057,414
15	2021	0	0	-312,214	-344,612	0	0	0	12,274	7,968	-656,826	20,243	8,734,482
Total		952,500	0	-4,215,609	-5,134,396	0	0	0	204,329	132,648	-8,397,505	336,977	

4.4.5 Summary

In SMILE/Suceava 5.6, a total of 15 buses were introduced with LPG rather than diesel fuel. Based on cost data and impact evaluation results provided, the following conclusions can be drawn about the cost and benefit of using LPG buses:

- Substantial benefits would be seen from using LPG buses rather than using diesel buses. Over the whole evaluation period, the net present value of extra benefit less the extra cost is estimated to be €9,335k
- Economically, one of the main advantages of using LPG is the lower cost of fuel used. Although LPG buses have slightly lower fuel efficiency than that of diesel buses, application of LPG buses benefit substantially from the lower price of LPG in Suceava (due to lower tax). In the evaluation period, savings from reductions of fuel cost contribute to 41% of the extra benefits of using LPG buses.
- In this case of LPG applications, the maintenance cost of LPG buses was 32% lower than that of diesel buses and this contributes to 50% of overall benefits in the evaluation period. The results show that when maintenance costs of LPG buses are the same as diesel buses, the NPV would reduce by 55%.

In Suceava, LPG buses go to public stations for refuelling. If bus companies wanted to build their own LPG stations to ensure bus operation, the cost of LPG stations should be considered in the cost/benefit analysis.

In addition, if the lower cost of LPG compared with diesel is partly due to lower tax, then there will also be a cost to government, which has not been taken into account in the analysis.

One issue with the use of LPG is that LPG is heavier than air and must be handled with caution. LPG leaks and spillage will not float upward and dissipate as will natural gas. LPG will "pool" in low spots and, unless blown away by air movement, will ignite if it comes in contact with a spark or open flame. This may have some special requirements for LPG bus maintenance which means additional cost for LPG buses. In this CBA study, such an impact was not addressed in the CBA analysis.

4.5 SMILE/Suceava 5.7: Marketing for alternative fuels in the public and private sector

4.5.1 Description of the measure

The main reason for implementing this measure was to reduce the environmental impact of traffic by using less polluting vehicles and by replacing the existing traditional fuels with alternative and less polluting fuels.

In SMILE/Suceava 5.7, LPG was demonstrated as an alternative fuel with 85 taxis being equipped with an LPG system and evaluated. Actual implementation of the measure included:

- Stage 1: Organising the implementation team and assigning the tasks
- Stage 2: Procurement of the Feasibility Study to design the SMILE measures implementation
- Stage 3: Organising marketing campaigns for alternative fuels and clean vehicles
- Stage 4: Organising promotion campaigns for alternative fuels and clean vehicles
- Stage 5: Monitoring the LPG fuel and vehicles market and promotion campaigns designed for the political sector
- Stage 6: Training for SMILE team members regarding biogas fuel
- Stage 7: Evaluation activities
- Stage 8: Dissemination activities

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of SMILE/Suceava 5.7: Marketing for alternative fuels in the public and private sector

4.5.2 Operating costs and revenues

In 2008, the fleet had 257 taxis in Suceava of which 85 taxis were powered by LPG, and the rest were powered by either diesel (32%), or gasoline (68%). Table 4.5-1 shows the monthly economic performance indicators from the evaluation result sheets provided by Suceava.

Table 4.5-1 Monthly economic performance indicators (2008)

	Diesel	Gasoline	LPG
Distance run (km/month)	3560	3880	3750
No of passengers per month per vehicle	440	400	425
Costs (Euro)	387.2	489.3	312.6
Incomes (Euro)	576.1	644.6	625.3
Cost per km (Euro/km)	0.106	0.126	0.083
Income per passenger (Euro/passenger)	1.31	1.61	1.47

Annual operation costs and revenues of the fleet

Based on the mileages and passengers carried, annual operating costs and revenues for the three types of taxis are shown in Table 4.5-2.

Table 4.5-2 Annual operating costs in 2008 (€, in 2008 prices)

		Diesel	Gasoline	LPG
Annual operating cost (Euro)	With LPG taxis	310,104	601,424	315,782
	Without LPG taxis	463,354	898,639	0

Table 4.5-3 shows the fuel efficiency of taxis powered by different fuels. As can be seen, LPG taxis consume 45.3% and 27.6% more fuels than diesel taxis and gasoline taxis. On the other hand, the price of LPG is much lower than that of diesel and gasoline. In Suceava, the average LPG price was €0.42/litre, compared to €0.84/litre for diesel in the project period.

Table 4.5-3 Efficiency of different fuels (2008)

	DACIA Diesel	OPEL Gasoline (premium)	DACIA LPG
Consumption of fuel (litres/100 km)	8.6	9.8	12.5

4.5.3 Monetised values of environmental impacts

Pollutant emissions

According to the evaluation results sheets provided, using LPG reduces pollutant emissions. Table 4.5-4 shows emissions of CO, NOx and PM10 taxis with and without using LPG in 2008.

Table 4.5-4 Pollutant emissions in 2008

	CO (kg)	NOx (kg)	PM10 (kg)
With LPG taxis	5747	5133	293
Without LPG taxis	6199	5282	437

The costs used for monetizing the reductions of air pollutant emissions are shown in Table 4.5-5. In the project period, average annual savings from reduction of CO, NOx and PM10 are estimated to be €877.

Table 4.5-5 Monetised values of pollutant emissions

	€/tonne	Source
CO	4	Plassat 2005
NOx	2,200	HEATCO 2006
PM10	3,800	HEATCO 2006

Greenhouse gas emissions

Table 4.5-6 shows the CO_2 emission in 2008 which were based on evaluation results sheets provided by Suceava.

Table 4.5-6 CO_2 emissions in 2008 (tonnes)

With LPG taxis	472
Without LPG taxis	678

Using the value of €25/ton of CO_2 (IMPACT 2008), the monetised values of the impacts in the cases of with and without using LPG are summarised in Table 4.5-7:

Table 4.5-7 Monetised values of CO_2 emissions (€, in 2008 price)

With LPG taxis	11,794
Without LPG taxis	16,957

4.5.4 Economic evaluations

In this study, costs and benefits of using LPG taxis were evaluated for the period of 2008-2022 (against taxis using petrol and diesel).

Assumptions

- Compared to the situation where only traditional fuels were used, the changes in operating costs were purely because of using LPG
- Taxis with and without using LPG have equal lifetime
- Discount rate: 3.5%
- Applications of LPG taxies did not result in additional demand for the taxi services
- Taxis with and without using LPG have equal mileages, and the annual mileages remain unchanged in the evaluation period
- Pollutant emissions and greenhouse gas emission levels remain unchanged in the evaluation period.
- The price difference between LPG and diesel remains the same.
- The rest value of the LPG taxi reduces equal in comparison with other fossil fuelled taxis
- No residual values remain at the end of the evaluation period

NPV in the lifetime of LPG taxis

Detailed results of costs, benefits and NPV of using LPG taxis are shown in Table 4.5-8:

- The NPV remains positive which means that the extra benefits are larger than the extra cost. Over the evaluation period, the NPV is calculated to be €2,078k.

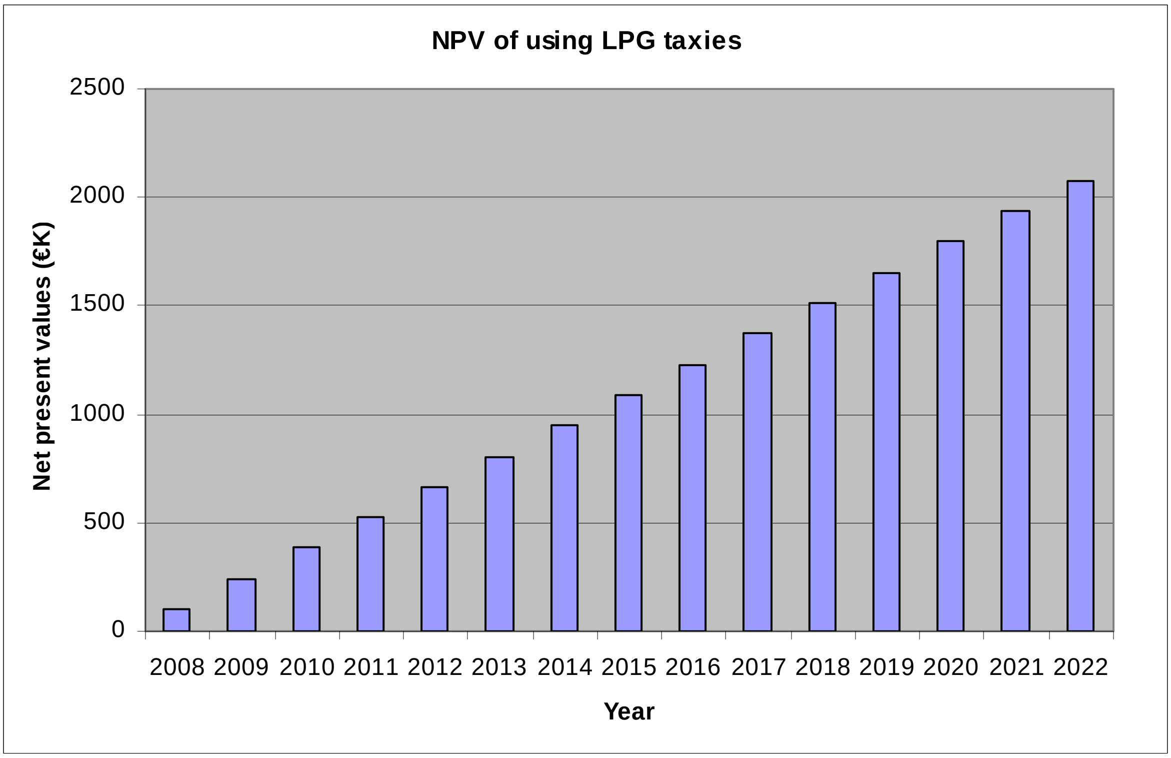


Figure 4.5-1 NPV of using LPG

— Savings in pollutant reduction and savings from GHG reduction account for 1% and 3% respectively.

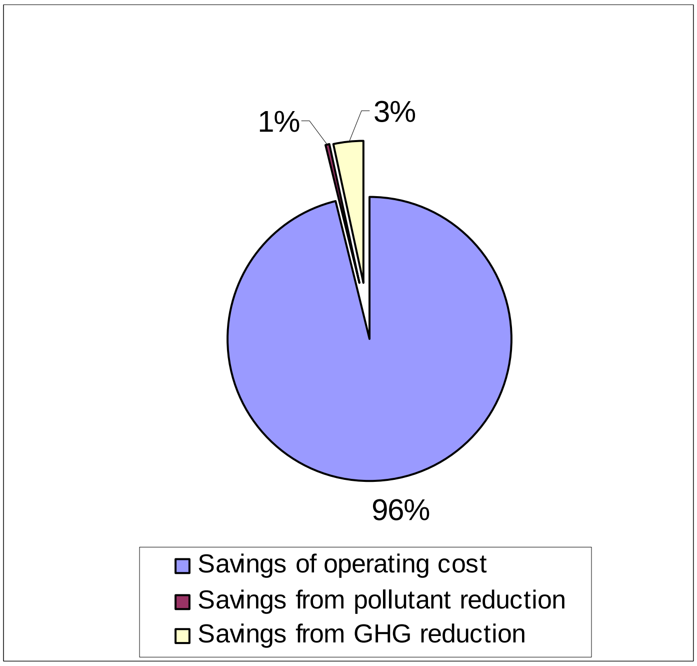


Figure 4.5-2 Distribution of benefits

Table 4.5-8 Extra cost, benefits and NPV of using LPG taxis (in 2008 price)

Year		Extra capital cost		Extra Operating cost	Extra Revenue	Extra non-user benefits				Total extra cost	Total Extra benefits	NPV
		Vehicle (Euro)	Filling stations (Euro)	(Euro)	(Euro)	JT savings (Euro)	Accident reduction (Euro)	Emission reduction (Euro)	Greenhouse gas reductions (Euro)	(Euro)	(Euro)	(Euro)
1	2008	38,250	0	-134,683	0	0	0	877	5,163	-96,433	6,039	102,472
2	2009	0	0	-134,813	0	0	0	864	5,088	-134,813	5,952	243,237
3	2010	0	0	-134,943	0	0	0	851	5,014	-134,943	5,866	384,046
4	2011	0	0	-135,074	0	0	0	839	4,942	-135,074	5,781	524,900
5	2012	0	0	-135,204	0	0	0	827	4,870	-135,204	5,697	665,801
6	2013	0	0	-135,335	0	0	0	815	4,799	-135,335	5,614	806,750
7	2014	0	0	-135,465	0	0	0	803	4,730	-135,465	5,533	947,749
8	2015	0	0	-135,596	0	0	0	791	4,661	-135,596	5,453	1,088,798
9	2016	0	0	-135,727	0	0	0	780	4,594	-135,727	5,374	1,229,899
10	2017	0	0	-135,859	0	0	0	769	4,527	-135,859	5,296	1,371,053
11	2018	0	0	-135,990	0	0	0	758	4,462	-135,990	5,219	1,512,262
12	2019	0	0	-136,121	0	0	0	747	4,397	-136,121	5,143	1,653,527
13	2020	0	0	-136,253	0	0	0	736	4,333	-136,253	5,069	1,794,848
14	2021	0	0	-136,384	0	0	0	725	4,270	-136,384	4,995	1,936,228
15	2022	0	0	-136,516	0	0	0	715	4,208	-136,516	4,923	2,077,667
Total		38,250	0	-2,033,963	0	0	0	11,895	70,059	-1,995,713	81,954	

4.5.5 Summary

In SMILE/Suceava 5.7, the application of LPG fuel in taxis was demonstrated. Based on the cost data and impact evaluation results provided by Suceava, the following conclusions can be drawn about the costs and benefist of using LPG taxis:

- In the evaluation period, the NPV of using LPG taxis remains positive which means that the extra benefits outweigh the extra cost of using LPG taxis rather than existing petrel/diesel taxis,.
- One of the main advantages of using LPG is the lower price of LPG in Suceava. Although LPG taxis consumed 27.6% more fuel than non-LPG taxis, overall the fuel cost of LPG taxis was much lower than that of diesel and gasoline taxis.

It is not taken into account if part of the lower costs of LPG is due to lower taxes of government in relation to other fossil fuels.

4.6 SUCCESS/La Rochelle 5.2 Introduction of new clean buses

4.6.1 Descriptions of the measure

In 2008, the La Rochelle Urban Community introduced 10 new buses which fully complied with the EEV (Enhanced Environmental Vehicles) standards, currently the strictest standards regarding environmental requirements at the European level. These buses use a process known as selective catalytic reduction (SCR) that injects an aqueous urea solution marketed under the name of AdBlue, into the gas stream and converts 85% of the nitrogen oxides in the exhaust gases into nitrogen and steam. The main objective of the measure was to improve the environmental performance of the bus fleet in La Rochelle.

The measure was implemented in the following stages:

Stage 1: Market Study (End of 2006 – March 2007) – La Rochelle Urban Community decided to purchase 10 new standard buses in 2007-2008, in full compliance with the willingness of local decision-makers to go further in the development of clean vehicles. EEV buses were considered as one of the most appropriate solutions for La Rochelle urban transport fleet.

Stage 2: Specifications and call for tender procedure (January to June 2007) – From the study, specifications were written for the purchase of 10 clean buses. The call for tender procedure was launched in April 2007 and the HEULIEZ Company was selected in June 2007 for delivering 10 EEV buses.

Stage 3: Installation of additional equipment (from spring 2007) – A study was carried out in order to assess the modifications for complying with the EEV norm concerning the vehicles as well as the installation of additional equipment required. The installation of a pump (5 m3-tank and specific equipments) supplying the AdBlue solution was planned at the filling bus station (bus depot). Indeed, such equipment did not exist in La Rochelle as no Euro 4 buses had been introduced in the PT fleet (SCR technology only used from Euro 4).

Stage 4: Preparation and equipment of the first 5 EEV buses (September to November 2007) – The buses were prepared and equipped with devices in order to be integrated into the La Rochelle bus fleet (Exploitation Aid System, Real time information, ticketing systems, and vocal announcement).

Stage 5: Tests (December 2007) – EEV buses were tested in traffic real conditions.

Stage 6: Introduction of the EEV buses (since January 2008) – 5 buses were first introduced from January 2008 and the 5 additional buses from May 2008. They represent over 10% of the whole bus fleet.

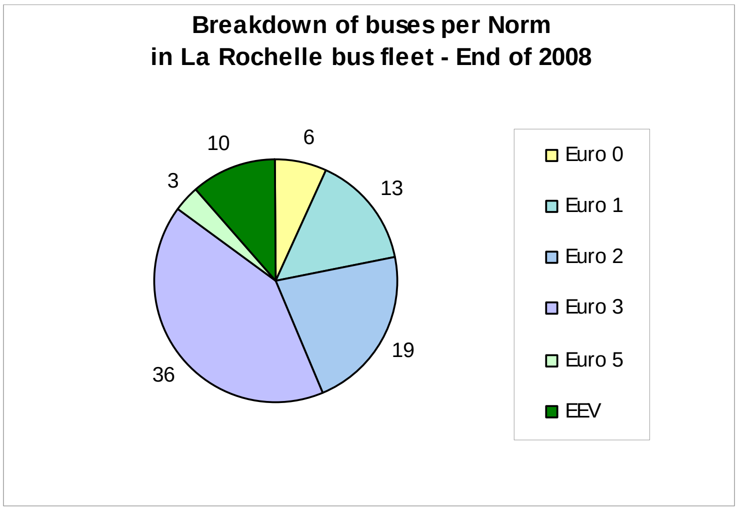


Figure 4.6-1 Breakdown of buses per norm in La Rochelle PT fleet (End of 2008)

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of SUCCESS/La Rochelle 5.2 Introduction of new clean buses

4.6.2 Monetised cost of the measure

<u>Set-up costs</u>

For EEV buses, the total set-up cost was 2.8 M€ including investment for 10 EEV buses (2.4M€ 2007/8), installing the ad-blue pump at the bus depot (0.125 M€), bus livery (0.01 M€) and indirect costs (0.25 M€).

For the GX317 buses, its price was 0.21 M€ (2007/8). For this study, it is assumed that GX317 buses have same livery and indirect cost as those of EEV buses.

<u>Operational costs</u>

In this study, the operational costs considered include fuel consumption costs, personnel costs, and maintenance costs. According to the evaluation result sheets provided, the fuel consumption costs for EEV buses was 0.442€/km in 2008, compared to 0.441€/km for the EURO III buses (GX317). The fuel cost of EEV buses included the Ad Blue cost.

For EEV buses, the maintenance cost was 0.77 €/km which included labour costs, spare parts costs and external repair costs. For the EURO III buses, the corresponding cost was 1.077€/km. For this study, an annul mileage of 42,000km was used to calculate annual cost of fuel consumption and maintenance.

Table 4.6-1 Operational cost in 2008

	EURO III	**EEV**
Fuel cost (€)	17640357	185640
Personnel cost (€)	12000	12000
Maintenance cost (€)	420000	323400
Other (€)	374852	374852

Total	18447209	895892

4.6.3 Monetised benefits of the measure

Savings from reductions of pollutant emissions

In the evaluation result sheets, the following emission measurements were provided for CO, HC, NOx, and particulates:

Table 4.6-2 Emissions rate (g/km)

	CO	HC	NOx	Particulate matters
GX 317 Euro III	2.6	0.67	19.69	0.18
HEULIEZ EEV	0.04	0.01	6.4	0.02

Based on mileages and the cost of pollutant reductions, the total savings from reductions of pollutant emissions was estimated to be 54,857€ in 2008 where

Savings from reductions of GHG emissions

Only CO2 emissions were provided in the evaluation result sheets. For EEV buses, the CO2 emission rate was measured to be 1,067.3g/km, compared to 1,090.44 g/km for the EURO III buses. In 2008, the total savings from reduction of CO2 emission was estimated to be 447 €.

Values recommended in in Plassat (2005), HEATCO (2006), and IMPACT (2008) were based in calculation of the savings from air pollutant and GHG emissions,.

Table 4.6.3 Emission cost

	€/tonne	Sources
CO	2	Plassat 2005
HC	2,000	Plassat 2005
NOx	7,700	2002 price, IMPACT (2008)
PM10	50,500	2002 price, IMPACT (2008)
CO2	25	2000 price, IMPACT (2008)

4.6.4 Economic evaluations

In this study, cost, and benefits analysis of using EEV buses has been carried out for the time period of 2007-2014). The NPV calculation is based on changes in costs and benefits for investing in EEV buses rather than traditional diesel buses.

Assumptions

— EEV and EURO buses have equal lifetime

- Discount rate: 3.5%
- Applications of EEV buses do not result in additional demand and revenue for the bus services
- EEV and EURO III buses have equal annual mileages
- For both EEV and EURO buses, pollutant emissions and greenhouse gas emission remain unchanged in the evaluation period.
- No residual values remain at the end of the evaluation period

NPV in the evaluation period

Details of the costs, benefits and NPV of the measure are shown in Table 4.6-4.

- As can be seen, NPV becomes positive in year 3 (i.e. 2009) which means that the extra cost for implementing EEV buses (in comparison with that of diesel buses) would be recovered one year after operation. Over the whole evaluation period, the net present value of extra benefit less the extra cost is estimated to be €707k

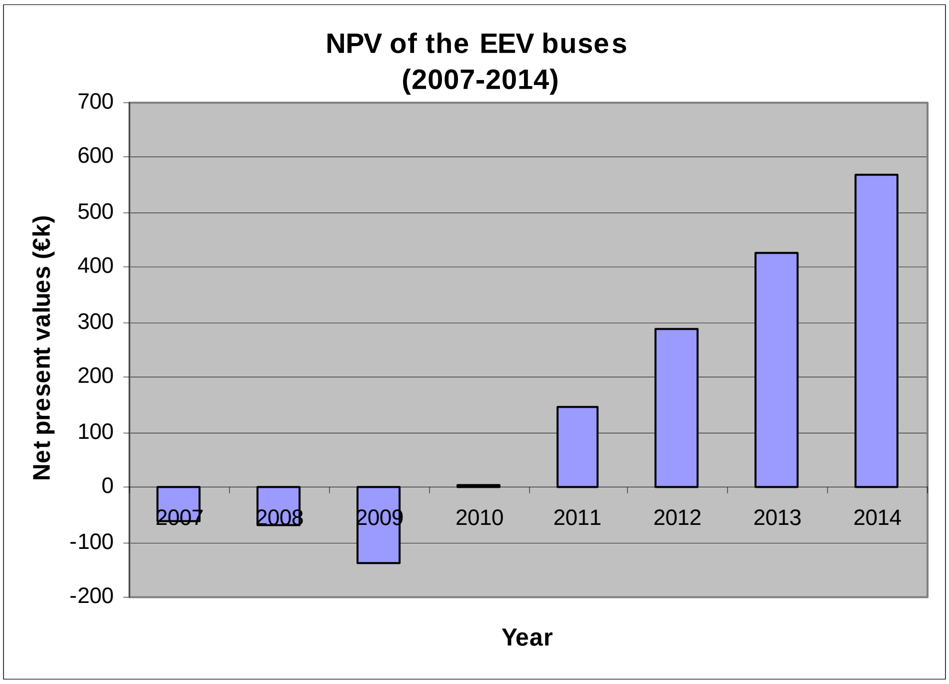


Figure 4.6-2 NPV of EEV buses in the evaluation period

- The extra cost of using EEV buses included the cost in purchasing the EEV buses and fuel consumption. The purchase cost of the 10 EEV buses accounted for 99% of the total cost.

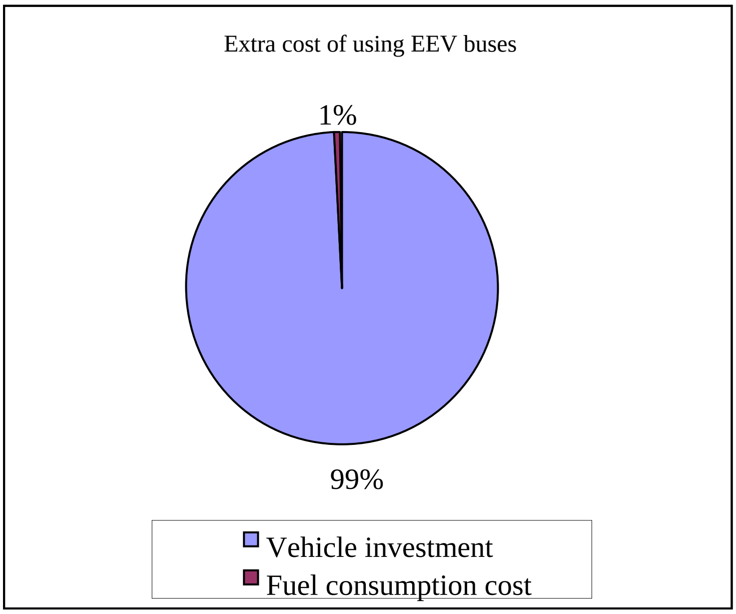


Figure 4.6.3 Total extra cost

— The benefits of using EEV buses consisted of savings in maintenance costs, and savings from reductions in pollutant and GHG emissions. Of the total benefits, savings of maintenance cost accounted for 68.3%, and savings from reductions of pollutant emissions and savings from reductions of GHG emissions accounted for 31.4% and 0.3% respectively.

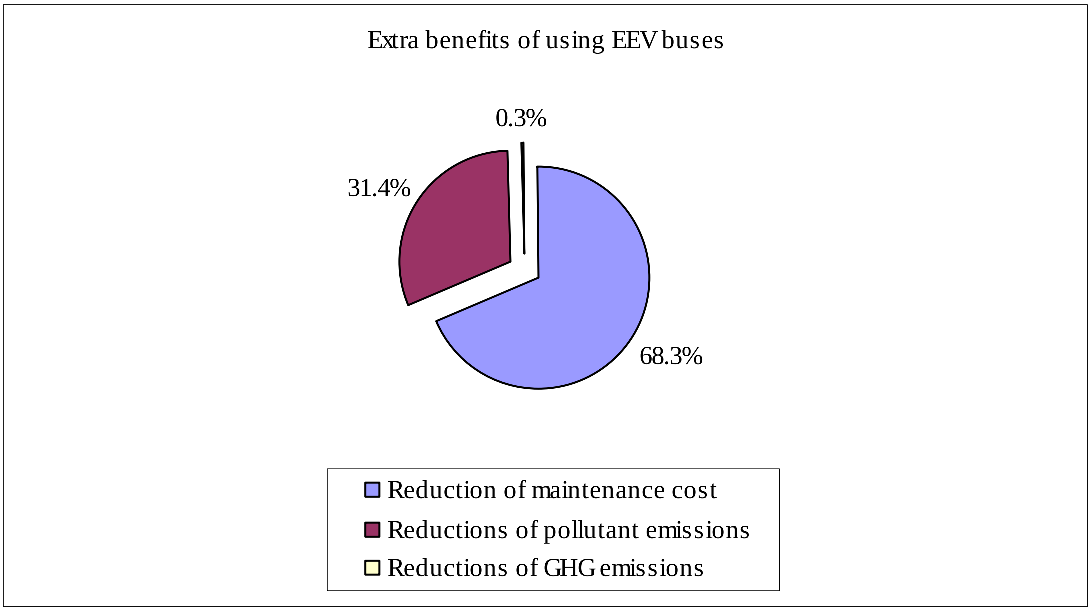


Figure 4.6-4 Distribution of the total extra benefits of using EEV buses

In the case of La Rochelle, maintenance costs of EEV buses was 23% lower than that of diesel buses. In order to understand the sensitivity of NPV, a series of differences in maintenance cost between LPG buses and diesel buses were investigated. The results given in Figure 4.5-6 are for maintenance cost of EEV increases from 77% to 100% of the maintenance cost of diesel buses. As can be seen, the NPV become negative when EEV and diesel buses have equal maintenance cost.

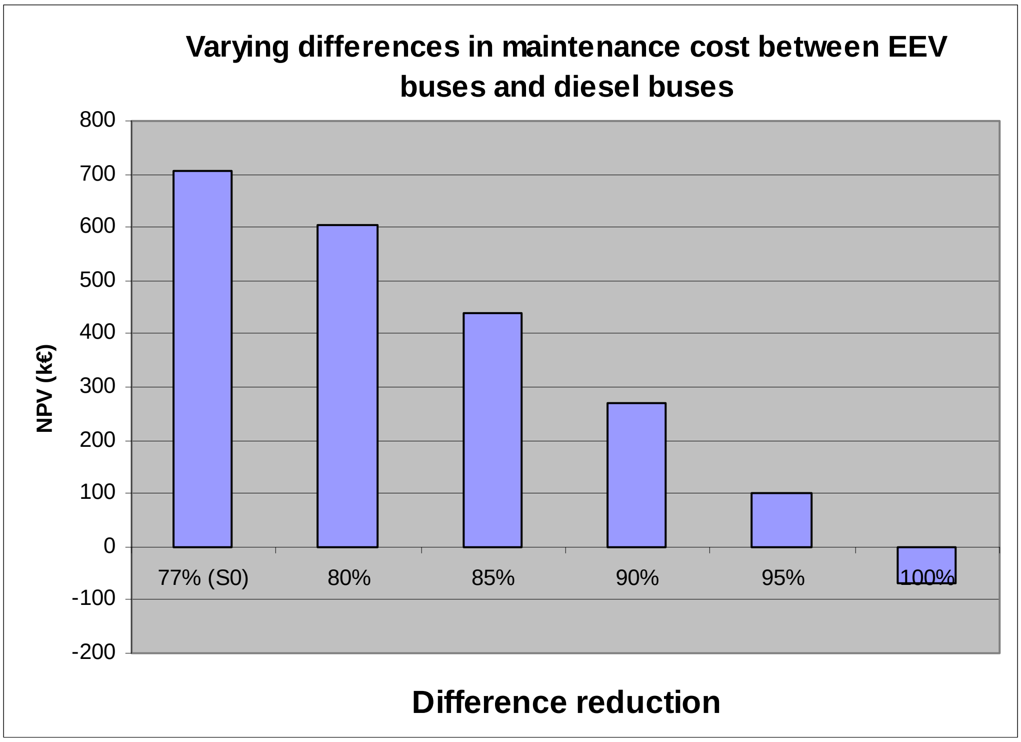


Figure 4.6-5 NPV with different gaps in maintence cost between EEV and diesel buses

Table 4.6-4 Cost, benefit and NPV of the measure (in 2007 price)

Year		**Extra set-up cost**		**Extra operational cost**		**Extra user benefits**	**Extra non-user benefits**				**Total extra cost**	**Total extra benefits**	**NPV**
		Vehicle (Euro)	**Filling stations (Euro)**	**Fuel (Euro)**	**Labour and parts (Euro)**	**Revenue (Euro)**	**JT savings (Euro)**	**Accident reduction (Euro)**	**Emission reduction (Euro)**	**Greenhouse gas reductions (Euro)**	**(Euro)**	**(Euro)**	**(Euro)**
1	2007	212,500	0	420	-96,600	0	0	0	46,932	447	212,920	143,979	-68,941
2	2008	212,500	0	426	-96,693	0	0	0	46,252	441	212,926	143,386	-138,481
3	2009	0	0	433	-96,787	0	0	0	45,582	434	433	142,803	3,888
4	2010	0	0	440	-96,880	0	0	0	44,921	428	440	142,229	145,678
5	2011	0	0	447	-96,974	0	0	0	44,270	422	447	141,666	286,897
6	2012	0	0	453	-97,068	0	0	0	43,628	416	453	141,112	427,555
7	2013	0	0	460	-97,161	0	0	0	42,996	410	460	140,567	567,661
8	2014	0	0	468	-97,255	0	0	0	42,373	404	468	140,032	707,226
Total		425,000	0	3,548	-775,418	0	0	0	356,954	3,400	428,548	1,135,773	

4.6.5 Summary

In MOBILIS/La Rochelle 5.2, EEV buses were tested against diesel buses. Based on the cost data and impact evaluation results, the following conclusions can be drawn:

- The extra cost of implementing EEV buses was recovered after one year of operation. Over the whole evaluation period, the net present value of extra benefits less the extra costs+ is estimated to be €768k
- One of the main advantages of EEV buses is the lower emissions compared to standard diesel buses. In the evaluation period, savings from reduction of pollutant emissions account for one third of the total benefits of EEV buses.
- A major disadvantage is that EEV buses are about 15% more expensive than their counterparts.
- In this case of EEV bus application, the maintenance costs of EEV buses was 23% lower than that of diesel buses and this contribute to 65% of total benefits in the evaluation period. If the maintenance cost of EEV buses increases to the level of diesel buses, the NPV would become negative.

4.7 SMILE/Malmo 9.1: Car sharing for business and private persons

4.7.1 Descriptions of the measure

Car-sharing may be considered to be similar to having access to your own car - without owning one (and is also known as 'car clubs', particularly when applied to private individuals only). This particular measure is important for developing a transport system where citizens are not dependent on traditional private car ownership for all of their mobility. Specifically this measure aimed to establish five car-sharing sites in the city of Malmö for different kinds of users to provide people, companies and organizations in Malmö with access to environmentally sound vehicles and flexible transport wherever and whenever needed and Sunfleet established five car sharing locations in Malmö

No commercial car-sharing alternatives existed in Malmö prior to SMILE. Five car-sharing sites with a total of 15 cars for public and private companies, private users and other organizations were established by the end of 2007. Almost all cars were clean vehicles, i.e. could run on fuels other than petrol (the exception being some petrol fuelled 'super minis').

All 5 sites were located in the central parts of Malmö. One of the sites was located next to the Central Station, which is interesting for a possible partnership with Skånetrafiken (Regional Transit Authority). By letting all users access all car sharing sites the chance of availability increases and it also creates more possibilities for the use of the cars and for the car sharing business to succeed.

At each site, Sunfleet attempted to offer cars with different alternative fuels in response to customer preference. This means that sites have different car models and of varying sizes. Unlocking/locking the door can be done by using subscriber's mobile phones or text messages.

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of SMILE/Malmo 9.1: Car sharing for business and private persons.

4.7.2 Monetised cost of the measure

<u>Vehicle investment</u>

In the project period, 15 vehicles were purchased. Only new cars were bought and they were changed every second year. An average cost for the vehicles including VAT was 225,000 SEK with a residual value of 55%.

<u>Parking site costs</u>

According to evaluation result sheets provided, 5 parking sites were established. The mounting fees for parking signs, etc, varied between 500 and 2,000 SEK

<u>Operating costs</u>

According to the evaluation result sheets provided, the operation costs (including cost for unlocking/locking the door using subscriber's mobile phones or text messages, and cost for marketing activities) of the car-sharing sites in the period of March 2006 to April 2008 are shown in Table 4.7-2.

Table 4.7-1 Number of vehicle-months in the five car-sharing sites

	Centralen	Västra Hamnen	Anna	Caroli	WTC
Months in operation	25	24	13	13	5

Table 4.7-2 Total operating costs in the period March 06-April 08

	Centralen	Västra Hamnen	Anna	Caroli	WTC
“Installation” cost (SEK)	26,000	21,000	29,000	12,000	13,000
Vehicle use cost (SEK)	315,335	304,726	310,472	154,757	87,285
Operating Cost (SEK)	341,335	325,726	339,472	166,757	100,285

4.7.3 Monetised benefits of the measure

Revenue

According to evaluation result sheets of the measure, the operation revenues of car-sharing in the period of March 2006 to April 2008 are shown in Table 4.7-3.

Table 4.7-3 Total revenue in the period of March 06-April 08

	Centralen	Västra Hamnen	Anna	Caroli	WTC
Vehicle revenue (SEK)	342,132	387,902	330,774	115,984	127,016
Subscription revenue (SEK)	67,475	75,041	69,042	36,139	22,676
Total revenue (SEK)	409,607	462,943	399,816	152,123	149,692

Savings from reductions of pollutant emissions

According to evaluation result sheets provided, emissions of CO2, NOx and PM10 are shown in Table 4.7-3.

Table 4.7-3 Monthly emssions with and without Car-Sharing

	Do-nothing	Car-sharing
CO2	6,000kg	3,470kg
NOx	2,100g	845g
PM10	120g	105g

According to evaluation results sheets provided by Malmo, the total reductions of CO2, NOx, PM10 and their monetised values are shown in Table 4.7-4 (Assuming an average of 16 months in operation).

Values recommended in IMPACT (2008) were based for monetizing the reductions of CO2, NOx and PM10.

Table 4.7-4 Total savings in the period of Mar 2006 to April 2008

	SEK per tonne of emission	Sources
CO2	263	IMPACT (2008), exchange rate: € 1= SEK10.5
NOx	23,100	
PM10	476,700	

4.7.4 Economic evaluations

In this study, costs and benefits of car-sharing are evaluated against a Do-Nothing scenario over the time period of 2005-2008) with NPV and BCR (benefit cost ratio) being used as the main evaluation indicators.

Assumptions

- Evaluation period: 4 years
- Discount rate: 3.5%
- All kilometres driven by Sunfleet cars would otherwise be driven by petrol-fuelled cars.
- That the mix of fuel usage by the vehicles has been, in terms of energy content, 25.6% gas, 40.9% petrol, 33.5% E85.
- "Fuel gas" is a 50-50 mixture of natural gas and locally produced biogas.
- The monthly distance travelled in April 2008 using Sunfleet vehicles (i.e. 30,000 km) is equal to that travelled by other vehicles during April 2005.
- No consideration has been given to (a) access/egress to the car-sharing sites nor (b) reduced costs of permanent car ownership

NPV in the evaluation period

Detailed results of costs, benefits and NPV of the car-sharing are shown in Table 4.5-6:

- In the evaluation period, NPV of car-sharing is estimated to be SEK-1374k and benefit-cost ratio (BCR) is 0.654.

Table 4.5-5 Cost/benefit indictors (in 2006 price)

PVC (SEK)	**PVB (SEK)**	**NPV (SEK)**	**BCR**
3,952,365	2,579,437	-1,372,929	0.65

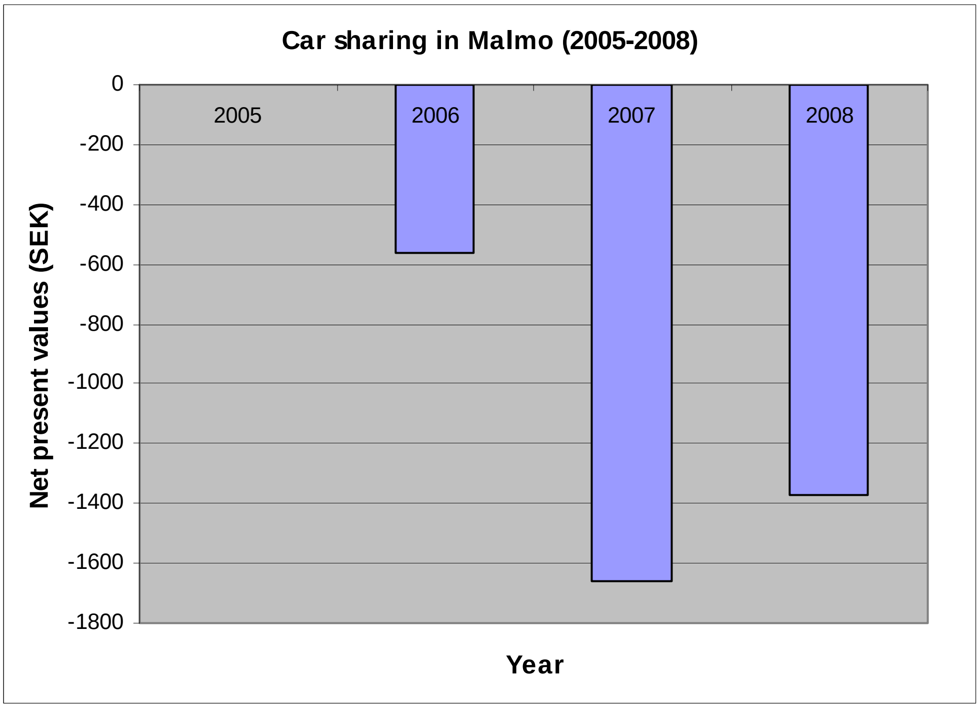


Figure 4.7-1 NPV of car-sharing in Malmo

- Net revenue accounts for about 99%, and savings from emission reductions accounts for less than 1% of the present value of benefit (PVB)
- Vehicle investment costs, parking site investments and operating costs account for 52.7%, 0.2% and 47.1% of the present value of cost (PVB) respectively

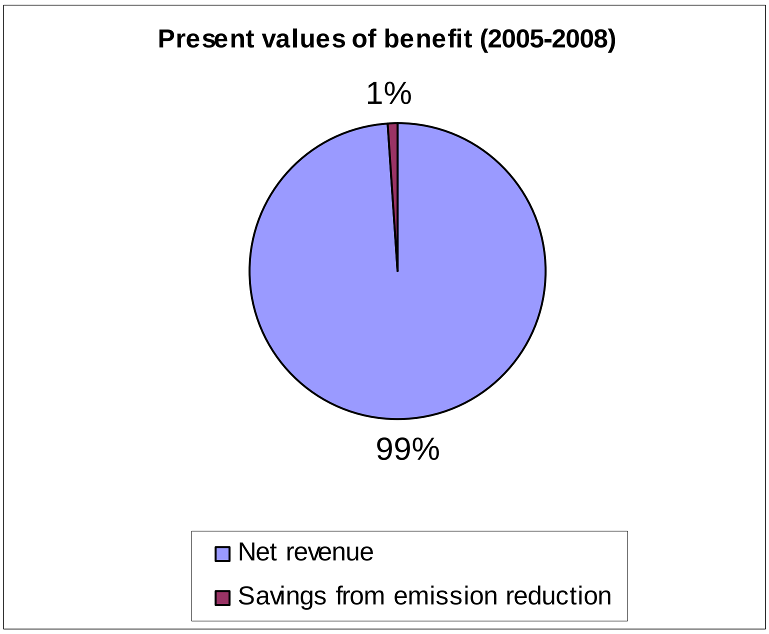


Figure 4.7-2 Present value of benefit

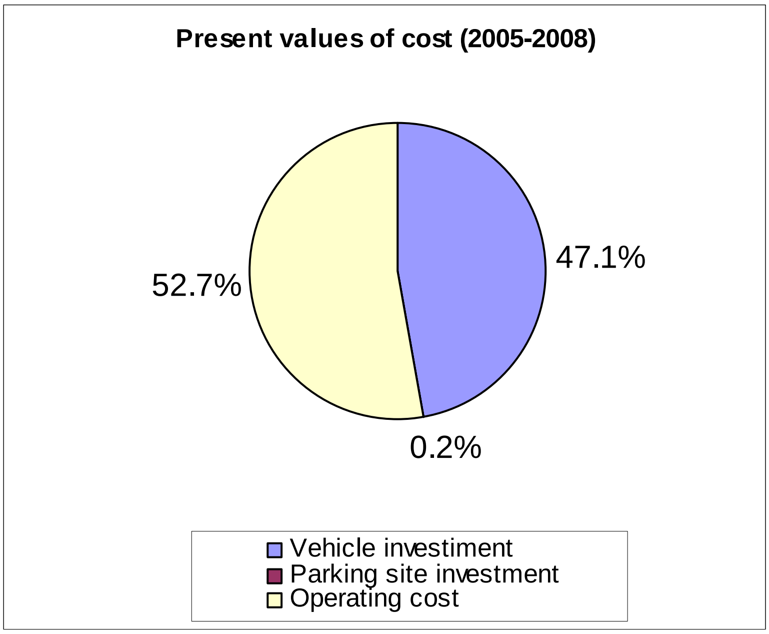


Figure 4.7-3 Present value of cost

Table 4.6-1 Cost, benefit and NPV of car-sharing (20065 price)

Year	Capitial cost		Operating Cost	Operating revenue	Savings from emission reductions		Total cost	Total benefits	NPV
	Vehicle Investment (SEK)	Parking site investment (SEK)	(SEK)	(SEK)	Pollutant emission (SEK)	Greenhouse gas emissions (SEK)	(SEK)	(SEK)	(SEK)
2005	0	0	0	0	0	0	0	0	**0**
2006	618,750	6,250	260,049	321,430	207	4,069	889,118	32,5705	-563,413
2007	1,238,696	0	614,042	758,977	204	4,010	1,856,748	763,190	-1,656,971
2008	0	0	1,202,548	1,486,389	201	3,952	1,206,500	1,490,542	-1,372,929
Total	1,857,446	6,250	2,076,640	2,566,796	611	12030	3,952,365 PVC	2,579,437 PVB	

4.7.5 Summary

In SMILE/Malmo 9.1, a car-sharing service with 15 clean cars at five sites was demonstrated in Malmo. Based on the cost data and impact evaluation results provided, the following conclusions can be drawn about the costs and benefits of car-sharing:

- Based on the data provided, the total investment was not recovered during the project period even with the non-user benefits being included. The NPV is estimated to be SEK-1,373k.
- The vehicle investment cost was the major cost for providing the service which accounted for over half of the total cost.
- Because of using clean cars, some savings would be seen from reductions of CO_2, NO_x and PM_{10} against the full petrol car utilisation. However, the contribution was marginal and accounts for less than 1% of the total benefits.

Because no detailed results were provided about changes in travel behaviour away from the use of the private car, the benefits from reduced private car use were not considered in this study. Thus may be very significant in the longer run.

4.8 SMILE/Norwich 11.4: Car pooling (sharing)

4.8.1 Description of the measure

Car pooling is known as car sharing in the UK and for the purposes of this report is defined to be ‘the practice whereby individuals get together to share private vehicles for specific journeys.

This measure has worked with the business community and larger organisations in the Norwich area of England to identify which establishments could benefit from setting up a car sharing scheme. The establishments with the highest potential to benefit from car sharing have been approached and supported through set up and implementation of car share schemes. The measure seeks to

1. Contribute to a reduction in local congestion by reducing the number of commuters travelling to the establishments by single occupancy car trips. The reduction in congestion will be measured by the number of car share members within the individual establishments and collectively members of the public group.

2. Contribute to a reduction in environmental pollution measured as a reduction in CO2 emissions. This will be measured by the amount of CO2 saved through the measure implementation.

3. Reduce the number of miles travelled by commuters to get to and from their workplaces.

4. Reduce the cost of commuting by reducing the number of miles travelled by the individual commuters by car sharing to work – measured by miles and therefore money saved on travel expenses.

The measure was implemented in the following stages:

Stage 1 : Time and resource allocated (May 2005 – June 2005) Funding for the re-branding was agreed and on-going costs of using the software were negotiated with the software supplier.

Stage 2: Update to existing car Share facility, Re-brand and Re-launch (May 2005 – June 2006) A professional marketing organisation was appointed to re-brand the look of the car share initiative for the Norfolk Public Group. DIVA the appointed company designed a new car share suite of promotional material for both management and users. The website was also re-branded and launched at the Royal Norfolk Show in June 2006.

Stage 3: Identified target establishments (May 2005 – September 2006) Organisations with the potential for car sharing were approached. The workplaces with large numbers of employees and a history of on site car parking issues were identified as being the most likely to benefit form a formal car share scheme.

Stage 4: Approached target businesses (September 2005 – November 2007)

The following businesses in the CVITAS area were targeted as establishments suffering with chronic parking issues for both staff and visitors.

- Norwich City Council (Norwich CC),
- Norfolk County Council (Norfolk CC),
- Norfolk & Norwich Hospital (N&N)
- University Of East Anglia (UEA)
- Norwich Union (NU)
- Norwich City Football Club (NCFC)

Businesses were contacted to set up car share schemes.

Stage 5: Public Groups set up (September 2005 – November 2007) Public groups were set up to increase match rate between members of the private groups. These included the main overarching group for the general public, Norwich Commuters and the Royal Norfolk Show, a large Norfolk event that causes mayhem on the road network each year due to the volume of vehicles converging on one site on the outskirts of the CIVITAS area.

Stage 6: Implement Marketing & Campaigning (July 2005 – ongoing through life of project) Some of the orgnaisations held events to launch and promote their schemes supported by the measure leader.

Stage 7: Schools approached to pilot different approaches to car sharing. (May 2006 – May 2008) Notre Dame school, a large school in the CIVITAS area with a wide catchment of pupils accessing the school from all over Norfolk, was approached to trial a school version of car sharing at www.schoolrun.org. The school had developed a travel plan and the mode of travel survey showed a high potential for car sharing to school. The school were offered a discounted rate to try an online car share scheme called 'School Run'. Cluster schools in the CIVITAS area were offered the chance to enourage parents to car share from the school to workplaces in Norwich. Another school cluster in the CIVITAS area piloted a big promoton of car sharing with large area maps and flyers promoting car share at parents' evenings.

Table 4.8-1 Data collected for the period Sep 2005 – May 2008

No.	Impact	Indicator 1 Members (approx potential members)	Indicator 2 CO2 tonnes saved	Indicator 3 Miles saved	Indicator 4 Money Saved
1	Broadland Business Park	38 (2000)	0.68	3,721	£372
2	Drayton & Taverham Cluster	4 (unlimited)	0	0	0
3	N&N Hospital	179 (3000)	12.41	65,036	£6,504
4	Norfolk County Council	206 (2000)	19.11	100,656	£10,065
5	Norwich City Council	17 (700)	0	0	0
6	Norwich Commuters Club	130 (unlimited)	19.34	101,723	£10,172
7	Norwich City Football Club	26 (unlimited)	1.07	5,416	£542
8	Norwich Independent Schools	New 08	-	-	-
9	Norwich Union (Pilot)	26 (1000)	4.45	22,846	£2,285
10	Royal Norfolk Show	14 (unlimited)	0.13	663	£66
11	University East Anglia	287 (30,000)	19.27	101,414	£10,141
12	May Gurney	New 08	-	-	-
13	General Public Group	2167 (unlimited)	76.46	401,475	£40,147
Total			**304**	**993,690**	**£99,369**

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of SMILE/Norwich 11.4: Car pooling (sharing).

4.8.2 Monetised cost of the measure

According to the data provided, staff costs and operating costs (including cost of marketing activities) in the project period are shown in Table 4.8-2

Table 4.8-2 Cost in the project time

	Capital cost (£)	Operating cost (£)
2005	6298	1260
2006	5494	1099
2007	5785	1210
2008	11279	58800

4.8.3 Monetised benefits of the measure

Savings of fuel consumption cost

This is the money that has been saved by the car sharing individuals. By removing the single occupancy car journey the consumption of fuel for that journey has not occurred. The estimated cost of that journey is the financial saving to the individual. This calculation is based on the current fuel prices and consumption for the particular vehicle. In the period Sep 2005 – May 2008, the financial savings to private the user group and the public user group were estimated to be £40,147 and £59,222 respectively.

Savings of congestion reduction

According to Sansom et al.(2001), an average congestion cost (off peak and peak) of 4.6 pence/km is appropriate. Based on the total mileages saved, annual savings from congestion reduction is estimated to be £18,284.

Savings of accident reduction

According to cost and traffic data provided in Transport Statistics GB 2008, an average accident cost per passenger vehicle km was about 14.7 pence (for passerger cars). During the project period, car-sharing resulted in mileage savings of 397,476 vehicle-km per year. This results in a estimated annual savings of £58,521 from accident reduction.

Savings from reducing CO2 emissions

Based on emission and traffic data in Transport Statistics (2008 Edition), total emissions of NOx, SO2, and PM10 in the project period were estimated to be 192.52 kg, 4.07 kg, and 5.92kg respectively. Air pollutation cost recommned by IMPACT (2008) was adjusted to take into account yearly increase in the cost (assuming 1% each year). The total savings from reductions of pollutant emissions were estimated to be £3,657 in the project period.

Table 4.8-3 UK Air pollution cost (Source: IMPACT 2008)

	factor cost in £/t of pollutant	Source
NOx	3,382	IMPACT (2008) using

SO2	5,723	exchange rate: £1= €1.2
PM10	43,445	
CO2	20.8	

<u>Savings from reducing CO2 emissions</u>

The measure implementation has saved a total of 304 tonnes of CO2 with 76.46 tonnes from the public groups and 227.54 tonnes saved by the private groups. In the project period, the total savings is estimated to be £6,096.

4.8.4 Economic evaluations

In this study, cost and benefits of car-pooling is evaluated against Do-Nothing over the time period of 2005-2010) with NPV and BCR (benefit cost ratio) being as the main evaluation indicators.

<u>Assumptions</u>

- Evaluation period: 5 years
- Discount rate: 3.5%
- Constant pollutant emission rates in the evaluation period
- Constant GHG emission rates in the evaluation period

<u>NPV in the evaluation period</u>

Details about the costs, benefits and NPV of the car-sharing are shown in Table 4.5-4:

- In the evaluation period, NPV of the car-sharing remains positive. Over the whole evaluation period, the NPV is estimated to be £757k and benefit-cost ratio is 7.743 (Table 4.5-5)

Table 4.5-5 Cost/benefit indictors (in 2006 price)

PVC	**PVB**	**NPV**	**BCR**
£101,594	£432,941	£331,347	4.26

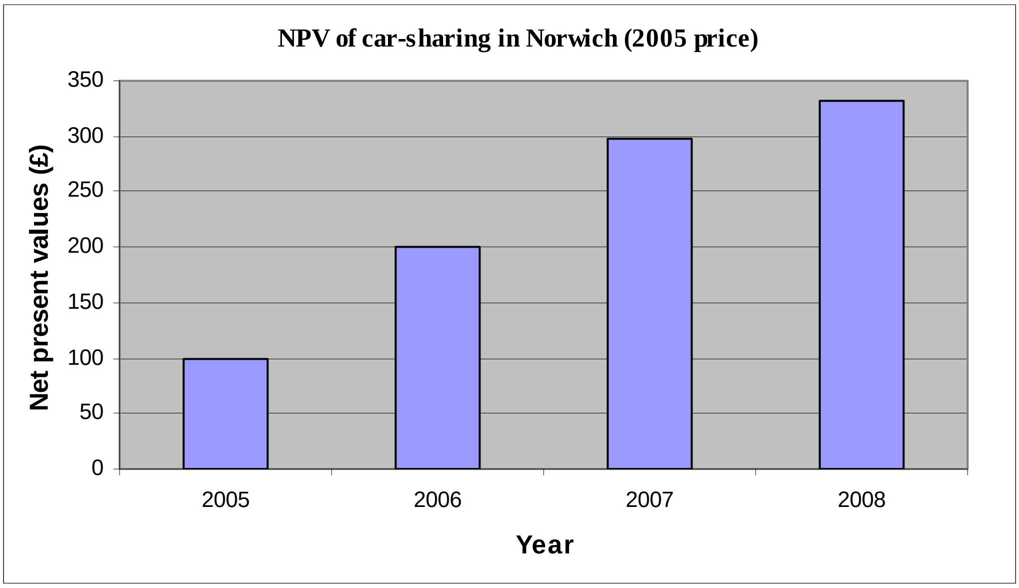


Figure 4.8.1 NPV in the evlaution period

— Of the total benefits of the car sharing, user benefits account for 12%, and non-user benefits accounts for 88%.

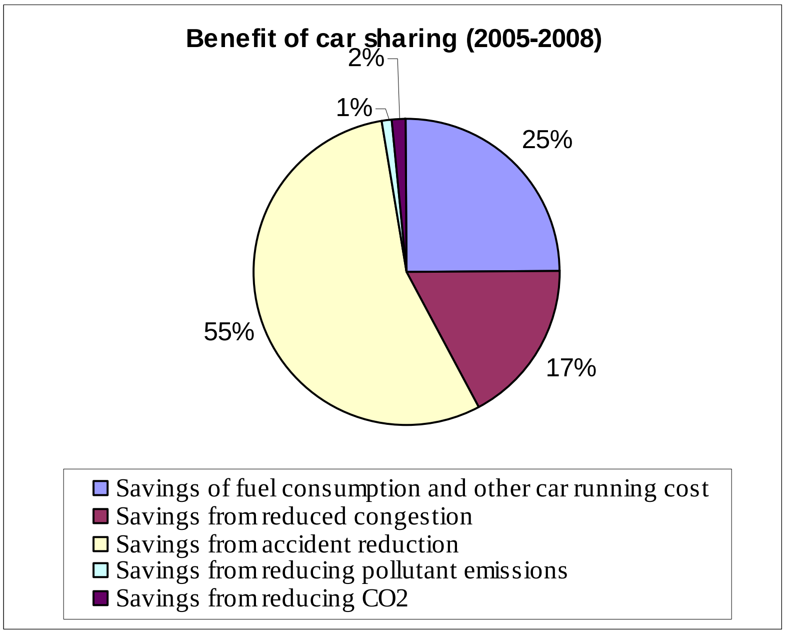


Figure 4.8.2 Benefits of car-sharing in SMILE/Norwich 11.4

— Of the total non-user benefits of the car sharing, savings from reductions of congestion, accidents, pollutant emissions and CO_2 emissions accounted for 17%, 55%, 1% and 2% respectively.

— Of the total cost in the evaluation period, staff costs accounted for 32% and operating costs account for 68%.

Table 4.5-4 Cost and benefit of car-sharing (2005 price)

Year	Staff cost (£)	Operating cost (£)	Savings in fuel consumption and other car running cost of Car-sharing users (£)	Non-user benefit				Total Cost (£)	Total benefits (£)	NPV (£)
				Savings from congestion reduction (£)	Savings from accident reduction (£)	Pollutant emission (£)	Greenhouse gas emissions (£)			
2005	6,298	1,260	27,101	19,102	61141	973	1662	10194	109980	99786
2006	5,499	1,100	27,127	18,826	60255	959	1638	9197	108805	199395
2007	5,796	1,212	27,153	18,553	59382	945	1615	9569	107648	297474
2008	11,312	58,800	27,179	18,284	58521	932	1591	72635	106507	331347
Total	28,905	62,372	108,560	74,765	239300	3810	6507	101,594 PVC	432941 PVB	

4.8.5 Summary

In SMILE/Norwich 11.4, car-sharing was demonstrated with travellers sharing a vehicle rather than making car journeys with a single occupant. Based on the cost data and impact evaluation results provided, the following conclusions can be drawn about the costs and benefits of car-sharing:

- Providing a car-sharing service requires little physical investment and the main costs incurred include staff costs and operating costs of the car-sharing service.
- The CBA results of the Norwich case show that the present value of benefits outweighs the present value of costs by £331,347
- In terms of BCR, the benefit is 4.26 times the cost in the project time period.

4.9 CARAVEL/Genoa 9.4: Car sharing service in Genoa

4.9.1 Descriptions of the measure

Car sharing (CS) is the practice whereby individuals subscribe to a club or service to hire cars usually on a short temporal basis. It gives a lot of advantages to users and to the city:

- From the user's point of view: savings in terms of money and time, free access to Restricted Traffic Areas, possibility of using reserved public transport lanes, possibility of free parking on public paying parking places, discounted access to city services (museums, theatres, etc.).
- From city point of view: more urban space available to citizens with a lower use of parking places, reduction of pollution due to the decrease of driven mileage and the high-level standards of the car sharing vehicles, new and more flexible transport services offered to the citizens.
- A new culture of mobility: diffusion of a new culture of the use of the car, contribution to a more rational modal choice by the citizens, internalization of external costs of transportation.

The general objective of the measure was to improve the use and diffusion of car sharing in Genoa, to give a widespread service over the city, fully integrated with the urban transport system with a high percentage of bio-fuel (25%) clean vehicles, and to improve the general knowledge and awareness of car sharing through promotion actions and communication campaigns. At the same time, another objective is to open the use of car sharing to new users and applications, and mainly:

- To involve the Municipality of Genoa as a massive user of car sharing
- To set up a car sharing service for goods distribution in the central area of Genoa
- To set up an experimental car sharing service for impaired people.

This scheme has been implemented involving the Municipality of Genoa as a first customer. This kind of scheme needed the definition of all the procedures for reservation, access to the service, etc. and it has required a software tool to be adopted for managing multiple levels of reservation and dealing with this scheme. From the contractual point of view, it was decided that during the project period the Municipality paid the tax for the use of the vehicles, while the local operator (Genova Car Sharing) paid the other charges (insurance, periodic cleaning, possible damage repair, incident management, etc.). The measure was implemented in the following stages:

Stage 1: Scheme design (from February 1st, 2005 – to February 1st, 2006) – Development of a special kind of mixed car sharing scheme that allows contemporary management of special dedicated fleets in a Corporate car sharing scheme and a traditional car sharing scheme.

Stage 2: Integration into the FAMS framework (from August 1st, 2005 – to February 1st, 2007) – It included an analysis of the possibility of using car sharing for disabled people. The idea was developed with the associations of disabled persons and had a positive acceptance by the City Council and other stakeholders. During this stage a questionnaire was sent by mail to 1000 impaired citizens.

Stage 3: Design and implementation of a special car sharing service for disabled persons (from June 1st, 2006 – to February 1st, 2009) – The stage included the set up of a special experimental car sharing service (with a single special car) for disabled people, able to cover the needs of about 90%. The Province of Genoa financed the project with 8.000 euro to cover the possible operating deficit coming from the service.

Stage 4: Definition of the operational plan for the launch of the car sharing service (from February 1st, 2005 – to February 1st, 2006) **-** The stage included the elaboration of the operational plan for the improvement of the service, with the definition of all the aspects of the operational plan for the enlargement of the service in the target areas: type and number of vehicles to buy per month, number of parking places to open per month, where to increase the service with the new parking places. Naturally these choices also depended on economic aspects.

Stage 5: Car procurement procedures (from May 1st, 2005 – to February 1st, 2006) – The stage included tenders and other procedures to provide the cars for the service (economy cars, utility cars and cargo).

Stage 6: Set up of the technological system (from August 1st, 2005 – to February 1st, 2007) – The stage included the equipment of the new car, the improvement of the reservation software, infrastructures (parking places, etc.) and the set up of the system.

Stage 7: Definition of the procedures for the management of the mixed car sharing scheme (from August 1st, 2005 – to May 1st, 2006) – The stage included the definition of all the operational scheme and the procedures to manage the mixed car sharing service for the Municipality of Genoa; definition of all the contractual aspects between the Municipality of Genoa and the supplier of the car sharing service.

Stage 8: Gradual launch of the service (from May 1st, 2006 – to February 1st, 2008) **-** The stage included the development and launch of the car sharing system and its gradual extensions. The gradual launch has been chosen to better balance costs and revenues of the service. Generally one or two parking places have been activated each time. The expansion of the service covered all the contractual period. This stage also included all the communication and advertising activities.

Stage 9: Personnel training (from February 1st, 2006 – to May 1st, 2006) **-** The stage included training activities for employers who has to manage the available cars at the Municipality's disposition.

Stage 10: Extension of the service (from February 1st, 2008 – to February 1st, 2009) The service was gradually extended according to the designed plan.

Stage 11: Promotion of car sharing service (from November 1st, 2005 – to February 1st, 2009) – The stage involved promotional and communication campaign for the citizens, direct marketing activities, information campaign through direct information and media.

Stage 12: Evaluation of the service (from November 1st, 2005 – to December 1st, 2008) **-** All the evaluation activities have been performed according to the evaluation plan.

More details about the implementation and evaluation of the measure can be found in the evaluation results sheets of CARAVEL/Genoa 9.4: Car sharing service in Genoa.

4.9.2 Monetised cost of the measure

Set-up cost

Based on the evaluation result sheets provided, monthly CS users in the project period are shown in Table 4.9-1:

Table 4.9-1 Number of CS users per month

	CIVITAS case	BAU case
2005	505	498
2006	754	723

2007	1127	1050
2008	1685	1524

During the project, the number of CS cars increased from 16 to 98. It was estimated that there would be 60 CS cars without CIVITAS. It is assumed that the average price of a CS car was €10,000, the total investment for purchasing CS cars in the project period is estimated to be €380,000.

Operational cost

According to the evaluation result sheets of the measure, the operating cost (including cost of marketing activities) per CS user was €58.86 in Jan. 2005 and €58.37 in September 2008. Results in Table 4.9-2 show the estimated annual cost in the project period.

Table 4.9-2 Annual cost of car-sharing operation (€)

	CS with CIVITAS	BAU case
2005	309,366	289,678
2006	506,857	415,403
2007	830,421	595,695
2008	1,360,538	854,236

4.9.3 Monetised benefits of the measure

Annual revenue

According to evaluation results sheets of the measure, the average revenue per CS user was €62.94 in Jan. 2005 and €61.68 in September 2008. Results in Table 4.9-3 show the estimated annual revenue in the project period.

Table 4.9-3 Annual cost of car-sharing operation (€)

	CS with CIVITAS	BAU case
2005	309366	289678
2006	506857	415403
2007	830421	595695
2008	1360538	854236

Savings from emission reductions

Table 4.9-4 shows the annul reductions of emissions in the project period (source: Carvel/Genoa 9.4 Evaluation results sheet).

Table 4.9-4 Annual reductions of pollutants emissions (kg)

	CO	**NOx**	**VOC**	**PM10**	**CO2**

2005	16,079	1,499	1,795	131	331,570
2006	24,527	2,303	2,702	209	566,230
2007	35,493	3,342	3,890	306	851,750
2008	44,410	4,182	4,867	384	1,066,920

Values recommended by Plassat (2005), HEATCO (2006) and IMPACT (2008) are shown in Table 4.9-5 which were based to monetise the emission reductions.

Table 4.9-5 Air pollution and GHG emissions cost

	€/tonne of emission	Source
CO	4	Plassat (2005)
NOx	5,700	HEATCO(2006) IMPACT (2008)
VOC	1,100	
PM10	148,600	
CO2	25	

In the project period, the savings from reduction of pollutant emission and GHG emission were estimated to be €249,252 and €80,805 respectively.

4.9.4 Economic evaluations

In this study, costs and benefits of car-pooling are evaluated against a Business-as-usual (BAU) scenario over the time period of 2005-2008 with NPV and BCR (benefit cost ratio) being the main evaluation indicators.

Assumptions

- Discount rate: 3.5%
- Pollutant emissions and greenhouse gas emission rates remain unchanged in the evaluation period.

NPV in the lifetime

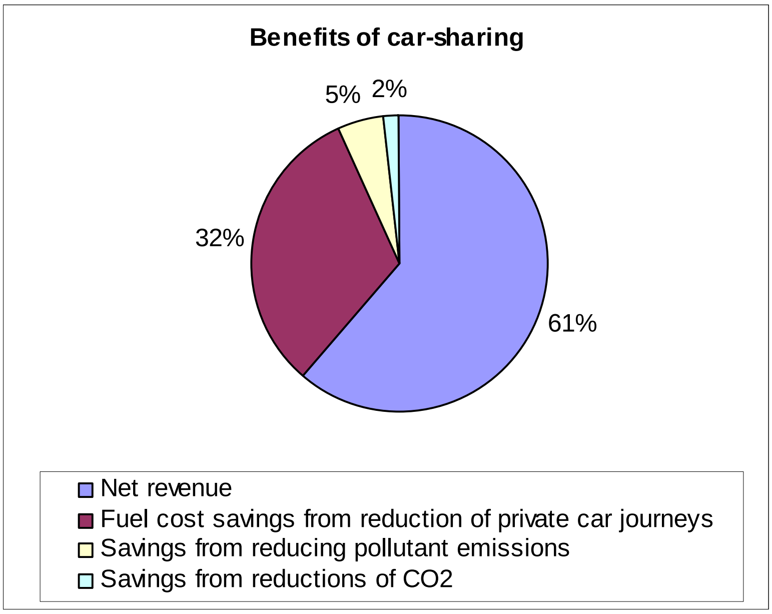
Details about the costs, benefits and NPV of the car-sharing are shown in Table 4.6-7.

- In the evaluation period, the NPV of car-sharing remains positive. Over the whole evaluation period, NPV is estimated to be €1,744k and benefit-cost ratio is 1.54

Table 4.5-6 Cost/benefit indictors (in 2005 price)

PVC	PVB	NPV	BCR
€3,240,934	€4,984,980	€1,744,038	1.54

- The largest contribution comes from increases in revenue which accounts for 61% of the total benefits of car-sharing.
- Car-sharing resulted in reductions of private car use. Savings in fuel cost from such reductions contributes to 32% of the total benefit.
- Savings from reduction of emissions (pollutant and GHG) contributes 7% of the total benefit.



- Among the total cost, investment costs for CS vehicles accounts for 12%, and operational costs (including vehicle operation, maintenance) accounts for 88%.

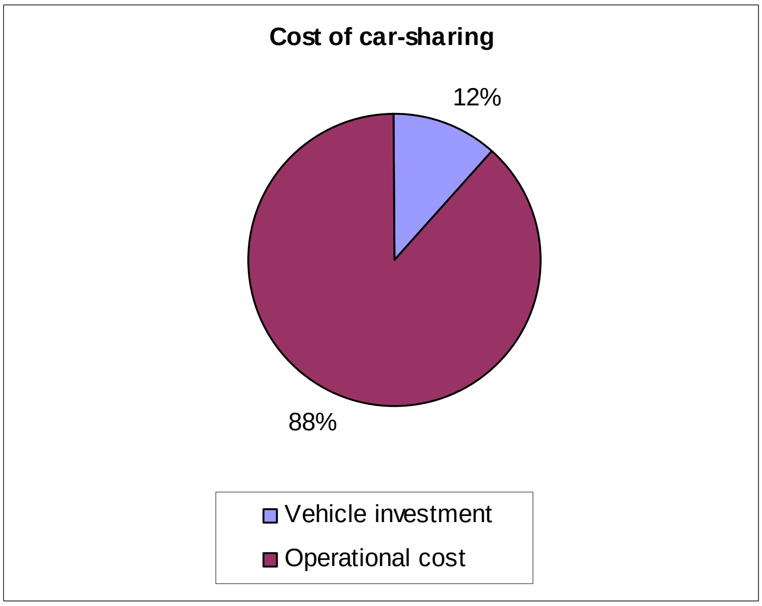


Table 4.9-7 Cost, benefit and NPV of car-sharing (2005 price)

	CS vehicle investment (€)	Operational cost (€)	Operating revenue (€)	Savings from fuel cost reductions (€)	Savings from Emission reductions		Total cost (€)	Total benefits (€)	NPV (€)
					Air pollutant (€)	GHG (€)			
2005	90,000	353,890	376,096	183,346	65,103	21,106	443,890	645,651	201,761
2006	90,087	529,438	562,660	315,702	64,159	20,800	619,525	963,321	545,557
2007	100,193	792,068	841,770	472,994	63,229	20,498	892,261	1,398,491	1,051,786
2008	100,290	1,184,976	1,259,333	635,670	62,313	20,201	1,285,267	1,977,518	1,744,038
Total	380,570	2,860,372	3,039,859	1,607,711	254,804	82,605	3,240,943 PVC	4,984,980 PVB	

4.9.5 Summary

In CARAVEL/Genoa 9.4, “car-sharing” was demonstrated where travellers rent cars from car clubs rather than drive their own cars. Based on the cost data and impact evaluation results provided, the following conclusions can be drawn about the costs and benefits of the car-sharing scheme:

- For the evaluation period, large benefits are seen from running car-sharing services in terms of NPV and BCR.
- Car-sharing resulted in reductions of fuel cost which come from reduced private car journeys and using more fuel efficient CS cars. In the Genoa case, fuel savings contributed 30% of the total benefit of the car-sharing.
- Reduction of private car journeys and using fuel efficient cars reduced pollutant and GHG emissions. Savings from such reductions contribute to 7% of the total benefit of car-sharing.
- Vehicles investment is one of the major costs for providing such a service. In this case, vehicle investment cost accounted for 12% of the total cost (2005-2008)

There maybe other costs involved for providing car-sharing service, for example cost for CS parking spaces. As no data were available, such costs were not included in this cost-benefit analysis.

In this CBA study, the following values are used to monetise the impacts of the CIVITAS measures:

5 SUMMARY AND CONCLUSIONS

5.1 About cost-benefit of CIVITAS measures

In this study, cost-benefit analyses were carried out for 9 measures demonstrated in CIVITAS II. The input for the analysis comes from the evaluation result sheets and cost data provided by the cities.

For most measures studied, NPV calculations are based on changes in costs and benefits between the CIVITAS measure and the reference case, where a positive NPV means that the extra benefit outweighs the extra cost for implementing the CIVITAS measure. Based on the study result, the following conclusions can be drawn about the cost and benefits of the measures:

- NPV and BCR for the 9 measures are summarised in the table below. For most of the measures studied, the NPV are positive and BCR are larger than 1.0 which means that the investment (or extra investment) can be recovered within the evaluation period
- For some CIVITAS measures, the capital costs are much higher than those of existing measures. For example in Toulouse, a CNG bus is 24% more expensive than a diesel bus and substantial cost is required to build CNG stations. Such large investment is difficult to be recovered through operating revenue. In such cases, subsidies from local authorities are necessary which can be justified by benefits in terms of reductions in pollutant/GHG emissions and congestion.
- Savings from reductions of pollutant and GHG emissions depend on the nature of the measure and the scale of applications. For example, the benefits of Soot Filters mainly come from reducing particulate emissions, whilst using clean fuels such as CNG and bio-gas have greater potential to reduce a wide range of pollutant and GHG emissions.
- Savings in fuel consumption costs are one of the major benefits of the CIVITAS measures, particularly for measures involving clean vehicles and alternative fuels. Some measures benefited from lower prices of the alternative fuels (e.g. LPG in SMILE/Suceava 5.6), and others benefit from improved fuel efficiency of the vehicles (e.g. EEV buses in SUCCESS/La Rochelle 5.2).
- Two types of alternative car use were demonstrated: ‘Sharing a journey’ (car pooling) e.g. SMILE/Norwich 11.4 and ‘car-clubs’ (car sharing) e.g. SMILE/Malmo 9.1 and CARAVEL/Genoa 9.4. NPV calculations show that ‘Sharing a journey’ (car pooling) is more beneficial than ‘car-clubs’ (car sharing). The BCR of SMILE/Norwich 11.4 is estimated to be 7.74, compared to 0.65 and 1.34 for SMILE/Malmo 9.1 and CARAVEL/Genoa 9.4 respectively.
- For some measures, only the total cost of the project/measure (including staff cost for the projects) were provided. Such data are useful for understanding the cost for the measure demonstration, however for CBA, more details are required about the capital costs and operational costs of the measure.

Some benefits/costs are not included in the NPV and BCR calculations either because no measurements were provided (e.g. comfort of drivers/travelers) or because of the difficulty in monetization of the impacts (e.g. noise). Also, the information provided by the projects was not necessarily eigher consistent or comprehensive. Thus, the analyses presented in this report should not be used as the sole basis for judging the financial viability of the measures.

Table 5.1 Summary of the key CBA results

	Reference case	Evaluation time period	NPV (or changes	BCR

			in NPV)	
MOBILIS/Toulouse 5.1: Large scale operation of clean bus fleet	CNG buses vs. Diesel buses	2005-2019	€225k	-
MOBILIS/Toulouse 5.2-1: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Equipping diesel buses with soot filters)	Diesel buses with and without SF	2007-2021	€12,165k	-
MOBILIS/Toulouse 5.2-2: Solutions for alternative fuels in Toulouse and complementary measures to achieve a 100% clean fleet (Buses using bio-diesel)	Bio-diesel buses vs. petrol diesel buses	2008-2022	€8,520k	-
SMILE/Suceava 5.6: Alternative fuel bus fleet	LPG buses vs. diesel buses	2007-2021	€8,734k	-
SMILE/Suceava 5.7: Marketing for alternative fuels in the public and private sector	LPG taxis vs. petrol/diesel taxis	2008-2022	€2,078k	-
SUCCESS/La Rochelle 5.2 Introduction of new clean buses	EEV buses vs. Euro III buses	2007-2014	€707k	-
SMILE/Malmo 9.1: Car sharing for business and private persons	Car rental vs. 'do nothing'	2005-2008	SEK-1,373k	0.65
SMILE/Norwich 11.4: Car pooling (sharing)	Sharing a car journey vs. 'do nothing'	2005-2008	£331k	4.26
CARAVEL/Genoa 9.4: Car sharing service in Genoa	Car rental vs. 'do nothing'	2005-2008	€1,744k	1.54

Table 5.2 Emission cost of air pollutant and GHG

Measures	Economic values					Comments/source
	CO	HC	NOx	PM10	CO2	
MOBILIS/Toulouse 5.1, MOBILIS/Toulouse 5.2, SUCCESS/La Rachelle	€4/tonne	€2,000/tonne	€7,700/tonne	€156,900/tonne	€25/tonne	Values for France (Source: Plassat 2005 and IMPCAT 2008)
SMILE/Suceava 5.6 SMILE/Suceava 5.7	€4/tonne	-	€2,200/tonne	€3.800/tonne	€25/tonne	Value for Romania (Source: Plassat 2005 and IMPCAT

						2008)
SMILE/Malmo 9.1	-	-	SEK23,100/tonne	SEK476,000/tonne	SEK263/tonne	Value for Sweden (Source: Plassat 2005 and IMPCAT 2008). Exchange rate used: €1 = SEK10.5
SMILE/Norwich 11.4	-	-	£3,392/tonne	£43,445/tonne	£20.8/tonne	UK value (Source: Plassat, 2005 and IMPACT 2008). Exchange rate used: £1 = €1.2
CARAVEL/Genoa 9.4	€4/tonne	-	€5,700/tonne	€148,600/tonne	€25/tonne	Value for Italy (Source: Plassat 2005 and IMPCAT 2008)

5.2 Issues and lessons learned

For many measures, the cost data and impact evaluation results provided were not good enough for carrying out CBA analysis:

- In some measures, only limited indicators were included in their original evaluation plan. For those impacts which were not addressed in the evaluation, it is impossible to estimate the costs and benefits associated.
- Some key impact measurements are missing in the evaluation result sheets provided. For example, traffic impacts with measures such as access control/environmental zones (e.g. local/network impacts)
- In CBA analysis, costs and benefits are required to be evaluated over the lifetime of the measure. However for many measures, only the impact measurements in the project time period were provided.
- Some measures were implemented at a very late stage of the project and impact measurements were made in a very short period. This makes it very difficult to understand the trend of the impacts and make estimation beyond the project period. For example for measures involving using new vehicle technologies (e.g. alternative fuels), the operation cost and maintenance cost at early stage of applications are often different from those at later stages.
- For CBA analysis, the costs and benefits of a CIVITAS measure need to be compared with those of a reference measure/case (baseline or business as usual). However for some measures, such comparable results were not available:
    - No clear reference cases defined
    - Impact measurements were made only in the ‘after’ scenario
    - Inconsistency in impact measurements between the CIVITAS and the reference case (e.g. time scale, measurements methods)

- In some measures, only the result in the last year was provided although the measures were implemented for several years. For CBA analysis, the impacts of the measure should be compared with those of reference measure over the whole implementation period.
- For some measures, local values of costs and benefits were not provided (e.g. local values of emission cost).

For some measures, socio-economic assessment may not be feasible if the impacts of the measure cannot be measured soundly (e.g. too short time period). While it may be possible to estimate costs, cost-effectiveness or wider social benefits, such estimates are unlikely to be either reliable or readily transferable to other contexts.

Recommendations

Based on the study results, the followings are recommended for future CIVITAS CBA analysis:

- A template should be used to ensure all costs and benefit data are collected and in a consistent way.
- Data regarding the impact of a measure should be collected over the whole implementation period (not just the last year). This is true for both the CIVITAS measure and the reference measure.
- In CBA analysis, the costs and benefits are evaluated over the lifetime of the measure. Therefore, an estimation of the impacts and costs beyond the project period is required if the evaluation period is longer than the project period. This is true for both the CIVITAS measure and the reference measure.

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ANNEX A: SET-UP COSTS AND OPERATING COSTS DURING THE PROJECT PERIOD

		Set-up Costs	Operating cost	Total cost
SMILE/Malmo 5.1: Clean municipal fleets	2005-2006	1,568,990	412,800	1,981,790
	2006-2007	1,725,810	45,406	1,771,216
	2006-2007	3,959,820	12,590	3,972,410
	2007-2008	2,547,000	12,000	2,559,000
Money unit: Swedish krona (SEK)	**Total**	**9,801,620**	**482,796**	**10,284,416**
SMILE/Malmo 5.2: Biogas on the net	2005-2006	0	0	0
	2006-2007	0	0	0
	2006-2007	0	0	0
	2007-2008	3,298,000	135,000	3,433,000
Money unit: Swedish krona (SEK)	**Total**	**3,298,000**	**135,000**	**3,433,000**
SMILE/Malmo 5.3: Clean heavy vehicles with CO2	2005-2006	205,296	2,133,763	2,339,059
	2006-2007	83,067	3,332,124	3,415,191
	2006-2007	497,689	1,984,795	2,482,484
	2007-2008	69,750	3,185,250	3,255,000
Money unit: Swedish krona (SEK)	**Total**	855,802	10,635,932	11,491,734
SMILE/Suceava 5.6: Alternative fuel bus fleet	2005-2006	37,528	0	37,528
	2006-2007	39,329	0	39,329
	2006-2007	1,642,112	0	1,642,112
	2007-2008	1,690,280	0	1,690,280
Money unit: Romanian New Leu (RON)	**Total**	**3,409,249**	**0**	**3,409,249**
SMILE/Suceava 5.7: Marketing alternative fuels	2005-2006	33,563	0	33,563
	2006-2007	33,244	0	33,244
	2006-2007	50,044	0	50,044
	2007-2008	30,052	0	30,052
Money unit: Romanian New Leu (RON)	**Total**	146,903	0	146,903
SMILE/Malmo 5.8: Environmental adopted cars	2005-2006	9,500	19,100	28,600
	2006-2007	0	10,500	10,500
	2006-2007	0	11,000	11,000

		Set-up Costs	Operating cost	Total cost
	2007-2008	0	0	0
	Total	**9,500**	**40,600**	**50,100**
SMILE/Malmo 6.1: Low emission zone	2005-2006	0	202,287	202,287
	2006-2007	0	296,840	296,840
	2006-2007	0	160,693	160,693
Money unit: Swedish krona (SEK)	2007-2008	0	50,000	50,000
	Total	**0**	**709,820**	**709,820**
SMILE/Norwich 6.2: Introduction of low emission zone	2005-2006	158,000	3,000	161,000
	2006-2007	386,000	3,000	389,000
	2006-2007	0	3,000	3,000
Money unit: British Pound (£)	2007-2008	0	3,000	3,000
	Total	**544,000**	**12,000**	**556,000**
SMILE/Norwich 6.3: Time Controlled Access Restrictions	2005-2006	1,960	0	1,960
	2006-2007	1,490	0	1,490
	2006-2007	266,705	0	266,705
Money unit: British Pound (£)	2007-2008	94,750	0	94,750
	Total	**364,905**	**0**	**364,905**
SMILE/Suceava 6.4: Extension of low emission zone	2005-2006	35,811	21,005	56,816
	2006-2007	56,775	31,253	88,028
	2006-2007	64,754	23,522	88,276
	2007-2008	233,602	15,322	248,924
Money unit: Romanian New Leu (RON)	**Total**	**35,811**	**21,005**	**56,816**
SMILE/Malmo 7.1: Marketing of clean vehicles by subsidized parking	2005-2006	75,000	175,000	250,000
	2006-2007	0	55,000	55,000
	2006-2007	0	0	0
Money unit: Swedish krona (SEK)	2007-2008	0	0	0
	Total	**75,000**	**230,000**	**305,000**
SMILE/Norwich 7.2: Influencing the choice of smaller, cleaner vehicles	2005-2006	3,780	0	3,780
	2006-2007	6,850	0	6,850
	2006-2007	10,400	0	10,400
	2007-2008	44,000	0	44,000

		Set-up Costs	Operating cost	Total cost
	Total	**65,030**	**0**	**65,030**
SMILE/Malmo 8.1: Marketing of New Bus Route	2005-2006	90,289	3,365,405	3,455,694
	2006-2007	0	452,656	452,656
	2006-2007	0	7,923	7,923
	2007-2008	0	3,135	3,135
Money unit: Swedish krona (SEK)	**Total**	**90,289**	**3,829,119**	**3,919,408**
SMILE/Malmo 8.2: Improved Security/Safety on Buses	2005-2006	90,289	3,365,405	3,455,694
	2006-2007	0	452,656	452,656
	2006-2007	0	7,923	7,923
	2007-2008	0	3,135	3,135
Money unit: Swedish krona (SEK)	**Total**	**90,289**	**3,829,119**	**3,919,408**
SMILE/Malmo 8.3: Integrating of cycling with PT	2005-2006	740,000	5,000	745,000
	2006-2007	1,038,000	20,000	1,058,000
	2006-2007	3,275,000	40,000	3,315,000
	2007-2008	3,600,000	150,000	3,750,000
Money unit: Swedish krona (SEK)	**Total**	**8,653,000**	**215,000**	**8,868,000**
SMILE/Norwich 8.4: Rail Station Interchange	2005-2006	12,717	0	12,717
	2006-2007	85,728	0	85,728
Money unit: British Pound (£)	2006-2007	379,078	0	379,078
	2007-2008	91,495	17,015	108,510
	Total	**569,018**	**17,015**	**586,033**
SMILE/Norwich 8.5: On street ticket vending machine with real time information	2005-2006	64,423	109,983	174,406
	2006-2007	160,588	22,632	183,220
	2006-2007	5,970	24,466	30,436
Money unit: British Pound (£)	2007-2008	0	7,000	7,000
	Total	**230,981**	**164,081**	**395,062**
SMILE/Norwich 8.6: Linking individual passenger transport information with healthcare appointments	2005-2006	0	3,728	3,728
	2006-2007	0	3,997	3,997
	2006-2007	0	2,337	2,337
	2007-2008	0	0	0
Money unit: British Pound (£)	**Total**	**0**	**10,062**	**10,062**

		Set-up Costs	Operating cost	Total cost
SMILE/Suceava 8.8: Bus priority measures	2005-2006	64,012	23,551	87,563
	2006-2007	35,695	1,688	37,383
Money unit: Romanian New Leu (RON)	2006-2007	40,769	0	40,769
	2007-2008	68,516	2,511	71,027
	Total	**208,992**	**27,750**	**236,742**
SMILE/Suceava 8.9: PT information	2005-2006	27,083	2,553	29,636
	2006-2007	19,870	0	19,870
Money unit: Romanian New Leu (RON)	2006-2007	58,747	11,200	69,947
	2007-2008	215,135	21,581	236,716
	Total	**320,835**	**35,334**	**356,169**
SMILE/Malmo 10.1: Freight driver support	2005-2006	50,801	0	50,801
	2006-2007	0	541,286	541,286
	2006-2007	0	678,884	678,884
Money unit: Swedish krona (SEK)	2007-2008	0	1,870,000	1,870,000
	Total	**50,801**	**3,090,170**	**3,140,971**
SMILE/Malmo 10.2: Satellite based traffic management for SME's	2005-2006	620,000	170,000	790,000
	2006-2007	0	275,000	275,000
	2006-2007	0	260,000	260,000
	2007-2008	0	270,000	270,000
Money unit: Swedish krona (SEK)	**Total**	**620,000**	**975,000**	**1,595,000**
SMILE/Norwich 10.3: Strategic Freight Stakeholders Club	2005-2006	15,000	0	15,000
	2006-2007	0	0	0
	2006-2007	0	0	0
Money unit: British Pound (£)	2007-2008	0	0	0
	Total	**15,000**	**0**	**15,000**
SMILE/Norwich 10.4: Priority Access For Goods Vehicles	2005-2006	41,680	0	41,680
	2006-2007	0	1,100	1,100
	2006-2007	0	1,100	1,100
Money unit: British Pound (£)	2007-2008	0	500	500
	Total	**41,680**	**2,700**	**44,380**
SMILE/Norwich 10.6: goods	2005-2006	0	4,142	4,142

		Set-up Costs	Operating cost	Total cost
	2006-2007	0	23,931	23,931
	2006-2007	0	129,617	129,617
	2007-2008	0	9,000	9,000
	Total	**0**	**166,690**	**166,690**
SMILE/Malmo 10.7: Sustainable SME logistics for the food industry	2005-2006	428,622	0	428,622
	2006-2007	179,761	0	179,761
	2006-2007	707,477	0	707,477
Money unit: Swedish krona (SEK)	2007-2008	706,672	0	706,672
	Total	**2,022,532**	**0**	**2,022,532**
SMILE/Malmo 11.1: Managing Mobility Needs of Private Persons and Business Sector	2005-2006	9,691	345,079	354,770
	2006-2007	0	1,020,443	1,020,443
	2006-2007	0	2,433,901	2,433,901
Money unit: Swedish krona (SEK)	2007-2008	0	771,780	771,780
	Total	**9,691**	**4,571,203**	**4,580,894**
SMILE/Malmo 11.2: Eco-Driving for municipal employees	2005-2006	7,180	1,890	9,070
	2006-2007	276,970	28,610	305,580
	2006-2007	1,196,140	231,920	1,428,060
Money unit: Swedish krona (SEK)	2007-2008	1,100,000	130,000	1,230,000
	Total	**2,580,290**	**392,420**	**2,972,710**
SMILE/Norwich 11.3: Travel planning	2005-2006	31,116	6,223	37,339
	2006-2007	27,821	5,564	33,385
	2006-2007	25,557	73,237	98,794
Money unit: British Pound (£)	2007-2008	51,114	106,436	157,550
	Total	**135,608**	**191,460**	**327,068**
SMILE/Norwich 11.4: Car pooling	2005-2006	6,298	1,260	7,558
	2006-2007	5,494	1,099	6,593
	2006-2007	5,785	1,210	6,995
Money unit: British Pound (£)	2007-2008	1,1279	58,800	70,079
	Total	**28,856**	**62,369**	**91,225**
SMILE/Norwich 11.5: Individual travel advice	2005-2006	557	3,446	4,004
	2006-2007	1,688	9,813	11,501

		Set-up Costs	Operating cost	Total cost
	2006-2007	113,400	64,434	177,834
	2007-2008	0	12,576	12,576
	Total	**115,645**	**90,269**	**205,914**
SMILE/Suceava 11.7: General information and awareness raising Money unit: Romanian New Leu (RON)	2005-2006	9,813	0	9,813
	2006-2007	10,486	0	10,486
	2006-2007	28,210	0	28,210
	2007-2008	150,320	16,311	16,6631
	Total	**198,829**	**16,311**	**215,140**
SMILE/Malmo 11.8: EcoDriving för Hospital Employees Money unit: Swedish krona (SEK)	2005-2006	14,200	0	14,200
	2006-2007	10,700	0	10,700
	2006-2007	2,700	208,000	210,700
	2007-2008	0	0	0
	Total	**27,600**	**208,000**	**235,600**
SMILE/Malmo 11.9: Heavy Eco-driving Money unit: Swedish krona (SEK)	2005-2006	15,130	0	15,130
	2006-2007	0	500,245	500,245
	2006-2007	0	581,196	581,196
	2007-2008	0	320,000	320,000
	Total	**15,130**	**1,401,441**	**1,416,571**
SMILE/Malmo 12.1: Use of real time applications for travellers Money unit: Swedish krona (SEK)	2005-2006	8,645	1,110,826	1,119,471
	2006-2007	0	2,608,121	2,608,121
	2006-2007	0	3,242,247	3,242,247
	2007-2008	0	3,282,203	3,282,203
	Total	**8,645**	**10,243,397**	**10,252,042**
SMILE/Malmo 12.2: Traffic monitoring Money unit: Swedish krona (SEK)	2005-2006	1,100,000	0	1,100,000
	2006-2007	1,857,000	0	1,857,000
	2006-2007	1,889,000	0	1,889,000
	2007-2008	2,300,000	0	2,300,000
	Total	**7,146,000**	**0**	**7,146,000**
SMILE/Malmo 12.3: Mobile internet services in connection to bus information	2005-2006	5,938	19,399	25,337
	2006-2007	0	1,712,205	1,712,205
	2006-2007	0	4,889,461	4,889,461

		Set-up Costs	Operating cost	Total cost
	2007-2008	0	5,652,595	5,652,595
	Total	**5,938**	**12,273,660**	**12,279,598**
SMILE/Malmo 12.4: Internet tool for traffic planning Money unit: Swedish krona (SEK)	2005-2006	0	208,000	208,000
	2006-2007	0	30,000	30,000
	2006-2007	0	136,000	136,000
	2007-2008	0	540,000	540,000
	Total	**0**	**914,000**	**914,000**
SMILE/Tallinn 12.5-12.6: PT priority system and automatic call & infor signs in bus Money unit: Estonian Kroon (EEK)	2005-2006	69,351,356	12,000	69,363,356
	2006-2007	0	12,000	12,000
	2006-2007	0	12,000	12,000
	2007-2008	0	942,000	942,000
	Total	**69,351,356**	**978,000**	**70,329,356**
SMILE/Malmo 12.7: Bus priority systems Money unit: Swedish krona (SEK)	2005-2006	1,152,745	0	1,152,745
	2006-2007	1,279,665	0	1,279,665
	2006-2007	1,482,418	0	1,482,418
	2007-2008	236273	0	236,273
	Total	**4,151,101**	**0**	**4,151,101**
SMILE/Norwich 12.8: Traffic and Travel Information for Freight Operators Money unit: British Pound (£)	2005-2006	34,000	0	34,000
	2006-2007	0	2,000	2,000
	2006-2007	0	500	500
	2007-2008	0	500	500
	Total	**34,000**	**3,000**	**37,000**
SMILE/Norwich 12.9: Real Time Passenger Information Money unit: British Pound (£)	2005-2006	7,188	0	7,188
	2006-2007	7,585	0	7,585
	2006-2007	65,596	0	65,596
	2007-2008	29,476	8,713	38,189
	Total	**109,845**	**8,713**	**118,558**
	Total	**0**	**709,820**	**709,820**
SMILE/Norwich 8.5: On street ticket vending machine with real time information	2005-2006	64,423	109,983	174,406
	2006-2007	160,588	22,632	183,220
	2006-2007	5,970	24,466	30,436

		Set-up Costs	Operating cost	Total cost
	2007-2008	0	7,000	7,000
	Total	**230,981**	**164,081**	**395,062**
SUCCESS/Preston 5.6: Hybrids/Biodiesel	2005-2006	24,735	0	24,735
	2006-2007	20,459	0	20,459
	2006-2007	32,629	14,603	47,232
Money unit: British Pound (£)	2007-2008	0	60,000	60,000
	Total	77,823	74,603	152,426
SUCCESS/Preston 6.3: Air Quality Monitoring	2005-2006	2,977	0	2,977
	2006-2007	3,385	0	3,385
	2006-2007	17,186	0	17,186
Money unit: British Pound (£)	2007-2008	16,850	0	16,850
	Total	40,398	0	40,398
SUCCESS/Preston 7.3: Parking Strategy	2005-2006	2,084	0	2,084
	2006-2007	9,335	0	9,335
	2006-2007	82,187	0	82,187
Money unit: British Pound (£)	2007-2008	1,250	0	1,250
	Total	94,856	0	94,856
SUCCESS/Preston 7.5: Parking Management	2005-2006	923	0	923
	2006-2007	3,695	0	3,695
	2006-2007	11,216	0	11,216
Money unit: British Pound (£)	2007-2008	53,440	0	53,440
	Total	69,274	0	69,274
SUCCESS/Preston 8.7: Creation of and ‘Overground’ network for PT services	2005-2006	4,549	0	4,549
	2006-2007	17,410	0	17,410
	2006-2007	33,589	665	34,254
Money unit: British Pound (£)	2007-2008	6,500	2,176	8,676
	Total	62,048	2,841	64,889
SUCCESS/Preston 8.8: Demand responsive and feeder services	2005-2006	1,676	0	1,676
	2006-2007	2,101	0	2,101
	2006-2007	16,483	15,160	31,643
	2007-2008	35,597	36,093	71,690

		Set-up Costs	Operating cost	Total cost
	Total	55,857	51,253	107,110
SUCCESS/Preston 8.9: Improved infrastructure for collective transport	2005-2006	10,203	0	10,203
	2006-2007	149,539	0	149,539
	2006-2007	49,432	0	49,432
Money unit: British Pound (£)	2007-2008	113,995	0	113,995
	Total	**323,169**	**0**	**323,169**
SUCCESS/Preston 8.9: Improved infrastructure for collective transport	2005-2006	4,977	0	4,977
	2006-2007	19,965	0	19,965
	2006-2007	26,647	0	26,647
	2007-2008	40,293	0	40,293
Money unit: British Pound (£)	**Total**	**91,882**	**0**	**91,882**
SUCCESS/Preston 8.9: Promotion of car sharing and car clubs	2005-2006	3,979	0	3,979
	2006-2007	35,415	0	35,415
	2006-2007	11,194	0	11,194
Money unit: British Pound (£)	2007-2008	26,513	0	26,513
	Total	**77,101**	**0**	**77,101**
SUCCESS/Preston 10.4: Freight Partnerships	2005-2006	2,945	0	2,945
	2006-2007	2,369	0	2,369
	2006-2007	4,019	0	4,019
Money unit: British Pound (£)	2007-2008	11,400	0	11,400
	Total	**20,733**	**0**	**20,733**
SUCCESS/Preston 10.5: Freight routing and signing. Etc.	2005-2006	968	0	968
	2006-2007	1,781	0	1781
	2006-2007	6,417	0	6,417
Money unit: British Pound (£)	2007-2008	68,166	0	68,166
	Total	**77,332**	**0**	**77,332**
SUCCESS/Preston 11.5: Planning for alternative transport	2005-2006	1,974	0	1,974
	2006-2007	8,567	0	8,567
	2006-2007	37,744	0	37,744
Money unit: British Pound (£)	2007-2008	49,278	0	49,278
	Total	**97,563**	**0**	**97,563**

		Set-up Costs	Operating cost	Total cost
SUCCESS/Preston 11.6: Personalised travel planning Money unit: British Pound (£)	2005-2006	5,972	0	5,972
	2006-2007	281,238	0	281,238
	2006-2007	209,276	0	209,276
	2007-2008	259,692	0	259,692
	Total	**756,178**	**0**	**756,178**
SUCCESS/Preston 11.7: Business travel plan Money unit: British Pound (£)	2005-2006	3,312	0	3,312
	2006-2007	9,611	0	9,611
	2006-2007	29,611	0	29,611
	2007-2008	**78,580**	**0**	**78,580**
	Total	**121,114**	**0**	**121,114**
SUCCESS/Preston 11.8: School travel plan Money unit: British Pound (£)	2005-2006	3,687	0	3,687
	2006-2007	7,079	0	7,079
	2006-2007	10,372	0	10,372
	2007-2008	10,600	0	10,600
	Total	**31,738**	**0**	**31,738**
SUCCESS/Preston 12.6: Management and control Money unit: British Pound (£)	2005-2006	662	0	662
	2006-2007	2,558	0	2,558
	2006-2007	31,160	0	31,160
	2007-2008	33,452	0	33,452
	Total	**67,832**	**0**	**67,832**
SUCCESS/Preston 12.7: Data collection Money unit: British Pound (£)	2005-2006	1,734	0	1,734
	2006-2007	6,068	0	6,068
	2006-2007	32,321	0	32,321
	2007-2008	13,600	0	13,600
	Total	**53,723**	**0**	**53,723**
SUCCESS/Preston 12.8: Development of common database Money unit: British Pound (£)	2005-2006	30,357	0	30,357
	2006-2007	30,737	0	30,737
	2006-2007	102,327	0	102,327
	2007-2008	22,000	0	22,000
	Total	**185,421**	**0**	**185,421**
SUCCESS/Preston 12.9/7.4:	2005-2006	7,644	0	7,644

		Set-up Costs	Operating cost	Total cost
	2006-2007	16,779	0	16,779
	2006-2007	8,346	0	8,346
	2007-2008	106,605	0	106,605
	Total	**139,374**	**0**	**139,374**
SUCCESS/Preston 12.10: Information dissemination	2005-2006	1,572	0	1,572
	2006-2007	9,447	0	9,447
	2006-2007	41,363	0	41,363
Money unit: British Pound (£)	2007-2008	61,000	0	61,000
	Total	**113,382**	**0**	**113,382**
SUCCESS/Preston: 6.4/6.5/11.4 Adelphi Clearzone	2005-2006	5,332	0	5,332
	2006-2007	21,691	0	21,691
	2006-2007	108,680	0	108,680
Money unit: British Pound (£)	2007-2008	851,584	0	851,584
	Total	**987,287**	**0**	**987,287**
SUCCESS/Preston: 6.4/6.5/11.4 City Centre Clearzone	2005-2006	11,397	0	11,397
	2006-2007	47,874	0	47,874
	2006-2007	59,173	0	59,173
Money unit: British Pound (£)	2007-2008	206,852	0	206,852
	Total	**325,296**	**0**	**325,296**
SUCCESS/Preston: 6.4/6.5/11.4 ley land Clearzone	2005-2006	4,231	0	4,231
	2006-2007	10,989	0	10,989
	2006-2007	73,705	0	73,705
Money unit: British Pound (£)	2007-2008	91,910	0	91,910
	Total	**180,835**	**0**	**180,835**

ANNEX B: MESURE EVALUATION RESULTS TEMPLATE

Measure title: **Measure Name**

City: **City name** *Project:* **Project name** *Measure number:* **xx.yy**

A Introduction

A1 Objectives

The measure objectives are:

- **Objective 1** objective 1 objective 1
- **Objective 2** objective 2 objective 2

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A2 Description

Body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body..

B Measure implementation

B1 Innovative aspects

Select one or more innovative aspects from the list below (see Guidance notes for further explanation), then describe each in more detail with a few sentences:

Innovative Aspects:

- New conceptual approach
- Use of new technology/ITS
- New mode of transport exploited
- Targeting specific user groups
- New economic instrument
- New policy instrument
- New organisational arrangements or relationships
- New physical infrastructure solutions
- Other – *please describe*

The innovative aspects of the measure are:

- **Innovative aspect 1** – Bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text bullet text
- **Innovative aspect 2** – Bullet text bullet text bullet text bullet text bullet text bullet text...

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B2 Situation before CIVITAS

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B3 Actual implementation of the measure

The measure was implemented in the following stages:

Stage 1: Title title title title *(Date from - Date to) – Stage description text stage description text stage description text stage description text stage description text stage description text ….*

Stage 2: Title title title title *(Date from - Date to) – Stage description text stage description…*

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Where possible include diagrams and maps to aid understanding.

B4 Deviations from the original plan

The deviations from the original plan comprised:

- **Deviation 1 title** – Deviation description text deviation description text deviation description text deviation description text deviation description text
- **Deviation 2 title** – Deviation description text deviation description text deviation .....

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B5 Inter-relationships with other measures

The measure is related to other measures as follows:

- **Measure 1 no.** – Description of relationship description of relationship description of relationship description of relationship description of relationship
- **Measure 2 no.** – Description of relationship description of relationship description ….

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C Evaluation – methodology and results

C1 Measurement methodology

C1.1 Impacts and Indicators

Table of Indicators. *Insert own table where available, use landscape layout as necessary*

No.	Impact	Indicator	Used	Etc..
	Table text Table text Table text	Table text Table text Table text Table text		

Detailed description of the indicator methodologies:

Indicator 1 (*Name of indicator*) – Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text Bullet text

Indicator 2 (*Name of indicator*) – Bullet text Bullet text Bullet text Bullet text …..

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C1.2 Establishing a baseline

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C1.3 Building the business-as-usual scenario

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C2 Measure results

The results are presented under sub headings corresponding to the areas used for indicators – economy, energy, environment, society and transport.

C2.1 Economy

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C2.2 Energy

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C2.3 Environment

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C2.4 Transport

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C2.5 Society

Body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body …

C3 Achievement of quantifiable targets

No.	Target	Rating
1	Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text *Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text Table text*	
2		
3		
4		
NA = Not Assessed O = Not Achieved ★ = Substantially achieved (at least 50%) ★★ = Achieved in full ★★★ = Exceeded		

C4 Up-scaling of results

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C5 Appraisal of evaluation approach

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C6 Summary of evaluation results

The key results are as follows:

- **Key result 1** – description text description text description text description text description text description text description text
- **Key result 2** – description text description text description text description text…

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D Lessons learned

D1 Barriers and drivers

D1.1 Barriers

- **Barrier 1** – description text description text description text description text description text description text description text
- **Barrier 2** – description text description text description text description text ….

………

D1.2 Drivers

- **Driver 1** – description text description text description text description text description text description text description text
- **Driver 2** – description text description text description text description text description..

....

D2 Participation of stakeholders

- **Stakeholder 1 -** Description text description text description text description text description text description text description text
- **Stakeholder 2** – Description text description text description text description text ….

....

D3 Recommendations

- **Recommendation 1 -** Description text description text description text description text description text description text description text
- **Recommendation 2** – Description text description text description text description text...

....

D4 Future activities relating to the measure

Body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text body text …

ANNEX C: CNG & GREENHOUSE GAS EMISSIONS

C.1 CO2 Emissions

1. The use of CNG and LPG fuels in heavy vehicles produces similar greenhouse gas emissions as conventional diesel vehicles on a per kilometre basis (although alternative vehicles have greenhouse gas emission benefits relative to gasoline use in light vehicles). For heavy vehicles, although gaseous fuels have a lower carbon content, fuel use (MJ/km) is increased for LPG and CNG vehicles (as engine efficiency is lower for spark ignition engine) and alternative vehicles have a weight penalty. The emission test programmes in the literature generally report that dedicated LPG and CNG heavy vehicles have similar emissions to modern diesel vehicles, but that converted or bi-fuel alternative fuel vehicles often compare less favourably[1].

2. Calculation of CO2 emissions based on Toulouse Diesel and CNG bus data

The method recommended by 2006 IPCC Guidelines for National Greenhouse Gas Inventories [2] was used:

EQUATION 3.2.1
CO_2 FROM ROAD TRANSPORT

$$Emission = \sum_a [Fuel_a \bullet EF_a]$$

Where:

Emission = Emissions of CO_2 (kg)

$Fuel_a$ = fuel sold (TJ)

EF_a = emission factor (kg/TJ). This is equal to the carbon content of the fuel multiplied by 44/12.

a = type of fuel (e.g. petrol, diesel, natural gas, LPG etc)

C.2 CH4 emissions

Natural gas (NG) is a mixture of hydrocarbons, mainly methane (CH4), and is produced either from gas wells or in conjunction with crude oil production. The composition of natural gas used was 91.6 percent methane, 5.0 percent ethane, 0.4 percent propane, 0.1 percent butane, 0.8 percent nitrogen and oxygen, and 2.1 percent carbon dioxide. Natural gas is consumed in the residential, commercial, industrial, and utility markets [1]. Emissions of CH4 are more difficult to estimate accurately than those for CO2 because emission factors depend on vehicle technology, fuel and operating characteristics. Both distance-based activity data (e.g. vehicle kilometres travelled) and disaggregated fuel consumption may be considerably less certain than overall fuel sold. CH4 emissions are significantly affected by the distribution of emission controls in the fleet. Thus higher tiers use an approach taking into account populations of different vehicle types and their different pollution control technologies [2].

1. Equation used for calculation of CH4 emissions [2].

$$Emission = \sum_{a,b,c,d} [Distance_{a,b,c,d} \bullet EF_{a,b,c,d}] + \sum_{a,b,c,d} C_{a,b,c,d}$$

Where:

Emission	= emission or CH_4 (kg)
$EF_{a,b,c,d}$	= emission factor (kg/km)
$Distance_{a,b,c,d}$	= distance travelled (VKT) during thermally stabilized engine operation phase for a given mobile source activity (km)
$C_{a,b,c,d}$	= emissions during warm-up phase (cold start) (kg)
a	= fuel type (e.g., diesel, gasoline, natural gas, LPG)
b	= vehicle type
c	= emission control technology (such as uncontrolled, catalytic converter, etc.)
d	= operating conditions (e.g., urban or rural road type, climate, or other environmental factors)

2. Choice of emission factors

CH4 emission rates depend largely upon the combustion and emission control technology present in the vehicles; therefore default fuel-based emission factors that do not specify vehicle technology are highly uncertain. Even if national data are unavailable on vehicle distances travelled by vehicle type, inventory compilers are encouraged to use higher tiered emission factors and calculate vehicle distance travelled data based on national road transportation fuel use data and an assumed fuel economy value for related guidance.

Because CH4 emission rates are largely dependent upon the combustion and emission control technology present, technology-specific emission factors should be used, if CH4 and N2O emissions from mobile sources are a key category. Table C1 gives the emission factors from European data.

Table C1: Emission factors for European gasoline and diesel vehicles

TABLE 3.2.5
EMISSION FACTORS FOR EUROPEAN GASOLINE AND DIESEL VEHICLES (mg/km), COPERT IV MODEL

Vehicle Type	Fuel	Vehicle Technology/ Class	N_2O Emission Factors (mg/km) Urban Cold	N_2O Urban Hot	N_2O Rural	N_2O Highway	CH_4 Emission Factors (mg/km) Urban Cold	CH_4 Urban Hot	CH_4 Rural	CH_4 Highway
Passenger Car	Gasoline	pre-Euro	10	10	6.5	6.5	201	131	86	41
		Euro 1	38	22	17	8.0	45	26	16	14
		Euro 2	24	11	4.5	2.5	94	17	13	11
		Euro 3	12	3	2.0	1.5	83	3	2	4
		Euro 4	6	2	0.8	0.7	57	2	2	0
	Diesel	pre-Euro	0	0	0	0	22	28	12	8
		Euro 1	0	2	4	4	18	11	9	3
		Euro 2	3	4	6	6	6	7	3	2
		Euro 3	15	9	4	4	7	3	0	0
		Euro 4	15	9	4	4	0	0	0	0
	LPG	pre-ECE	0	0	0	0	80		35	25
		Euro 1	38	21	13	8				
		Euro 2	23	13	3	2				
		Euro 3 and later	9	5	2	1				
Light Duty Vehicles	Gasoline	pre-Euro	10	10	6.5	6.5	201	131	86	41
		Euro 1	122	52	52	52	45	26	16	14
		Euro 2	62	22	22	22	94	17	13	11
		Euro 3	36	5	5	5	83	3	2	4
		Euro 4	16	2	2	2	57	2	2	0
	Diesel	pre-Euro	0	0	0	0	22	28	12	8
		Euro 1	0	2	4	4	18	11	9	3
		Euro 2	3	4	6	6	6	7	3	2
		Euro 3	15	9	4	4	7	3	0	0
		Euro 4	15	9	4	4	0	0	0	0
Heavy Duty Truck & Bus	Gasoline	All Technologies	6		6	6	140		110	70
	Diesel	GVW<16t	30		30	30	85		23	20
		GVW>16t	30		30	30	175		80	70
		Urban Busses & Coaches	30		30	30	175		80	70
	CNG	pre-Euro 4	n.a.				5400			
		Euro 4 and later (incl. EEV)					900			
Power Two Wheeler	Gasoline	<50 cm^3	1		1	1	219		219	219
		>50 cm^3 2-stroke	2		2	2	150		150	150
		>50 cm^3 4-stroke	2		2	2	200		200	200

3. Calculation of CH4 emissions

Using the equation shown above and the emission factors in Table C1 gives :

	Total km	Emission factors (mg/km)	Total CH4 emission (kg)
Diesel bus	1003526	175	175.6
CNG bus	1003526	900	903.2

4. Unit price of CH4 reductions

Methane in the Earth's atmosphere is an important greenhouse gas with a global warming potential of 21 over a 100-year period. This means that a methane emission will have 21 times the impact on temperature of a carbon dioxide emission of the same mass over the following 100 years [3] and [4]. Methane has a large effect for a brief period (a net lifetime of 8.4 years in the atmosphere), whereas carbon dioxide has a small effect for a long period (over 100 years). Because of this difference in effect and time period, the global warming potential of methane over a 20 year time period is 72 [4]

Table C2: Greenhouse Gas Global Warming Potential

Table 1: Greenhouse Gas Global Warming Potentials to convert greenhouse gases to carbon dioxide equivalent and to find their Shadow Price of Carbon

Greenhouse Gas	100 year Global Warming Potential[33]
Carbon Dioxide	1
Methane	21
Nitrous oxide	310
HFC-23	11,700
HFC-32	650
HFC-41	150
HFC-43-10mee	1,300
HFC-125	2,800
HFC-134	1,000
HFC-134a	1,300
HFC-152a	140
HFC-143	300
HFC-143a	3,800
HFC-227ea	2,900
HFC-236fa	6,300
HFC-245ca	560
Chloroform	4
Methylene chloride	9
Sulphur hexafluoride	23,900
Perfluoromethane	6,500
Perfluorethane	9,200
Perfluoropropane	7,000
Perfluorobutane	7,000
Perfluoropentane	7,500

[33] The GWP figures listed in the table below are the 1995 Global Warming Potential values in terms of CO_2. Whilst the GWP have since been updated, the Kyoto Protocol states that "global warming potentials used by Parties [to the Protocol] should be those provided by the Intergovernmental Panel on Climate Change in its Second Assessment Report ("1995 IPCC GWP values")…".

C.3 N2O emissions

1. In natural gas, nitrogen and oxygen accounts for about 0.8% and Nitrous oxide (N2O is the main greenhouse gas considered in this study. Emissions of N2O are more difficult to estimate accurately than those for CO2 because emission factors depend on vehicle technology, fuel and operating characteristics. Both distance-based activity data (e.g. vehicle kilometres travelled) and disaggregated fuel consumption may be considerably less certain than overall fuel sold. N2O emissions are significantly affected by the distribution of emission controls in the fleet. Thus higher tiers use an approach taking into account populations of different vehicle types and their different pollution control technologies [2].

2. Equation used for calculation of CH4 emissions [2].

$$Emission = \sum_{a,b,c,d}[Distance_{a,b,c,d} \bullet EF_{a,b,c,d}] + \sum_{a,b,c,d} C_{a,b,c,d}$$

Where:

Emission = emission or N2O (kg)

$EF_{a,b,c,d}$ = emission factor (kg/km)

$Distance_{a,b,c,d}$ = distance travelled (VKT) during thermally stabilized engine operation phase for a given mobile source activity (km)

$C_{a,b,c,d}$ = emissions during warm-up phase (cold start) (kg)

a = fuel type (e.g., diesel, gasoline, natural gas, LPG)

b = vehicle type

c = emission control technology (such as uncontrolled, catalytic converter, etc.)

d = operating conditions (e.g., urban or rural road type, climate, or other environmental factors)

3. Choice of emission factors

N2O emission rates depend largely upon the combustion and emission control technology present in the vehicles; therefore default fuel-based emission factors that do not specify vehicle technology are highly uncertain. Even if national data are unavailable on vehicle distances travelled by vehicle type, inventory compilers are encouraged to use higher tiered emission factors and calculate vehicle distance travelled data based on national road transportation fuel use data and an assumed fuel economy value for related guidance. According to data in Tables C3 and C4, emission factors of N2O are 3mg/km for diesel buses, and 101 m/km for CNG buses.

Table C3: N2O and CH4 Emission factors for USA gasoline and diesel vehicles

(Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy)

Vehicle Type	Emission Control Technology	N_2O		CH_4	
		Running (hot)	Cold Start	Running (hot)	Cold Start
		mg/km	mg/start	mg/km	mg/start
Light Duty Gasoline Vehicle (Car)	Low Emission Vehicle (LEV)	0	90	6	32
	Advanced Three-Way Catalyst	9	113	7	55
	Early Three-Way Catalyst	26	92	39	34
	Oxidation Catalyst	20	72	82	9
	Non-oxidation Catalyst	8	28	96	59
	Uncontrolled	8	28	101	62
Light Duty Diesel Vehicle (Car)	Advanced	1	0	1	-3
	Moderate	1	0	1	-3
	Uncontrolled	1	-1	1	-3
Light Duty Gasoline Truck	Low Emission Vehicle (LEV)	1	59	7	46
	Advanced Three-Way Catalyst	25	200	14	82
	Early Three-Way Catalyst	43	153	39	72
	Oxidation Catalyst	26	93	81	99
	Non-oxidation catalyst	9	32	109	67
	Uncontrolled	9	32	116	71
Light Duty Diesel Truck	Advanced and moderate	1	-1	1	-4
	Uncontrolled	1	-1	1	-4
Heavy Duty Gasoline Vehicle	Low Emission Vehicle (LEV)	1	120	14	94
	Advanced Three-Way Catalyst	52	409	15	163
	Early Three-Way Catalyst	88	313	121	183
	Oxidation catalyst	55	194	111	215
	Non-oxidation catalyst	20	70	239	147
	Heavy Duty Gasoline Vehicle - Uncontrolled	21	74	263	162
Heavy Duty Diesel Vehicle	All -advanced, moderate, or uncontrolled	3	-2	4	-11
Motorcycles	Non-oxidation catalyst	3	12	40	24
	Uncontrolled	4	15	53	33

Table C4: Emissions factors for alternative fuel vehicles (mg/km)

(Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy)

Vehicle Type Vehicle Control Technology	N_2O Emission Factor	CH_4 Emission Factor
Light Duty Vehicles		
Methanol	39	9
CNG	27 - 70	215 - 725
LPG	5	24
Ethanol	12 - 47	27 - 45
Heavy Duty Vehicles		
Methanol	135	401
CNG	185	5 983
LNG	274	4 261
LPG	93	67
Ethanol	191	1227
Buses		
Methanol	135	401
CNG	101	7 715
Ethanol	226	1 292

4. Unit price of N2O reductions

N2O in the Earth's atmosphere is an important greenhouse gas with a global warming potential of 310 over a 100-year period. This means that a methane emission will have 310 times the impact on temperature of a carbon dioxide emission of the same mass over the following 100 years [3] and [4].

Sources

[1] Hensher D. A. and Button K. J. (2003) Handbook of transport and the environment. pp240

[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

[3] Tom Beer, Tim Grant, Geoff Morgan, Jack Lapszewicz, Peter Anyon, Jim Edwards, Peter Nelson, Harry Watson & David Williams. Comparison of transport fuels final report (ev45a/2/f3c) to the Australian greenhouse office http://www.environment.gov.au/settlements/transport/comparison/index.html

[4] The Social Cost Of Carbon And The Shadow Price Of Carbon: What They Are, And How To Use Them In Economic Appraisal In The UK, Economics Group, Defra December 2007, at http://www.defra.gov.uk/environment/climatechange/research/ carboncost/pdf/background.pdf

[5] How to use the Shadow Price of Carbon in policy appraisal. http://www.defra.gov.uk/environment/climatechange/research/carboncost/step1.htm.