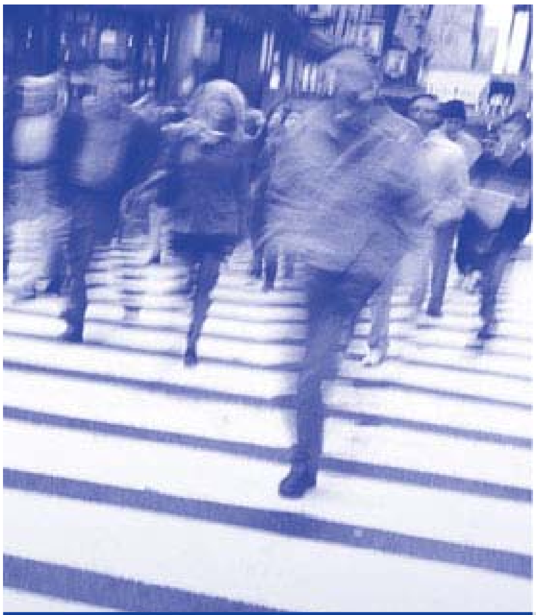

CIVITAS
Cleaner and better transport in cities

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Cluster Report 2: Clean Vehicles and Fuels

Deliverable: D2.2

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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: 29th January 2010

CONTENTS

1 Introduction

1.1 Measure Overview

In any urban future, there will be a role for cars (largely because of the complexity of trip patterns), buses will take an increasing share of trips, and goods vehicles will be needed to support the commercial activities so essential for city vitality. Thus whilst a range of approaches will be used to encourage improvements in urban sustainability, the development and introduction of cleaner vehicles is, and will remain a key area of activity within the CIVITAS programme. This cluster report focuses on the results of those measures which have addressed clean vehicles and fuels.

There are 26 measures relating to the introduction of clean vehicles and fuels in CIVITAS II compared to the 36 measures in the same application area in CIVITAS I. This lower number of measures reflects the extent of development of clean vehicle technologies, some of which have moved from small scale technology trials to more mainstream adoption in the last 5 years and an increasing realisation of current practical limitations to the implementation of others among the technologies. As a result, whilst fewer in number, the measures in CIVITAS II have generally been much more substantial in scale than in the earlier programme. Also, the significant inclusion of measures from cities in countries which more recently joined the EU has given a wide range of base level scenarios from which significant growth was possible.

A key issue throughout this cluster has been securing the delivery of more environmentally sustainable fuels of sufficient quality and quantity for practical implementation of a measure. In many cases, the full environmental impact of using a fuel and its long term availability has not been considered and this may affect the European-wide application of some measures.

1.2 Sustainable Fuels

Various fuels have been considered and/or used. For clarity of understanding the subsequent measures, the various liquid/gas fuels are described below: -

i). Compressed Natural Gas (CNG)

CNG is a methane fuel which, in terms of local pollutants (e.g. CO, HC, NO_x and particulates), has a reputation for producing lower tailpipe emissions than diesel or petrol. However, the use of more advanced combustion and after-treatment to achieve latest emissions standards and fuel economy requirements for petrol and diesel vehicles means that the scale of this benefit is decreasing. CNG generally offers better CO_2 performance per joule energy but methane emissions are significantly higher than those for petrol and diesel and should be taken into account for fair comparison of the contribution to climate change. Combustion is quieter, making it an attractive alternative fuel for Heavy Duty Vehicles (HDVs), particularly buses and delivery vehicles in noise sensitive areas.

Whilst all internal combustion engine vehicles can be adapted to use CNG, most vehicles currently using the fuel are either dedicated, or dual-fuel conversions using spark-ignition (e.g. petrol). Production CNG vehicles do exist, but are essentially conventional spark-ignition powered vehicles with retrofit components added during production. Diesel vehicles can be converted to run with diesel/CNG blends but most are converted to single fuel use. The conversion kits can be relatively costly for passenger cars and the storage density of CNG is comparatively low compared to liquid fuels, requiring relatively large tank sizes, making it more suited to HDVs. (LPG is a more suitable option for passenger cars when available). CNG offers energy diversity benefits as it does not rely on oil, but there are energy security issues because of the declining production of gas in Europe and because the majority is currently transported by fixed pipelines. However, LNG shipping facilities (see below) are increasing. The availability of fuelling stations varies from country-to-country and it is often used in specific applications where a vehicle fleet is based at a single location which allows refuelling. Refuelling technology can either be based on slow filling compressors to which a vehicle needs to be connected over a period of hours, typically overnight at a depot, or on more sophisticated high pressure systems which offer refuelling times similar to petrol or diesel powered vehicles.

ii). Liquefied Natural Gas (LNG)
LNG is natural gas liquefied using cryogenics for low temperature storage. When combusted it offers a similar level of emissions to CNG. It is liquefied to aid transport via shipping but is not commonly used as a vehicle fuel due to the need for it to be cooled to -160^{o}C. The need for on-board cooling equipment makes it more suited to larger vehicles.

iii). Liquid Petroleum Gas (LPG)
LPG is a by-product 'wet' gas produced in the production of petroleum or natural gas, and upon oil extraction. It is a mixture of Propane and Butane and was often burnt off as a waste product (flaring) until fiscal penalties made it cost effective to be used as a fuel. Petroleum gas is liquefied under pressure and so does not require cooling like LNG. It is suited to petrol vehicles as a dual-fuel option and conversions are relatively inexpensive. LPG produces less CO_2 per joule than petrol and diesel fuels and compares favourably on a well-to-wheel basis. Traditionally it has had a reputation for being a cleaner burning fuel than petrol or diesel but, as with CNG, these benefits are diminishing as petrol and diesel engine emissions standards are tightened.

iv). Methane
The term methane is sometimes used to describe natural gas (CNG or LNG).

v). Biofuels
This is a generic term used to describe fuels derived from organic material. Various processes exist to do this and the fuels are in various forms such as bioethanol/spirits, biodiesel or biogas. They are often used in blends with conventional fossil liquid fuels. '1st generation' fuels directly converted harvested biomass (e.g. sugar cane, wheat, palm oil) into fuels. This led to considerable concerns about the balance of using agricultural land for fuel rather than food crops. '2nd generation' fuels are aimed at exploiting non-food crops and crop waste. Questions remain as to the source of land used to grow these non-food crops, as land which is marginal for food crops is also generally marginal for fuel crops and related activities such as deforestation of rainforests for fuel crops remain an issue. Depending on the source of the 'feedstock' and nature of the biomass to liquid (or gas) chemistry, the comparative CO_2 benefit over conventional fuels varies widely and can be either positive or negative. HC, CO and NO_x emissions can be reduced substantially by biofuels, but some engine modifications may be necessary, particularly to the engine map.

vi). Biodiesel
Biodiesel is a variety of biofuel produced by a transesterification of raw vegetable oil or animal fat. A number of processes can be exploited to do this. The benefit of biodiesel is that it produces less lifetime CO_2 when burnt, but the extent of change of CO_2 generation is very dependent on the farming and production techniques used. The general consensus is that tailpipe emissions are similar, if not lower, for biodiesel when compared to conventional diesel. There are some concerns that whilst hydrocarbon emissions are shown to decrease or at least remain comparable to conventional diesel, the composition of hydrocarbons shifts to more unregulated compounds which have a higher toxicity. Some approaches to measurement of tailpipe hydrocarbons will focus

on a proxy Hydrocarbon with an adjustment factor used to account for all other hydrocarbons. However, this factor may be inappropriate for the distribution of hydrocarbons for the chemistry of any particular biodiesel. Biodiesel quality and level of blending has implications for the overall environmental benefits.

vii). Biogas
Biogas is traditionally produced from waste landfill sites as a by-product of decay, or specialist digesters using sewage, algae or other biomass. When from landfill sources, the composition varies making it more difficult to combust in the controlled manner required by internal combustion engines. Microbial digesters are airtight containers with the biomass broken down under anaerobic conditions. The subsequent gas is then removed. New developments in this area are using microalgae which is grown in ponds and then added to a digester. When the efficiency of the digestion reaction falls below a certain level, the remaining biomass can be added to a biofuel cell to provide electricity as it further decomposes.

viii). Conventional fuel/biofuel blends
Biofuels often have different combustion properties from their conventional counterparts. To allow vehicles to operate on both conventional and biofuels, the biofuel option is often blended with the conventional fuel. Blends such as **E85** indicate that the mixture is 15% petrol and 85% bioethanol. E85 requires some engine design modifications because of the additional corrosive properties of the ethanol. After upgrading, the composition of biogas is near identical to Natural Gas and their vehicle-quality fuel is known as biomethane.

Table 1.1 provides information on a number of other terms which have been used by the cities in the description of their measures.

Table 1.1: Definition of Terms

Term/ acronym	Definition
EURO standards	In general, EURO standards refer to varying limits on CO, HC, NO_x and PM_{10} tailpipe emissions from road vehicles when 'driven' over specific test cycles. Different standard numbers (i.e. Arabic numerical for Light duty vehicles and Roman numerical for Heavy Duty Vehicles) refer to the limits required from vehicles introduced after specific dates. Euro 5 standards are now in force. Standards are now available for EURO 6 (LDV) and VI (HDV). Whilst mainly covering petrol and diesel fuels, the HDV standards also have limits for pollutants relevant to Compressed Natural Gas or Liquid Petroleum Gas fuel. An example of the changes is given in **Figure 1**. Other aspects include excess emissions at cold start, in-use reliability of components to maintain emissions performance and evaporative emissions.
HDV	**Heavy Duty Vehicle** – this vehicle class is defined by the vehicle weight; buses, coaches and trucks fall into this category
LDV	**Light Duty Vehicle –** lighter vehicle classes covering passenger cars, vans and minibuses.
EEV	**Enhanced Environmentally-friendly Vehicle** – a voluntary standard introduced by some EU states to encourage HDV manufacturers to go beyond the EURO standards in force at the time. The limits lie somewhere between EURO V and VI.

Term/ acronym	Definition
ZEV	**Zero Emissions Vehicle –** Vehicles producing no tailpipe pollutants, i.e. either electric or fuel cell vehicles.
Filters	Diesel Particulate Filters which remove a significant proportion of particulates from exhausts, using a variety of different technologies. Evidence suggested early filter technologies increased NO_x and fuel consumption, but they have been improving in this respect. Filters are good at removing solid particulates but less efficient for liquid particulates. Some filters are referred to as SOOT filters. Filters typically remove 90% of particulates. The emphasis has been on PM_{10}, but more recent medical evidence would indicate that it is the smaller particulates that generate the more major health problems. Also, filters have been shown to result in a small reduction in engine life.
DPF	**Diesel Particulate Filters** - See 'Filters'
Soot filters	See 'Filters'.
D2	Grade of diesel used to power ordinary road vehicles. (The '2' indicates the fraction number in the distilled fuel oil (or gas oil) used for this fuel type.)
HEV	**Hybrid Electric Vehicle -** Combination of combustion and electric power are used as the vehicle propulsion.
Hybrid	See 'HEV'
ULSD	**Ultra lower sulphur diesel –** A refined diesel fuel with sulphur levels below 10ppm.
AdBlue	This is an aqueous urea additive product used to enable Selective Catalytic Reduction (SCR) after-treatment in HDVs. It is added to the exhaust as it passes through the SCR. SCR reduces NO_x emissions by converting them to nitrogen. Various emulsions have been used as additives.

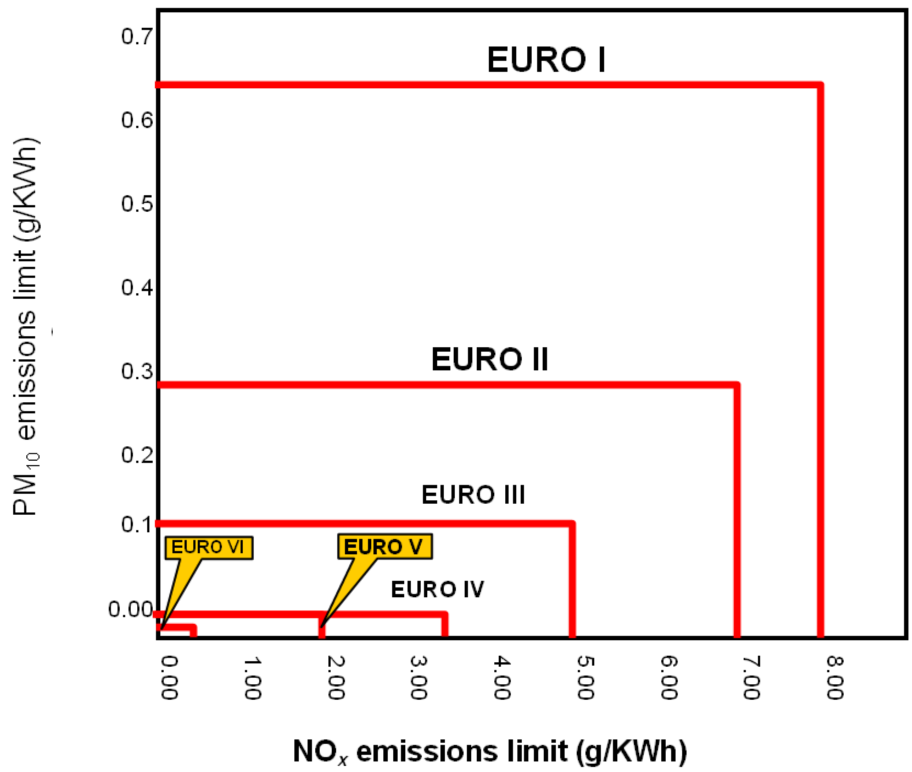

Figure 1: Decreasing emissions limits for HDV (using steady state cycles)

1.3 The Measures

The clean vehicles and fuels measures in CIVITAS II relate to the provision of alternative fuels and exhaust after-treatment systems (on old or new vehicles), the measured and modelled implications of introducing the fuels and the subsequent effect on user attitudes and behaviour.

Most of the CIVITAS II measures related to the coherent consideration of applications which included two or three of the above strands, and it has been difficult to identify clusters within which measures clearly fall. Therefore, the measures have been described as a single cluster, but with the interpretations drawn under the three headings of:

a) Provision of Alternative Fuels.
b) Operational Impacts of Alternative Fuels.
c) User Attitudes and Behaviour towards Alternative Fuels.

There has been a significant emphasis on biofuels, but a range of other fuelled vehicles, including hybrids, have been considered.

The majority of measures have focused on the performance of clean buses. Such measures have value not only in their specific operational and environmental benefits, but also in their role in the management of demand as they can be seen as providing an approach to urban mobility which is sustainable. The demonstration of the use of more sustainable fuels has also been used to raise awareness and influence behaviour more generally. However, in many of the measures, the broader role and opportunities have not been identified.

In Table 1.2 below, the measures have been grouped under three headings according to the main thrust of the measure, although the applications are not so unique for them to be separated as formal clusters. The use of LPG to power boats in Venice has been closely tied to the parallel use of LPG for buses.

Table 1.2: Clean Vehicles and Fuel Measures

City	No.	Measure Title	Outline Description	Success of implementation[1]	Success of outcome[1]
a) Provision of alternative fuels (mainly)					
Burgos	5.2	Support for clean fuels and introduction of clean public and private fleets.	Implementation of clean fuel collection, storage, use and promotion, with initial bus application of CNG and biodiesel.	2	3
La Rochelle	5.3	Implementation of biofuel filling stations.	Provision of 2 biofuel stations for a 30% pure plant oil and 70% diesel mix, addressing legal issues, and promoting the use of biofuels.	2	3
La Rochelle	5.5	Cooking oil recycling pilot projects.	Implementation of a cooking oil collection system and processing plant.	1	3
Malmö	5.2	Biogas on the net.	Injection of biogas from a waste treatment plant into the local gas grid and establishing two fuelling facilities.	2	3
Norwich	5.4	Clean vehicle trials.	Create and promote a biodiesel supply chain and test the technical feasibility of a range of blends.	3	2
Toulouse	5.2	Solutions for alternative fuels and complementary measures to achieve a 100% clean fleet	Assessment of technical and market potential of biodiesel, biogas and soot filters and testing of B30 on 81 converted buses and soot filters on 129 diesel buses.	3	3

City	No.	Measure Title	Outline Description	Success of implementation[1]	Success of outcome[1]
b) Operational impacts of alternative fuels (mainly)					
Debrecen	5.3	Operation of biofueled and CNG vehicles and framework condition for alternative fuel use.	Introduction and testing of CNG buses (3 new and 3 converted from diesel). Biodiesel tests of 10, 20, and 50% against a 4% standard.	1	2
Genoa	5.1	Transition towards clean fleets.	Introduction and testing of range of cleaner buses, (EURO IV, EEV, particulate filters) extension of zero emission zone and a special project.	-	3
Krakow	5.3	Transition towards clean vehicle fleets.	CNG demand responsive mini buses introduced and hybrid bus trialled.	1	
La Rochelle	5.1	Development of clean collective transport.	Hybrid technologies reviewed and 2 petrol/electric hybrid mini buses trialled as park and ride shuttles and the technology promoted.	1	1
La Rochelle	5.2	Introduction of new clean buses.	Implementation and testing of EEV buses with selective catalytic reduction that injects an aqueous urea solution into the fuel stream.	1	3
Ljubljana	5.4	Implementation and large-scale deployment of biodiesel and CNG fleets.	Biodiesel generation and testing on pure biodiesel (B100) buses converted from Pre-Euro.	1	1
Malmö	5.1	Clean municipal fleet.	Introduce clean (mostly E85) vehicles in the municipal fleet of light vehicles and use the visible presence of these vehicles to promote the adoption of clean vehicles more generally.	1	1
Malmö	5.3	Clean heavy vehicles.	Introduce alternative natural gas/biogas fuelled heavy vehicles and provide eco-driving training.	1	2
Malmö	5.8	Clean fleet UMAS.	Introduce clean vehicles in the Malmö Hospital (UMAS) fleet by influencing the staff responsible for vehicle purchasing to choose more environmentally sustainable vehicles.	1	1
Ploiesti	5.8	Conversion of buses to LPG.	Introduction of new LPG buses and assess technical/attitude/economic impacts.	3	2
Potenza	5.5	Introduce clean vehicles in a large fleet of urban buses.	Methane/natural gas mini-buses purchased.	2	2
Preston	5.6	Introduction of clean buses.	Trials of engine cleaning technology (including fuel conditioner) and biodiesel.	0	1
Suceava	5.6 8.8 8.9	Alternative fuel bus fleet and support measures	New LPG buses, new priority and related traffic management measures and bus information systems	3	3
Toulouse	5.1	Large scale operation of clean bus fleets and preparation of sustainable supply structures for alternative fuels.	To introduce new CNG buses, provide a new CNG filling station for 125 buses and promote a CNG micro-compressor for home use with passenger cars.	3	3
Venice	5.5B	Deployment of CNG buses.	Introduce CNG buses and increase attractiveness of Public Transport.	1	1
Venice	5.5A	Deployment of LPG boats.	Introduce LPG on pilot fleet of 10 pilot boats (new bi-fuel outboard motors), raise awareness, and develop a local action plan.	1	1

City	No.	Measure Title	Outline Description	Success of implementation[1]	Success of outcome[1]
c) User attitudes and behaviour towards alternative fuels					
Lubljana	11.8	Set up information posts and campaign on clean vehicles and alternative fuels.	Integrated dissemination programme to promote clean vehicles and alternative fuels.	3	3
Malmö	7.1	Marketing of clean vehicles by subsidised parking.	Identification and application of a strategy to encourage the purchase of clean cars by subsidised parking.	2	1
Norwich	7.2	Influencing the choice of vehicle towards smaller and more fuel-efficient vehicles.	Development and implementation of parking incentive/awareness scheme to encourage the purchase of more environmentally sustainable cars.	3	2
Suceava	5.7	Marketing for alternative fuels in the public and private sectors	Demonstration of the financial benefits of LPG conversion for taxi operators.	2	3

Note 1: Rating of success: 0=not successful, 1=moderately successful, 2=successful, 3=very successful

Table 1.1 also shows the ratings of success of the measures in relation to the implementation process and the outcome. The estimated ratings were made by the CIVITAS projects themselves and collected at the end of the project. In relation to other clusters, cluster 2, Clean vehicles and fuels related measures, is characterised by a moderately successful implementation process and an above average success of the outcome.

2 Implementation

Within CIVITAS II there were different approaches carried out to promote clean vehicle fleet:

- technological upgrading of vehicle fleet of public transport;
- development and implementation of clean fuels;
- development and implementation of electric buses;
- development and implementation of methane buses and
- concepts to encourage motorists to own less polluting cars.

The following implementation steps could be identified:

- Identification of the objectives and analysis of basic conditions

There are a number of reasons to introduce and encourage clean vehicles: for example, contribution to protect the environment, reducing maintenance and repair costs and reducing fuel costs. Data regarding different technical solutions for clean fuels and for more fuel efficient vehicles need to be collected and analysed. The positive and negative effects of alternative approaches have to be assessed. The needs and priorities of the stakeholders (especially the car industry, bus and taxi operators or other commercial operators, producers of alternative fuels as well as city councils and citizens) have to be taken into consideration and can be found out by surveys and/or round table discussions.

- Elaboration of a strategic development plan and an investment plan

Based on the identified objectives a strategic development plan should map out the available resources of the city, the air pollution situation and the long-term basis of alternative fuels. A strategic development plan and an investment plan are not only important to outline the project but also vital for presenting the project to the public and the local authorities. The plans usually need to be confirmed by local decision-makers.

- Political and legal approval and support

Although approaches to promote a clean vehicle fleet usually have a strong social acceptance, implementation needs to be politically and legally approved. In view of the amount of financial investment for the technical design and implementation, official support is essential from the very start of the project.

- With regard to the five different approaches to promote clean vehicle fleet, the following implementation steps were reported:
  - Technological upgrading of the vehicle fleet of public transport

  Investigations of similar measures in other European cities lead to best practice solutions and can take advantage of synergetic effects. A market study helps to obtain suitable suppliers for solutions, for instance re-building of diesel buses fitted with particle filters (Toulouse, Genoa). Specifications have to be written and the call for tender procedure launched. Basic criteria considered are the financial offer, the respect of deadlines and the ecological aspects.

  - Development and implementation of clean fuels

  Baseline data on average fuel consumption rates, clean fuel blend and clean fuel efficiency need to be collected, with an assessment of how clean fuel blend impacts on fuel efficiency and emissions vary across the bus fleet. Research on alternative fuel technology (often in collaboration with universities) points out the state-of-the-art and leads to up-to-date technical solutions. The implementation steps are: identify available alternative fuels such as natural gas, biodiesel or biofuel sources (e.g. cooking oil tank farms); define the mechanism for the procurement of raw materials for fuel production (e.g. specific plants or cooking oil); and then adapt vehicles to run on alternative fuels. For long-term usage, clean fuel filling stations should be built.

- Development and implementation of electric, including hybrid electric, vehicles

Electric mobility is a current topic in several European cities (Genoa, La Rochelle). The recharging system of electric vehicles is a big challenge and research on technology is necessary. Downtown areas are recommended for application because of the shorter range of electric buses. A general maintenance programme has to be defined.

- Development and implementation of methane buses

There are two approaches here: bi–fuelled methane/petrol buses or pure methane buses. Technical data concerning methane buses has to be registered. A state-of-the-art analysis including security aspects and refuelling requirements offers a good overview of possible measures. Finally the buses have to be adapted and tank farms and refuelling stations installed.

- Concepts to encourage motorists to purchase less polluting, more fuel efficient and smaller cars.

There are different concepts to encourage motorists to change to less polluting cars. The following points give some ideas for managing the change and increasing people's willingness to buy clean cars:

  - communication and information campaigns about the relationship between vehicle length and emissions (Norwich)
  - free or subsidised parking for clean vehicles (Malmö)
  - financial benefit for taxi drivers using clean fuel cars (Suceava)
  - tax incentives.

Quantitative questionnaires among the citizens establish public opinion regarding willingness to buy a clean car and the limiting factors.

- Constructing and testing of technical devices

Buses with alternative fuels or electric buses have to be tested in real conditions. It was reported that the timeframe for the initial trial from start to finish was between 6 and 8 weeks (Preston). In addition to this, it is advisable to organise information sessions for drivers and maintenance engineers.

- Training for staff members

The preparation of instructions on how to maintain and manage the vehicles adapted on alternative fuels can avoid problems at the beginning of the implementation. It is also advised to design a user-manual.

- Communication and information campaigns

Communication with stakeholders should start at the very beginning of the project and can be done by producing and sending out brochures, posters, advertisement and/or postcards to citizens and coach drivers/operators. It is also advised to make the information available on the internet.

- Promotion

Promotion of the new measures helps to raise awareness among the public about the benefits in quality of life. There is also the possibility of combining the measure with other benefits for the citizens regarding air quality, reducing emissions and sustainable contribution to climate protection. It is also helpful to use media such as newspapers or to hold a press conference with an official press release and a press kit.

3 Drivers and Barriers

The tables below show the drivers and barriers, as reported by the individual project teams.

3.1 Drivers

Drivers were asked about in an open question format. They were asked to be reported only if they were recognized as being more than what would normally be expected. To give a better overview and to compare the different measures with each other, categories have been created. A tick mark indicates that the specific driver was indicated at least once in the evaluation for the measure.

Within CIVITAS II, projects were implemented which have a strong social acceptance. The public acceptance and political commitment to reduce emissions is usually strong (Table 3.1). In detail, the drivers were described as follows:

- Overall interests and current needs

The use of a more environmentally friendly and sustainable source of fuel is at the forefront of improving air quality. The motor industry and producers of biofuels could see good prospects and support the implementation of the measures.

- Public demand and political support/awareness

Strong political interest can support the implementation. Usually there is a strong political commitment to improve air quality in all European cities. It was reported that an exhibition of more environmentally-friendly buses during a meeting of the European Union Committee encouraged implementation (Krakow).

3.2 Strategies to overcome barriers

Measures concerning clean vehicles and fuels dealt with technical and organisational barriers as well as financial issues (see Table 3.2). In detail, strategies to overcome barriers were described as follows:

- Knowledge of the specific legal framework

Within CIVITAS II the evolution of national legislation regarding the use of biofuel was not predictable and new laws had to be passed in line with the technological development.

- Technical specifications

Biofuels require the control of bacterial growth in the fuel tanks. It is advised to supply a cleaning machine and equipment at the very beginning of the project (La Rochelle). Fuel quality standards are also required and must be adhered to by producers for successful vehicle operation and achievement of potential environmental benefits.

- Financial restrictions

Careful planning ensures remaining within the given financial resources. If substantial costs increase for major components, the budget has to be modified in cooperation with local authorities otherwise the missing budget will result in political controversy. Timescales have to be agreed by all participants in order to get political and stakeholder support.

- Stringent contractual conditions for quality and deadlines

Delays may occur from unforeseeable difficulties with suppliers, starting from the company responsible for printing information materials to those responsible for the technical implementation. There is a need for stringent contractual conditions for quality of the products and deadlines plus subsequent monitoring of those conditions.

Table 3.1: Clean Vehicles and fuels: Drivers

City	Measure	Driver related to above expected…				
		engagement / commitment of organisation or persons involved	experience and know-how of persons involved	support from outside the project team to implement measure	good structures / cooperation / management within project team	unsatisfying situation before and/or need to improve the situation
a) Provision of alternative fuels (mainly)						
Burgos	Support for clean fuels & introduction of clean public and private fleets (5.2)				✓	
La Rochelle	Implementation of biofuel filling station (5.3)	✓		✓		
La Rochelle	Cooking oil recycling pilot project (5.5)	✓				
Malmö	Biogas on the net (5.2)	✓				
Norwich	Alternative fuel vehicle fleets (5.4)			✓		✓
Toulouse	Solutions for alternative fuels (5.2)	✓			✓	
b) Operational impacts of alternative fuels (mainly)						
Debrecen	Operation of biofuel and CNG vehicles and framework conditions for alternative fuel use (5.3 D)	✓				
Genoa	Transition towards clean vehicle fleets (05.1)	✓				
Krakow	Transition towards clean vehicle fleets (5.3)	✓	✓		✓	
La Rochelle	Development of clean collective transport (5.1)	✓				
La Rochelle	Development of clean light vehicle fleet (5.2)	✓				
Ljubljana	Implementation and large-scale deployment of biodiesel and CNG fleets (5.4)	✓	✓	✓		
Malmö	Clean municipal fleet (5.1)	✓			✓	
Malmö	Clean heavy vehicles with CO_2 cooler (5.3)			✓		
Malmö	Environmentally adopted cars (5.8)	✓				
Ploiesti	Conversion of buses to LPG (5.8)			✓		✓
Potenza	Introduce clean vehicles in a fleet of urban buses (5.5)	✓			✓	✓
Preston	Introduction of clean buses (5.6)				✓	✓
Suceava	Alternative fuel bus fleet (5.6)	✓		✓	✓	
Toulouse	Large-scale operation of clean bus fleets (5.1)	✓		✓	✓	✓
Venice	Deployment of CNG buses and LPG boats (5.5)			✓		

City	Measure	Driver related to above expected…				
		engagement / commitment of organisation or persons involved	experience and know-how of persons involved	support from outside the project team to implement measure	good structures / cooperation / management within project team	unsatisfying situation before and/or need to improve the situation
c) User attitudes and behaviour towards alternative fuels						
Ljubljana	Information points and campaign on clean vehicles and alternative fuels (11.8)			✓		
Malmö	Marketing of clean vehicles by subsidized parking (7.1)	✓		✓		
Norwich	Influencing choice of veh. Towards smaller & more fuel efficient vehicles (7.2)	✓				✓
Suceava	Marketing of alternative fuels in the public and private sector (5.7)	✓		✓		

Table 3.2: Clean vehicles and fuels: Barriers

City	Measure	acceptance barrier	delays during the project	financial barrier	institutional barrier	lack of labour resources	legal barrier	management barrier	market barrier	organisational barrier	political barrier	spatial barrier	technical barrier
a) Provision of alternative fuels (mainly)													
Burgos	Support for clean fuels & introduction of clean public and private fleets (5.2)			✓									✓
La Rochelle	Implementation of biofuel filling station (5.3)						✓						✓
La Rochelle	Cooking oil recycling pilot project (5.5)			✓									✓
Malmö	Biogas on the net (5.2)							✓					
Norwich	Alternative fuel vehicle fleets (5.4)			✓	✓				✓		✓		
Toulouse	Solutions for alternative fuels (5.2)		✓	✓				✓			✓		✓
b) Operational impacts of alternative fuels (mainly)													
Debrecen	Operation of biofuel and CNG vehicles and framework conditions for alternative fuel use (5.3)			✓	✓		✓			✓			✓
Genoa	Transition towards clean vehicle fleets (5.1)			✓									✓

City	Measure	acceptance barrier	delays during the project	financial barrier	institutional barrier	lack of labour resources	legal barrier	management barrier	market barrier	organisational barrier	political barrier	spatial barrier	technical barrier
Krakow	Transition towards clean vehicle fleets (5.3)			✓			✓			✓			✓
La Rochelle	Development of clean collective transport (5.1)												✓
La Rochelle	Development of clean light vehicle fleet (5.2)							✓					✓
Ljubljana	Implementation and large-scale deployment of biodiesel and CNG fleets (5.4)			✓	✓					✓			✓
Malmö	Clean municipal fleet (5.1)	✓		✓									
Malmö	Clean heavy vehicles with CO_2 cooler (5.3)			✓				✓	✓	✓		✓	✓
Malmö	Environmentally adopted cars (5.8)			✓									
Ploiesti	Conversion of buses to LPG (5.8)												✓
Potenza	Introduce clean vehicles in a fleet of urban buses (5.5)		✓										
Preston	Introduction of clean buses (5.6)												✓
Suceava	Alternative fuel bus fleet (5.6)	✓		✓								✓	✓
Toulouse	Large-scale operation of clean bus fleets (5.1)	✓		✓	✓		✓			✓			
Venice	Deployment of CNG buses and LPG boats (5.5)		✓	✓			✓	✓	✓	✓	✓		✓
c) User attitudes and behaviour towards alternative fuels													
Ljubljana	Set-up of information points on clean vehicles and alternative fuels (11.8)				✓					✓	✓		✓
Malmö	Marketing of clean vehicles by subsidized parking (7.1)										✓		
Norwich	Influencing choice of veh. Towards smaller & more fuel efficient vehicles (7.2)			✓						✓	✓		✓
Suceava	Marketing of alternative fuels in the public and private sector (5.7)	✓		✓							✓	✓	✓

4 Impacts

Measures in this cluster deal with the sourcing, provision and use of fuels which are environmentally more sustainable than conventional diesel or petrol.

Whilst there is substantial commercial involvement in many measures, the applications are driven by local authority organisations and the majority have been focused on buses. Thus, benefits are derived not just to the environmental operations but also hope to contribute to wider awareness, attractiveness and use of public transport. There are significant results related to changes in awareness, but little evidence of changes in mode use which can be explicitly linked to the clean buses. Nonetheless, increased awareness and a positive public view of clean buses are helpful to politicians making decisions which generally involve increased cost to achieve the environmental savings. Cost, convenience, comfort and reliability generally feature more strongly when considering public transport use.

The provision of clean vehicles in CIVITAS II measures covers the following four areas:

i) Experimental vehicles used for testing/demonstration.
ii) The modification of existing vehicles.
iii) The expansion of the take-up of 'clean' vehicles in a fleet which already contains some 'clean' vehicles.
iv) The introduction of a significant number of new vehicles where there was previously no precedent.

The detail of the evaluations has been different in different cities, with relatively few direct measurements of environmental impacts and with the majority focusing on financial information, operating characteristics and awareness/attitudes. Changes in fuel consumption are often given as whole fleet effects as these are most readily measured. Many environmental impact estimates are based on the scaling up of standard or manufacturers' values of pollutants and fuel consumption. Whilst such values can give an indication of the overall scale of the impacts, the practical effects of variations in 'real-world' conditions of use are lost. The environmental assessment varies in scope from only considering tailpipe emissions to considering the 'well-to-wheel' emissions. With regards to CO_2 and other pollutants with non-local impacts (e.g. climate change, trans-boundary acidification), it is the latter which provides the best comparison. Where specific operational comparisons have been made such as with the hybrid minibuses in La Rochelle, performance in the real world is poorer than expected, but the studies lead to new and valuable insights.

Impacts have often focused on local pollutants only, rather than CO2, as climate change issues came to prominence after the start of the programme.

In Tables 4.3 and 4.4 and the following text, key outputs and impacts have been identified and discussed. Much more detail and content are provided in the individual measure templates and the project reports.

Table 4.3: Clean Vehicles and fuels – Outputs

City	No.	Fuels/Technology Used					Supply Chain Addressed	Application Areas/No. of vehicles				Awareness/ Marketing	Remarks
		Biodiesel	Biogas	LPG	Electric	Other		Light	Heavy	Mini buses	Buses		
a) Provision of alternative fuels (mainly)													
Burgos	5.2	✓	✓				✓	✓			27 (biodiesel) 8 (CNG)	✓	Promotion of biodiesel fuel stations for private vehicle usage and introducing biodiesel (B20) and CNG buses.
La Rochelle	5.3	✓					✓		8			✓	All background conditions addressed to implement the 2 biodiesel filling stations to supply city trucks.
La Rochelle	5.5	✓					✓	✓	✓	✓	✓	✓	Plant on stream, for future application to urban fleet.
Malmö	5.2		✓				✓	57	✓			✓	Biogas from sewage treatment plants. *Estimated no. of new cars bought based on usage.
Norwich	5.4	✓					✓				12	✓	Deviations because of supply and performance findings.
Toulouse	5.2	✓	✓			✓	✓				81 (biodiesel) 101 new diesel + filters 28 filters (converted)	✓	Research, market analysis and testing of B30 and soot filters.

City	No.	Fuels/Technology Used					Supply Chain Addressed	Application Areas/No. of vehicles				Awareness/ Marketing	Remarks
		Biodiesel	Biogas	LPG	Electric	Other		Light	Heavy	Mini buses	Buses		
b) Operational impacts of alternative fuels (mainly)													
Debrecen	5.3		✓				✓				6		3 new buses (CNG) 3 converted (CNG) and several diesel for biofuel tests
Genoa	5.1		✓		✓	✓	✓				30 EURO IV 17 ZEV (Trolley bus) 55 EEV		Bi-fuel diesel/electric trolley buses. Upgrading to EURO IV/V (+50 particulate filters). Demonstration of electric minibuses halted due to technical failure.
Krakow	5.3		✓		✓	✓	✓				5		5 new CNG buses. Hybrid electric bus trialled.
La Rochelle	5.1				✓					2			Petrol/electric hybrid minibuses trialled.
La Rochelle	5.2					✓	✓				10		Aqueous urea solution injected into the fuel stream and particulate fuel filters.
Ljubljana	5.4	✓					✓				20		Difference numbers of buses were used for different tests.
Malmö	5.1		✓		✓	✓		313				✓	Replacement of municipal fleet of light vehicles with a range of 'clean' vehicles.
Malmö	5.3		✓						10			✓	Eco driving training.
Malmö	5.8		✓					23					Biofuel – CNG/petrol (dual fuel) Biofuel – E85/petrol (bi-fuel but single tank) Eco driving training/promotion
Ploiesti	5.8			✓							25		Old buses converted to LPG and refurbished interior.

City	No.	Fuels/Technology Used					Supply Chain Addressed	Application Areas/No. of vehicles				Awareness/ Marketing	Remarks
		Biodiesel	Biogas	LPG	Electric	Other		Light	Heavy	Mini buses	Buses		
Potenza	5.5		✓							4		✓	
Preston	5.6					✓	✓				5		Trial of engine cleaning technology which proved unsuitable.
Suceava	5.6 8.8 8.9			✓			✓				30	✓	Integrated with support measures. Biogas not able to be delivered in projects
Toulouse	5.1		✓			✓					68		Included particulate filters and home CNG compressors. New bus filling station for CNG. 28 buses supplied. 40 on order.
Venice	5.5B		✓				✓			5	35		New filling station built to support 35 new CNG buses.
Venice	5.5A			✓							10*		*Boats NOT buses fitted with dual-fuel LPG engines.
c) User attitudes and behaviour towards alternative fuels													
Ljubljana	11.8							✓				✓	3 information points on clean vehicles and alternative fuels set up.
Malmö	7.1							1031				✓	Awareness and subsidised parking for green vehicles.
Norwich	7.2							✓				✓	Awareness of more sustainable vehicles.
Suceava	5.7			✓			✓	85*				✓	Awareness of the benefits of LPG, has encouraged further interest in the purchase of new vehicles

*maximum number

Table 4.4: Clean Vehicles and Fuels – Impacts

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
a) Provision of alternative fuels (mainly)					
Burgos	5.2	● MJ/vkm reduced from 23 to 21 and MJ/pass.km fell from 0.75 to 0.66. ● Substantial increase of 50% in use of biodiesel in private fleets to 1.9 million litres between 2005 and 2007/8. The lower use of biofuels between 2007 and 2008 may be an anomaly of the survey approach. ● Total CO_2, NO_x and PM_{10} emissions were estimated to have fallen by 10, 15 and 40% respectively.	● 38 old buses replaced by 27 new biodiesel and 8 CNG buses.	● Awareness of the use of fuels in PT increased by 13% to 74% between 2007 and 2008. ● Awareness of specific benefits and between user groups was very varied. .	● The high profile implementation of biofuels has led to an increasing awareness and adoption of cleaner fuels by the public generally. ● The results were based on data from the bus operators, some additional interpretive calculations and surveys of users.
La Rochelle	5.3	● The net present cost of the measure over 5 years of operation is estimated to be €84,200. ● When idling, the reduction in hydrocarbons was between 41% and 34%, NO_x up to 22% and CO_2 between 5% and 18%. ● Fuel consumption change considered neutral overall.	● Vehicle reliability as before the shift to clean fuel, after some initial problems. ● Vehicles running on biofuel (30% pure plant oil and 70% diesel) showed no increase in wear and tear. ● Driver satisfaction among the 11 drivers involved was neutral on balance, with some drivers less satisfied by restart capabilities and perceived increase in fuel consumption.	● Publicity increased awareness. ● Neutral response from drivers. ● Broad public support with 96% considering the initiative satisfactory or very satisfactory.	● Bacteria growth in the fuel tank because of water condensation was addressed by bactericide, decanters and a tank mixer. ● Fuel consumption results from one of the eight trial vehicles differed substantially from the others. This reduced the level of confidence in interpretation of some results. ● Results were based on direct measurements on test beds and questionnaires of drivers and user.
La Rochelle	5.5	● By 2008, 49 agreements in place with restaurants to supply cooking oil to the new recycling plant. ● 71% of the oil proved usable. ● The 4,400 kilos collected is short of the 27,300 kilos (30,000l) target. ● Overall, there are 370/380 establishments with 175,000 litres per year. With 30,000 needed to		● 90% of population supportive of initiative. 82% of restaurant owners interested in system to collect/recycle oil. ● The incentive is that, otherwise, restaurants face a charge for taking used oil away and penalties for disposing of oil in sinks or in waste.	● Ensuring oil quality standards is a technical barrier and biofuels expertise important. ● Current legislation is difficult to contend with. ● Results were based on user measurements and records.

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		supply the municipal waste and water trucks, this indicates an adequate supply.			
Malmö	5.2	● Net reduction in CO_2 in the area was 431,000 kg in 2008. ● Differences in CO and NO_x were considered negligible.	● Slow filling gas station in Malmö can handle 15 heavy vehicles overnight and a new fast fuelling facility in Ystad. Gas from the net.	● Awareness/acceptance not assessed.	● Vehicle gas (50% natural gas/50% biogas) used because of limited supply of biogas from the water treatment plan. ● Results based on operating data and emission estimates from standard operating models.
Norwich	5.4	● Energy content of the biodiesel is 10% lower than for ultra low sulphur diesel (ULSD). Trials with B100 confirmed this with a 10% increase in fuel consumption. ● B100 gave an estimated 30% well-to-wheel reduction in CO_2. ● Up to B20, fuel economy and NO_x emissions were not noticeable different to USLD. ● The use of B20 across the Anglian bus fleet would reduce CO_2 emissions by about 600 tonnes/year.			● Initial problems of fuel quality were addressed by changing supplier. ● Limited data from operators and additional interpretations using models.
Toulouse	5.2	● Extra cost of soot filters on 28 buses = €0.28/100km. ● Extra fuel and maintenance cost for 8 buses running on biodiesel was €2.56/100km. ● With soot filters, particulates fell from 6000gm/1000km to 55gm/100km. ● Biodiesel (B30) reduced CO emissions and particulates by 20%. ● Since start of MOBILIS: NO_x down by 30% CO down by 55% HC down by 40% Particulates down by 85% across			● The 81 buses converted to biodiesel with a 30% blend were either EURO 0 or EURO I. The buses retrofitted with particle filters were EURO 2. ● Results based on operator records and manufacturers data.

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		whole bus fleet and 91% down for the buses retrofitted with filters at a cost of €0.28/1000 km.			
b) Operational impacts of alternative fuels (mainly)					
Debrecen	5.3	● A range of diesel blends were trialled up to B50. ● Fuel consumption increased with 10, 20% biofuel levels, but surprisingly returned to diesel levels at 50%. ● 4.4% biodiesel gave a 10% saving in fuel, but some reduction in engine performance. ● Insufficient biogas was available from waste site for application. ● Detailed tables of measured changes in emissions suggest some counter intuitive results.	● 6 additional CNG fuel buses and at least one existing CNG bus transformed to cleaner operation.	● Survey of bus drivers indicated that they did not consider the higher levels of biofuel was satisfactory.	● 3 new buses (CNG) ● 3 converted (CNG) ● Results based on direct measurements and questionnaire surveys.
Genoa	5.1	● Total investment of €367m in 104 vehicles (30 EURO IV buses, 17 EURO IV trolley buses, 55 new EEV vehicles, 2 small EURO IV buses and 50 soot filters). ● Clean energy use (electric and methane) increased from 4.5% to 6.2% between 2005 and 2008. ● Over same period, measures reduced CO, NO_x and PM_{10} emissions in the fleet of conventional buses by 16%, 4% and 27% respectively.	● New NaveBus (ferry) system resulted in the transfer of 70,000 trips from car to pt. Between August 07 and December 08. ● Most users between 36 and 65 and 55% were in employment.	● Public perception of cleaner vehicles said to be supportive but not quantified.	● Dual-fuel diesel/electric trolley buses. ● Upgrading to EURO IV (+50 particulate filters). ● Demonstration of electric minibuses halted due to technical failure. ● Some buses ordered but not delivered in time for evaluation. ● Results based on operating data and modelling.
Krakow	5.3	● CNG consumption on the 5 buses introduced was 60% higher than for diesel vehicles, though the reason could not be identified and may have been the result of a recording error. ● Noise levels in CNG buses satisfactory but higher than for diesel. External noise	● CNG bus usage (exploitation) improved over the trial for CNG and was as high as for diesel after one year. ● 100 CNG vehicle expansion abandoned because of concerns over energy supply from Russia.	● 63% supported buses powered by ecological fuel. ● Less than half would be prepared to pay more for this.	● 5 new CNG buses. ● Hybrid bus trialled. ● Results based on operating data, modelling and attitudinal surveys.

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		measurement showed reduced noise levels. ● Energy consumption for CNG vehicles 60% higher than for diesel, but inexplicable.			
La Rochelle	5.1	● The two hybrid minibuses had maintenance costs 70% higher than for electric vehicles at €0.42/km. ● Energy consumption of hybrid was 24% greater than equivalent diesel. ● Hybrid vehicle emissions were similar to EURO IV diesel, except for NO_x, CO, and particulates where the diesel performed substantially better. (NO_x was 13-37% greater depending on battery condition.) ● The relatively poor results for the hybrid were put down to the small engine and limited battery performance. ● Regenerative braking provided 15% of the energy used.	● Hybrid shuttle buses were less reliable (163% higher out-of-service than for electric vehicles), but this was hidden from users by maintaining the services with standby vehicles.	● There was a high level of awareness of the hybrid buses (75% of users and 95% of all sample of users/nonusers considered the introduction of hybrid buses satisfactory or better).	● The fully electric vehicles were less liked than the hybrid, because of their relatively poor performance on the hills. ● The hybrid performed badly compared to a EURO IV diesel because of the small engine in the hybrid, the limited battery capability and the need to use the engine at high revs for significant periods of operation. ● Results based on detailed records of operations, vehicle based measurements and attitudinal surveys.
La Rochelle	5.2	● The 10 new EEV buses used EURO IV engines with retrofit particulate filters and an AdBlue aqueous urea system. ● Maintenance costs compared to EURO III buses were no more than 7% higher and reliability was at least as high as EURO III buses. ● Substantial reductions in emissions (C0 – 98%, HC -98%, NO_x -68%, PM_{10} -89%, CO_2 -2%)		● A general survey found the EEU bus initiative very satisfactory (58%) or satisfactory (38%)	● The cost of fuel per vehicle/km was similar because of the cost of the AdBlue. ● Results based on detailed records of operations, manufacturers data and questionnaire surveys.
Ljubljana	5.4	● Servicing costs of the B100 biodiesel vehicles 15% higher than for diesel buses, fuel consumption	● Some concern that in winter the biodiesel will not be reliable because of low	● General survey showed majority of respondents favoured the use of public transport as it reduced	● Initial quality of biodiesel produced on small farms (from rape seed) was a problem with

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		7.5% higher, and power 6.0% lower based on laboratory tests. ● Total cost of a B100 biodiesel vehicle over diesel EURO II is €500/year. ● Environmental changes with B100 biodiesel over EURO II diesel: CO – 49% HC – 68% PM_{10} – 46% Smoke – 45% NO_x + 13%	temperatures (-7°C).	pollution.	higher water content and viscosity than standard. ● Increased sourcing from Pinus, a small biodiesel production company, improved quality and it was assumed that better farmer training and equipment could produce the same results. ● The poor quality of the biodiesel could have been the main cause of increased servicing problems. ● Results based on detailed records of operator and producers, vehicle tests and laboratory results.
Malmö	5.1	● A change within clean LDVs in the municipal fleet rests to some extent with the choices of individual managers who specify the requirements. ● Before SMILE the % of clean vehicles grew at about 0.3% per month. By the end of SMILE this had risen to 0.9% per month. ● Total CO_2 emissions fell by about 18% during the project period, little long term change in NO_x and PM_{10} and outcome depends on assumptions of fleet size/distance travelled (i.e. larger vehicles), etc.	● Malmö has lower take-up of clean vehicles than comparator cities of Gothenburg and Stockholm. (Stockholm has a fee based entry system to encourage the private purchase of clean vehicles which may have had a greater effect). ● Local awareness initiatives may not be as effective as national ones although 313 out of 333 vehicles purchased in Malmö were 'clean'.	● Respondents said 34% of municipal vehicles were clean. (Lower than real value in 2008). ● Over twice as many (22%) felt that clean vehicles were more important than eco-driving, but 46% considered them equally important. ● A survey outside car dealerships showed that there was no evidence of a link between awareness of clean vehicle issues and an influence on purchasing decisions.	● The increase in the rate of choosing clean vehicles as replacement must be partly influenced by the increased availability of such vehicles. ● No direct measures of vehicle emissions; emissions/energy usage may have been influenced by parallel eco driving training for municipal employees.
Malmö	5.3	● 6% (1.6SEK/v.km) reduction in fuel costs, but 0.69 SEK/v.km increase in operating costs. ● Eco driving gave initial 13% reduction in truck fuel consumption. (Estimated to fall to 3% without regular annual training), for the ten trucks	● 10 new methane powered heavy vehicles in use and 16 drivers have received eco driving training.	● Low level of public awareness.	● 100% biogas was not available. The 10 diesel trucks used a mixture of (50% natural gas and 50% biogas). ● The ecodriving training was not repeated in the structured way which was planned. ● There was no link between the

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		compared to those they replaced. ● Estimated reductions in emissions based on standard values and mileages were: CO_2 – 50% NO_x – 64% PM_{10} – 76%			10 new vehicles and the vehicles driven by those receiving the eco driving training. There may have been some small overlapping effect. ● Results based on interviews, calculations and awareness surveys.
Malmö	5.8	● For the whole fleet: CO_2 down 20% NO_x down 12.8% PM_{10} down 2.5%	● Hospital fleet of clean cars increased to 21 (18 E85 and 3 gas). 29 remain petrol.	● Majority of decision makers accepted need for clean vehicles. ● Limited choice from vehicle manufacturers (mainly Ford) influenced decisions towards E85 vehicles running largely on ethanol. ● Also, drivers perceived the E85 vehicles as having good performance characteristics with readily available fuel.	● Replacement of vehicles by clean vehicles was 71% in 2006, and 100% thereafter. ● The target of a 50% clean vehicle fleet was not fully reached only because of the rate of turnover of vehicles. ● Impacts calculated from standard values not measured.
Ploiesti	5.8	● LPG buses cost €0.10/v.km more than the diesel buses mainly because of depreciation. ● Fuel consumption was 90% higher than for the equivalent diesel vehicles (expected), but fuel costs lower. ● Tail pipe measurements gave CO_2 emissions reduction of 83.5% but varied substantially depending on operating conditions. ● Substantial reductions in CO, NO_x, and PM_{10} estimated. Costs of maintenance and repair were not considered lower.	● Staff training for maintenance needed careful consideration. ● Buying new buses was considered better than refurbishing old.	● Comfort benefits from the refurbishment were well liked by passengers, but 7% were concerned about the safety of LPG. ● 81% of public transport users were aware of the LPG buses.	● The LPG buses were conversions of very old diesel buses which had little residual value. ● Results based on company data records, measurements, modelling, and user surveys.
Potenza	5.5	● Substantial environmental benefits identified from manufacturers' literature in all areas except CO_2 where a 12.5% increase was predicted. (CNG minibuses compared to EURO II diesel minibuses.)	● 4 new CNG powered minibuses used on conventional routes, although initially purchased for dial-a-ride.	-	● Delivery of buses delayed until late 2008 because of specification and procurement processes. ● Impact estimates based on manufacturers figures.
Preston	5.6	● The 5% biodiesel produced no	-	-	● Firepower purge and fuel

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		changes in fuel consumption and may have contributed to sludge build up. ● The biodiesel was considered when the firepower fuel system proved unsuitable for the more advanced buses in Preston.			conditions withdrawn from UK market following issues with EURO IV engine management systems and trials not fully completed. ● The work has interested Preston in hybrid vehicles in the future.
Suceava	5.6 8.8 8.9	● Low patronage and old bus fleet gave operating revenue deficits of between €-0.05 and €-0.02 were changed to €+0.03 €/pkm by 2008. ● Noise levels increased with the new buses but many external factors involved. ● Beneficial environmental indicators were given for the new vehicles from the manufacturers' data but nothing available for the old EURO 0 vehicles.	● 757% increase in passengers between July 2005 and June 2008.	● Very substantial increase in service quality perceived by all groups. ● Substantial increases in awareness, satisfaction and patronage. ● However, the increased fares were seen as a deterrent to bus use.	● Results based on operators data, and manufacturers data, and surveys of users.
Toulouse	5.1	● CNG fuel costs were 40% less than diesel but maintenance costs were 23% higher. ● Overall, total costs of CNG buses were more than 20% higher than for diesel buses at £112/100km. ● However, maintenance and fuel costs will reduce with time. ● Emissions were much reduced with CNG. Figures from manufacturers show CNG buses reduce CO (-75%), HC (-61%), PM_{10} (-91%) and raise NO_x by 1%.	● 68 new CNG buses (28 + 40 in 2009). ● New CNG filling station. ● Buses with particulate filters.	● Commercial failure of mini compressors for home use with only 58 installed. ● Positive feedback from inhabitants on the use of CNG buses for environmental reasons.	● Substantial parallel research and development work to support the implementation. ● Study of gas quality/composition on operation. ● Results based on operators data, and manufacturers figures, and surveys of users.
Venice	5.5A	● Little power loss from LPG at cruising speed. 10% loss at higher speeds (general data). ● Small increases in fuel consumption more than offset by LPG price (45-50% lower on	● LPG very easy to install for both outboards and inboards (€1000 – 2000).	● The three elements of campaigns aimed at stakeholders, the public and engine installers/refuelling station owners were all successful. 11 of the latter have expressed interest for the allocation of special	● Results based on selected monitoring by company.

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
		mainland and (35-40% lower on islands).		funds.	
Venice	5.5B	● New CNG bus costs €42,500 more than standard diesel bus (20%) and maintenance costs 15-20% higher. Energy consumption of CNG buses also 20% higher. These partly offset as CNG 19% lower (expected 40% lower with new refuelling station).	● 35 new CNG buses purchased following testing of 2 diesel buses converted to CNG. ● 5 new CNG minibuses purchased. ● Number of bus passengers have increased, but difficult to identify why.	● Customer satisfaction with respect to the environment increased slightly.	● Initial studies of conversion of two diesel buses to dual fuel diesel CNG resulted in a decision to buy 35 new CNG buses as a better option than converting. ● Substantial procedural and other problems encountered. ● Results based on operator data, customer satisfaction data, and substantial environmental benefits estimated from standard figures.
c) User attitudes and behaviour towards alternative fuels					
Ljubljana	11.8			● A regular panel survey showed a small increase in satisfaction with the information, although there were 27,000 requests for MOBILIS newsletters from the website. ● 65% in a telephone survey indicated that greater use of public transport would help protect the environment. ● Many positive results from increased awareness for decision makers included new policy decisions including a city cycling coordinator.	
Malmö	7.1	● Savings based on these vehicles estimated to be: CO_2 (191,000 kg) NO_x (151 kg) HC (10.3 kg) This assumes that the scheme contributed to 10% of the purchase decision (best estimate).	● Over 1000 clean vehicle parking permits issued by October 2007.	● Awareness of clean cars high (97%). ● Awareness of the parking scheme was 39%. 5.5% in the survey were users, a high figure since only 7.4% of the fleet in Malmö are clean. ● However, safety and price were the most important factors when buying a new car and factors such as the clean car purchase bonus would	● The parking permit usage was made less attractive and gave free parking for the second-hour parked rather than the first hour as initially intended.

City	Measure No.	Economy Energy Environment	Transport	Society	Other comments
				have been significant.	
Norwich	7.2	● A length (m) based parking charge with 100% discount for alternatively fuelled private cars showed no effect on choice of vehicle. ● Several relevant environmental relationships determined from background sources.		● Apart from one zone where this became a local election issue, 52% of those surveyed were in support of the scheme.	● A measure such as this may influence long term decisions on car purchase. Although marketed earlier, its introduction in May 2008 did not allow meaningful measurements of change during the project. ● Results from published data and household surveys.
Suceava	5.7	● LPG taxis estimated to produce net returns to operator of more than 100% over petrol (EURO IV) and 40% over diesel (EURO IV). Fuel usage is higher, but fuel efficiency in MJ/vkm is similar to diesel and 15% lower than petrol. (Figures from external literature) CO_2 (-10%) CO (-7%) NO_x (-3%) PM_{10} (-33%)	● 85 LPG taxis (30% of fleet)	● Campaigns raised awareness of LPG and Biogas from 43% (2006) to 78% (2008). ● Clear tends in satisfaction with those satisfied with its existence and use increasing from 33% to 61%.	● Results from surveys of awareness and estimates of change from literature.

The Provision of Clean Fuels

Three cities, La Rochelle, Norwich and Ljubljana attempted to obtain biodiesel from local sources of oil.

In La Rochelle, a sound and detailed action plan was followed to develop a cooking oil to fuel conversion plant using oil from local restaurants. 49 restaurants signed up to the project. However, 29% of the cooking oil collected was unusable and a new collection service is envisaged to tap the substantial additional sources based on 82% positive response from a survey of 228 restaurants. Problems in dealing with the cooking oil to fuel conversion oil require significant technical expertise and there are many institutional and operational barriers to be overcome, but, on the basis of what has been learnt in the CIVITAS initiative, La Rochelle intends to move forward from the 4,000 litres of usable oil collected to date to the 130,000 litres which is estimated to be available from local restaurants. The cost of production is estimated to be €1.2 /litre which is considered favourable and only 30,000 litres would be required to run the city's waste and water treatment trucks.

Figure 2: Biofuel pump at the Water Treatment Department (La Rochelle, France)

In Norwich, there were substantial problems of supply of biodiesel as the quality fell short of what is required. Some tests were undertaken which indicated that the energy content of the finally delivered biodiesel is approximately 10% lower than for diesel. A 20% blend (B20) was suggested as a compromise between CO_2 savings, economy and NO_x effects. From published literature it was estimated that a B20 blend would save 600 tonnes of CO_2 per annum if applied to the whole Anglian bus fleet. In the measure, a 5% blend only was used with the bus fleet because of the reluctance of manufacturers to approve higher percentages. The measure as originally defined failed largely for institutional reasons which included privatised bus operations in the UK where drivers are cost and service, rather than the environment, oriented. Nonetheless, the raised awareness of the environmental benefits of alternative fuels is leading the city to actively consider other clean fuels.

In Ljubljana, oil was provided from many local farms. Again, quality was the major problem with high water content and viscosity. This was overcome by involving the small private firm PINUS, who had the necessary expertise. It was recommended that future oil processing should not be undertaken at the farms where the rape seed is grown, although training of better farmers may resolve the problem.

In general, a strong technical understanding together with an action plan/business case is needed if local sources of oil for biodiesel are to be produced effectively. However, a sound economic case can be made and the technical expertise and equipment will become increasingly available. A significant finding from the La Rochelle study was that collecting used oil for use in biodiesel overcomes waste management problems of inappropriate disposal of waste oil by restaurants, and actions to enforce stricter legal disposal would be beneficial.

Where substantial commercial biodiesel sources are available, more significant impacts can be achieved. In Burgos, biodiesel pumps have been introduced into filling stations (one major new filling station) which have had a substantial impact on the use of biodiesel generally.

In Toulouse, a new CNG filling station has been introduced to support a substantial increase in CNG powered buses, but selling mini compressors for home use was not successful with only 58 sold. In Krakow the CNG trial of 100 buses was abandoned because of the uncertainty of supply of CNG from Russia.

In Malmö, a biogas filling station has been implemented for the slow filling of 15 heavy vehicles overnight. This was 50% natural gas/50% biogas because of a limited supply of biogas from the water treatment fuel plant where the vehicles are based. An additional new biogas facility has been set up in Ystad some 60 km away, as a CIVITAS related initiative, although it has little direct impact on sustainable transport in Malmö.

The Impacts of Clean Fuels: Buses

<u>CNG</u>

In Toulouse, a supporting research study bench-tested pure methane and a mixture of methane with various proportions of hydrogen or nitrogen to determine the best gas mixture for bus propulsion. The 68 pure methane buses gave fuel costs which were 40% lower than diesel, but maintenance costs were two thirds higher. Overall, the total costs of CNG buses were over 20% higher at €112/100 vkm, although maintenance and fuel facility costs are expected to fall with time as experience and facilities grow. Generally, emissions were estimated to be much reduced, but these were based on manufacturers' figures and results may be different in a real operating environment.

In Venice, the new CNG street buses were 18-20% more expensive than the equivalent diesel buses. Energy use by the buses was 20% higher, but the CNG cost was 19% less than diesel. (Estimated to become 40% less with a new local filling station). The environmental benefits were evaluated against the EURO I buses being replaced and standard values were used to estimate emissions.

The 5 new CNG mini buses in Krakow were found to have energy consumption some 60% greater than an equivalent EURO V diesel vehicles. However, it is possible that the CNG mini bus operation did not conform to the test profile data used for the comparative diesel minibus; in that case, the energy consumption for the diesel bus would also have been likely to have been greater. Thus, the measured result is probably an overly high figure for relative energy consumption. In Potenza, the CNG mini buses were not deployed in time, but were awaiting delivery and a second data set was not available.

Eight new CNG vehicles were introduced into the CNG fleet in Burgos, and together with the biofuelled vehicles contributed to the following overall annual reductions in emissions. (Estimated from standard factors).

Year	Emissions		
	CO_2 (tonnes)	NO_x (kg)	PM_{10} (kg)
2005	37.5	219	2,376
2007	34.0	187	1,528

The substantial changes to the bus fleet in Genoa included 2 EURO IV minibuses which were bipowered methane/petrol and 55 methane powered buses for delivery in 2009/10. From 2005 to 2008, the percentage of clean energy vehicles (methane and electricity) increased from 4.5% to 6.2%. CO, NO_x and PM_{10} emissions were estimated from modelling to have been reduced in the bus fleet by 16%, 4% and 27% respectively mainly by upgrading the conventional bus fleet.

LPG
The 30 LPG buses in Suceava replaced old pre EURO vehicles in very poor condition and the bus operation was facing bankruptcy. The operating revenue deficits over successive quarters were 0.023 and €0.049/p.km. By 2008, this had changed to a positive figure of €0.03/p.km with a 75% increase in passengers. Comparisons between the old diesel buses, some intermediate EURO III operations of diesel buses and the LPG powered buses is limited because of vehicle size differences and detailed records of the environmental performance of the old buses were not available. Comparisons of values from limited test data with the vehicle under a light load and under acceleration were made against EURO III diesel buses. These gave savings of 31,000kg of CO_2, 25kg of CO, 514kg of NO_x and 32kg of PM_{10} per month, based on the following emission rates.

Bus	Emission Rates			
	CO_2 (tonnes)	CO (tonnes)	NO_x (kg)	PM_{10} (kg)
Diesel (EURO 3)	1.18 kg/vkm	3.7g/vkm	13.6g/vkm	0.27g/vkm
LPG (EURO 3)	0.93 kg/vkm	3.5/vkm	9.45g/vkm	0.01g/vkm

In Ploiesti, 25 old buses were refurbished and converted to LPG. The LPG converted buses were calculated to be €10/vkm more expensive than the old buses, largely because of amortization costs as the old buses had little value. Energy consumption was about one third higher with fuel consumption about 90% higher. CO emissions were found to be down between 50% and 85% from tailpipe measures. Other emissions were not measured. Savings following conversion did not occur and it was considered that purchase of new buses would be a better future option.

Biofuels
The 27 new EURO IV/V biodiesel buses in Burgos followed an initial testing phase with 5 vehicles. A 2 MJ/vkm saving was identified (0.09 MJ/p km). Energy saving of MJ/ p km fell from 0.75 to 0.66 partly as a result of a 2.5% increase in passengers. Emissions were calculated using standard factors and B20 biodiesel fuel was used. There was a change in fuel use from 74% gasoil and 26% CNG in 2004 to 62% biodiesel and 38% CNG in 2007 for the municipal buses as a whole.

In Debrecen, biofuels were tried up to B50 biodiesel. However, stated results are counter intuitive, inconsistent and cannot be explained, and this limits their value as sound indicators of impact. There was insufficient biogas available from the waste site.

In Ljubljana, practical testing of B100 biodiesel was limited by concerns that the fuel would freeze in the winter temperatures. Based on the initial laboratory tests fuel consumption was estimated to be 7.5% higher, and power 6% lower than for the comparator EURO II diesel buses. However there were reductions in CO (-49%), HC (-68%), PM_{10} (-46%) and Smoke (-45%). NO_x increased by 13%. Maintenance costs and requirements were found to be unacceptably high, although they may not remain so in the longer term.

The 81 biodiesel vehicles running on B30 introduced in Toulouse cost an extra €0.012/v.km. It was estimated that there was no change in NO_x and HC emissions but that the biodiesel resulted in a 20% reduction in CO and a 19% reduction in PM_{10} based on operator records and manufacturers data.

As a direct result of CIVITAS II, the following increases in clean vehicles have been generated.

Increases in the Clean Vehicle Fleet

Burgos
- 27 new biodiesel buses
- 80% increase in use of biodiesel in private fleet
- 8 new CNG buses
- Fleet changed from 73% gas oil/26% CNG in 2004 to 0% gas oil/62% biodiesel/ 33% CNG in 2007

Krakow
- 5 new CNG minibuses

Ljubljana
- 20 biodiesel buses

Malmo
- 10 trucks 50% natural gas/50% biogas (2006/7) (aim is for 100% biogas when available)
- 21 cars (18 E85/3CNG)

Toulouse
- 81 EURO 0/EURO I buses modified to biodiesel
- Soot filters added to 28 EURO II buses
- 68 new CNG buses

Suceava
- 85 LPG taxis
- 30 EURO III LPG buses
- 2 minibuses with particulate filters

La Rochelle
- 10 EEV buses (EURO V, with Ad Blue and particulate filters)
- 15 EEV buses ordered
- 2 hybrid minibuses for trials
- 10 biofuel trucks (30% pure plant oil/70% diesel)

Genoa
- 31 EURO IV buses (+ tender for 26 more)
- 10 EURO IV trolley buses (+7 awaiting delivery). Zero emission vehicles 57 methane powered EEV (ordered)
- 2 EURO IV minibuses (bi-powered methane/petrol)
- 4 electric minibuses with inductive recharging)

Ploiesti
- 25 old buses refurbished and LPG fuelled

Potenza
- Small number of CNG minibuses (not in service at end of project but the funds were available for subsequent purchase)

Preston
- 3 vehicles trialled with 5% biodiesel
- 5 vehicle trial of additive suspended

Venice
- 35 new CNG buses
- 2 buses converted to CNG (Trial)
- 5 new CNG buses
- 10 pilot boats with new biofuel outboards

A trial of buses with 5% biodiesel in Preston showed little difference in performance with significant vehicle-to-vehicle differences, but it was considered that the biodiesel may have contributed to some sludge build-up.

Other Technologies

In Toulouse, particulate filters were added to 28 EURO II buses which reduced measured PM_{10} emissions by 91%. Also 50 buses in Genoa were fitted with particulate filters which contributed to a reduction of 27% in PM10 emissions across the whole bus fleet based on modelled data.

Hybrid electric and electric vehicles have been trialled and introduced in La Rochelle and Genoa. In La Rochelle, a hybrid mini bus with a small engine was found to have similar NO_x and CO emissions to an equivalent EURO IV vehicle, but had reduced NO_x and used 24% less energy. There were significant reliability problems with a 163% higher out-of-service rate than for an alternative electric vehicle. It was generally considered that the vehicle was not suited to the operating situation as the engine often had to be used at high revolutions.

Figure 3: Hybrid minibus in La Rochelle

In Genoa, the increase in the number of electric trolley buses contributed substantially to the overall reductions in emissions.

<u>The Impacts of Clean Fuels: Non Buses</u>

In Burgos, the growth in availability of service stations selling biodiesel resulted in an increase in almost 90% in the use of biodiesel (B5) in the private fleets. (1.0m litres in 2005 to 1.9 litres in 2007).

Image 5: Promotion of bio diesel petrol station in Burgos

Figure 4: Inauguration of new bio diesel pump of a petrol station in Burgos

In Malmö, the provision of information on pollution led to the purchase of 21 more sustainable cars as the fleet of UMAS/Hospital vehicles came up for renewal. The choice was somewhat limited by the market availability of sustainable cars and 18 were E85/petrol, and 3 were CNG.

Also in Malmö, 10 trucks were initially intended to be run on 100% biogas, but because of the lack of availability were fuelled with 50% natural gas and 50% biogas. Fuel costs were reduced by 6% (1.57 SEK/vkm) but operating costs were increased by 0.69 SEK/vkm. The emissions reductions for these 10 vehicles were 50% for CO_2, 64% for NO_x and 76% for PM_{10}. The fleet of small municipal vehicles less than 3.5 tonnes was made substantially more sustainable by the purchase of 313 clean vehicles. Together with existing clean vehicles, this constituted about 65% of all the City's cars, vans, minibuses and light trucks. Reductions in emissions ranged from 7.3 to 19g/vkm of CO_2, 1.9 to 2.5 mg/vkm of NO_x, and 0.11 to 0.12 milligrams/vkm of PM_{10} depending on the baseline scenario chosen. These values were estimates from published figures.

Figure 5: CNG filling station in Malmo (Courtesy of Eon)

In Suceava, the marketing of LPG to private fleets led to 85 taxies (30% of the fleet) using LPG, 48 are new vehicles (DACIA Logan) and 37 older vehicles have been converted. Although fuel usage was found to be higher, efficiency in MJ/vkm is similar to EURO IV diesel taxis and 15% lower than for petrol taxies. Overall, net returns to the operator were estimated to be 100% over petrol and 40% over diesel in the first year of operations. The emissions are estimated from technical data as indicated in the following table.

Fuel*	Emissions	
	CO_2 (g/km)	CO (g/km)
LPG	124	0.68
Diesel	151	0.78
Petrol	195	0.93

- All based on latest DACIA Logan vehicle

Awareness and Behavioural Change

The most direct estimate of driving behavioural change was the 13% measured reduction in fuel consumption for truck drivers in Malmö following ecodriver training. The refresher courses were not fully implemented and, without these, the benefits were expected to fall to 3% in the long term.

Several measures were related to increasing the awareness of decision makers. That related measures were implemented implies that such approaches were generally satisfactory. However, it is difficult to fully separate the effects of the generation of awareness of different groups. An informed population will in turn give confidence to policy makers.

In Burgos, the percentage of the population aware of the use of biofuels in the public transport fleet rose from 13% to 74%. There was a large general increase in the overall use of biofuels, although this may have been due to the increased availability as understanding of specific benefits varied considerably.

In La Rochelle, 96% considered the biofuel filling station to be satisfactory or better, and there was a 90% support for the collection of cooking oil. In Genoa, the public perception of clean vehicles was supportive, but not quantified. In Suceava, the awareness of LPG and biogas fuels increased from 43% to 78% and satisfaction with such measures increased from 33% to 61%.

Figure 6: Promotional leaflet to restaurant owners regarding waste oil collection

In Venice, a very successful, detailed and orchestrated campaign aimed at stakeholders, potential customers and suppliers enabled the CNG/LPG initiative to go forward for both buses and boats respectively.

In two cities, Krakow and Suceava, the sustainability initiatives received substantial support in principle, but there were concerns about the effects on the cost of travel. An outcome, particularly identified in Ljubljana, was that public transport was seen in a much more positive and acceptable light.

In Malmö and Norwich, sustainable vehicles were given an advantage in parking. In Norwich, the non central area zonal scheme involved charging according to vehicle length (apart from clean vehicles which were not charged) whereas in Malmö, drivers of clean vehicles were given the second hour of parking free in certain central area car parks. Overall, there was marginal popular support for the scheme concept in Norwich, although the scheme has not been introduced. In Malmö, over 1000 permits have been issued and the impact of the measure has been estimated to be savings of 191,000 kg of CO_2, 151 kg of NO_x and 10kg of PM_{10}. These values are based on there having been a 10% increase in clean car purchase as a result of the scheme. Related awareness of clean cars has been increased to 97%, but only 39% were aware of the parking scheme. A large proportion of those with clean cars have permits. Whilst the increase in clean cars is substantial, it is not as large as the changes which occurred in Stockholm and Gothenburg over the same period, which indicates that many factors are involved.

In Ljubljana, results of a regular panel survey showed a small increase in satisfaction about the information on clean vehicles, although the website received 27,000 requests for the MOBILIS newsletter. The influence on politicians of the project overall, including the clean buses, has led to the appointment of a city cycling coordinator.

An interview survey in Ploiesti showed a good awareness of the use of LPG, although 7% expressed a concern about its safety. The physical refurbishment of vehicles and associated increases in comfort were particularly appreciated.

In La Rochelle, there was a very high level of user satisfaction (95%) with the hybrid vehicle. It was seen to perform better than the electric vehicle, particularly on gradients, but it is to be noted that the very low level of reliability was largely hidden from users by having stand-by vehicles.

Figure 7: Biodiesel promotional material in Burgos

5 Upscaling and Transferability

Table 5.1: Upscaling and Transferability Possibilities

City	No.	Upscaling	Transferability
a) Provision of Alternative Fuels			
Burgos	5.2	● Increase in biodiesel for bus use possible with correct marketing. ● There is a limit to the amount of used domestic oil available for biofuel. ● CNG readily transferred elsewhere.	● Transferable, but needs transition strategy, including awareness campaigns to offset costs against environmental benefits.
La Rochelle	5.3	● Based on the success of the scheme, plans are in place to extend the operation to 8 new heavy vehicles and a possible further extension to 30 light utility vehicles by 2010.	● Readily transferable if a reliable local supply of pure plant oil is available. (Trucks depot based with filling station.) ● 30% pure plant oil blend performed well with a slight increase in fuel consumption and reductions in emissions though very dependent on local fuel quality and vehicle individualities.
La Rochelle	5.5	● May be better run if a cooking oil collection ‘service’ were introduced ● Enforcement of regulations relating to cooking oil disposal would encourage participation ● Practical local limit estimated to be 130,000 litres/year compared to the 4,400 litres currently collected though some is likely to be of insufficient quality.	● Strong public support for this measure would indicate that it is transferable ● Need expertise in the production processes to ensure satisfactory final quality.
Malmö	5.2	● For general take-up of biogas, sufficient filling stations are needed to give drivers confidence that they will not run out of fuel ● Fuel could be supplied on the grid from a series of local sources ranging from sewage processing to the use of surplus crops	● Needs a substantial commitment to provide the biogas infrastructure but upgrading biogas from sewage treatment plants to natural gas quality and integrating it into existing energy systems has a high degree of transferability ● May be introduced iteratively with locally-based trucks such as those based at a water treatment plant where a slow overnight filling process can be readily implemented. ● Technical and regulatory barriers need to be overcome.
Norwich	5.4	● B5 biodiesel already available as is generally fuel suppliers approach to meeting UK Renewal Fuel Obligations. ● No practical upscaling, because of cost and warranty issues for B20.	● Issues of cost, fuel provision and storage, warranty, law and stakeholder commitment would be needed.
Toulouse	5.2	● Not relevant.	● An in-depth multi-criteria analysis is essential before taking any decisions on biofuels.
b) Operational Impacts of Alternative Fuels			
Debrecen	5.3	● Useful tests to inform future decisions. ● Additional costs of biodiesel a deterrent to expansion.	● Not envisaged.
Genoa	5.1	● Upscaling of all buses to EEV estimated to give reductions of 51% CO, 60% NOx, 93% PM10	● Renewal of the PT fleet is a measure that can be done in any city and should bring useful benefits

City	No.	Upscaling	Transferability
Krakow	5.3	● Intention to upscale to 100 CNG buses in 5 years uncertain because of control of supply by Russia.	● CNG buses could be adopted elsewhere subject to review of business and environmental cases.
La Rochelle	5.1	● Whilst the hybrid vehicle was disappointing in terms of its reliability and environmental performance, there are potential opportunities for better performing hybrid vehicles in view of the very positive feedback from both users and non users. There will be no upscaling using the vehicles tested.	● To be transferred elsewhere, potential users would need to carefully assess the suitability of any hybrid minibus to the circumstances of operation.
La Rochelle	5.2	● The success of the measure will lead to the purchase of a further 5 EEV buses per year of the type tested. It is anticipated that, between 2009 and 2013, these will save 7.36 tons of CO, 1.42 tons of HC, 30.2 tons of NOx and 407 kgs of particulates.	● This technology is readily transferable elsewhere, as a proven technology and an effective intermediate step towards zero emission vehicles. ● A competent supplier such as AdBlue is needed to provide the equipment and additive.
Ljubljana	5.4	● Not recommended for old buses (EURO 0) because of high costs. ● Crystallisation of biodiesel at temperatures below -7°C is a potential winter operating problem.	● Availability of trained staff crucial for any organisation contemplating the use of biodiesel. ● Production of oil at small farms is feasible. However, it is better to carry out transesterification of crude oil on an industrial scale.
Malmö	5.1	● Upscaling is limited to the municipal fleet of light vehicles which has reached 65% of all Municipal cars by the end of the project. 100% clean cars unlikely to be achieved because of the special requirements for some vehicles.	● The use of clean municipal vehicles is transferable to other cities with resources and where employees will use clean vehicles for work related activities rather than their own vehicle ● The broader impacts of the highly visible municipal fleet of clean vehicles together with awareness campaigns would have an effect which is transferable
Malmö	5.3	● Upscaling is possible for all 60 heavy vehicles, provided CNG filling facilities are made available and the financial case proves sound, particularly involving relative fuel and vehicle costs between diesel and CNG.	● This CNG powered-vehicles concept can be transferred elsewhere, where the environmental benefits are seen to outweigh any additional costs involved ● Eco-driving training is transferable to any fleet where there is support from the drivers. Regular retraining programmes would be necessary to maintain the level of benefits and companies exist to provide the necessary training.
Malmö	5.8	● Little opportunity to upscale this hospital application.	● Transferability to any organisation able and willing to promote the usage of clean vehicles and where resources are available to support such measures. ● Promotion of the associated environmental benefits can raise awareness and acceptance.
Ploiesti	5.8	● The measure will not be upscaled because of the higher than expected operating costs.	● Consider purchasing new buses if very old vehicles being converted, as costs of maintenance and repair may not come down with an LPG conversion.

City	No.	Upscaling	Transferability
			● The comfort element of the bus overhaul was most appreciated by users. ● Staff training essential before implementation.
Potenza	5.5	● The positive impact data from the trial mini buses has resulted in a commitment to further procurement and the consideration of services in other catchment areas	● The positive experience with the CNG minibuses could be used to justify the use of similar buses elsewhere.
Preston	5.6	● Firepower clean and purge engine system was not appropriate and will not be taken forward. ● Subsequent 5% biodiesel trials positive, but by the end of the project were part of standard fuel development and blending.	● Not appropriate.
Suceava	5.6 8.8 8.9	● Increase the 30 new LPG buses to cover the whole fleet.	● Considered to require municipal control of bus fleet for a similar application
Toulouse	5.1	● No further upscaling envisaged.	● Latest diesel buses are approaching CNG buses in terms of environmental performance, and detailed economic studies are necessary to support and confirm a political decision to use CNG.
Venice	5.5B	● Application at current limit. ● Action plan will support more widespread applications beyond the pilot boat fleet.	● The legislative issues are of more concern than the technical ones.
Venice	5.5A	● The new fuelling station will have an immediate and positive impact by reducing refuelling times by 45 minutes (travel and refuelling). ● Intend to expand with another 11 new CNG buses in 2009.	● The legislative issues are of more concern than the technical ones.
c) User Attitudes and Behaviour Towards Alternative Fuels			
Ljubljana	11.8	● The raised awareness of environmental sustainability issues amongst the population and the politicians has led to a new transport project and commitment for funding.	● Awareness campaigns can influence thinking and enable both sustainable policies and technical measures to be taken forward.
Malmö	7.1	● The measure has a city-wide effect and could not be upscaled. However, the application of equivalent measures elsewhere could influence the purchase of clean vehicles more widely.	● The provision of parking advantages for clean vehicles has been moderately successful. Other cities may introduce this type of measure, although the specific application design will need to be tailored to the local situation with appropriate resources and political support.
Norwich	7.2	● The measure was not implemented until the end of the project but could be applied to all residential areas with parking controls	● The measure could potentially be transferred to any city with Controlled Parking Zones. However, the public support was missed and the impacts unproven.
Suceava	5.7	● Estimated that 80% of private public transport vehicles (minibuses and taxis) could convert to LPG or biogas.	● LPG costs are generally lower than conventional alternatives depending on taxation, but conversion requires an initial cost. ● Confidence in technical support and supply are important but could enable widespread transferability. ● The financial case is strong.

In principle, the use of more environmentally sustainable fuels can be upscaled and transferred to most situations. However, there will be limits to both upscaling and transfer based on operating conditions, the costs involved in implementation, operational and performance characteristics, fuel availability, and the extent to which the fuel meets the environmental objectives. There are many other factors involved such as legacy systems, training and public/political acceptance.

In CIVITAS II, some cities have indicated that they will upscale some measures, and the decision for upscaling or not are discussed in the following paragraphs.

Biodiesel relies on waste oil or the production of oil from crops. The use of waste oil is hugely environmentally beneficial compared to oil from crops such as rape, as it would otherwise have to be disposed of safely, whereas the use of specific crops for fuel is seen to compete with food production.

The use of used cooking oil is likely to be upscaled in La Rochelle with a new collection system. The substantial technical issues have been overcome and only a small proportion of the oil potentially available is currently being delivered. A similar approach to the use of used oil was implemented in Burgos. The use of waste oil is transferable, but the measure experience indicates that any other authority considering such an approach would need to consider all the technical, political and operational issues with a clear strategy, as the practical delivery of usable biodiesel is complex. However, it has been shown that awareness campaigns can provide substantial public support. The scale of the operation will be limited by the amount of waste oil available in particular locations.

The situation of using plant oil collected from small farms, as trialled in Ljubljana, showed significant cost and production problems. Whilst the generation of oil from small farms is feasible, it is better to undertake the production processes on a larger scale where equipment and technical expertise is available. The major drawback for the use of biodiesel in Ljubljana was its proneness to crystallise at temperatures below -7^{o}C.

The provision of natural gas will be upscaled in Malmö, and methane could be generated from a wide range of sources, from sewage processing to the use of surplus crops. It can be effectively supplied at depots where vehicles are permanently based and where methane is readily available, such as at the waste treatment works in Malmö. For a more general uptake of biogas, a sufficient network of filling stations are needed to give drivers confidence that they will not run out of fuel. In Malmö, biogas from local sources could be gradually added to the natural gas grid. More generally, upscaling to all municipal heavy vehicles is possible, provided CNG filling facilities are available, but sound financial cases would be needed particularly considering relative fuel and vehicle costs between the latest diesel and CNG vehicles and the environmental outcomes.

In Krakow, the uncertainty of supply of CNG from Russia was a major concern. The environmental benefits of CNG were seen being very positive in Potenza for minibuses and a commitment for further procurement has been made. Venice will upscale with the purchase of 11 new CNG buses in 2009.

The base against which the various biodiesel, CNG and LPG fuels have been compared has varied considerably and only in one situation has a comparison been made against the latest EURO IV/V technology. The financial cases are very dependent on local fuel costs and taxation.

Those cities which have had the lowest environmental level of buses have tended to focus on the use of LPG. The results have been mixed and the Ploiesti measure of converting old buses to LPG will not be upscaled whereas Suceavea will buy new LPG buses to cover the whole fleet. In Venice, the dual fuel LPG buses to cover the whole fleet. In Venice, the dual fuel LPG pilot boats cannot be upscaled, but an action plan will spread LPG use to a wider range of boat users.

The hybrid vehicles trialled in La Rochelle performed relatively badly in terms of the environmental benefits and reliability. These will not be upscaled, nor recommended for transfer to similar operations elsewhere. However, the very positive public perception of such vehicles would indicate that improved hybrid minibuses may have a future role in sustainable urban transport.

Campaigns to raise the awareness of the environmental benefits of clean vehicles have generally been very successful. However, whilst this raised awareness has enabled politicians and others to act, there is little evidence that it has changed the travel/vehicle choice behaviour of individuals.

Of the two measures which provided parking advantages to those with clean vehicles, one was not implemented (Norwich) and one did not show substantial changes in purchasing behaviour (Malmö). However, such sustainable parking measures will only be likely to demonstrate a long term effect and be only one of many influences on an individual’s choice of car. As they are relatively simple to implement, and will have some influence, the concepts should be considered for transfer elsewhere.

6 Conclusions and Recommendations

6.1 Conclusions

1. The only hybrid vehicle to be evaluated, a petrol/electric minibus, proved not to be suitable for the application and produced savings in CO_2 of only 20%, with little difference in other pollutants, and poor reliability. However, the public were found to be very supportive of the use of this type of vehicle, and future hybrid vehicles with a combined engine/battery performance suited to the operational regime are likely to be more viable. This is an area where more advice should be available and research may be needed to obtain improved understandings of operational regimes and overall hybrid performance requirements. Standard driving profiles may not be an adequate basis for local decisions.

2. The generation of biofuels from waste such as cooking oil, water treatment or waste food can provide a worthwhile and cost effective contribution to environmental sustainability by powering vehicle fleets based at depots close to the fuel source. Such measures are well received by the public and can be very beneficial more widely, by raising awareness of sustainable vehicles. However, significant technical competence is needed to deliver a biofuel product, particularly oil, to a reliably acceptable standard. The whole process from collection through to the fuelling of vehicles needs careful consideration and the extent of any application will be limited by the amount and location of the available fuel sources. An example of a more general and flexible application is the insertion of available biogas into the e.ON natural gas grid serving parts of Sweden including Malmö. This approach would enable a steady increase in the use of biogas and in Sweden it is estimated that sufficient biogas could be available to power half of all vehicles.

3. Buses using various levels of biodiesel have been trialled and those running up to B20/B30 mixtures in more modern vehicles have proved both reliable and effective at reducing pollution.

4. The source and quality of the biodiesel fuel is important and technical support is needed from the feasibility stage to the delivery of the product. New standards and regulations may be required to transfer greater responsibility to the supplier rather than the user. The production of fuel from crops remains a contentious issue.

5. Buses using CNG have been found to bring environmental benefits, but the increasingly effective environmental performance of new diesel buses is reducing the advantage, and diesel buses are significantly cheaper. The case for CNG buses needs to be considered carefully, with all the factors taken into consideration. Several cities have measure templates which provide excellent advice and understanding. Energy security issues are still present, and apply to both CNG and diesel.

6. The use of particulate filters can be effective at reducing PM_{10} on older diesel vehicles at low cost, but filters which also address smaller particulates may be more important to address health impacts.

7. The use of LPG in taxis was found to be economically very worthwhile and gave significant CO_2 savings in particular application.

8. The relative attractiveness of fuel alternatives depends on issues of taxation, reliability of supply, technical competence to deal with all aspects of the fuel and its implications for engines, and regulations. These are critical issues to be addressed at National and European levels, particularly as environmental improvements from the introduction of clean vehicles and fuels have cost implications, which may become more significant in an increasingly financially constrained environment.

9. The ecodriving training was found to be effective in reducing fuel consumption and, hence, all related emissions. However, regular training would be required if the larger benefits are to be retained.

10. The measures to influence behavioural change in car purchasing have contributed to a substantial increase in the purchase of cleaner vehicles in Malmö. However, it is not possible to separate the impacts of the local measures from those undertaken at a national level in Sweden and in other cities. Also, the substantial changes in ownership have been enabled by the availability of cleaner vehicles in the market, particularly those which are E85. Successful take up of the clean cars involves a complex set of relationships between users, vehicle and fuel availability and policy measures.

11. Overall, CIVITAS has contributed to the introduction of 144 biodiesel (new or modified), 123 CNG, 55LPG, 21 electric vehicles, 72 EEV and 4 hybrid buses. In addition, 20 biogas trucks have been introduced, 30 vehicles have been fitted with SOOT filters and 85 taxis have been converted to LPG. Measures have contributed much more widely to the substantial growth in the public and private purchase of clean vehicles. More particularly, the attitudinal changes brought about by the measures are likely to stimulate the market for such vehicles and form a virtuous circle of increasing supply and demand.

6.2 Recommendations

12. Research is needed to better understand the relationships between hybrid characteristics and operating conditions so as to provide clear advice for the purchase of the most suitable public transport vehicles. City authorities should not assume that a hybrid vehicle will have performance characteristics suitable to their specific application.

13. Standards for biofuels are required to provide confidence to users. A major problem with many measures was the difficulty of ensuring delivery of a uniform and acceptable fuel to the biodiesel vehicle fleet and, unless clear standards are applied, transferability of biofueled vehicles to authorities which are less innovative will be delayed. Stringent contractual conditions were found to be necessary to overcome barriers associated with fuel quality.

14. A legal framework is needed at European and national level to enable the ready implementation of more sustainably fuelled vehicles. This was a considerable barrier which had to be overcome for several measures.

15. The promotion of alternative fuels for more sustainable operation will require coherent consideration of taxation policies for the different fuel types.

16. Policies, incentives and technologies should be developed to encourage ecodriving.

17. Technical support should be available to cities who wish to implement more sustainable vehicle fleets as the expertise needed to specify, implement and maintain such fleets is often outside the scope of traditional competences.

18. In most cases, measure benefits were identified as change against the pre-existing conditions. Therefore, in general, the largest benefits were obtained where initial fleet conditions were very poor, rather than where the most innovative future vehicles and fuels were adopted. It is recommended that consideration be given to including interpretations in the evaluations against a common base level.