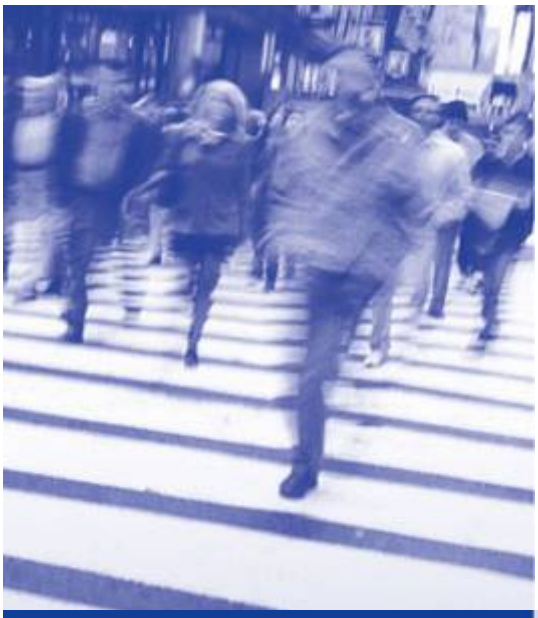

CiViTAS
Cleaner and better transport in cities

ARCHIMEDES
AALBORG • BRIGHTON & HOVE • DONOSTIA - SAN SEBASTIÁN • IAŞI • MONZA • ÚSTÍ NAD LABEM

D1.1 – Development and Experience of Alternative Fuel Demonstrations in ARCHIMEDES

June 2012

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1. Introduction

1.1 Background CIVITAS

CIVITAS - cleaner and better transport in cities - stands for CIty-VITAlity-Sustainability. With the CIVITAS Initiative, the EC aims to generate a decisive breakthrough by supporting and evaluating the implementation of ambitious integrated sustainable urban transport strategies that should make a real difference for the welfare of the European citizen.

CIVITAS I started in early 2002 (within the 5th Framework Research Programme);
CIVITAS II started in early 2005 (within the 6th Framework Research Programme) and
CIVITAS PLUS started in late 2008 (within the 7th Framework Research Programme).

The objective of CIVITAS-Plus is to test and increase the understanding of the frameworks, processes and packaging required to successfully introduce bold, integrated and innovative strategies for clean and sustainable urban transport that address concerns related to energy-efficiency, transport policy and road safety, alternative fuels and the environment.

Within CIVITAS I (2002-2006) there were 19 cities clustered in 4 demonstration projects, within CIVITAS II (2005-2009) 17 cities in 4 demonstration projects, whilst within CIVITAS PLUS (2008-2012) 25 cities in 5 demonstration projects are taking part. These demonstration cities all over Europe are funded by the European Commission.

Objectives:

- to promote and implement sustainable, clean and (energy) efficient urban transport measures
- to implement integrated packages of technology and policy measures in the field of energy and transport in 8 categories of measures
- to build up critical mass and markets for innovation

Horizontal projects support the CIVITAS demonstration projects & cities by :

- Cross-site evaluation and Europe wide dissemination in co-operation with the demonstration projects
- The organisation of the annual meeting of CIVITAS Forum members
- Providing the Secretariat for the Political Advisory Committee (PAC)
- Development of policy recommendations for a long-term multiplier effect of CIVITAS

Key elements of CIVITAS

- CIVITAS is co-ordinated by cities: it is a programme “of cities for cities”
- Cities are in the heart of local public private partnerships
- Political commitment is a basic requirement
- Cities are living ‘Laboratories' for learning and evaluating

1.2 Background ARCHIMEDES

ARCHIMEDES is an integrating project, bringing together 6 European cities to address problems and opportunities for creating environmentally sustainable, safe and energy efficient transport systems in medium sized urban areas.

The objective of ARCHIMEDES is to introduce innovative, integrated and ambitious strategies for clean, energy-efficient, sustainable urban transport to achieve significant impacts in the policy fields of energy, transport, and environmental sustainability. An ambitious blend of policy tools and measures will increase energy-efficiency in transport, provide safer and more convenient travel for all, using a higher share of clean engine technology and fuels, resulting in an enhanced urban environment (including reduced noise and air pollution). Visible and measurable impacts will result from significantly sized measures in specific innovation areas. Demonstrations of innovative transport technologies, policy measures and partnership working, combined with targeted research, will verify the best frameworks, processes and packaging required to successfully transfer the strategies to other cities.

Alternative fuels is one of the eight categories within CIVITAS ARCHIMEDES. Cleaner fuels and vehicles decrease local air pollution and greenhouse gas emissions, both of which help improve the quality of life for citizens. CIVITAS cities seek to explore innovations in these fields and share best practise. Many cities try to stimulate the spread of clean and energy-efficient public and private vehicles for passenger and freight transport. Biodiesel or biogas vehicles are seen as an element on the path towards energy independence from fossil fuels and relief from unstable oil prices. CIVITAS cities test the use of biodiesel, biogas, compressed natural gas and hybrid vehicles. They develop expertise in procurement and tendering and also explore opportunities to source biofuel locally.

CIVITAS has helped to achieve real progress in bringing cleaner vehicles into cities. Projects have demonstrated the positive impact of alternative fuels and vehicles. The market now features a wider variety of models that are reliable and competitive compared to conventional vehicles. In terms of fuels, catalyst retrofit diesel is still the main propellant used in clean vehicles, followed by CNG, LPG, biodiesel and biogas. The marketing of hybrid vehicles has started to become successful, compensating for the partial disappointment in the electric vehicle sector.

In terms of buses, Graz is the only city in Europe operating on 100 % biodiesel for the entire fleet. Europe generally is finding it hard to meet the Commission's targets of a 5.75 % market share for biofuels in the overall transport fuel supply by 2010.

Despite some good practices, the clean vehicles market is far from robust. CIVITAS has helped to strengthen it, and has also brought to light critical issues such as the importance of regulation, harmonisation, and tax and incentive issues. Joint procurements, sharing of experiences and supporting research and technological development in the area of innovative clean vehicle technology are all necessary.

The project aim for alternative fuels within ARCHIMEDES follows the general aim of CIVITAS PLUS to go well beyond the EU RTFO requirements using first generation bio-fuels in medium sized cities in an innovative manner and lay the foundations for maximising the opportunities for take-up of second generation bio-fuels and EEV vehicles. The expected benefits are:

- Reduce emissions of, and human exposure to, air and noise pollution (air quality improvement);
- Ensure transport systems complement good health and well-being;
- Reduce energy consumption from transport in urban areas;
- Ensure the transport system contributes towards a successful economy.

2 Participant Cities

The ARCHIMEDES project focuses on activities in specific innovation areas of each city, known as the ARCHIMEDES corridor or zone (depending on shape and geography). These innovation areas extend to the peri-urban fringe and the administrative boundaries of regional authorities and neighbouring administrations.

The two Learning cities, to which experience and best-practice will be transferred, are Monza (Italy) and Ústí nad Labem (Czech Republic). The strategy for the project is to ensure that the tools and measures developed have the widest application throughout Europe, tested via the Learning Cities' activities and interaction with the Lead City partners.

2.1 Leading City Innovation Areas

The four Leading cities in the ARCHIMEDES project are:

- Aalborg (Denmark);
- Brighton & Hove (UK);
- Donostia-San Sebastián (Spain); and
- Iasi (Romania).

Together the Lead Cities in ARCHIMEDES cover different geographic parts of Europe. They have the full support of the relevant political representatives for the project, and are well able to implement the innovative range of demonstration activities.

The Lead Cities are joined in their local projects by a small number of key partners that show a high level of commitment to the project objectives of energy-efficient urban transportation. In all cases the public transport company features as a partner in the proposed project.

2.2 Aalborg

The City of Aalborg, with extensive experience of European cooperation and having previously participated in CIVITAS I (VIVALDI) as a 'follower' city, is coordinating the consortium and ensures high quality management of the project. The City has the regional public transport authority (NT) as a local partner, and framework agreements with various stakeholder organisations.

Aalborg operates in a corridor implementing eight different categories of measures ranging from changing fuels in vehicles to promoting and marketing the use of soft measures. The city of Aalborg has successfully developed similar tools and measures through various initiatives, like the CIVITAS-VIVALDI and MIDAS projects. In ARCHIMEDES, Aalborg aims to build on this work, tackling innovative subjects and combining with what has been learned from other cities in Europe. The result is an increased understanding and experience, in order to then share with other Leading cities and Learning cities.

Aalborg has recently expanded its size by the inclusion of neighbouring municipalities outside the peri-urban fringe. The Municipality of Aalborg has a population of some 194,149, and the urban area a population of some 121,540. The ARCHIMEDES corridor runs from the city centre to the eastern urban areas of the municipality and forms an ideal trial area for demonstrating how to deal with traffic and mobility issues in inner urban areas and outskirts of the municipality. University faculties are situated at 3 sites in the corridor (including the main university site). The area covers about 53 square kilometres, which is approximately 5 % of the total area of the municipality of Aalborg. The innovation corridor includes different aspects of transport in the urban environment, including schools, public

transport, commuting, goods distribution and traffic safety. The implementation of measures and tools fit into the framework of the urban transport Plan adopted by the Municipality.

Figure 1: The Archimedes Corridor in Aalborg

2.3 Brighton & Hove

Brighton & Hove is an historic city, in the south-east of England, known internationally for its abundant Regency and Victorian architecture. It is also a seaside tourist destination, with over 11km of seafront attracting eight million visitors a year.

In addition, it is a leading European Conference destination; home to two leading universities, a major regional shopping centre, and home to some of the area's major employers. All of this, especially when set against the background of continuing economic growth, major developments across the city and a growing population, has led the city council to adopt a vision for the city as a place with a co-ordinated transport system that balances the needs of all users and minimises damage to the environment.

The sustainable transport strategy that will help deliver this vision has been developed within the framework of a Local Transport Plan, following national UK guidelines. The ARCHIMEDES measures also support the vision, which enables the city to propose innovative tools and approaches to increase the energy-efficiency and reduce the environmental impact of urban transport.

2.4 Donostia - San Sebastián

The city of Donostia -San Sebastian overlooks the sea and, with a bit more than 180,000 inhabitants, keeps a human scale. Some people consider the balanced combination of small mountains, manor buildings, and sea as the setting for one of the most beautiful cities in the world. We have a tradition in favouring pedestrians, cyclists and public transport.

For about twenty years, the city has been enforcing a strong integrated policy in favour of pedestrians, bicycles and public transport. Considering walking and cycling as modes of transport, has led to the building of a non-motorised transport network for promoting this type of mobility around the city.

Likewise, the city has extended its network of bus lanes. The city holds one of the higher bus-riding rates, with around 150 trips per person per year.

The CIVITAS project is being used as the perfect opportunity to expand Donostia -San Sebastian's Sustainable Urban Transport Strategy. With the package of CIVITAS measures Donostia-San Sebastian will:

- Increase the number of public transport users
- Decrease the number of cars entering in the city centre
- Increase the use of the bicycle as a normal mode of transport
- Maintain the high modal share of walking
- Reduce the number of fatal accidents and accidents with heavy injuries
- Reduce the use of fossil fuels in public transport.

2.5 Iasi

The City of Iasi is located in north-eastern Romania and is the second largest Romanian city, after Bucharest, with a population of 366,000 inhabitants. It is also the centre of a metropolitan area, which occupies a surface of 787.87 square kilometres, encompassing a total population of 398,000 inhabitants.

The city has five universities with approximately 50,000 students, the second largest in Romania. The universities and their campuses are located in the central and semi-central area of the city. In the same area, there are also a large number of kindergartens, schools and high schools with approximately 10,000 pupils. This creates a large number of routes along the main corridor, served by the public transport service number "8" (Complex Tudor Vladimirescu - Copou) with an approximate length of 10 km. The City of Iasi will implement its integrated measures in this area to be known as the "CIVITAS+Corridor".

The city's objectives in CIVITAS ARCHIMEDES are based on the existing plans related to transport, Local Agenda 21, approved in 2002, and the Sustainable Social-Economic Development Strategy for City of Iasi. The CIVITAS Plus objectives will be integrated in the Strategy for metropolitan development which was finalized in October 2009.

2.6 Monza

Monza is a city on the river Lambro, a tributary of the Po, in the Lombardy region of Italy, some 15km north-northeast of Milan. It is the third-largest city of Lombardy and the most important economic, industrial and administrative centre of the Brianza area, supporting a textile industry and a publishing trade. It is best known for its Grand Prix.

The City of Monza, with approximately 121,000 inhabitants, is located 15 km north of Milan, which is the centre of the Lombardia area. This area is one of the engines of the Italian economy; the number of companies is 58,500, i.e. a company for every 13 inhabitants.

Monza is affected by a huge amount of traffic that crosses the city to reach Milan and the highways nodes located between Monza and Milan. It is also an important node in the Railways network, crossed by routes connecting Milan with Como and Switzerland, Lecco and Sondrio, Bergamo and Brianza. "Regione Lombardia", which in the new devolution framework started in 1998, has full responsibility for establishing the Local Public Transportation System (trains, coaches and buses) and has created a new approach for urban rail routes using an approach similar to the German S-Line or Paris RER.

Monza has recently become the head of the new "Monza and Brianza" province, with approximately 750,000 inhabitants, so will gain the full range of administration functions by 2009. Plan-making

responsibilities and an influence over peri-urban areas will require the city to develop new competencies.

In this context, the objective of the City of Monza in participating in CIVITAS as a Learning City is to set up an Urban Mobility System where the impact of private traffic can be reduced, creating a new mobility offer, where alternative modes become increasingly significant, leading to improvements to the urban environment and a reduction in energy consumption (and concurrent pollution).

2.7 Ústí nad Labem

Ústí nad Labem is situated in the north of the Czech Republic, about 20 km from the German border. Thanks to its location in the beautiful valley of the largest Czech river Labe (Elbe) and the surrounding Central Bohemian Massive, it is sometimes called 'the Gateway to Bohemia'. Ústí is an industrial, business and cultural centre of the Ústí region.

Ústí nad Labem is an important industrial centre of north-west Bohemia. The city's population is 93,859, living in an area of 93.95km^2. The city is also home to the Jan Evangelista Purkyně University with eight faculties and large student population. The city used to be a base for a large range of heavy industry, causing damage to the natural environment. This is now a major focus for improvement and care.

The Transport Master Plan, to be adopted in its first form in 2007, will be the basic transport document for the development of a new urban plan (2011), which must be developed by the City subject to the provisions of the newly adopted Building Act. This will characterise the development of transport in the city for the next 15 years, and so the opportunity to integrate Sustainable Urban Transport Planning best practices into plan development during the project means an ideal match of timing between city policy frameworks and the ARCHIMEDES project.

The project's main objective is to propose transport organisation in the city, depending on the urban form, transport intensity, development of public transport, and the need for access. The process, running until 2011, will include improving the digital model of city transport that Ústí currently has at its disposal. The plan will have to deal with the fact (and mitigate against unwanted effects that could otherwise arise), that from 2010, the city will be fully connected to the D8 motorway, running from Prague to Dresden.

3. Background to the Deliverable

This deliverable summarises the research and demonstration activities conducted in relation to workpackage 1 of the CIVITAS ARCHIMEDES project – Alternative Fuels and Clean Vehicles.

3.1 Introduction to the Measures

Research and demonstration activities in respect of alternative fuels and clean vehicles have been conducted in five of the ARCHIMEDES cities, namely Aalborg, Brighton, Donostia - San Sebastian, Iasi and Monza, in the form of measures 1, 2, 4, 5 and 7. These measures are introduced in the following sections.

The results from the individual measures are reported in detail as follows:

Measure No:	Research Deliverables	Implementation Deliverables
1	R1.1 R1.2	T1.1/T1.3 T1.2/T1.3 T1.5
2		T2.1
4	R4.1	T4.1 T4.2 T4.3
5	R5.1	T5.1 T5.2 T5.3
7	R7.1	T7.1

This deliverable draws together the experiences gained from the individual measures and presents the common issues and conclusions that can be drawn at the workpackage level. Further information and outcomes of the measures can be found in D10.3 Final Evaluation Report and D12.4 Final version of measure level result templates.

Measure 1: Bio-fuels in Aalborg

In this measure the opportunities of using high blend bio-fuels in standard vehicles have been explored. The measure contained a research study on first and second generation bio-fuels and three demonstration tasks on the use of bio-fuels at individual fleet level. The experiences in developing a supply infrastructure for bio-fuels have been gathered.

A study on first and second generation bio-fuels was performed to determine the state of the art and to find the best sources for the full scale demonstrations within the measure. The study focused on the environmental impact, impacts or requirements for vehicle engines and up-scaling potential and included four Danish pilot projects. One of the main outcomes of the study was the decision to use second generation bio-fuels.

Based on the research study, the Public Transport Authority of North Jutland (Nordjyllands Trafikselskab) has planned and implemented the use of biodiesel in 50 buses in their fleet through a tender for the city buses in Aalborg. The bus contractors were responsible for negotiating with the biodiesel supplier and for setting up a fuelling station that could facilitate the use of biodiesel.

Also based on the research study, the Municipality of Aalborg has together with the Postal Service, oil supplying companies and the City of Aalborg planned and implemented the use of biodiesel in 50 postal vehicles in and around the City of Aalborg and the establishment of a fuelling station and biodiesel supply.

Furthermore, a new tourist shuttle hybrid bus running on "Eco-branded" bio-fuels which runs between parking areas and key places in the city as the tourist attractions and the new waterfront was implemented.

The technical research and development of a methanol fuel cell pack for service vehicles was due to technological and financial issues cancelled and replaced by an Electric Vehicles trial to gather experiences from ordinary users of Electric Vehicles in their present state of the art.

Measure 2: Electric vehicle Charging Points in Brighton & Hove

The aim of this measure was to install ten (subsequently reduced to eight through budget constraints) Green Electric Vehicle Charging Points in the CIVITAS area. They would be powered by sustainably-generated electricity. The measure was intended to help realise the potential for densely located fuelling stations to encourage the take-up of alternative fuels and to test the belief that scarcity of supply is holding back the wider take up of electrically powered vehicles.

Measure 4: Bio-fuels and Clean Vehicles in Donostia - San Sebastian

This measure has comprised a research study on different alternative fuels (bioethanol, hydrogen, hybrids and second generation biodiesel) and three demonstration projects on the use and promotion of biodiesel by the urban public transport company CTSS of Donostia - San Sebastian. Part of the bus fleet has been replaced by new EEV vehicles, lowering the emission levels further. The use of biodiesel in the local buses has served as a local showcase and promotional actions have been carried through to convince other fleet operators and individual car users to switch.

The research study has analysed the present and future fuel options for transportation in combination with the new traction technologies and supported the bio-fuel demonstration projects in Donostia - San Sebastián as well as the future introduction of other alternative fuel types and propulsion technologies. In the analysis traditional liquid fuels (diesel and petrol as reference), liquid fuels processed from vegetable derivatives (biodiesel and ethanol), gaseous fuels (LPG and natural gas), as well as the application of electricity and hydrogen as an energy source have been contemplated.

Two of the demonstration projects have consisted of the planning, introduction and testing of biodiesel at increasingly higher blends and on an increasingly higher number of the bus fleet, the planning and introduction of a bio-fuel filling-mixing station and the implementation of a new fleet of EEV buses. As a part of these demonstration projects a hybrid bus has been purchased and tested.

The third demonstration project comprised the development and implementation of a promotional campaign to encourage people of Donostia - San Sebastián to start using biodiesel as part of the modification of their behaviour pattern in relation to use of mineral fuels and to increase the quantity of oil that is recycled.

Measure 5: Bio-fuels – Use of LPG in Iasi

Iasi has adapted an energy management approach to urban waste. This measure has therefore covered energy recovery methods that can substitute the use of diesel in buses. A research study to determine emission levels at five strategic locations within the CIVITAS corridor has been conducted. Based on the research study, the original plan was for PTI to implement the use of bio-methane in 30 buses in their fleet through a tender and towards the end of the ARCHIMEDES period introduce the use of bio-methane through the production of a bio-methane energy supply from landfill. However, due to the shift in land-ownership of the site for bio-methane energy supply from the local council to the region and problems with financing the bio-methane energy supply, it has not been possible for the local council to establish the bio-methane energy supply and subsequently implementing the use of bio-methane.

The measure has therefore consisted of two demonstration projects; one regarding the implementation of the use of LPG in 30 buses to lower PM emissions and one regarding promotional material for bio-fuels and LPG. The LPG trial is planned as a forerunner for future use of CNG in buses.

Measure 7: Hybrid Bus in Monza

This measure concerns the implementation of a hybrid bus in Monza. A research study to gain best practice examples from other cities that have implemented a hybrid bus has been performed. Furthermore, hybrid technology has been tested through the procurement of a hybrid bus to be put into operation on one of the most crowded bus routes in Monza in order to gather robust and precise data to ensure appropriate decisions within future procurement of urban public transport buses in Monza. This will pave the way to the promotion of this alternative vehicle on the one hand, and on the other hand contribute to reducing the environmental impact of the public transport fleet in Monza. The objective of the introduction of the hybrid bus was to reduce emission values of up to 25% with respect to classic diesel powered buses.

4. Analysis

4.1 Comparison of Measures

4.1.1 Objectives

Three of the five measures cover bio-fuels, whilst the other two measures have covered EV charging points and a Hybrid Bus respectively.

In Aalborg, the main project aim was to obtain the operation of 50 buses, 5 HGV's and 45 vans on at least a 10 % substitution of diesel with CO_2 neutral bio-fuels. This was expected to lead to 140 t less CO_2 emissions annually within the busfleet and to 175 t less CO_2 emissions annually within the fleet of HGV's and vans. The research towards the use of high blend bio-fuels should lay the foundation for maximising the opportunities for introducing second-generation bio-fuels and EEV vehicles. A target of between 7,500 and 15,000 passengers per year was set for the tourist shuttle hybrid bus.

The objectives of the EV trials that replaced the methanol fuel cell pack were to identify the conditions under which EVs, in their current state of development, are an attractive alternative to ordinary cars, to gather experience with intelligent charging and the placement of charging points and to evaluate the overall CO_2 savings for the project.

In Donostia - San Sebastián, the main project aim was to reduce the emissions of air pollutants and greenhouse gases by operating biodiesel buses at high blends. This was expected to lead to the substitution of more than 3,600,000 litres of fossil fuels to biodiesel. The research towards the use of biodiesel should lay the foundation for maximising the opportunities for introducing second-generation bio-fuels and EEV vehicles. The demonstration of the bus fleet and the additional promotional actions and incentives were expected to have an awareness raising effect on other local fleet operators and individual citizens. It was also an aim to replace a high proportion of the bus fleet during the CIVITAS Plus lifetime, and the ARCHIMEDES project stimulated a commitment that all 30 planned new vehicles would be of EEV standard.

After the scope of the measure in Iasi changed from using bio-methane to using LPG, the main aim of this measure has been to operate 30 buses on LPG fuel and to install a LPG distribution station. The measure was expected to decrease the level of pollutant emissions in the CIVITAS corridor (NO_2 by 25 %, CO by 15 % and CO_2 by 10 %), reduce greenhouse gas emissions, and demonstrate the impact of alternative fuels and increase knowledge and awareness on air quality.

In Brighton, the objectives of the EV charging points measure were to implement the first electric vehicle charging points in the UK and to test how the installation of electric vehicle charging points in the CIVITAS area would improve the take up and usage of electrically powered vehicles and assess whether increase in supply results in increase in demand helping to realise the potential for densely located fuelling stations to impact on take-up of alternative fuels. It was also an aim to obtain public opinion and perception of alternatively fuelled vehicles and the views of EV users on the CIVITAS scheme and their suggestions for future development.

In Monza, the objective of the hybrid bus measure was to develop a technical specification for the delivery of a hybrid bus based on the study of best practice examples from other cities that have implemented hybrid buses and to procure a hybrid bus to test new technologies in order to gather data to take appropriate descisions on future procurement choices for urban buses. The aim through the implementation of the hybrid bus in Monza was to reduce emissions by up to 25 % with respect to ordinary diesel powered buses.

4.2 Differences in Approach by City and Activity

Research and preparatory activities in respect of alternative fuels and clean vehicles have been conducted in four of the ARCHIMEDES cities, namely Aalborg, Donostia - San Sebastian, Iasi and Monza. All these initial activities have formed the background for the following demonstration tasks.

In Aalborg, the research study outlined that second generation tallow-based biodiesel is the only engine fuel which without a doubt gives a positive CO_2 displacement in the overall Danish energy system, which was a very important reason for the choice of this fuel. Based on the conclusions and recommendations from the research study, it was decided to use second generation bio-fuels made from animal fat (tallow) in two of the demonstration tasks. The difference in reduction and the ethical questions of using farm land to grow crops for biodiesel production have been important elements in the choice of the product.

The planning process for both demonstration tasks was initiated during the preparation of the CIVITAS ARCHIMEDES project and involved the Public Transport Authority in North Denmark, the City of Aalborg and Post Danmark (The National Postal Service) respectively.

The operation of bus services was carried out by private contractors based on tenders let according to EU procedures. The bus contractors were responsible for negotiating with the biodiesel supplier and for setting up a fuelling station that could facilitate the use of biodiesel. Both winning bus contractors chose to set up an additional tank containing a 50 % bio-fuel blend at their normal filling station, and then automatically mix the 10% blend in the diesel pump on location by mixing from the tank with biodiesel and the tank with conventional diesel. Since both companies are also running buses on conventional diesel they will still have the possibility to do so. And it is also possible to change to B15, B20 or more, for some or all buses, if required, without changing blend in the tank or changing the infrastructure. Also, due to the difficulties that may occur during cold periods, the possibility to switch to a blend below 10 % is also available.

The operation of the postal service vehicles was carried out by the National Postal Service. Due to reductions in their vehicle fleet, at the start of the planning process only 30 vehicles seemed to be available for the project. However, 48 vehicles ended up being run on bio-fuels with a mix of blends B10, B15 and B20 during the course of a year. The postal service has been responsible for negotiating with the biodiesel supplier, and the postal service has also been responsible for setting up a fuelling station that could facilitate the use of biodiesel. It was chosen to establish the fuelling station

at the Postal Service centre. In spite of the fact that all relevant stakeholders were included at a fairly early stage of the planning process for this fuelling station, getting the building permission turned out to be a long and confusing process that ended up delaying the demonstration project. In contrast to the installation established for public transport, at the Postal Service's depot the biodiesel is already in the right blend when arriving at the fuelling station. This makes only one tank necessary and - due to the 'low' blend, B10-B20 - the need for heating the tank does not exist.

> First and second generation bio-fuels are defined by the feedstock and not the production method. First generation biodiesel are methyl esters based on edible crops (soy beans, sunflower, palm oil and rape seed oils) whereas second generation fuels are based on residues or waste (pork and beef tallow, used cooking oils or sludge for biodiesel or a range of waste products that can be transformed into biomethane via anaerobic digestion processes). The production method for 1st and 2nd generation biodiesel is basically the same; however purification by distillation is often required for 2nd generation feedstock.
>
> The advantages of first generation biodiesel are that it is available in large quantities and has been tested extensively for decades. The potential for second generation biodiesel is not as large as for first generation. The second generation fuel, however, is somewhat cheaper and much more sustainable. In fact, the use of first generation bio-fuel is highly controversial. Many scientists point to the fact that the raw materials can be burned with much lower energy losses in power plants. Some even claim that certain types of first generation bio-fuels yield a negative energy balance. It has also been claimed that global demand for first generation bio-fuel has pushed the prices of food upwards. Although this may be difficult to prove, there is certainly an ongoing and very sensitive debate on the fuel versus food issue. However there seems to be consensus about the fact that second generation biodiesel from waste tallow is one of the most sustainable engine fuels available.

In Donostia-San Sebastián, the research study comprised a multi-criteria analysis on alternative fuel options from the point of view of the Municipal Bus Company of San Sebastián (CTSS). In summary, the study concluded that the best short term option (2009-2012, i.e. the ARCHIMEDES project period) was to use diesel and biodiesel in varying blends to power buses equipped with the latest technology clean and efficient diesel engines. On this basis CTSS embarked on an expansion of its use of biodiesel in both existing and new vehicles and also invested in new diesel-engined buses that met the EEV standard. In the medium-to-long term the following three possible options were considered worthy of follow up, with the exact course depending upon the way in which the commercially available technology is developed in relation to CTSS' specific needs:

- Diesel-Electrical Hybrid Vehicles, preferably with diesel engines optimised for use in urban buses, because they offer a significant improvement in overall efficiency and can be applied to any size of bus from minibuses up to articulated buses.
- Pure Electric Vehicles, because of their overall good efficiency and zero emissions, even though their application may remain limited to smaller vehicles (minibuses only) and for reduced range operations.
- Fuel cell or fuel cell hybrid vehicles, which are not currently realistic alternatives because of the high levels of cost and current levels of efficiency, but which were judged to represent a future option that should be taken into account.

Gradually, the use of combined diesel and biodiesel at increasingly higher blends (B20, B30, B50 and B100) has been implemented. During the course of the ARCHIMEDES project part of the bus fleet has also been replaced by new EEV standard vehicles, lowering emission levels further. A MAN in series hybrid bus has also been tested on different bus lines since September 2011 recording fuel comsumption data to identify which routes fit better to the hybrid technology. The use of biodiesel in

the local buses has served as a local showcase backed up by promotional actions, i.e. a press conference and a public presence in front of the town hall with a collection of used oil, to convince other fleet operators and individual car users to switch fuels.

The hybrid bus in Donostia-San Sebastián in operation.

A fuel mixing station has been established on the premises of CTSS, where the pure biodiesel is also stored, and is working with excellent results. Samples of blends are taken and tested periodically to control the accuracy of the system. Also many quality controls of fuel samples and fuel filters have been carried out to ensure that the quality of the biodiesel used in the buses has met the Standard EN 14214.

To the left the biofuel filters and to the right the mixing and filling station in Donostia - San Sebastián.

An EV Trial in Aalborg, allowing 80 ordinary families to each test one of 10 electric vehicles for a period of three months, has run for a period of two years. The vehicles have been produced by Peugoet, Mitshubishi and Citroen. Each family has been loaned an electric vehicle and had a charging point installed at home. A further 15 charging points have been installed at strategic locations around Aalborg. There has been an ongoing monitoring of driving patterns, CO_2 usage and also an ongoing upgrading of the charging methods. In total, over 100,000 km have been driven in the electric vehicles.

> On a national scale electric vehicles have in total run over 2 million km in Denmark. The energy that the electric vehicles have used to drive this distance is equivalent to the energy that the Danish Wind Energy Park produces in 10 minutes.

In Brighton, research conducted in 2009 indicated that there was only one company in the UK, Elektromotive Ltd, with experience of installing on-street charging points at the time. The charging points supplied by Elektromotive are slow charge points and it is exclusively these that have been installed in the Brighton area. Sites for the charging points were identified in liaison with the UK Department for Transport (DfT) to arrange authorisation for the signing and lining necessary for the EV charging point bays, and the selection of the supplier of the charging points. Following this evaluation process four charging points were installed in Brighton during September / October 2009 and have been in use since February 2010.

To make the EV charging point scheme more attractive to potential users, the decision was taken early in the life of the project to make registration and usage of the charging points completely free of charge in order to remove a barrier towards using EV's. The initial registration of the user to the scheme, with the supply of access keys, charging cable and parking permit are all free of charge. In addition, while the user's vehicle is recharging at a charging point, the electricity consumed is also supplied free of charge and there is no charge made for parking in the bay. As part of the impact evaluation process for Electric Vehicle Charging Points, a survey was conducted in late 2009 to collect baseline information on residents' awareness of the measure being implemented.

From the beginning of the CIVITAS initiative in September 2008, the Electric Vehicle charging point project has been extensively reported by the local press. The launch ceremony when the first charging points became operational received wide coverage in both local and national press and on local television. The installation of four more charging points took place in January 2011.

In Iasi, the research study clearly showed that particulate and NO_2 pollution emissions and also noise levels are above the value limit that is legally acceptable at the five locations along the CIVITAS ARCHIMEDES corridor. The transformation of 30 buses to work on LPG has been completed along with the installation of an LPG fuelling station. The promotion campaign was launched and an evaluation of emission levels of vehicles through measurements performed on CIVITAS ARCHIMEDES Corridor has been concluded.

LPG (Liquefied Purification Gas) is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. In some countries, LPG has been used since the 1940s as an alternative to petrol for spark ignition engines. Two recent studies have examined LPG-fuel oil fuel mixes and found that smoke emissions and fuel consumption are reduced but hydrocarbon emissions are increased. LPG burns more cleanly than petrol or fuel oil and is especially free of the particulates from the latter. LPG has a lower energy density than either petrol or fuel-oil, so the volumetric fuel consumption is higher. Not all automobile engines are suitable for use with LPG as a fuel. LPG provides less upper cylinder lubrication than petrol or diesel, as a consequence LPG fueled engines are more prone to valve wear, if not suitably modified.

In Monza the Van Hool in series hybrid bus (specifically model A330Hyb) was identified as the most suitable bus to be procured according to the needs of the City of Monza and the currently available technology based on the outcomes of the study phase. The key factors in this choice was the driving attributes and the length of the bus with regards to the narrow roads in the historical centre of Monza, the passenger capacity, the proposed technology and the compatibility between the scheduled deadlines in ARCHIMEDES and the availability of vehicles. In order to guarantee a quick delivery of the bus, it was decided to sign a lease.

A hybrid vehicle is a vehicle which combines two different power sources to move the vehicle, e.g. an electric motor and a heat engine. The electric energy is stored in batteries, supercapacitators or an electrically operated flywheel. In a parallel hybrid vehicle the single electric motor and the internal combustion engine are installed so that they can both individually and together power the vehicle making the energy efficiency is higher than a series hybrid that is exclusively propelled by the electric motor with no mechanical connection to the engine.

However, by the time the order was confirmed Van Hool could no longer guarantee to deliver the A330Hyb bus within the required time frame, and therefore the IVECO Citelis Hybrid bus was identified as a suitable replacement. The bus was presented to the city and to the press on May 3rd 2011, two months behind schedule. News of the presentation of the hybrid bus resulted in considerable coverage in the local, national and trade press. The hybrid bus was immediately put into operation on Line Z206, one of the most frequent PT lines in Monza that includes one of the two CIVITAS ARCHIMEDES corridors. Due to the innovative equipment of the hybrid bus compared with rest of the conventional NET fleet, it has been necessary to plan training for both drivers and maintenance technicians.

Presentation of the hybrid bus at the Consortium Meeting in Monza.

During the test of the hybrid bus a number of aspects were monitored to help determine the costs and benefits of the hybrid bus, i.e. emissions, noise production, battery duration, reliability of braking system and installed equipment and running costs. It turned out the first vehicle delivered suffered from several technical problems of the sort often associated with a prototype vehicle. In order to to get more valid test results a second vehicle was delivered for testing after several extra months of development work.

In contrast to Monza, the hybrid bus chosen in Aalborg was a parallel hybrid bus making the energy efficiency is higher than a series hybrid.

4.3 Problems Encountered & Solutions Attempted

4.3.1 Technical Issues

Biodiesel

The main technical disadvantages with biodiesel experienced through the demonstration projects concern transportation and storage, suitablilty at low temperatures and the running costs and fuel economy. General concerns are the potential impact of biodiesel on engine performance and durablilty, although no major problems of this kind have been registred in the demonstration projects.

One of the outcomes of the research study in Aalborg was that cold temperature properties of biodiesel are very different from fossil diesel and the storage and mixing temperatures which, for tallow biodiesel in particular, is a critical parameter in the Danish climate. Tallow Methyl Ester (TME) biodiesel typically requires heated tank installations for handling in pure form (B100). The problem is reduced when mixing with ordinary diesel or with additives. Blends B10 and B15 should be limited to approximately -10 °C, whereas B30 should not be relied on during winter. It is absolutely necessary to measure cold weather properties in the ready mixture, not only in the base components. Biodiesel might need heating before the admixing process with diesel. Tallow biodiesel requires heating at approximately 25 ºC when mixed; otherwise a deposition in the finished mix could result. The need for two-stage mixing could arise in the case of long transport distances where, for example, due to the cold temperature properties, neat TME must be diluted to B50 before transportation.

The affect of colder temperatures on 100 % TME. To the left is TME in temperatures of 5-10 ºC and to the right is TME in temperatures of -5 - 0 ºC. Note the difference in transparency.

The research study also showed that biodiesel is likely to increase the dilution of the engine lubrication oil in diesel engines. When using B30 or lower blends however, no significant deterioration of engine oils is likely to occur, if service intervals are adapted according to the manufacturer's specifications. Typically this means that engine oil has to be changed twice as often as for conventional fuels. Another conclusion was that blends in the range B10 or B15 TME are not likely to damage factory mounted or retrofit exhaust after treatment equipment. Power and torque can usually be expected to drop consistently with volumetric energy content in the fuels. This was however not noticed by most drivers. Laboratory tests indicated a slight improvement of engine thermal efficiency. Emissions of CO, HC and PM decreased while NOx was slightly increased. Special requirements on equipment, pumps, gaskets, coating etc. are often the result of rubber materials that lack compatibility with B100 biodiesel. The problem is not so predominant for concentrations below B30 and can therefore often be neglected in the vehicle when using a lower admixture. However, the mixing plants that are in contact with B100 must have the appropriate hose and gasket material.

Because of the limitations of bio-fuel blends due to the climate in Aalborg, it was decided that the buses and postal service vehicles should run on bio-fuels with a mix of blends B10, B15 and B20 during the course of a year. For the bus demonstration task, both contractors chose to install an additional tank containing a 50% bio-fuel blend at their normal filling station, and then automatically mix the 10% blend in the diesel pump on location by mixing from the tank with biodiesel and the tank with conventional diesel. However, due to the properties of biodiesel making it less liquid when cold, the additional tanks have to be heated. One company has chosen to have the additional tank indoor in the garage, while the other company has a tank outside that is heated during cold periods. Both solutions are working, but the latter has higher operational costs and derived production of CO_2, due to the energy required for the heating. Accurate mixing of blends has been a challenge for both companies. This is considered as a common challenge when dealing with new technologies, and the challenge was overcome by January 2011, when the contractors had become used to working with the biodiesel product and the tanks.

In contrast to the installation established for public transport, where the ordinary diesel and the bio component (50 % solution) are kept in separate tanks and first mixed to form the required blend in the pump, at the Postal Service's depot the biodiesel is already in the right blend on delivery to the fuelling

station. This makes only one tank necessary and due to the 'low' nature of the blend (B10-B20) there is no need to heat the tank.

The climatic conditions in Donostia - San Sebastián are much less restrictive than in Aalborg and therefore there are few limitations in the use of high blends of second generation bio-fuels. Furthermore, CTSS stored the pure biodiesel on its own premises for use it in its own bio-fuel mixing station, which allows use of different blends in different vehicles, if required. Up to now there have been no problems with the stability in the storage of the pure B100 product.

Initially, there were problems in Donostia - San Sebastián in mixing the correct blend (B20) in the combined bio-fuel filling and mixing station. This was due to the presence of biodiesel (up to 5 %) in the base diesel which is in compliance with the EN590 standard. This caused some problems with the vehicle warranties. These problems were overcome once allowance was made for the biodiesel content of the base diesel was allowed for, meaning that the correct blend was obtained.

Through the monotoring programme in Donostia - San Sebastián an increasing excess fuel consumption at increasingly higher bio-fuel blends has been detected, which has a significant impact on the overall running costs of each bus. The monotoring programme also identified problems:

- with saturation of fuel filters, mainly affecting buses with common rail fuel injection system, i.e. buses with Euro 4 and more modern engines,
- and with specific errors of "low pressure in the injection rail" in the the fuel injection system resulting in the change of injectors in the best case or the change of the high pressure fuel pump (which is much more expensive) in the worst case.

For these reasons, blends of B50 and B100 were not apllied more widely to the bus fleet and therefore the initial target of 20 buses running on B100 has not yet been met.

Initial problem with saturation of fuel filters affecting buses with common fuel injection system in Donostia-San Sebastián.

LPG

The transformation of 30 buses to work on LPG along with the installation of an LPG fuelling station in Iasi has been completed without any major technical issues, though it is estimated that the remaining life span of the LPG buses is only 6 years and the life span of the LPG distribution unit is 8 years (based on the date when it is recommended to change the LPG tanks because of the risk of corrosion).

Electric Cars

The testing of electric vehicles in Aalborg has been completed without any major technical problems, though there have been general problems with the 12 V storage battery running dry. The vehicles have been able to run 90-110 km per battery charge, which is the major technical limitation with EVs at the current time. Also, the charging time has been a slight obstacle. At the start of the trial period the charging time was eight hours using a 10 amp battery. The charging time has now been reduced by using a 16 amp battery.

Two of the Electric Vehicles in Aalborg.

Although the EV scheme has been operating in Brighton since February 2010, the take up by users so far, as measured by registrations and usage, has been relatively slow. The slow take up of the infrastructure by EV users may be due to a lack of availability of up to date electric vehicles in the UK. However, electric vehicles from a range of mainstream manufacturers are now increasingly coming to the marketplace, so this should change.

Hybrid Buses

In Monza, the technical specifications that the hybrid bus had to comply with (i.e. the driving attributes, the length of the bus and the passenger capacity), contributed to a narrowing of the market. The choice of electric/diesel hybrid bus technology was because it was not possible to build tanks suitable to contain any kind of gas (LPG or methane) at the TPM depot where the bus would be based. Furthermore, mechanics at the garage were already familiar with hybrid drive mechanisms, which made it easier to be able to give both routine and emergency maintenance at the garage, which was a basic requirement.

Since the hybrid bus delivered in Monza by IVECO was originally intended for the French market, some interventions have been necessary to upgrade the vehicle and make it suitable for registration under Italian law. Furthermore, some minor adjustments have been realized to make the vehicle match the ATM/NET fleet standards, including installation of air conditioning and improvements to the electrical system. These requirements have been fulfilled with the second test hybrid bus.

The tourist shuttle hybrid bus in Aalborg has been purchased and made operational without any major technical issues.

4.3.2 Process Issues

For the test of bio-fuels it has been a challenge that many of the vehicle manufacturers were reluctant to provide the operator with the necessary guarantees for engine components, because they were not confident about the quality of bio-fuel mixes supplied to operators. After negotiations with the manufacturers, agreements have been reached in both Aalborg and Donostia - San Sebastián to keep the factory warranties for all used biodiesel blends. However, this was not easy to arrange, taking time and staff effort; and such problems form a barrier towards the deployment of bio-fuels usage – a long-standing problem that still needs to be addressed at EU level.

In Aalborg, the higher cost of biodiesel compared to conventional diesel gave a challenge to ensure the right payment from the public transport authority to the contractors. If not properly addressed in the tender, this issue could have made the project more expensive.

A major challenge in having the buses to run on biodiesel in Aalborg was how to place the responsibility for reliable operation of the bus services. The tendering of the service makes it possible to give the contractors full responsibility for operating the fleets as requested in the tender. This means that the responsibility for extra maintenance or insurances on the buses is also the responsibility of the contractors. The pricing of the risk for running on biodiesel had to be explicit in the bid for the tender, and will be reimbursed by the public transport company as part of the demonstration project. The benefit of this process is that it creates an incentive for operators to develop competitive solutions for bio-fuel usage.

Furthermore, due to challenges in getting planning permission for establishing the fuelling station at the Postal Service centre in Aalborg, the process was unfortunately slightly delayed according to the schedule. This in spite of the fact that all relevant stakeholders were included at a fairly early stage of the process, including the oil supplier, the producer of the fuelling station, the planning control unit at the city of Aalborg and the environmental department. The possible long process of setting up a special fuelling station in future projects should be taken into account, not least as a fuelling station does impose a threat to the local environment.

To the left; the Alderman from the Technical and Environment Department at the City of Aalborg cuts the red tape for the fuelling station and to the right; the first refuelling of bio-fuel is performed.

In Brighton, there was a delay in the availability of the first four charging points, which were ready for use at the end of September 2009, as the details of the membership scheme were still being worked on. At the same time the contract with Elektromotive Ltd was being developed, and the contract went through a number of iterations with a variety of changes being put forward for discussion by both sides. The agreed contract sets out that, in return for an annual payment by the city council, Elektromotive shall administer the scheme and also act as the daily point of contact with members and operate a help line to deal with any queries relating to the scheme. The contract with Elektromotive Ltd was finalised, and details of the user's membership scheme completed, in time to start signing up users to the scheme from February 2010.

The latest round of charging point installations in Brighton was completed by Elektromotive at the end of January 2011, but there have been delays in the connection to the electricity grid supply and the installation of an electricity meter by the respective electricity suppliers. Previously EDF arranged the electrical connections and then also acted as BHCC's electricity supplier. This simplified the process as the same company (EDF) connected the charging points to a convenient supply, installed an electricity meter and then supplied us with the electricity. The situation has now changed and while the provider of all new electrical connections in the Brighton & Hove area is UK Power Networks (formerly EDF Energy networks), the electricity supplier to the city council, who also has responsibility for meter installation, has changed and is now Scottish & Southern Energy (SSE). This change of supplier came about when Brighton & Hove City Council recently decided to switch the supplier for their electricity. Changes of this nature should not affect the future of the EV project as Brighton & Hove City Council continues to require that all electricity used is 100% renewable.

Electric Vehicle charging point in Brighton.

In Iasi, the land-ownership of the site for the bio-methane energy supply was passed from the local council to the region with the result that it was not possible for the local council to establish the bio-methane supply on that site. This legal matter and problems with the financing of the bio-methane energy supply forced the cancellation of the use of bio-methane. There were also problems in finding

a local firm that could test pollution emissions to the standard required as a part of the study of emission levels.

In Monza, it was difficult to obtain detailed and reliable information about the state of hybrid technology from vehicle providers as this technology in many cases is only just being introduced on a worldwide basis. It was difficult to get up-to-date information on the pros and the cons of the different specific technical approaches adopted by various manufacturers; it was even harder to obtain information about their future research strategies, which is important when making initial purchase decisions and an initial commitment to a vehicle or technology that might very soon become obsolete. Furthermore, the availability to obtain a hybrid bus in the short term to test in real service operation was extremely limited.

4.4 Main Outcomes & Results

4.4.1 Impacts

The main objective for implementing biodiesel in the bus and postal fleet in Aalborg was to reduce dependence on fossil fuel and to reduce the emission of CO_2, since test results shows that other emission reductions are not really significant in comparison with traditional diesel products. The research study showed that first generation biodiesel produced from rapeseed oil or sunflowers typically leads to a reduction of between 45 % and 58 %. However, Life Cycle Assessments of biodiesel from vegetable or animal waste products show that these second generation biodiesel products normally lead to a typical CO_2 (equivalent) reduction of 88 %.

It has been demonstrated that second generation biodiesel, TME, made from animal fat (tallow) can be used without major problems in public transport fleets and delivery vehicles. It is possible to reduce CO_2 emissions and fossil fuel consumption from vehicles without increasing other emissions significantly, without modifying vehicles and without encountering major problems in vehicle performance. Providing fuel consumption remains unchanged, an average 15 % substitution of diesel with CO_2 neutral bio-fuels in the delivery services is expected to lead to 210 tonnes less CO_2 being emitted annually.The experiences from other projects so far are good, and the fuel from DAKA - or equivalent fuel from other suppliers - can therefore be recommended for large scale demonstrations.

In Donostia - San Sebastian, the overall use of biodiesel has increased to more than 30 % of all fuel used in the CTSS fleet, with B30 being used as the minimum blend across the whole CTSS bus fleet since 2011. CO_2 and air pollutant emissions (CO, HC, NOx and PM) have decreased considerably by means of the introduction of clean vehicles (of EEV standard) and the use of high biodiesel blends in a significant proportion of the CTSS buses. In 2011, the relative reduction of all pollutant emissions is more than 20 %, ranging from 20.15 % for CO_2 emissions to 45.33 % for PM emissions. In absolute terms, the use of bio-fuel has reduced CO_2 emissions by 1,707 tonnes while local pollutant emission savings nearly reached 81.3 tonnes in the same year (24.3 tonnes of CO; 6.7 tonnes of HC; 47.7 tonnes NO_x and 2.57 tonnes PM). However, the use of bio-fuels has led to increased fuel consumption which, together with the increased requirements for maintenance, has resulted in higher operation and maintenance costs. Nevertheless, a significant impact on the energy side is the decreased dependency on fossil fuels for the operation of this service.

50 families have now completed the three month trial with an electric vehicle in Aalborg travelling over 2 million km in total. The results of these trials show that the users have been very satisfied with their electric vehicles and there is in general willingness towards buying an electric vehicle within the testing families. The electric vehicle has in most cases become the primary vehicle in the family as it can cover up to 95 % of all trips made by a family, which has exceeded the initial expectations.

Following the start of the Electrical Vehicle Charging Points project in Brighton in February 2010, the number of registered users has steadily grown. There were recorded 18 users by April 2011. Records of the actual usage of the charging points currently operating are manually downloaded on a regular basis. Registration details are being used to conduct a user survey to test satisfaction of the initiative, abd to explore how the provision will continue in the future. Calculations indicate that the electric vehicles potentially can reduce CO_2 emissions by 55 %.

The use of LPG instead of diesel in the bus fleet in Iasi has shown a decrease in operation costs by 10 % and a decrease in maintanence costs by 30 %. Although positive impacts on NO_2 (39 % reduction) and CO (36 % reduction) have been achieved, this is overshadowed by the increase in CO_2 emissions by 52 % caused by a greater fuel consumption than expected in comparison with the diesel baseline.

The passenger target for the tourist shuttle hybrid bus in Aalborg has been reached. The structure of the tourist bus route with many stops at busstops and traffic junctions was suitable for a hybrid bus. The hybrid bus has been running with 33 % lower fuel consumption and hence lower CO_2 emissions than regular buses. In 2012, the shuttle bus will be operating on 100 % sustainable biodiesel. Following these positive results, hybrid buses were put into operation on three bus lines in Aalborg on the 1st of January 2012. These buses are also running with significantly lower fuel consumption.

The tourist shuttle bus in service in Aalborg.

In Donostia - San Sebástian the hybrid bus has alson been running with up to 30 % lower fuel comsumption compared to a diesel vehicle.

The initial evaluation activities in Monza indicate that the higher capital costs in purchasing a hybrid bus (€360,000 compared to €220,000 for a traditional bus) will be neutralized over time as the operational maintenance costs for the hybrid bus are considerably lower than for a traditional bus (0,0029 € per km compared to 0,0044 € per km). These data should be considered indicative since the number of operational vehicles is still small and NET does not yet have a reliable financial report. Furthermore, the diesel engine of a hybrid bus is used only for charging and not for traction, so smaller

engines are mounted. Consumption will benefit from the average weight reduction (in some cases around a tonne): fuel consumption and emissions of carbon dioxide and greenhouse effect gases are expected to be reduced to 40-50 % in comparison with a traditional diesel bus. The first evaluation results concerning fuel savings have been very positive showing a reduction by nearly 40 % at average speeds of 11.5 kph and a reduction by nearly 30 % at average speeds of 25 kph.

Further outcomes and results can be found in D12.4 Final version of measure level result templates.

4.4.2 Changes to Processes

In Aalborg, the original plan to run a service vehicle on a methanol fuel cell pack was abanboned due to the fact of limited knowledge and excessive costs towards the development of the unit. In Iasi, legal matters regarding land-ownership and financing of the bio-methane energy supply has made it impossible to implement the use of bio-methane. Therefore the scope of these two measures was changed.

In Brighton, the decision to make registration and usage of the charging points completely free of charge to make the EV charging point scheme more attractive to potential users, was taken early in the life of the project to try to establish an incentive for using EV technology.

In Monza, the administrative change of Public Transport Operator from TPM to NET changed the original scope of the measure from implementing the use of biodiesel in the bus-fleet to implementing a hybrid bus as NET at that point of time did not work with biodiesel. Later in the process, it was neccesary to change the provider of the hybrid bus as the original provider could not deliver on time.

Generally, planning processes have proved to be robust to implement cleaner fuels even within a narrow timescale such as the ARCHIMEDES project. Various legal matters, such as land-ownership, obtaining factory warranties for vehicles and placement of fuelling stations, have influenced the implementation of the clean fuel projects and potential legal matters should therefore be addressed, where they can be foreseen, in the initial planning phase.

4.5 Future Plans

The “alternative fuel options” subject is, in general, a living topic that is progressing day to day with the latest research and development news. While results from the studies performed and demonstration tasks in Aalborg, Donostia - San Sebastián and Iasi remain valid and contain valuable experience at this point of time, new greener fuel options or new technologies, developments and improvements continue to appear with the potential to reduce global and local emissions and reduce production costs and social impacts. It is therefore important that the cities involved continue to refresh and review research and results with the latest information to maintain valid conclusions for future planning and implementation.

In Donostia - San Sebastian the hybrid and bio-fuel technologies have been expanded within the bus and municipality fleet. 82 municipal vehicles are powered by bio-fuel blends. The municipality has introduced 13 hybrid cars and 7 electric vehicles among the Municipal Police, the Mobility Department and the Town Hall services, as well as 4 electric bicycles, as part of the ARCHIMEDES demonstration project. The results from the purchased hybrid bus will be used as a showcase for the decision for the next purchases. As in Aalborg, the extra purchasing and running costs could prevent further implementation of bio-fuels which will depend on the future availability of other suppliers, the price difference with the conventional buses and the development of the hybrid technology.

The electric car trial will end in March 2013 after having given in total 80 families the opportunity to test electric cars. The evaluation for the project in Aalborg will be concluded within the timeframe of CIVITAS ARCHIMEDES; but the national evaluation will be performed in 2013. Whether the EV-trial will continue mainly depends on future funding schemes.

If the EV charging point project indicates an appropriate level of demand, and future funding/revenues allow, then the scheme could readily be extended with additional charging points in other locations. In-depth evaluation of this measure will lead to insights into future implementation. The Third Local Transport Plan (LTP3) for Brighton & Hove contains an allocation of £25,000 in 2011/12, for the ongoing expansion of the EV charging point network. This amount will be sufficient to enable another 2 charging points to be installed at a new location within the city. This allocation is purely capital funding and is therefore not intended to cover running costs, which are currently being funded through the CIVITAS budget. When the CIVITAS project ends in 2012 another source of revenue funding will need to be identified if the project is to continue. It will be likely that charging for the use of the EV charging points will be introduced to cover running costs and to make it more feasible for registered users to use EV charging points across the neighbouring schemes based on a common charge scheme. The process of identifying possible sites for the charging points will be starting shortly, and this will be followed by consultation with local councillors and other stakeholders to determine the preferred location. Some charging points in Brighton have been installed in locations which were formerly Pay & Display and this has resulted in a potential loss of parking revenue. More recently, locations selected for new charging points have avoided this situation by using sites where there would not be a loss of parking revenue to the city council, Following on from the Brighton & Hove initiative, a number of other local authorities (West Sussex, Hampshire, and some parts of East Sussex) in the surrounding area have come together in a South Coast network to install EV charging points in both on and off-street locations. BHCC is exploring how it might be possible to allow access to the charging points in Brighton to users registered in the South Coast network scheme, and how in turn users from Brighton & Hove could access the charging points installed by the South Coast network.

Measurements like the ones of the research study in Iasi can also be performed in other places in Iasi with heavy traffic in order to have a realistic record of existing pollution emissions and to take action with a view to reducing emission levels in the future. By transforming diesel buses into LPG buses vehicle emissions are expected to be reduced leading to an improvement of the air quality, although the 30 buses that are transformed represent a low percentage of the total vehicles that circulate on CIVITAS corridor. The calculated increase of CO_2 does, however, suggest that further transformation of diesel buses into LPG buses is not a sustainable long term solution; results from other projects, such as CIVITAS SMILE in the nearby Romanian city of Suceava suggest fuel consumption and CO_2 emissions would be considerably better if dedicated gas engines, rather than engine conversions, are used.

Following the introduction of hybrid buses on three bus lines in Aalborg, the hybrid buses have found their way into the "normal" busfleet. The buses are benefitting from the established infrastructure and other experiences from the ARCHIMEDES project. Whether the postal service will continue using biodiesel is not yet clear. The product is still more expensive than conventional diesel and, as the EU funding will end, the postal service will have to decide whether biodiesel is one of the strategies to achieve their objectives on green transport.

The difficulties in obtaining a hybrid bus and making it operational in Monza will most likely result in the municipality not continuing to test hybrid buses regardless of potential benefits.

5. Conclusions and Recommendations

Workpackage 1 focuses on technological opportunities to reduce the impact of public transport vehicles on the local and global environment without negatively impacting on the mobility offering made to potential customers; i.e. the citizens. A wide range of technologies exist on the market now and are in development for the future, which offer different benefits and possible drawbacks and are likely to be applicable to different transport applications, depending on their characteristics such as the size of vehicle required and the speed / distance profile of the route. This makes it difficult to formulate a universal plan for all cities to adopt.

This is emphasised by CTSS in San Sebastian who stated that their analysis is based on their own situation and is not necessarily applicable to other cities. This is also emphasised by the diversity of the systems covered in depth by the research deliverables within ARCHIMEDES workpackage 1: particularly bio-fuels, EVs, LPG and hybrid technologies. The cities' reactions to them depend on issues such as the current local state of technological development and what is available on the local market, which in itself varies, as well as the information that they have managed to collect from the large and ever-changing pool of information that is available. This situation is unlikely to be clarified in the near future and may become more complex as energy security issues focus policies towards exploiting local energy sources.

This section summarises results, conclusions and recommendations regarding the various technologies within this workpackage. More detailed information regarding the different measures can be found in D10.3 Final Evaluation Report and D12.4 Final version of measure level result templates.

5.1 Conclusions

The experiences regarding bio-fuels are that:

- It is possible to reduce CO_2 emissions and fossil fuel consumption from vehicles without increasing other emissions significantly, without modifying vehicles and without encountering major problems in vehicle performance. Saturation of fuel filters affecting the fuel injection system was a problem in Donostia-San Sebastián.
- Excessive fuel costs have made running costs higher than expected.
- Also excess fuel consumption at increasingly higher bio-fuel blends has been detected in Donostia - San Sebastián having a significant impact on the overall running costs of a bus.
- Second generation biodiesel produced from tallow (animal fat) is very sensitive to low temperatures, and therefore there are clear limitations regarding transportation, mixing and use of high blends in colder climates.
- It has been a general problem that many of the vehicle manufacturers were reluctant to provide the operator with essential guarantees for engine components because they were not confident about the quality of bio-fuel blends supplied to operators.
- Setting up a special fuelling station can be a long process depending on local planning procedures, not at least as a fuelling station does impose a threat to the local environment.
- CTSS stores the pure biodiesel on its own premises for use in its own bio-fuel mixing station, which allows use of different blends in different vehicles, if required. Initially, there were problems in Donostia - San Sebastián in obtaining the correct blend (B20) in the bio-fuel filling and mixing station due to the existing percentage of biodiesel in the base diesel complying to the EN590 standard.

The experiences regarding Electric Vehicles are that:

- EVs have the potential to reduce CO_2 emissions considerably.

- Limited usage of EVs in Brighton may be due to the lack of availability of up to date electric vehicles in the UK. However, electric vehicles from a range of mainstream manufacturers are now increasingly coming to the marketplace, so this should change.
- Users of the EVs in Aalborg have been satisfied with the vehicles and there is a general willingness towards buying an EV within the testing families. The EV has in most cases become the primary vehicle in the family as it can cover up to 95 % of all trips.
- The limited battery reach of 90-110 km, the limited number of charging points and the charging time are the main technical issues.

The experiences regarding the use of LPG in converted engines are that:

- LPG can reduce operational costs and maintainance costs compared to conventional diesel.
- LPG can reduce NO_2 and CO emissions; however, in these circumstances LPG was shown to lead to a significant increase in CO_2 emissions. Experience from elsewhere backs up this finding and suggests that better results can be obtained from dedicated LPG engines.
- Given that a major part of LPG is derived as a by-product from oil refining, the use of LPG is not sustainable in the long term and rather represents a convenient local interim solution while a better long term strategy is elaborated and other alternatives are found.

The experiences regarding use of hybrid technology are that:

- Higher capital costs in purchasing a hybrid bus will be neutralized over time as the operating costs for the hybrid bus are considerably lower than for a traditional bus.
- Fuel consumption and emissions of carbon dioxide and greenhouse gases are expected to be reduced considerably in comparison with a traditional diesel bus.
- It was difficult to obtain detailed and reliable information about the state of hybrid technology from vehicle providers as in many cases this technology is just being introduced on a worldwide basis and is still developing rapidly.
- The availability to obtain a hybrid bus in the short term to test in operation was extremely limited. The technical specifications that the hybrid bus needed to comply with, i.e. the driving attributes, the length of the bus and the passenger capacity, contributed to narrowing the market even further.
- Training for both drivers and maintenance technicians due to the innovative equipment of the hybrid bus has been necessary.

5.2 Recommendations

The results of the research studies and demonstration tasks in workpackage 1 comprise an up-to-the-minute account of experiences regarding the use of bio-fuels and the different technological opportunities to reduce the impact of public transport vehicles on the local and global environment. For future planning and implementation of all the options covered in workpackage 1, research should be carried out taking into account local circumstances as the fuel and vehicle technologies are under constant development.

For future projects regarding the implementation and use of bio-fuels, the following points should be considered:

- Climate attributes and their limitations on storing, transporting and using bio-fuels; Cold weather properties should be measured in the ready mixture, not only in the base components. Biodiesel might need heating before the admixing process with diesel. The need for two-stage mixing could arise in the case of long transport distances.
- Agreements with vehicle manufacturers to cover their diesel engines under warranty with the use of biodiesel should be reached early in the process.

- The possible long process of setting up a special fuelling station should in future projects be taken into account, not at least as a fuelling station does impose a threat to the local environment.
- Appropriate steps for the storage of biodiesel must be used.
- Higher fuel costs than standard diesel and increasing excess fuel consumption at increasingly higher bio-fuel blends can lead to higher running costs than expected.

For future projects regarding the implementation and use of EVs, the following points should be considered:

- The availability of electric vehicles on the market is still one of the main obstacles towars obtaining a higher use.
- Lower purchasing costs or financial incentives for having an electric vehicle would lead to a more widespread use of electric vehicles.
- Technology is under constant development and should in time make battery charging easier, which also would lead to a more widespread use of electric vehicles. A research study on the latest techonology should be performed.
- A car sharing scheme or a low-cost car rental scheme could potentially supplement the use of electric vehicles, so that all trips can be made without owning a standard car. This type of complementary scheme is mainly for large and / or dense cities or areas.

For future projects regarding the implementation and use of LPG, the following points should be considered:

- LPG should mainly be considered as a short term solution.
- Dedicated gas engines which have higher energy efficiency than diesel engines converted to LPG use should be used to prevent an increase in CO_2 levels.

In future cases for the implementation and use of hybrid technology, the following points should be assessed:

- The opportunities towards integrating hybrid technology in a wider range of buses should be considered to increase the opportunities within the public transport market.
- Lower purchase costs would be a big incentive for using hybrid buses and should be monitored over time.