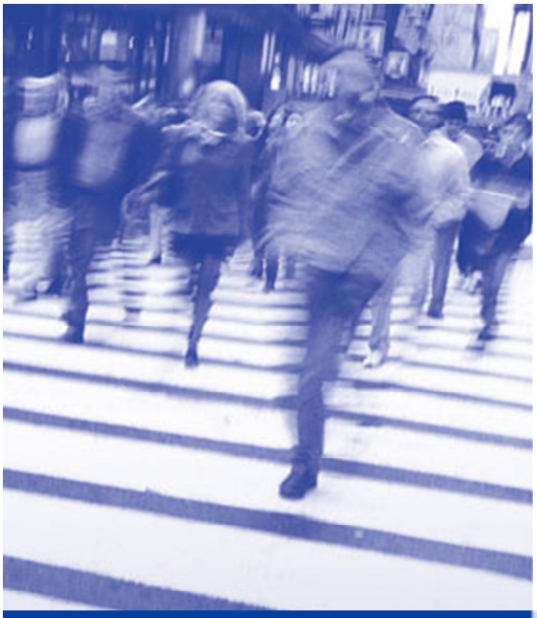

CiViTAS
Cleaner and better transport in cities

AALBORG

Aalborg

T1.1 T1.3
Biofuel Buses, Supply in Aalborg

Aalborg Kommune
15 March 2011

THE CIVITAS INITIATIVE
IS CO-FINANCED BY THE
EUROPEAN UNION

Project no.	TREN/FP7TR/218940 ARCHIMEDES
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Start date of the Project	15/09/2008
Duration:	48 months
Measure:	M1 Biofuels in Aalborg
Task:	Task 1.1, 1.3
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THE CIVITAS INITIATIVE IS CO-FINANCED BY THE EUROPEAN UNION

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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.

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. 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

3. Background to the Deliverable

The main project aim of CIVITAS ARCHIMEDES Measure 1, which contains the three demonstration tasks regarding bio-fuels, is to demonstrate the use of biofuels at the individual fleet level, using first generation biofuels in an innovative manner, and lay the foundations for maximising the opportunities for take-up of second generation bio-fuels.

Providing fuel consumption remains the same the 10% substitution of diesel with CO_2 neutral biofuels in public transport applications in the CIVITAS corridor is expected to lead to 140 tonnes less CO_2 emissions annually. .

This deliverable is the result of merging what were originally planned as two separate deliverables T1.1 and T1.3. The purpose of merging the deliverables is to create better visibility of the lessons learned during implementation of three much related tasks. Task 1.3 which concerns the implementation of bio-fuel supply is hence supporting task 1.1, since the success measure is dependent on the supply of fuel.

3.1 Summary Description of Tasks

This deliverable concerns two different tasks, described as follows:

- As part of a new tender in 2010 for operating the city buses in Aalborg, and based on the inputs from research report 11.1.1 (Study of impact using 1G and 2G bio fuels in Public Transport and Delivery Service vehicles) Nordjyllands Trafikselskab (NT) has set up requirements for the contractors to run a total of 50 buses on at least 10% biodiesel. NT will report on fuel consumption and impacts on vehicle reliability. The link to task 11.1.1 will enable the assessment of environmental impacts.

- The winning contractors have been given the responsibility to establish the required supply infrastructure in co-operation with oil suppliers as part of ARCHIMEDES task 1.3.

4. Bio-fuels in Aalborg

4.1 Description of Work Done

This deliverable covers two tasks as described above. The tasks concern the demonstration of biodiesel in 50 buses operating in the City of Aalborg, all within the CIVITAS corridor. The second task is to ensure the supply of biodiesel for the vehicles. Since biodiesel in the percentages being demonstrated is not available on the open market in Denmark, special arrangements have had to be set up, including new diesel tanks at the bus operators.

4.1.1 Initiating the planning process

The planning process of implementing biodiesel in the fleet mentioned above was initiated during the preparation of the of the CIVITAS ARCHIMEDES project with informal discussions between the Public Transport Authority in North Jutland and the City of Aalborg.

At the beginning of the CIVITAS ARCHIMEDES project one working group was set up to deal with the tasks.

The Working group consisted of:

- The ARCHIMEDES secretariat in Aalborg
- The Public Transport Section at the City of Aalborg
- The Regional Public Transport Authority (NT) (project manager)

4.1.2 Study of Impact Using 1st Generation and 2nd Generation Biofuels

This section includes the main conclusions from Task 11.1.1 (Study of impact using 1G and 2G bio fuels in Public Transport and Delivery Service vehicles).

Only about 2.500 m^3 of Tallow Methyl Ester (TME) based B10, B15 and B30 (blends containing 10%, 15% and 30% respectively of biodiesel mixed with conventional diesel) has successfully been used in Denmark so far.

The cold temperature properties of biodiesel are very different from conventional (fossil) diesel. Tallow biodiesel, especially, typically requires heated tank installations for handling in pure form (B100). The problem is reduced when mixing with ordinary diesel or with additives. The B5Next project has shown that it is possible to produce a tallow-based B5 that is usable under the same conditions as standard Danish winter diesel. B10 and B15 should be limited to approximately -10℃, whereas B30 should not be r elied on during winter. Low temperature stability is not consistently dependent on base fuel cold properties. It is absolutely necessary to measure cold weather properties in the ready mixture, not only in the base components. While B10 and B15 TME can be derived from domestic diesel qualities, B30 TME requires a special low density base-diesel to comply with the density requirement of the Fuel Quality Directive.[1] This makes B30 significantly more expensive.

[1] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC (Text with EEA relevance). Source: http://eur-lex.europa.eu/

Biodiesel might need heating before the admixing process with diesel to ensure a homogenous product. Tallow biodiesel requires heating at approximately 25 ºC when it is 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.

A diesel engine is an internal combustion engine with a high compression ratio that brings about a fuel dilution of the engine lubricating oil – especially in the engine warm-up period – because the fuel seeps down past the piston and dilutes the engine oil. Biodiesel has been shown, according to various international experiences, to increase this dilution. When using B30 or lower blends, however, no significant deterioration of engine oils is likely to occur, when service intervals are adapted according to the manufacturer's specifications. Typically this means that engine oil has to be changed twice as often.

In the Biodiesel DK project; analyses of the motor oil in the vehicles have regularly been made – partly to protect against engine failure and partly to test possible engine oil change intervals. No critical fuel/oil dilution has been detected.

Fuels like B10 and B15 TME are not likely to damage factory mounted or retrofit exhaust after treatment equipment.

Because the pure biodiesel has a lower volumetric energy content, the higher the blend the lower the overall energy content. Power and torque can be expected to drop in proportion to the volumetric energy content in the fuel. This was not, however, noticed by most drivers for the blends in question. Laboratory tests indicated a slight improvement of engine thermal efficiency. Emissions of CO, HC and PM decreased while NO_X was slightly increased.

The cost of TME is not the only cost issue. Also to be considered is the cost of extra service, base diesel price and fuel logistics. A surplus consumption due to lower volumetric energy content may also be expected.

Approval of new tank installations is a time consuming process. The two pilot projects that for the past year have worked with centralised admixture have spent seven and ten months respectively on the design and completion of the mixing plants.

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.

For biodiesel it is particularly important to consider the storage and mixing temperatures which for tallow biodiesel, in particular, is a critical parameter. Therefore it is even more important that the mixing takes place under controlled conditions. On the other hand the ready-mixed B10 or B15 will be rather unproblematic to transport and could be transported by ship if needed.

According to the recent life-cycle analysis study from the Technical University of Denmark 2nd generation tallow-based biodiesel is the only engine fuel which gives without a doubt a positive CO_2 displacement in the overall Danish energy system. This is a very important reason for choosing this fuel.

According to tests carried out by DTI, blended fuel produced by DAKA in Denmark has practically no negative environmental impacts compared to standard diesel.

Experiences from field tests show no need for conversion of vehicle engines. Standard vehicles can be used with little or no modification; the most significant change might be use of different rubber seals or hoses.

Local production of tallow-based 2nd generation biodiesel was established in 2008 and the plant is already prepared for up scaling. Potentially it will be able to deliver 5% of all diesel in Denmark.

The experiences from other projects so far are good and the fuel from DAKA - or equivalent fuel from other suppliers - was therefore recommended for large scale demonstration.

Based on the conclusions and recommendations from task 11.1.1, the ARCHIMEDES demonstration tasks 1.1 and 1.2 will include 2nd generation bio-fuels made from animal fat.

4.1.3 Dealing with a Tender

NT is the Regional Public Transport Authority and has the legal responsibility of the entire public transport system in the region of North Denmark. It administers the network of regional bus routes, city bus routes in six cities (Hjørring, Frederikshavn, Brønderslev, Hobro, Thisted and Nykøbing) and Aalborg, and local bus routes within all the 11 municipalities in the region.

However, the City of Aalborg has its own section of public transport planning, also involved in the project as part of the Department of Health and Sustainable Development.

The operation of bus services is carried out by private contractors based on tenders let according to EU procedures.

The bus operators own the buses and pay the fuel cost etc. and are paid by the hour based on the contract requirement in the tender. To make the buses run on biofuel (which is more expensive) it was necessary to incorporate this as a requirement in the tender, so that contractors could take into account the increased costs in their pricing structure.

A major challenge in having the buses run on biodiesel was where 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 tender for operation of the city buses in Aalborg was elaborated by NT through spring and summer 2009. The following requirements for use of biofuels were incorporated into the tender:

- Blend – at least 10 % AFME (Animal Fat Methyl Ester)
- Base diesel to ensure the right temperature stability
- Temperature stability
- Establishment of bio-fuelling stations and delivery of biodiesel
- Maintenance and service intervals for the buses

- Guarantees and insurances
- Compensation for extra costs related to fuel and maintenance
- The use of biodiesel after the end of the ARCHIMEDES project
- Data collection, including fuel consumption and maintenance etc.

These requirements were written into the tender and were all based on the ARCHIMEDES research deliverable R11.1.1. To establish the economic model for determining the extra costs in relation to biodiesel use, the contractors were required to give two prices for operating the buses:

1) The price for operating one package of bus routes, running on a 10 % bio-diesel blend, and
2) The price for operating the same package of buses on standard diesel.

The difference between the two prices is the extra costs related to running the package of bus routes on biodiesel. A very important element in the model is that both prices can be used; since the biodiesel project is only expected to be running for 2 years (the lifetime of ARCHIMEDES), and the tender as such is running for a longer period, both prices can be used through the duration of the tender. The pricing model, however, does not take this into account, and the price for operation on biodiesel after the end of the ARCHIMEDES may differ from the actual costs.

Realistic prices are in that way required. If the price of running buses on biodiesel is too high, the contractor risks not winning the contract. If the prices are too low the contractor risks that higher costs of running the buses will lead to losing money. Since the difference between the two prices is granted by the ARCHIMEDES Project, it could be thought that the contractors might set a high difference, but the model makes sure that this will not happen. The price difference might be too high if the costs of the biodiesel trial are too expensive, or the price for running on standard diesel is too low. In both cases this might cause trouble for the bidder, either because they will not win the tender, or because they might lose money if they are to run on standard diesel alone.

In the winning bids, the difference between operating on standard diesel or bio-diesel (10% blend) are between 2% and 4% of the total operating costs. Compared to the price difference between biodiesel fuel and ordinary diesel, the model for calculating the difference in running expenses must contain other elements, e.g. increasing costs for maintenance and fuelling and tasks for collecting data. If biodiesel during the following years becomes more regularly used, the difference in cost may decrease, if the supply of biodiesel also increases. The model does not, as above, take this into account.

The big difference on the estimated costs for running on biofuels – 100% difference from 2% to 4% - is supposed to be explained by the fact that one of the bidders had previous experiences with running vehicles on biofuels. Knowing the possible problems and expected extra costs made it possible for him to calculate his extra price (2%) more accurately than the other bidder, who had to include some unknown costs in the calculation, and therefore had to calculate with bigger economical security margin.

The public Transport Authority has in the contract the possibility to require a higher blend, if the demonstration of 10% is proved to be a success. The bus operators shall be compensated for any extra cost due to the increased requirements. The extra costs will be re-calculated if these requirements are implemented.

The pre-qualification call was announced in August 2009, with a deadline the 4th of September 2009. The tendering process after this point was as follows:

- Deadline: Provisional bids: 28th October 2009
- 1st round of negotiation: 9th to 11th November 2009
- Deadline: Adjusted bids: 27th November 2009
- 2nd round of negotiation: 7th to 10th of December 2009
- Deadline: Final bids: 18th December 2009

The tender was decided the 15th of January 2010, with a starting date for the city buses of the 27th of June 2010.

4.1.4 Fuelling Stations

The bus contractors are responsible for negotiating with the biodiesel supplier, and the bus contractors were also responsible for setting up a fuelling station that could facilitate the use of biodiesel. For the bus contractors extra costs up to approximately 25,000 € was granted by the ARCHIMEDES project.

Both winning bus contractors, Arriva A/S and City Trafik A/S chose to set up an additional tank containing 50% biofuel 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 the blend to a blend below 10% is also present.

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 is more expensive in operational costs due to the energy required for the heating and derived production of CO_2.

Figure 2 The bio-fuel tank at City Trafik A/S

Mixing the right blends has been a challenge for both companies. This is considered as a common challenge when dealing with new technologies, and the challenge has been

overcome by January 2011, when the contractors have become used to working with the biodiesel product and the tanks.

4.1.5 Operating in a Cold Climate

Figure 3

The difference between 100% AFME on the 1st of October 2010 (5 – 10 C°) and the 20th of November 2010 (-5 – 0 C°). It is the same container displayed. Note the difference in transparency.

As temperature is decreasing, the AFME-product is coagulating, similar to pig fat or butter in the refrigerator. Figure 3 shows this effect for 100% AFME; it indicates, that the climate can be an important issue to deal with, while implementing a 10% biodiesel blend in the two fleets in Aalborg.

To avoid any problems – since the bus service relies on a fully operating fleet – and yet to demonstrate a new and innovative technology, the following considerations have been made:

- For the buses it has been chosen to have a fixed blend of 10%, still exceeding the national targets based on European policies of 5.75 % in 2010 (by volume 6% biodiesel) by 66 %.
- If safe operation of the bus traffic is endangered due to biodiesel problems caused by temperature decreases, the contractors are allowed to pause the demonstration, using standard diesel if they are afraid that operation may fail due to the climate. However, this has to be documented. Even though temperatures have been down to -18 degrees at short periods this winter, use of B10 has given no problems.

4.1.6 Benefiting the Environment

The main objective for implementing biodiesel in the bus fleet is 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. However, Life Cycle Assessments of biodiesel from vegetable or animal waste products normally will lead to a typical CO_2 (equivalent)

reduction of 88%. Using a blend of 10% biofuels will in that case lead to a reduction of 8.3 % CO_2 (equivalent) reduction per litre used compared to a litre of conventional biodiesel.

1st generation biodiesel produced from rapeseed oil or sunflowers are leading to a typical reduction of between 45% and 58%. 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 emissions will be further assessed through the project.

4.2 Specification of bio-diesel products

DAKA bio-diesel product:

Daka™ Biodiesel

Analysis	Unit	Limit values Lower	Upper	Analytical method
Ester content	% (m/m)	96,5	-	EN 14103
Density at 15°C	kg/m³	860	900	EN ISO 3675 EN ISO 12185
Kinematic viscosity at 40°C	mm²/s	3,5	5,0	EN ISO 3104
Flash point	° C	120	-	Per EN ISO 3679
Sulphur	mg/kg	-	10	Per EN ISO 20846 Per EN ISO 20884
Coke residue (at 10% distillation residue)	% (m/m)	-	0,3	EN ISO 10370
Cetane number	-	51,0	-	EN ISO 5165
Sulphate ash	% (m/m)	-	0,02	ISO 3987
Water	mg/kg	-	500	EN ISO 12937
Grime	mg/kg	-	24	EN 12662
Corrosion of copper (3 hours at 50 °C)	Degree of corrosion	Class 1	Class 1	En ISO 2160
Oxidation stability at 110 50 °C)	Hours	6	-	EN 14112
Acid value	mg KOH/g	-	0,5	EN 14104
Iodine value	g iodine/100g	-	120	EN 14111
Linoleic acid methyl ester	% (m/m)	-	12	EN 14103
Polyunsaturated fatty acid methyl esters (>= 4 double bonds)	% (m/m)	-	1	
Methanol	% (m/m)	-	0,2	EN 14110
Monoglycerides	% (m/m)	-	0,8	EN 14105
Diglycerides	% (m/m)	-	0,2	
Triglycerides	% (m/m)	-	0,2	
Free glycerine	% (m/m)	-	0,02	EN 14105 EN 14106
Total glycerine	% (m/m)	-	0,25	EN 14105
Sodium + potassium	mg/kg	-	5	EN 14108 EN 14109
Calcium + magnesium	mg/kg	-	5	Per EN 14538
Phosphorus	mg/kg	-	10	EN 14107

Figure 4 Data sheet for bio diesel component. source: http://www.daka.dk

4.2.1 About Bio-diesel

The following text is the description of the biodiesel product from DAKA, copied from the website: www.daka.dk:

From www.daka.dk

Biodiesel consists of fatty acid methyl esters (FAME) created as the result of a reaction between an alcohol and oils/fats of vegetable or animal origin.

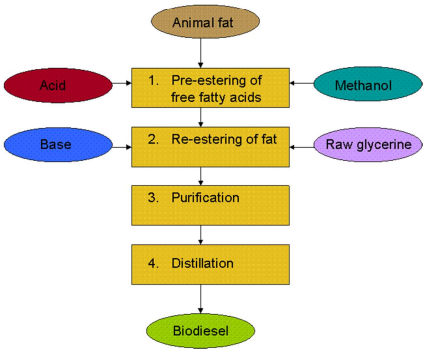
Methanol (wood alcohol) is usually the alcohol of choice, but ethanol may also be used.

The conversion process releases glycerine, a by-product of the biodiesel production process.

Process flow diagram for biodiesel.

Daka Biodiesel

Process flow diagram for Daka Biodiesel



Biodiesel may be used both as a CO2 neutral fuel in diesel engines, and as a bio fuel oil. The European diesel standard, EN 590, generally allows up to 5% biodiesel to be added, while a number of passenger cars, lorries and buses may run on 100% biodiesel with a few minor adjustments.

The structure of all oils/fats is principally the same, regardless of whether they are of vegetable or animal origin. They consist largely of triglycerides, and only the proportion of individual fatty acids differs. It is especially the content of unsaturated fatty acids in relation to the saturated fatty acids that is important for the product. As

the following table shows, palm oil and animal fat contain almost the same level of unsaturated fatty acids, while the level is far higher in rapeseed oil and soy bean oil.

	Animal fat	**Rapeseed oil**	**Palm oil**
Palmitic acid (16:0)	24	4	42
Palmitoleic oil (16:1)	4	0	0
Stearic acid (18:0)	16	2	4
Oleic acid (18:1)	43	60	43
Linoleic Acid (18:2)	11	20	10
Linolenic acid (18:3)	1	10	0
Other	1	4	1

A high level of unsaturated fatty acids lowers the congealing point, not just for the oil/fat, but also for the resulting FAME. This is especially significant in connection with the use of pure biodiesel, while it is less important as regards admixtures.

Daka Biodiesel will primarily be produced using refined animal fat extracted from slaughterhouse by-products and dead animals from primary agriculture. Other by-products in the form of used cooking oil and other oils unsuitable for food production may also be used in the production process.

Denmark has a large animal production, and we must ensure that the by-products that are not of sufficient quality to end up on the dinner table are put to the best possible use.

For some people, the use of dead animals from agriculture will be controversial. These raw materials, however, are no different from those that reach the slaughterhouse. Traditional fossil fuels also stem from dead plants and animals, but we do not believe that we should wait 100 million years before the present by-products from agriculture can be recycled!

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AALBORG KOMMUNE TRAFIK & VEJE
STIGSBORGBRYGGE 5
DK-9400 NØRRESUNDBY

Att.: Jens Mogensen

Deres ref. / Your ref.	Vor ref. / Our ref.	Dato / Date
	NT	17.01.2011

Sample received from: ARRIVA

Certificate of Quality
34705

Sample submitted as: GASOIL

Description on label: Arriva
A

Seal on sample: -

The above sample was examined with following result:

Free Fatty Methyl Ester	11,4	% vol.	Method: EN 14078

Sample received: 11.01.2011
Analysis completed: 17.01.2011

Packed in 5 ltr. Plastic can.

Intertek Denmark
Niels Birkedal Thomsen

-- SEE TERMS AND CONDITIONS ON REVERSE --

Figure 5 Analyse certificate for fuelmix. Source : Intertek Denmark

4.3 Communication

4.3.1 Media Coverage

The media coverage of the biofuel measure has been acceptable to the project, although the focus of the media coverage has been more concerned about the actual product than the energy and environmental benefits from the demonstration.

TEKNIK- OG miljørådmand Mariann Nørgaard og Thomas Kastrup-Larsen, formand for Nordjyllands Trafikselskab, hældte de første fire liter grønnere brændstof på en bybus. Biodiesel er tyktflydende og skal blandes med almindelig diesel.

Foto: Aalborg Kommune

Det er tanken der tæller

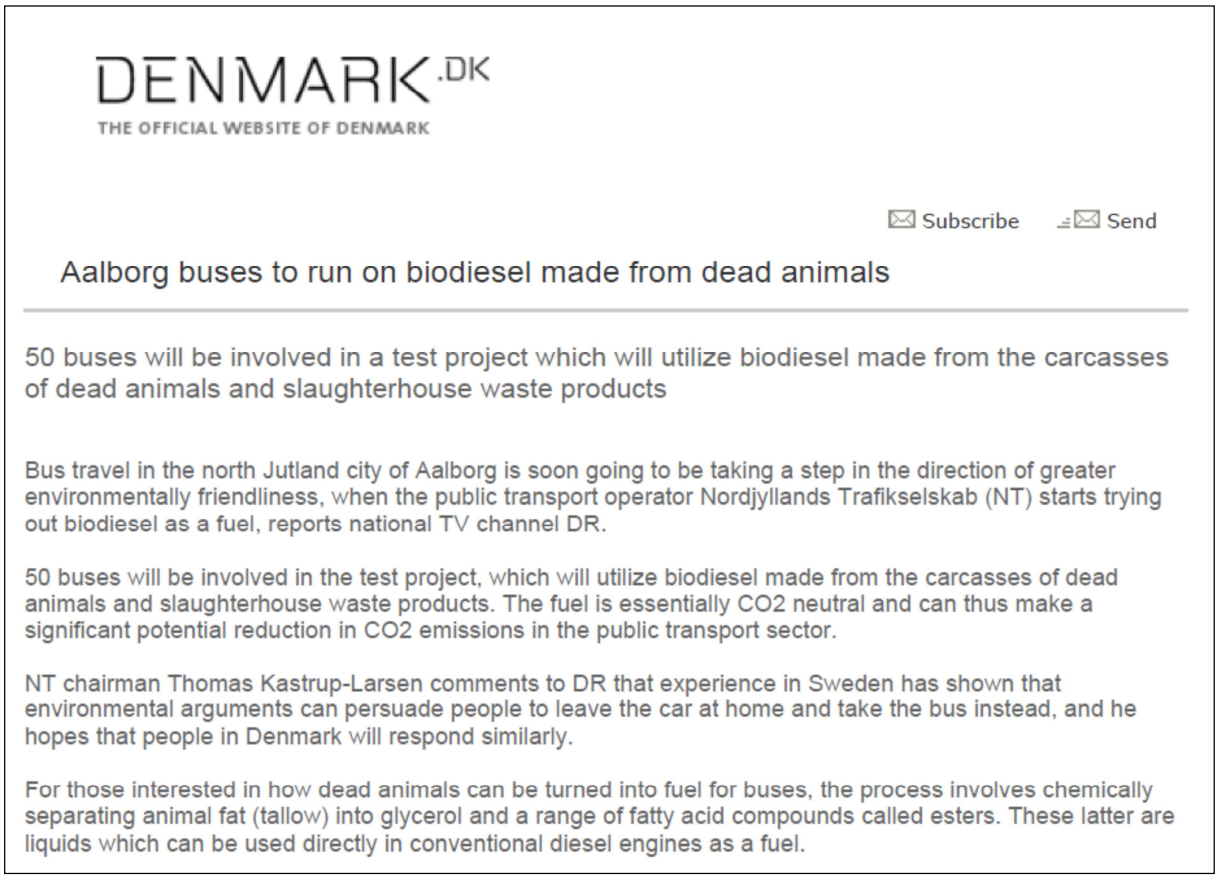
AALBORG: Aalborgensere fik fredag morgen et rundstykke og juice med på vejen, da de skiftede bus på busterminalen i Aalborg.

Aalborg Kommune og Nordjyllands Trafikselskab var den glade giver, og anledningen var, at halvdelen af bybusserne nu begynder at køre på med et mere miljøvenligt brændstof i tanken, nemlig biodiesel. Brændstoffet er fremstillet af selvdøde dyr og slagteriaffald.

De morgenfriske havde også mulighed for at se og lugte til den biodiesel, der nu bliver hældt i tankene. Flere af de forbipasserende bemærkede, at selvom biodiesel er lavet af dyr, så var der ingen lugt ved det.

Brug af biodiesel er et forsøg, der foreløbig varer til 2012.

Figure 6 Newspaper - Nordjyske, 2nd October 2010



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Aalborg buses to run on biodiesel made from dead animals

50 buses will be involved in a test project which will utilize biodiesel made from the carcasses of dead animals and slaughterhouse waste products

Bus travel in the north Jutland city of Aalborg is soon going to be taking a step in the direction of greater environmentally friendliness, when the public transport operator Nordjyllands Trafikselskab (NT) starts trying out biodiesel as a fuel, reports national TV channel DR.

50 buses will be involved in the test project, which will utilize biodiesel made from the carcasses of dead animals and slaughterhouse waste products. The fuel is essentially CO2 neutral and can thus make a significant potential reduction in CO2 emissions in the public transport sector.

NT chairman Thomas Kastrup-Larsen comments to DR that experience in Sweden has shown that environmental arguments can persuade people to leave the car at home and take the bus instead, and he hopes that people in Denmark will respond similarly.

For those interested in how dead animals can be turned into fuel for buses, the process involves chemically separating animal fat (tallow) into glycerol and a range of fatty acid compounds called esters. These latter are liquids which can be used directly in conventional diesel engines as a fuel.

Figure 7 Denmark.dk – the official website of Denmark, 6th March 2009

P4 Nordjylland

DR RADIO P4

Nordjyllands Trafikselskab vil næste år lade 50 busser køre rundt med biodiesel i tanken. Biodiesel er blandt andet baseret på selvdøde dyr og slagteriaffald.

Foto: Lars E. Rohde © P4 Nordjylland

Busser med døde dyr i tanken

25. feb. 2009 09.44

Busser, der kører på selvdøde dyr. Det bliver snart virkeligheden i Aalborg.

Nordjyllands Trafikselskab (NT) vil næste år - som et forsøg - lade 50 busser køre rundt med biodiesel i tanken. Biodiesel er blandt andet baseret på selvdøde dyr og slagteriaffald. Det er CO2-neutralt og forurener derfor langt mindre end almindelige brændstoffer.

- Jo mere miljørigtig vi gør den kollektive trafik, og jo mere vi markedsfører os med de rigtige produkter - jo flere passagerer kan vi få ind, vurderer Thomas Kastrup-Larsen, formand for NT.

Ifølge ham viser erfaringer fra Sverige, at miljøargumenter har fået en del svenskere til at droppe bilen til fordel for bussen.

- Og jeg tror egentlig, at danskerne er klar til at lytte til de samme argumenter, siger Thomas Kastrup-Larsen.

Det bliver i første omgang Aalborg, der får de miljørigtige busser på gaden, men NT håber på, at det på sigt bliver i hele Nordjylland.

- Nu skal vi lige have det til at fungere i dagligdagen og have busserne til at kunne køre på det, men hvis det lykkes, så ser jeg ikke noget problem i at vi kan udbrede det til hele Nordjylland, siger Kastrup-Larsen.

Figure 8 P4 Nordjylland @ www.dr.dk/nordjylland, 25th February 2009

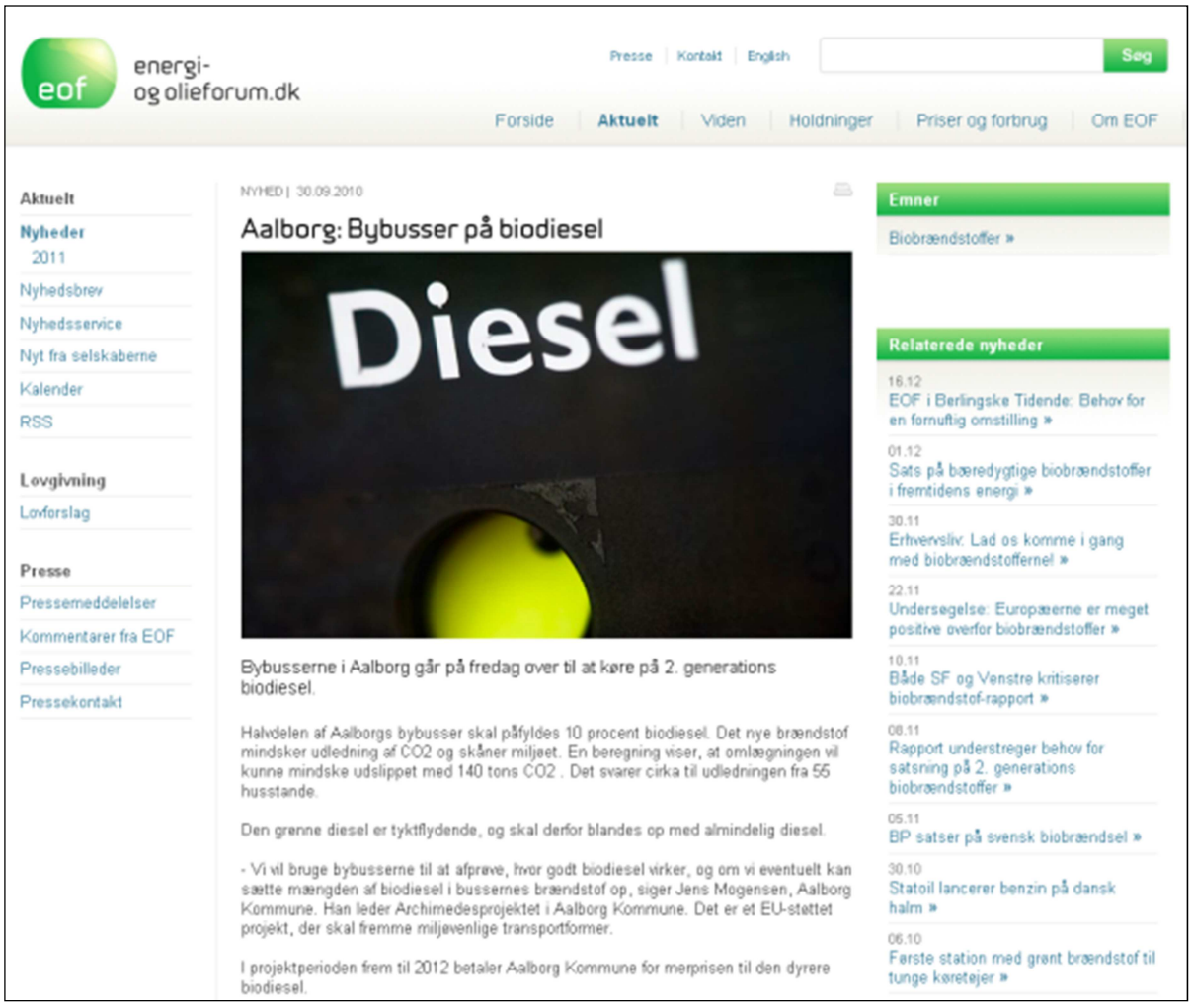

Figure 9 Buses on bio-diesel – Energy and Oil Forum – 30th September 2010

Bybusser skal køre på døde dyr

OMSTILLING: Brændstoffet i 50 busser blandes op med biodiesel

Af Lars Termansen
lars.termansen@nordjyske.dk

AALBORG: Bybusser i Aalborg går fra på fredag over til at køre på døde dyr.

Busserne tankes med biodiesel fremstillet af selvdøde dyr.

Den ny brændstof mindsker udledning af CO2 og skåner miljøet, og cirka halvdelen af Aalborgs bybusser - cirka 50 - vil blive påfyldt 10 procent biodiesel.

En beregning viser, at omlægningen vil kunne mindske udslippet med 140 tons CO2. Det svarer cirka til udledningen fra 55 husstande. Men den grønne diesel er tyktflydende, og derfor skal den blandes op med almindelig diesel.

- Vi vil bruge bybusserne til at afprøve, hvor godt biodiesel virker, og om vi eventuelt kan sætte mængden af biodiesel i bussernes brændstof op, siger Jens Mogensen, Aalborg Kommune.

Han leder Archimedes-projektet i Aalborg Kommune. Det er et EU-støttet projekt, der skal fremme miljøvenlige transportformer.

I projektperioden frem til 2012 betaler Aalborg Kommune for merprisen til den dyrere biodiesel.

Anden generation

Bybussernes nye brændstof er biodiesel af anden generation, som er fremstillet på affaldsprodukter. Foruden selvdøde dyr er det typisk slagteriaffald.

Første generation er baseret på landbrugsafgrøder som majs, raps og sukkerrør, og kritikerne mener, at det er forkert at bruge primære fødekilder - landbrugsafgrøder - til produktion af brændstof.

Det er nemlig med til skrue prisen i vejret på landbrugsvarer, hvilket er til skade for ulandene.

Begge typer biodiesel har lavere udledning af CO2 end almindelig diesel, men for passagererne i Aalborgs bybusser vil der ikke være nogen mærkbar forskel.

- Busserne kører i forvejen med partikelfilter, så røgen vil ikke mærkes renere eller se anderledes ud end hidtil. Røgen udleder bare mindre CO2, tilføjer Jens Mogensen.

Archimedes-projektet udløber i 2012, og derfor er det uvist, om bybusserne efter den dato fortsat tankes med biodiesel.

I EN prøveperiode tankes bybusserne delvis med biodiesel.
Arkivfoto: Lars Pauli

Figure 10 Buses will run on dead animals, 30th September 2010

4.4.1 Bio-diesel Controversies

Dead animals and the use of food are controversial topics in relation to biofuels. Also in Denmark this has been discussed. The discussion related to the use of food has not been present in Aalborg, since 2nd generation biofuel was chosen as the product early in the phase.

Instead discussions have been focused on the smell of the biodiesel product. People have been worried of the aspect of using dead animals because they know how dead animals smell. This is not the case with the chosen product in Aalborg since the fat used for the diesel is refined and thereby the smell disappears. It would not be possible to run on unrefined animal fat.

Another raised question has been if it is disgusting or unethical to use slaughterhouse waste. DAKA, the producer of biodiesel states on its website the following, in the section for frequently asked questions:

"Isn't it disgusting/unethical to use slaughterhouse waste and dead animals to make biofuel?"

"No. In fact, we firmly believe it would be unethical not to make use of this resource. Slaughterhouse waste used to be turned into feedstuffs, but that's no longer possible. That doesn't mean we should simply dispose of the waste products in landfill sites. Fossil fuels come from dead animals and plants too, but we don't think we should bury slaughterhouse waste in the ground and wait 100 million years for it to turn into oil – especially not since we can do it in just two days!"

www.daka.dk

Århus i grøn overhalingsbane

Århusianske bilister tanker fra 1. marts som de første i landet biodiesel på samtlige 75 tankstationer i Århus-området. De århusianske bybusser vil også køre på døde dyr.

Af Morten Ravn
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ÅRHUS: Nej, det lugter ikke. Sporvejenes gule bus bumpler heller ikke af sted. Den kører nøjagtig lige så behageligt, som den plejer. Forskellen er blot, at århusianerne som de første i landet ruller i den grønne overhalingsbane på en ny miljøvenlig biodiesel fra 1. marts.

Der er ingen forskel i køreglæden på den gamle diesel og den biodiesel, som alle Århus Sporvejes busser og samtlige diesel-bilister i Århus kommer til at køre.

Det viser en prøvetur ud til Samtanks anlæg på Oliehavnen i Århus. Det er her, at den almindelige, konventionelle diesel som forsøg får tilsat fem procent - næsten - C2-neutral biodiesel - lavet på dyreaffald fra firmaet Daka i Løsning.

Århus er forrest i den grønne kørebane. I 2010 skal alle Danmarks dieselbiler køre på samme miljøvenlige diesel.

»Det er glædeligt for os, at vi ikke længere skal afskibe hele vores produktion af biodiesel fra Århus Havn til udlandet. Vi kan måske være ligeglade med, hvor vi sælger vores produkt, men det er rart, at Danmark er kommet med på vognen,« siger direktør Kjær Andreasen fra Daka, der har investeret 180 mio. kr. i projektet.

Projektet har været tre år undervejs. Danmark holder faktisk bagest i køen, når det gælder biodiesel.

Hed debat

Det skyldes en ophedet debat om, hvorvidt biodiesel tager mad ud af munden på den tredje verdens fattige og slet ikke er så miljøvenlig, fordi store landbrugsarealer bruges til at udvinde biobenzin og -diesel. Men den form for biodiesel, vi skal køre på i Århus, er udvundet af dyreaffald, som alligevel ikke kan bruges til fødevarer.

Århus Kommune, Region Midtjylland og samtlige oliselskaber, der gør sig i Århus, har været med i udviklingsarbejdet. Direktør for Oliebranchen Peter Stigsgaard fortæller om benzinselskabernes rolle i projektet.

»Vi skal sikre, at vi sælger kunderne en ordentlig vare, som alle bilmærker kan køre på. Uden skader eller problemer. Det er tilfældet nu. Når blandingsforholdet kun er fem procent biodiesel er vi også sikre på, at dieselen kan klare de kolde temperaturer her i nord, så den ikke stivner,« siger Peter Stigsgaard.

På rette grønne vej

Han tør ikke spå om, hvornår andelen af biodiesel kan sættes op til 20 eller 50 procent. En ting er forskning - en anden er, at alle EU-lande bliver enige om at producere den samme vare, som alle bilmærker kan køre på.

Foreløbig glæder den politiske side i Midtjylland, regionsformand Bent Hansen (S), og den århusianske rådmand Peter Thyssen (R) sig over, at Midtjylland har taget førersædet i den grønne kørselsretning. En blanding af fem procent grøn diesel oven i den almindelige svarer i prøveperioden frem til november til, at 50.000 biler udelukkende kører på biodiesel.

»Biodiesel flytter ikke hele læsset. Men mange bække små, som vi siger. Vi er i gang med at gøre det her på den rigtige facon, når vi udnytter affaldet til grøn diesel. Århus Kommune har et ønske om at være C02-neutral i 2030. Med biodiesel i busserne bliver det lidt mere trendy at køre kollektivt. Det er vejen frem,« siger Peter Thyssen.

AFFALD TIL BILENERGI. Direktør Kjær Andreasen, Daka, leverer biodieselen til Samtank på Oliehavnen i Århus. Herfra køres den ud til samtlige tankstationer i Århus. Foto: Morten Ravn

BIODIESEL PÅ DØDE DYR

Fem procent af den diesel, som bliver tanket på de 75 tankstationer i Århus, er fra 1. marts tilsat fem procent biodiesel.

Det sker som forsøg under titlen B5Next frem til november. Folketinget skal inden sommerferien vedtage et lovforslag, som gør ordningen permanent over hele landet i 2010.

Biodieselen er produceret af slagteriaffald hos Daka i Løsning. Det vil sige, at biodiesel er udvundet af fedtet fra døde dyr. Pointen er, at biodieslen udvundet af affald, som ikke er egnet til menneskeføde. Det sker uden anvendelse af fødevarer og derfor er FAME-dieslen, som den hedder, langt mere C02-venlig end biodiesel, som laves på for eksempel majs på store landbrugsarealer.

Biodieslen belaster miljøet mindre end almindelig diesel. Samtlige oliseselskaber i Århus-området er med i forsøget. Selskaberne har især været interesseret i, at bilisten ikke mærker nogen forskel på sin bil uanset om den kører på almindelig diesel eller biodiesel. Mængden af biodiesel er så lille, at alle dieselbiler - uanset mærke - også i hård frost kan starte.

YES, VI GØR DET. Regionsformand Bent Hansen og rådmand Peter Thyssen, forrest, tanker de første grønne dråber i en århusiansk bybus. Foto: Morten Ravn

Figure 11 Bio-diesel debate in Denmark – Aarhus Stiftstidende 19th February 2009

4.4 Problems Identified

Various challenges have been experienced during the implementation of biodiesel process. The challenges have all been addressed earlier in this report. The main challenges are listed below:

1. **Tendering process, how to fix the extra costs for biofuels:** This challenge was important in order to ensure the right payment for the contractors. If not properly addressed in the tender, this issue could have made the project more expensive.

2. **Tendering process, how to fix the responsibility:** A major challenge in having the buses to run on biodiesel 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 bio-diesel 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.

3. **Technical issues, bio-diesel has other properties than standard diesel:** As described above, the AFME-product is coagulating at a higher temperature than standard diesel. This is an important challenge in a cold climate as the Danish in Northern Europe. A strategy on how to deal with the temperature has been important to ensure reliable operation of the buses. The strategy has been to pause the demonstration project if the temperature dropped dramatically. The strategy has not been used even though temperatures have been down to -18 degrees during the night in the winter 2010/2011.

    - Also biodiesel, as ordinary diesel can blend with the oil of the motor during operation, but in contrary with ordinary diesel, biodiesel is changing the properties of the oil in the engine, and can cause trouble for the engine while operating. This means that more frequent oil changing is recommended.

    - Engine manufacturers can also be concerned about the warranties of the engines. The latter challenge has not been an issue in this project since the producer of the buses have not foreseen any problems with the engines and the guaranties have not been cancelled due to the bio diesel demonstration project.

4. **Fuelling facilities, mixing the right blend:** A problem which has not been foreseen was the difficulties in mixing the fuels at the contractors. Although the station was supposed to give 10% the result when tested showed a lower percentage. Cleaning of the tubes and warmer weather solved the problem.

4.5 Future Plans

The demonstration project will be ongoing until the end of the ARCHIMEDES project. There are no plans on increasing the blend of bio fuels.

From March 2011 50 additional vehicles from the postal service will start running on between 10% and 20% biodiesel (task 1.2). The implementation of this will be reported in a separate deliverable, number T1.2 T1.3, in April 2011.

Data collection is ongoing and the numbers will be evaluated by Danish Technological Institute in accordance with the evaluation plan for measure 1, Biofuels in Aalborg.

On 15th and 16th of June 2011, the City of Aalborg will participate in the conference “Clean Vehicles, Clean Fuels, Cleaner Cities” in Donostia San Sebastian, presenting the preliminary results of the demonstration, especially focussing on the challenges related to the cold climate of Denmark.