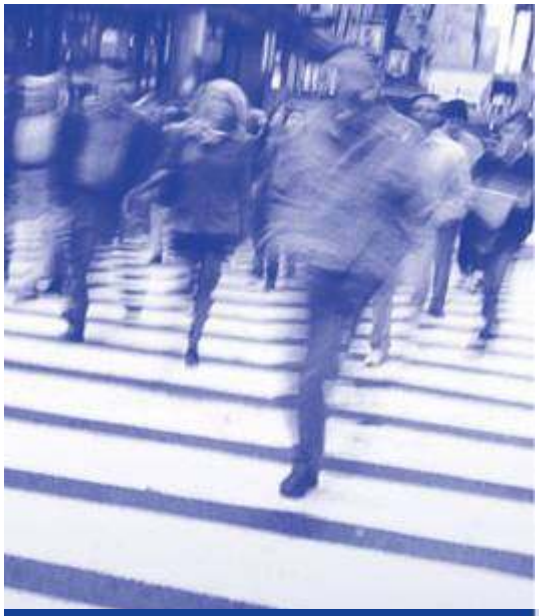

CiViTAS
Cleaner and better transport in cities

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

Donostia – San Sebastian

T4.2 – 20 Public Buses using 100% Biodiesel

CTSS

September 2012

THE CIVITAS INITIATIVE
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Contents

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.

1.3 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.

1.3.1 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. Donostia – San Sebastian

The city of Donostia -San Sebastián 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. Consideration of 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.

2.1 Objectives in CIVITAS

The CIVITAS project is a perfect opportunity to expand our Sustainabile Urban Transport Strategy. With the package of CIVITAS measures Donostia-San Sebastián wants to:

- 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.

3. Background to the Deliverable

The present deliverable refers to ARCHIMEDES Measure number 4, Biofuels and Clean Vehicles in Donostia – San Sebastian.

In 2009 CTSS, the urban public transport company of Donostia – San Sebastian carried out a study of alternative fuel options in Donostia –San Sebastian. The study looked at a range of fuel and vehicle technology options from a range of perspectives including operational, environmental and financial performance. The study, including the multi-criteria analysis that led to the production of the conclusions and recommendations that will determine CTSS' future clean vehicle and fuel strategy, is available as ARCHIMEDES Deliverable R4.1.

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 – 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 engine 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.

3.1 Summary Description of the Task

Based on the study results, within this task (Task number 1.5: Public transport bio-fuels and clean vehicles) biodiesel has been tested by CTSS at progressively higher blends. 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. The use of biodiesel in the local buses has served as a local showcase backed up by promotional actions to convince other fleet operators and individual car users to switch fuels.

ARCHIMEDES Deliverable T4.1 reported on the initial steps in this programme, which involved

- Installation of a biofuel filling-mixing station.
- 50 buses running on 20% biodiesel.
- 15 new EEV buses being brought into operation.

The initial application described in Deliverable T4.1 went well, although the need for an ongoing programme of fuel monitoring was identified for CTSS, vehicle manufacturers and fuel suppliers to gain experience through this innovative programme.

This document, ARCHIMEDES Deliverable T4.2, provides additional information on progress towards the original stated objective of having 20 buses operating on 100% biodiesel by September 2011.

4. 20 Public Buses Using 100% Biodiesel

4.1 Outline Description of the Work Done

During the ARCHIMEDES project the San Sebastian public transport company (CTSS) has introduced and gradually increased the use of sustainable biodiesel (sourced from used cooking oil) in its fleet. Over time both the number of vehicles using biodiesel and the blend levels have increased.

At the start of the ARCHIMEDES project 2 sets of targets were set, one based on the number of vehicles using different blends and one set on the overall fleet average composition, as follows:

- Target 1: B20 to be used in at least 50 buses and B100 (i.e. pure biodiesel) to be used in at least 20 buses
- Target 2: the overall proportion of biodiesel used within the CTSS fleet to be at least 30%

As will be explained later in this deliverable, the deployment of biodiesel within the CTSS fleet has been subject to some technical problems, which has meant that the use of the highest blends and pure biodiesel has been slower than anticipated since it was first introduced in March 2011.

A first version of this report was produced in January 2012 by when the distribution of biodiesel blend by bus was as follows:

- B30 is used in 101 buses
- B50 is used in 8 buses
- B100 is used in 3 buses

In spite of ongoing technical issues which are described later along with the attempts being taken to address them, steps have been taken to further increase the use of biodiesel in the fleet, so that by September 2012

- B30 is used in 91 buses
- B50 is used in 15 buses
- B100 is used in 6 buses

Therefore in absolute terms the target of 20 buses running on B100 has not yet been achieved. However, the overall average proportion of biodiesel used in the CTSS fleet is now 35%.
CTSS is applying more than the 30% of Biodiesel in its fuel consumption.

4.2 Summary of Activities Undertaken

The biofuel filling-mixing station 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. A high level of support has been requested and provided from both the Biodiesel supplier and the Bus Manufacturer to explain the results of this analysis and its consequences. This has involved workshops and face to face technical meetings with both organisations.

In September 2011 the Learning History workshop, which forms part of the ARCHIMEDES process evaluation, was arranged with the local stakeholders to disseminate and debate about the activities undertaken.

At the end of 2011, five more EEV vehicles were introduced so exceeding the original schedule and these are all now running using 50% biodiesel following permission being granted by MAN.

4.3 Main Outcomes

The main outcome has been an increase in the overall average use of Biodiesel to more than 30% of all fuel used in the CTSS fleet, with B30 being the minimum blend being used in 2011 across all the CTSS bus fleet.

An ongoing programme of monitoring of higher blends (B50 and B100), the results of which have determined the speed and extent of use of these higher blends.

4.4 Problems Identified

The reason that the initial target for 20 buses to be running on B100 has not been met is that the monitoring programme has identified problems with operation at higher blends which have not yet been overcome. These problems are:

- An increasing excess fuel consumption has been detected of up to a 6.74% due to the lower energy content of the Biodiesel by volume compared to standard diesel fuel. This has a significant impact on the overall cost of running a bus on high blend biodiesel and can make widespread deployment of the highest biodiesel blends uneconomic.
- Widespread use of B30 in the newest buses has coincided with problems with fuel system being detected. During 2011 and early 2012 there was an increasing number of vehicles with premature problems in the fuel injection system. The problems have affected vehicles with Euro 4 standard onwards, including the newest EEV vehicles.

4.4.1 Fuel Filter Problems

Two different cases have been identified from the existing monitoring programme, as described below:

1. **Saturation of fuel filters.**

This problem is affecting buses with common rail fuel injection system, i.e. buses with Euro 4 and more modern engines. A high number of these vehicles have required their fuel filters to be changed earlier than the recommended value of 30000km. The reduction in operating life is not consistent, with some changes being required in the range 21,000 to 27,000 km and then the same vehicle not seeing a reduction for the next change.

When the fuel filters were changed, unexpected waste has been found mixed with the biofuel blend. Samples of the waste in the filters and fuel has been analysed both by the Biodiesel and the Bus suppliers, and also by independent laboratories.

Figure 1: Waste taken from the fuel filter walls

Figure 2: Dirty fuel filter

2. **Early error in the fuel injection system**

In some cases the diagnosis system of the vehicle reported a specific error of “low pressure in the injection rail”. And the solution becomes:

- in the best case a change of injectors, or
- in the worst case with a change of the high pressure fuel pump (which is much more expensive),

In some buses the problem repeats but in others not, and there are some new vehicles that has not been affected yet. Given this variation it has difficult to come to a firm conclusion about the cause of the problem and hence devise a long term solution in combination with the fuel and vehicle suppliers – this is, therefore, an ongoing real issue that has required further, lengthy investigation.

4.5 Risks and Mitigating Activities

The increase in the proportion of biodiesel to the B30 blend was been identified as the starting point of the current problems with the injection systems in the newest buses.

In the first instance, a quality control of the Biodiesel and Diesel storage system was carried out. Analysis was conducted on the fuel in the underground tanks and to filters of the fuel pumping station. The results were positive, in that there was no water in the system; nor was a bacterial problem found, which had been suspected as a first idea.

Later, analysis of the blends in the same fuel tanks of the vehicles affected was carried out. Also analysis was carried out on the tanks of the trucks supplying fuel to CTSS. In both some deviations were found in comparison with the quality sheet chart from the Biofuel supplier. The deviations covered:

- Total contamination
- FAME content
- Oxidation stability
- Acidity number

As follows:

	Supplier	Independent Analysis	LIMIT
Total contamination (mg/kg)	6,4	24,2	max 24
FAME content (% m/m)	97,3	94,4	min 96,5
Oxidation stability (hours)	9,1	5,1	min 6,0
Acidity number (mgKOH/g)	0,3	0,52	max 0,5

From the perspective of the biofuel suppliers the deviations are acceptable and have no relation with the current problem, but the opinion of the bus supplier is totally the opposite.

In words of biofuel supplier, minimal deviations in some of the quality parameters of the biodiesel cannot be considered potentially risky for the engines because:

- they don't influence on engine's injection system behaviour
- there is no specific Standards for Diesel-Biodiesel blends.

In contrast the bus manufacturer finds these deviations unacceptable and advised CTSS to change to its officially recommended biodiesel, which is rapeseed biodiesel fulfilling EN14214.

To make such a change would raise different questions for CTSS because of the ongoing food vs fuel debate in respect of biodiesel – questions which are solved through the use of waste cooking oil as the biodiesel feedstock.

Given this ongoing disagreement CTSS has been monitoring the fleet maintenance state to gain further evidence. CTSS has not found any clear evidence to clearly accuse the Biodiesel for either:

1. premature saturation of fuel filters in buses, or
2. damage to injection system components

Figure 3 shows the distribution of distances at which fuel filter changes were needed for a subset of the CTSS fleet, split according to the biodiesel blend being used.

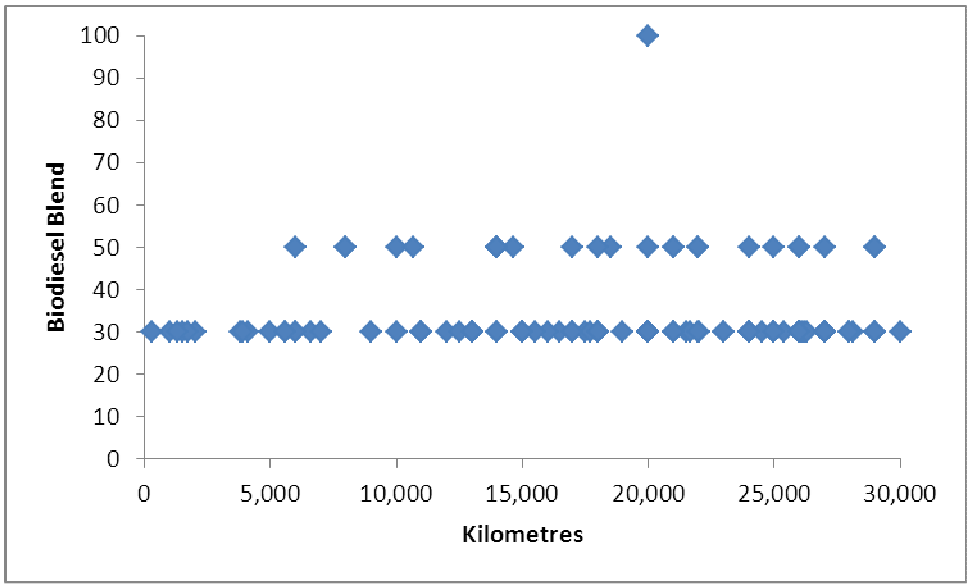

Figure 3

The average distance for the buses operating on B30 was 18311 km and for B50 was 18187 km. The sole value for a B100 bus in this dataset was 20000km.

Further detailed investigation of the data led to an interesting finding: the periods with the highest frequency of vehicles showing problems match the periods when the diesel filter of the biodiesel mixing pumping station needed to be changed.

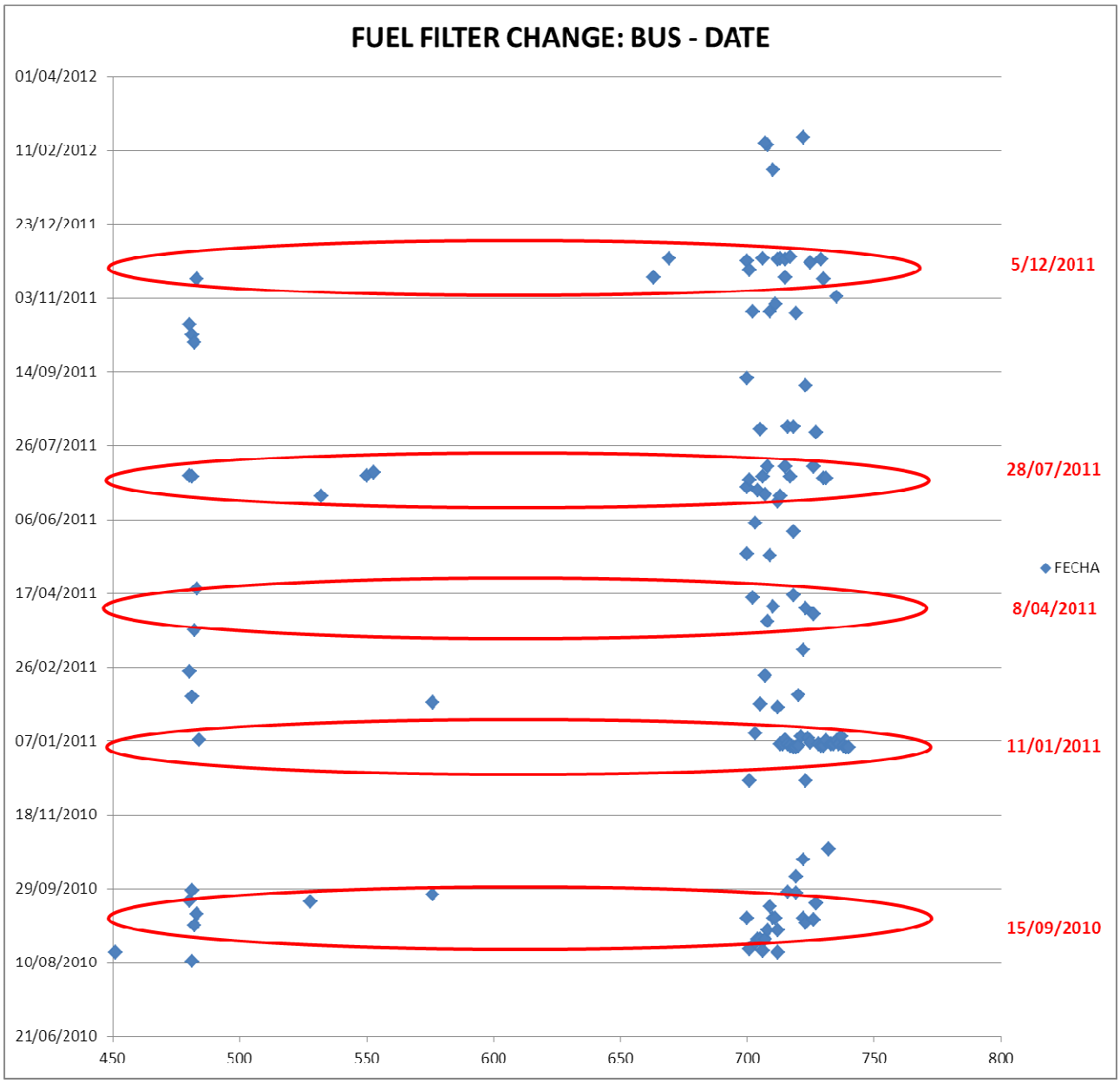

Figure 4: distribution of bus fuel filter change dates, highlighting the link to the scheduled change date of the filter on the biodiesel blend mixing station.

This has suggests that the common request by bus manufacturers that the fuel filters of buses running on biodiesel are changed more frequently than those running on standard diesel is replicated for the mixing station. Acting on this has reduced the subsequent incidence of problems, but not stopped them completely, so there is still a need to reach agreement between the bus manufacturer and biodiesel supplier.

4.6 Dissemination Activities

In September 2011 a promotion campaign for recycling used cooking oil was arranged. Previously, a press conference was done with the participation of the Mobility Councillor, CTSS director, a famous chef, and representatives of the Biofuel supplier and the local Oil recycling company.

Figure 3: Press conference

The event day had a high success due to the good weather and that other activities were arranged at the same time like: Entertaining activities for children, Clown shows and regional product commerce.

Figure 4: Event day, and Mayor recycling

4.7 Future Plans

A report of the in depth study of the situation still need to be agreed by both the Biodiesel supplier and the bus manufacturer to get to a clear conclusion. It will need to address questions such as:

- Apart from EN14214 quality Biofuel, is a more specific standard for Biodiesel blends needed to ensure that the newest vehicles can run with high blends of biodiesel?

- Will the problems also affect vehicles with less modern engines than Euro 4 over a longer timescale, or not?