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**CO-OPET
Support Initiative for the Organisations for Promotion of
Energy and Transport Technologies
Contract No NNE5/00048/2002**

**Deliverable 5:10 – biofuel market
Part A
Overview of RD&D Projects
in Biofuels for Transport**

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Summary

This report provides a review of public-funded Research, Development and Demonstration projects in the area of biofuels for transport. It was assumed to search only for projects carried out in the last five years, i.e. since 1998. The search was mainly done through databases available on the internet and was complemented with interviews with experts. It should be noted that RD&D for more efficient and cheaper production methods of chemicals that can also be used as biofuels (e.g. ethanol) was not taken into account. The main conclusions are:

- very few public-funded research and development projects on biofuels for transport were carried out at EU level in the last five years. Even in the twelve projects identified, transport is in some case only mentioned as a potential end-use sector for biofuels;
- the main work in this area seems to have been realised between 1978 and 1995 under different EU programmes and stagnated since then. The research accomplished in those years contributed to bring to the market bioethanol from sugar or starch and biodiesel from rapeseed. It also showed the cost and technical difficulty of lignocellulose hydrolysis, currently being tested in Sweden in pilot plants;
- a new area of research activity is the production of hydrogen from biomass, which is out of the scope of this study (e.g. www.biohydrogen.nl);
- a significant number of demonstration and pilot projects were identified which shows the reasonable maturity of some technologies.

The recently adopted EU Directive on biofuel for transport could stimulate further research in the area. However, in a first phase, for the technology reasonably known (at least ethanol from sugar and starch fermentation, as well as biodiesel) the main problem is the cost of the feedstock. The focus is therefore currently on the design and choice of the economic instruments that are able to stimulate a market for biofuels.

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1 Introduction

1.1 The "CO-OPET project"

The CO-OPET project (Support initiative for the Organisations for Promotion of Energy and Transport Technologies, NNE5-48-2002) is part of EU's 5th Framework Programme (FP5). It sorts under Programme Energy, Environment and Sustainable Development (EESD), Part B: Energy (Accompanying Measures). The objectives of this project are:

- increase and structure communication between network participants;
- increase information transfer from programmes and projects outside the network to the network participants;
- increase awareness about the OPET network and its activities and benefits.

Further information on the overall project and partners can be found at the OPET Network website: <http://www.opet-network.net>.

1.2 Objective

The objective of this report is to list the RD&D projects on the area of biofuels for transport carried out in the last five years. The research focused primarily on R&D projects funded by the European Union under the Framework Programmes, and additionally on the R&D projects carried out at National level and implementing agreements of the International Energy Agency. The demonstration part consisted mainly on pilot projects developed under the CIVITAS initiative and on some other National projects.

1.3 Methodology

Background information for this report was obtained through search on the internet and from direct contact with experts. Main internet sites consulted:

- www.nf-2000.org and www.biomatnet.org. This site makes available results of RTD projects supported by the European Commission in the area of Biological Materials for Non-Food Products (Renewable Bioproducts). It includes final results from the Fifth Framework Programme (FP5), FAIR Programme (FP4) and previous programmes, as well as ongoing research from the Fifth and Sixth Framework Programmes (FP5 and FP6);
- www.cordis.lu. The Community Research and Development Information Service, namely the sites the following sites: www.cordis.lu/era/, www.cordis.lu/fp6/, www.cordis.lu/fp5/, www.cordis.lu/en/src/f_002_en.htm, www.cordis.lu/euroabstracts/en/home.html.
- www.civitas-initiative.org. The CIVITAS Initiative addresses ambitious cities that are introducing, or that are seriously committed to introduce, sustainable urban transport policy strategies. The aim is to achieve a significant change in the modal split towards sustainable transport modes.
- www.trendsetter-europe.org. Trendsetter – setting trends for sustainable communities is a project under the CIVITAS initiative and has the following

objectives: to improve urban air quality, noise levels and congestion while supporting exceptional mobility and urban quality of life through Advanced mobility management schemes, promoted use of public and shared transport, improved goods logistics and efficiency, and increased use of low-noise and low emission vehicles. Trendsetter is a co-operation between five European cities - Graz, Lille, Pecs, Prague and Stockholm – that ensure real impact, by setting good examples and encouraging others to follow. Trendsetter involves 50 individual projects, all of which aim to improve mobility, quality of life, air quality, and reduce noise and traffic congestion. Examples of measures under Trendsetter include: Introduction of more than 1200 public and private clean cars, vans, buses and lorries; several IT-based transport information systems and traffic management systems, material logistic centre to optimise freight deliveries and environmentally focused parking zones. Several measures in the field of biofuels for transport were undertaken. Some experiences from Graz, Lille and Stockholm are described below.

Other sites with relevant information include:

- www.iea-amf.vtt.fi
- www.biohydrogen.nl
- www.ecn.nl
- www.gave.novem.nl
- europa.eu.int/comm/energy_transport/atlas/htmlu/biofuel.html
- eubionet.vtt.fi/
- www.vtt.fi
- www.stem.se
- www.etek.se
- www.baff.info

Experts contacted: The authors would like to thank Jim Combs – CPL Press, coordinator of BiomatNet, Ann Segeborg Fik, Lars Vallander and Olle Josefsson – Swedish Energy Agency, Jorg Gigler and Eric Van den Heuvel NOVEM – The Netherlands, and Lars Nilsson – LTU Technical University of Lund – Sweden for their contributions.

2 Research, Development and Demonstration projects

Research, Development and Demonstration projects that have been identified are described below. They have been classified in biodiesel, ethanol, and “others” which includes biogas and gasification.

2.1 Biodiesel

Diesel Reforming by Catalytic Technologies

Acronym: DIRECT

Objective: The DIRECT proposal addresses a very important target of the Community energy related policies, the reduction of fossil fuels consumption and Green HouseGases. It solves one of the roadblocks for introducing fuel cell technology to vehicles - the fuel supply. The DIRECT consortium develops a Diesel fuel operated SOFC with high efficiency and reliability as well as sulphur tolerance. It will be packaged for the use as Auxiliary Power Unit for vehicles and deliver 5 kWe. Attention will be paid to the best possible use of the waste energy for other applications in the vehicle or for improving the efficiency of the system. Beside Diesel the system will be able to use alternative fuels like Biodiesel and Synfuel. The consortium consists of experienced partners in the area of catalytic materials, system design and numeric simulation. Well-known vehicle manufacturers as application partners guarantee an user oriented approach in the project

Partners: ALLPPS FUEL CELL SYSTEMS GMBH (AS), CENTRO RICERCHE FIAT S.C.P.A. (I), CONVERTER TECHNOLOGY ENTWICKLUNGS- UND PRODUKTIONS GMBH (AS), LEYLAND PRODUCT DEVELOPMENTS LTD (UK), MIRA LTD (UK), OESTERREICHISCHES FORSCHUNG- UND PRUFZENTRUM ARSENAL, GES.M.B.H. (AS), PROTOTECH AS (NO), SUED -CHEMIE AG (DE)

Start date: 2002-12-01 to 2005-11-30 (36 months, ongoing)

Project Reference: ENK6-CT-2002-00644

Project cost: 3,598,180 €

Project Funding: 1,799,088 €

Programme Acronym: EESD

Programme type: FP5

Subprogramme Area: Key action Economic and Efficient Energy for a Competitive Europe

Contract type: Cost-sharing contracts

Stability of Biodiesel

Acronym: BIOSTAB

Objective: In order to assure customer acceptance standardisation and quality assurance is the key factor to the market introduction of biodiesel as a transport and heating fuel. In 1997 the European Commission mandated CEN to develop standards concerning minimum requirements and test methods of biodiesel. Working groups have achieved substantial progress. It turned out, however, that in one complex key parameter, fuel stability, detailed research is absolutely needed. It is proposed to investigate all relevant topics to overcome this gap of knowledge. Suitable determination methods for the oxidation, thermal and storage stability will be worked out. The influence of storage conditions on the fuel quality properties and the effects of natural and synthetic antioxidants will be investigated. A comprehensive test programme including bench and

field tests will be carried out in order to find a relationship between the stability and special effects during use.

Partners: BUNDESANSTALT FUER LANDTECHNIK (AS), GRAZ UNIVERSITY OF TECHNOLOGY (AS), INSTITUT DES CORPS GRAS (FR), INSTITUT FUER CHEMIE (AS), NOVAOL FRANCE SARL (FR), OELMUEHLE LEER CONNEMANN GMBH & CO. (DE), OMV AG (AS), STAZIONE SPERIMENTALE PER LE INDUSTRIE DEGLI OLI E DEI GRASSI (I)

Duration 2001-03-01 to 2003-08-31 (30 months, completed)

Project Reference: QLK5-CT-2000-00533

Project cost: 1,389,715 €

Project Funding: 958,891 €

Programme Acronym: LIFE QUALITY **Programme type:** FP5

Subprogramme Area: Key action Sustainable Agriculture, Fisheries and Forestry

Contract type: Cost-sharing contracts

Transport fuels via the HTU Process for liquefaction of biomass

The Biofuel company, along with other project partners, are assessing the feasibility of producing transportation fuels, using the hydro-thermal liquefaction of biomass, via the HTU process. A first demonstration is expected in 2007. The potential CO₂ emissions reduction after market penetration is estimated at 3.4 Mtonnes/year, assuming that 5% of the total Dutch diesel consumption is replaced. Potential and costs are as follows: Up to 5% of diesel fuel market in the Netherlands in the period 2009-2020. Cost per ton of avoided CO₂ less than 20 euro.

Project partners. GDA Amsterdam: Location of first commercial demonstration of HTU Process. TNO Automotive: Analysis of properties of HTU diesel components, motor performance tests on commercial automotive fuel blends. Van der Sluijs Handelsmaatschappij: logistics and blending of HTU components with commercial AGO; marketing of commercial HTU Diesel. Stichting Shell Research: sponsoring and liaison with potential Shell interest. Biofuel: representative for prospective HTU BV for commercial development of the HTU Process.

Timetable: 2004-2006, design and construction of first commercial HTU plant next to Waste Burning Plant in Amsterdam. 2006-2007: Demonstration of HTU Diesel fuel, concluded with 1-year field tests on 5 HD diesel vehicles. 2007-2009: Design and construction of large HTU plant including production of HTU Diesel. 2009+: Commercial introduction and further introduction of HTU Diesel fuels.

Programme: GAVE (Climate-neutral gaseous and liquid energy carriers), Netherlands

Bio-diesel

Objective. The aim is to investigate the possibility of using waste vegetable oils and fats to produce renewable fuel in any of three different ways:

- Use of recycled vegetable oil as a fuel extender for heating and diesel engines - material characterisation, clean up and boiler and engine trials will be followed by a demonstration heating application at Mallow County Cork Ireland, which will produce guidelines for the collection, clean up and limits of use of the waste vegetable oil as a fuel extender;
- Use of waste fat to produce biodiesel for engines and biogas for the production of heat and electricity - material characterisation for suitability for esterification, organic material which is not suitable will be used to produce biogas by anaerobic digestion to quantify the maximum energy output for a given input of waste fat;

- Use of biomass waste such as forest residuals or other organic waste to produce DME or methanol as a renewable fuel, heat and electricity.

Activities involved formation of a stakeholder group with local communities, entrepreneurs, national and regional energy companies/authorities, auto and oil companies to determine the legislative and financial infrastructure required.

Project reference: ALTENER 4.1030/C/00-014

Duration: 24-03-2001 to 24-12-2003 (21 months, completed)

Project Cost: 818,694 € Project funding: 410,624 €

Partners. Robin HOWARD-HILDIGE / University of Limerick IRELAND, Etienne POITRAT / ADEME FRANCE, Alfred EGGER / Abfallwirtschaft Tirol Mitte GMBH AUSTRIA, Christian CALLEGARI / Abwasserverband Hall in Tirol-Fritzens AUSTRIA, Dennis BROWN / Air Products PLC UNITED KINGDOM, Pat WALSH / Cork County Energy Agency IRELAND, Peter DABRINGER / Dabringer GmbH - SRL ITALY, Bengt SAVBARK / Ecotrafic ERD3 AB SWEDEN, Luis CERNUDA JODAR / Grupo Ecológico Nacional S.C.C.L SPAIN, Tomas EKBOM / Nykomb Synergetics AB SWEDEN, Bernard RICE / Teagasc IRELAND, Gunnar GIDENSTAM / Trollhättan Municipality SWEDEN

Technical Performance of Vegetable Oil Methyl Esters with a high iodine number (Sunflower Oil Methyl Ester, Camelina Oil Methyl Ester)

Objective. The objectives of the project are to gain more experience about the technical performance of biodiesel with a high iodine number. The suitability of a fatty acid methyl ester with a high iodine number will be demonstrated in order to have a broader basis of raw material sources for the biodiesel industry. The development of a CEN-biodiesel standard will be supported by definition of a limiting value of the iodine number of biodiesel.

Specific Objectives: Analysis of the physical and chemical properties of sunflower oil methyl ester (SME) and camelina oil methyl ester (CME) for comparison with known fatty acid methyl esters; Clarify with bench tests and fleet tests the possibility to use fatty acid methyl esters with an iodine number higher than the iodine number proposed in drafts of European standards; Comparison of the environmental impacts of the production of rape, sunflower and camelina; Dissemination of results in the European Union.

Technical Approach: *Phase I:* (Oct 1996 - Dec. 1997): In the first phase test fuel (camelina oil methyl ester - CME and sunflower oil methyl ester - SME) were produced for endurance run on test bench and a praxis test with one vehicle. Physical and chemical properties of the test fuel were also determined. *Phase II:* (Jan. 1998 - March 1999): Positive results of phase I will lead to a fleet test with 10 vehicles with CME. The long-term storage and oxidation products of the test fuels are analysed. The environmental impacts of the production of rape, sun flower and camelina under Austrian conditions are compared.

Results. Management of the project, with varying levels of participation in its capital. This company will then manage the project.

Duration 1996-10-01 to 2000-03-01 (30 months, completed)

Project reference: ALTENER XVII/4. 1 030/Z/96-013

Partners. Bundesanstalt für Landtechnik BLT AUSTRIA, Bundesversuchswirtschaft Wieselburg OMV Website: <http://www.omv.com>; TEAGASC Oak Park Research Centre Carlow Ireland; Motorenfabrik HATZ Germany; Various tractor and vehicle manufacturers.

All-biodiesel bus fleet in Graz (CIVITAS initiative – Trendsetter) – Demonstration

In the City of Graz, efforts to introduce new, clean fuels have focused on biodiesel. In the beginning of 2002, when the Trendsetter project started, 55 of the 140 buses of Graz's public transport company, Grazer Verkehrsbetriebe GVB, were running on biodiesel. Within Trendsetter, the target is to fully convert the municipal bus fleet to biodiesel. To achieve this, 41 new climate-controlled, wheelchair-accessible biodiesel buses will be introduced. The engines of the remaining GVB diesel busses will be modified to run on biodiesel. Additional costs for leasing 56 buses modified to run on biodiesel (compared to leasing conventional buses) are included in this measure. The expected result will be 100 % of the GVB bus fleet, running on biodiesel by mid-2005. Until October 2003, 10 buses were converted and 5 brand new biodiesel buses delivered. Another 19 buses were to be delivered in the beginning of 2004. A biodiesel fuelling station has been built to ensure simple and convenient biodiesel fuelling which is open for GVB buses as well as other municipal vehicles. The budget for this measure, about 590 000 €, is solely for investments in durable equipment.

More information: Peter Gspaltl, Stadt Graz, Peter.gspaltl@stadt.graz.at
Johann Müller, Grazer Stadtwerke AG, j.mueller@gstw.at

Taxi fleet in Graz converts to biodiesel (CIVITAS initiative – Trendsetter) – Demonstration

This measure focuses on the large scale introduction of biodiesel in a fleet environment. As part of this measure 60 percent of the Grazer Taxi company Taxi 878 fleet, about 120 cars, will shift from diesel to biodiesel. Taxi 878 is working to reduce its environmental impact. All drivers are introduced to environmental issues as a part of a one-day training programme for the entire company. Before Trendsetter, however, the company had not tested biodiesel. In order to facilitate the shift, a biodiesel refuelling station has been established at Taxi 878 headquarters. The biodiesel refuelling station is also open to the public, thus encouraging other companies as well as citizens to use biodiesel. The large-scale introduction of biodiesel in a taxi company will make it possible to gather information about repair, maintenance and service needs when using biodiesel. By October 2003, 14 Mercedes biodiesel Taxis had been delivered. Initially there were some technical problems which delayed the introduction somewhat, but these problems were solved. A central decision to use another fuel is not enough since most of taxis are franchised so facts and information must convince individual members to voluntarily change fuels. To support this initiative, an information campaign is planned with Taxi 878 members as the first target group. The campaign addresses subjects such as quality of the biofuel and compliance with existing DIN-Norms, using the fuel on cold winter days, and biodiesel use in general. Other taxi companies in Graz and in the region of Styria will learn from experience gained by Taxi 878. The activities funded under the budget available include: setting up and operating a biodiesel fuel station (as a subcontractor to Taxi 878); planning and producing the information campaign, evaluating service, repair and maintenance needs in comparison with conventional diesel taxis.

More information: Sylvia Loibner, Taxi 878 City Funk, s.loibner@taxi878.at

Graz collects cooking oil for biodiesel production (CIVITAS initiative – Trendsetter) – Demonstration

In Graz disposed cooking oil is collected and processed to produce biodiesel. Several awareness campaigns will improve the collection of used oil. Austrian cooking involves the use of a lot of deep frying oil. The used frying oil causes problems if it is disposed

into the local sewage system. As part of a general recycling initiative, a collection scheme for disposed cooking oil was established in Graz in the mid 1990's. The collected oil is sent to a plant where it is processed to produce biodiesel. However, the recycling rate is very poor. The aim of this Trendsetter measure is to double the volume of oil collected from households and to investigate how intelligent awareness campaigns can increase the collection of cooking oil as well as interest in public transport. Three awareness campaigns are planned:

- information leaflets and visits to restaurants in Graz which do not participate in the cooking oil collection today;
- distribution of leaflets about oil recycling opportunities on public buses, where riders can also pick up the actual containers used to collect the used oil. The same will be done in Taxis. The taxi drivers will be offered education about the environment in general and about recycling cooking oil in particular ;
- targeted campaign aimed at 2000 residents living in selected block buildings using leaflets distributed shortly before the collection bus visits their neighbourhood. This will also include information about public transport and free tickets, and about car sharing opportunities. Some of the households will also be selected for a telephone marketing campaign, and 300 will also be offered a personal consultation.

In addition, a special information bus will be designed and equipped. The bus, staffed with personnel from the City of Graz trained in mobility consulting, was placed at crowded sites and at different events during 2003. This measure was produced as a cooperative effort by the City of Graz, the public transport company in Graz (GVB), Austrian Mobility Research and the Styrian Transport Association.

More information: Astrid Hödl, Waste management Department, City of Graz, hoedl.astrid@stadt.graz.at, Karl Reiter, FGM-AMOR, reiter@fgm-amor.atreiter at

2.2 Ethanol

Agriculture and small to medium Scale Industries in peri-urban Areas through ethanol production for Transport in China

Objective: According to an analysis of the existing and future demand in gasoline in China's transportation sector, and the necessary request in oxygenated additives (MTBE, ethanol) in order to replace lead as octane booster, this proposal aims to give answers to the following question: How to produce and use bio ethanol, in a sustainable way with a mutual benefit between rural and urban people? This analysis based upon two case studies in Liaoning and GuangXi Provinces. This sustainability will be studied in terms of economy (micro and macro), environmental impacts, and social impacts (competition between food, feed and fuel, land use, job creation in rural areas) . Finally, the proposed scenarios will be discussed with a group of regional stakeholders in order to test their acceptability, to implement them in the two provinces and to envisage their feasibility in other Asian areas.

Partners: INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE (F), CENTER FOR GIS INDUSTRY DEVELOPMENT - CHINESE ACADEMY OF SCIENCE (China), SHANGHAI JIAO TONG UNIVERSITY (China), SHENYANG AGRICULTURAL UNIVERSITY (China), SORGHUM ORGANISATION AND RESEARCH GROUP FOR HIGH ALTITUDE OR LATITUDE (China), SWISS FEDERAL INSTITUTE OF TECHNOLOGY LAUSANNE (CH)
Start date: 2002-09-01 to 2004-08-31 (24 months, ongoing)

Project Reference: ICA4-CT-2002-10023

Project cost: 1,038,707 €

Project Funding: 447,527 €

Programme Acronym: INCO 2

Programme type: FP5

Subprogramme Area: Research for development **Contract type:** Cost-sharing contracts

Large Bioethanol / ETBE Integrated Project in China and Italy

Objective: The aim of this proposal is to elaborate a technical, economic and financial study on integrated bioelectricity/bioethanol/DDG production from Sweet-Sorghum in Italy and China. In fact, a detailed feasibility study is necessary to implement a large RE project on this new integrated concept and to attract investors. Existing commercial technologies will be integrated and applied to three sites: one in Europe (Basilicata, Italy) and two in China (Shandong Province and Inner Mongolia). The work is focused on identifying the plant configuration (from the receipt of the biomass at the plant gate to the products), even if the complete biomass chain (production of the resource, market for the products - ethanol, power, DDG, etc.) is evaluated. The possible conversion of bioethanol into ETBE is also considered, in view of bioethanol/ETBE use in polluted urban areas.

Project references: ALTENER ENK6-2000-80130

Duration: 01-02-2002, 01-08-2003 (18 months, completed)

Project Cost: 638,883 € **EC Funding** 319,442 €

Partners: ETA - Energia, Trasporti, Agricoltura Consulting Srl / ITALY; Wei DONG / Beijing E&E Biomass Development Co. Ltd CHINA; Harold WOUTERS / Berwin Leighton Paisner BELGIUM; Mr Jan Lindstedt / Bioalcohol Fuel Foundation SWEDEN; Mengjie WANG / China Association of Rural Energy Industry CHINA; Franco GHERI / Consulenze Tecniche Internazionali ITALY; Luciano CANTAFIO, / Delta T Corporation USA; Giuliano GRASSI / EUBIA - European Biomass Industry Association BELGIUM; Tord FJÄLLSTROEM / Energidalen I Sollefteaa AB SWEDEN; Paolo RANALLI / Istituto Sperimentale Per Le Colture Industriali ITALY; Peter KÖNIG / Siemens AG Power Generation / GERMANY; Jean CHAPELLE / Sorghum Organisation & Research Group SORGHAL / BELGIUM ; Peter HELM / Wirtschaft Und Infrastruktur GMBH & CO Planungs KG WIP Renewable Energies Division / GERMANY.

Centre for Swedish development of ethanol production, using cellulosic raw materials –Örnsköldsvik

Objective. The objective of the pilot plant is to build and operate a research/pilot plant where the production technology for ethanol and lignin from lignocellulose can be developed and verified. This pilot plant would serve as a "Center of excellence" for the development of ethanol and lignin from lignocellulose. By year 2008, the base should be set for the production plants for ethanol and lignin from lignocellulose with connection to combined heat and power plants, industrial process plants or similar.

The pilot project plant represents a significant scaling up from the previous laboratory scale into a size where further steps are not necessary until full production scale. Also the pilot plant makes possible to run the entire process from raw material to final product.

Process. A two-step approach will be followed combining diluted acid- and enzyme hydrolysis. The capacity will be 2 tons of dry substance for 500 l ethanol per 24 hours. A complete plant with recirculation of process streams will be used.

Project costs. The total cost of the project is 16 M€, 12 M€ being funded by the Swedish Government through STEM. The European Commission also supported the project.

Partners and organisation. The pilot plant has been established in Sekab's premises at Domsjö factory in Örnsköldsvik. The pilot plant is a fully furnished factory, but will not produce ethanol for selling purposes. The development company Etek Etanolteknik AB

was formed to operate to build and operate the plant. The owners of Etek are regional energy companies, Övik Energi AB, Skellefteå Kraft AB and Umeå Energi AB and Sekab. The pilot plant will be a research and development centre in co-operation with Lund University, Chalmers, Umeå University, Mid Sweden University and others.
More information www.etek.se.

2.3 Others

Small hybrid city-car operated with biofuels or LPG

Objective. The proposers intend to develop two types of commercial low-cost, low-pollution and small capacity with a maximum power of around 3.5 kW hybrid cars: These cars will be powered by a combined system Internal Combustion Engine/Electric Batteries- one with a diesel engine, one with an Otto-engine. In urban areas the IC engine would be switched off: the motion wheels will be driven by the electric motor using the energy stored in the charged batteries. In this way the vehicle will not produce pollutant emissions during town driving, thus classifying the proposed hybrid propulsion systems as a Near-ZEV. The scope of the proposed exploratory awards (feasibility study proposal) is to assess the business opportunity for manufacturing and marketing a small low pollution two-seats hybrid city-car to be used particularly in historical urban areas not suitable for the traffic conditions of the presence, like e.g. Florence (IT) and Barcelona (SP).

Project Reference: G3ST-CT-2000-00114

Duration: 2000-07-03 to 2001-07-02 - 12 months (completed)

Project cost: 29,820 € **Project funding:** 22,365 €

Partners: PASQUALI MACCHINE AGRICOLE S.R.L. (I), GALLEMI S.A. (SP)

FLEETS - Friendly Low Energy And Environmental Transport System

Objective. To reduce the energy consumption of public transport systems, which contribute substantially to environmental damage in cities. Its specific goal is the testing of the following aspects: electronic control systems for buses and trams; advanced hybrid systems; innovative diesel engines; biofuels; sophisticated batteries for application in electric vehicles; electrostatic mufflers; fleet energy and maintenance management; multimodal operations; including information systems for users.

Project Reference: TR./00287/95

Duration: 1996-01-01 to 1999-01-01 – 36 months (completed)

Project cost: 3,033,500 € **Project Funding:** 1,213,400 €

Partners: Azienda Speciale Consorziale Trasporti Pubblici (I)

Programme Acronym: NNE-THERMIE C **Programme type:** FP4

Subprogramme Area: TRANSPORT **Contract type:** Demonstration contracts

Equipment for Fuel Cyclical Pretreatment of Special Application to Biofuels

Objective: The aim is to design, manufacture and demonstrate the viability of application of a system specially conceived to improve the operation of internal combustion engines when they use biofuels. The proposed system is based on the combined use of a fuel pre-treatment system which applicability was already demonstrated through the THERMIE programme with a system of homogenization and preparation of fuel in the tank, before and during the engine operation. With its use it is expected to reach a substantial fuel saving, a notable decrease in contaminating emissions and consequently, a greater

flexibility in transport, as well as the promotion of the use of the biofuel, 70% diesel + 30% ester of sunflower oil.

Achievements: The results come from the buses of Elche where the three vehicles are Scania N-113 CLB buses. Vehicle C is a standard bus, while the others have a FPS equipment. The results show: (1) reduction in CO₂: the decrease in CO₂ emissions with the FPS and biodiesel is explained by the decrease in consumption that indicates on the one hand a greater efficiency of the motor; on the other hand, thanks to this effectiveness, less combustible is required; (2) reduction in opacity: There is a progressive decrease in the levels of emission concerning opacity. The best results are obtained when 30% of methyl ester is added in the fuel. Both vehicles comply with the rules of emissions EURO 3 concerning the opacity; (3) reduction in the sulphur emissions.

Duration: completed **Project Reference:** TR./00048/95

Project cost: 980,500 € **Project Funding:** 392,200 €

Partners: ITMA SA (SP)

Programme Acronym: NNE-THERMIE C **Programme type:** FP4

Subprogramme Area: TRANSPORT **Contract type:** Demonstration contracts

With methanol from biomass to biomobile

Summary. This project deals with the application of new technologies where biomass as a sustainable energy source is converted to a biofuel (biomethanol) for the use of automotive vehicles.

Timetable: HGP expects that commercial units of 15 to 20 MWth can be built within 1 to 2 years. To achieve optimum parameters, HGP is performing tests to realise an optimum dimension and composition of the biomass and various other parameters for the MeCon units. The methanol conversion plant has been operational for several months without major difficulties. The extra costs per tonne of avoided CO₂ (at time of regular application) are approximately 150 euro. This greatly depends on the gate fee of the biomass. **Duration:** 24 months (expected)

Project partners and their role: HGP (gasification), Methanor (methanol producer), North Refinery, Profactus B.V., Soldesa Hydrogen B.V., Hoek Loos (hydrogen handling), The Municipality of Amsterdam.

Programme: GAVE (Climate-neutral gaseous and liquid energy carriers), The Netherlands

Bioenergy for Europe: which ones fit best? A comparative analysis for the Community

Objective. A considerable amount of work has been carried out concerning the environmental impacts of biofuels in a number of EU countries. However, these studies differ, to varying degrees, concerning the nature of the biofuels discussed and the methods used. These are often similar, based on life cycle assessment, which should make the results comparable. However, this is true only to a limited degree. In some cases results concerning important environmental impacts are lacking. In other studies the system boundaries differ. The areas in which information was deficient were identified in detail by the Concerted Action 'Environmental aspects of biomass production and routes for European energy supply' (FAIR3-CT94-2455). This project summarised needs and recommended completion of a thorough study on the ecological impacts of all biofuels and for all countries in the EU. The objective of the shared cost project is to produce a

high quality overall environmental related decision base concerning the promotion of biofuels in the EU.

Partners: Guido REINHARDT / IFEU Institute for Energy and Environmental Research Heidelberg / GERMANY, Manfred WOERGETTER / BLT Wieselburg Agricultural Engineering Research / AUSTRIA, Mr Elio Smedile / CTI (Comitato Termotecnico Italiano) ITALY, Gerard GAILLARD / Eidgenössische Forschungsanstalt für Agrarwirtschaft und Landtechnik / SWITZERLAND, Bo Pedersen WEIDEMA / Technical University of Denmark DENMARK

Duration 1998-09-01 to 2000-09-01 (24 months, completed)

Project Reference: FAIR-CT97-3832

Project cost: 1,669,000 €

Project Funding: 887,000 €

Programme Acronym: LIFE QUALITY **Programme type:** FP5

Subprogramme Area: Key action Sustainable Agriculture, Fisheries and Forestry

Contract type: Cost-sharing contracts

Feasibility of Biomass/Waste-related SNG Production Technologies

At the end of 2003, the Dutch research institute ECN was the first in the world to successfully produce green gas through gasification of biomass. Large-scale production tests will follow shortly, in collaboration with the Dutch gas utility Gasunie.

Green gas, produced via gasification of biomass, can (after treatment) be upgraded to the same quality as natural gas. It can then also be transported via the existing gas infrastructure, or used as an alternative transport fuel. It can also be used to replace natural gas in stationary applications such as heating or electricity generation. It is now technically possible to produce this gas from other sources, such as wood. More information is available in the ECN report entitled Feasibility of Biomass/Waste-related SNG Production Technologies (<http://www.ecn.nl/library/reports/2003/c03066.html>).

The CHRISGAS project and Värnamo Växjö Biomass Gasification Center (VVBGC)

Objective. This project will develop and optimise an energy-efficient and cost-efficient method to produce hydrogen-rich gases from biomass, including residues. This gas can then be upgraded to commercial quality hydrogen or to synthesis gas for further upgrading to liquid fuels such as DME and methanol, or Fischer-Tropsch diesel.

The **demonstration** parts of the project consist of:

- conversion of several solid biofuels into a medium calorific value gas by gaseification;
- cleaning of the generated gas from particulates in a high temperature filter;
- purification of the generated gas by catalytic athermal steam reforming of tars, methane, and other light hydrocarbons to generate a raw synthesis gas consisting mainly of carbon monoxide and hydrogen.

A supporting **R&D** programme will be set with the following objectives:

- study the conditioning of the hydrogen-rich raw synthesis gas to the quality stipulated for syngas suitable for DME and other products;
- study the co-production of these fuels;
- develop a feed system based on a piston feeder.

The achievable yield of motor fuel from cellulosic biomass is higher for fuels derived via the gasification/synthesis gas route than via the hydrolysis/fermentation route as by using the first route all carbon can be converted to fuel whilst through the second route only carbon convertible to sugar can yield motor fuel. This fact also means that the production

cost for biomass derived motor fuels produced via gasification can be expected to be lower than those produced via fermentation.

The hub of the project will be the Värnamo Biomass Gasification Centre in Sweden and the use of the existing and unique biomass-fuelled pressurised IGCC (integrated gasification combined-cycle) CHP (combined heat and power) plant in Värnamo as a pilot facility. By building this Centre around this plant, gasification research and demonstration activities can be conducted at a much lower cost than if new equipment were to be built. Within this particular project, new process equipment will be developed and tested and implemented in this pilot facility to produce clean gas, rich in hydrogen, which can be used for vehicle fuel production. Also included in the project are studies related to the large-scale use of such plants and their impact on the environment and society at large.

Costs and organisation. The EU-project **CHRISGAS** (Clean Hydrogen Rich Synthesis GAS) is aimed towards the research of the production and cleaning process of hydrogen rich syngas and will be receive approx. 9,5 M€ from the European Commission. The Swedish Energy Agency (STEM) will provide 8,2 M€ to the project and to the formation of the **Värnamo Växjö Biomass Gasification Center (VVBGC)**. The VVBGC will be supplemented by additional guarantees, including direct and indirect support from the local municipalities of Växjö and Värnamo.

Partners to CHRISGAS. Växjö University, TPS Termiska Processer, KTH Stockholm, Värnamo Växjö Biomass Gasification Center (VVBGC), SEP, KS Ducente, Växjö Energi, Sydkraft, (Sweden), TK Energi (Denmark), Valutec (Finland), Pall Shumacher and Forschungszentrum Jülich (Germany), University of Bolonha, (Italy), TU Delft (The Netherlands), CIEMAT (Spain).

Production of CO₂-Neutral petrol and diesel via Fischer-Tropsch process

The aim of the project is to produce Fischer-Tropsch fuel through gaseification of biomass, namely from black liquor. The project will focus on the development of the catalysor, since it is a key component. KTH will focus on producing diesel type fuel while CTH – Chalmers will focus on producing gasoline type of biofuel.

Duration. 2003-07-01 to 2006-12-31 – On-going

Partners. KTH Royal Institute of Technology - Stockholm , CTH Chalmers - Goteborg (Sweden), Nykomb och NTNU – Trondheim (Norway).

Project cost. 640 k€ funded by STEM – Swedish Energy Agency.

Development and demonstration of blended methane and hydrogen as a fuel for busses.

The project aims the development and demonstration of busses using a blend of methane and hydrogen blended. Preliminary research at the Lund Technical University has shown the positive effects in the combustion efficiency. These results will be verified by testing one or two busses methane driven busses running on a blend of methane and hydrogen.

The project will also contribute to increase expertise within the gas distribution companies, vehicle manufacturers, agencies, and vehicle users e.g. transport companies. The project should help to develop a local market for hydrogen in Malmö, and eventually in other places. It should also contribute to a faster introduction in the market of gas driven motors into the market. Other specific objectives for the project are to increase the motor efficiency by 5% to 7% by using a blend of methane and hydrogen; to reduce NO_x and CO emissions by 10% and GHG emissions by 10 to 20%.

Duration. August 2003 to July 2005. On-going

Project Cost: 280 k€, funded by STEM – Swedish Energy Agency (120 k€), Sydkraft AB, Sydkraft Gas AB, Skånetrafiken, LTH, Volvo AB, Volvo Areo.

Partners. Sydkraft AB, Sydkraft Gas AB, Skånetrafiken, LTH – Lund University of Technology, Volvo AB, Volvo Areo

Joint fuel and engine programme Shell and Volkswagen

Volkswagen and Shell announced a joint programme for the development of new engine and fuel technologies. The programme will build on Volkswagen's optimised drive systems and Shell's GTL fuel technology to reduce consumption and emissions. Shell and Volkswagen believe that synthetic, liquid fuels form the ideal transition from hydrocarbon to hydrogen. GTL, a synthetic fuel derived from natural gas, offers diversity of energy supply and provides a bridge to future transportation fuels and technologies. Second generation bio-fuels will provide a sustainable option, offering CO₂ neutrality and avoiding competition with the food chain. Possible routes include the production of a liquid product ("SunFuel") identical with GTL fuel starting from the gasification of biomass. "SunFuel" is expected to be available in larger quantities by 2012.

Note 1: authors are not aware of public funding for this programme.

Note 2: DaimlerChrysler is also engaging in similar projects.

Large scale introduction of biogas and increased use of public transport in Lille – France (CIVITAS initiative – Trendsetter) – Demonstration

Lille Metropole is an intercommunal structure composed of 85 communes with a population of 1,2 million inhabitants. In Lille, Trendsetter focus on increasing biogas production and usage, namely:

- increasing massively the biogas production (locally from waste and sewage treatment) up to 3 M Nm³ per year by 2005;
- purchasing 128 new clean busses in Lille Metropole fleet replacing diesel busses;
- adapting the bus depots and lines and construction of a new compression unit.

In 2001, the Syndicat Mixtes des Transport was operating nearly 50 gas buses. Now the biogas fleet has increased to fully 100 partly thanks to Civitas and Trendsetter. During 2002 around 50 new biogas/CNG buses were purchased from the manufacturer Irisbus. Today most of the gas buses run on CNG but in 2005 a new biogas production plant will be in operation. Lille Metropole will build one new organic waste treatment plant where biogas will be produced. Lille Metropole has long experience of producing biogas from sewage sludge and production will be increase to 4 million Nm³. The biogas produced will be used in buses in Lille. This will produce biogas from household waste enough for about 100 buses. A new fueling depot able to serve around 100 buses over night will also be built.

More information: Yves Baesen, Public Transport Department, ybaesen@cudl-lille.fr and www.cudl-lille.fr

Waste collection with biogas lorries in Stockholm (CIVITAS initiative – Trendsetter) – Demonstration

For the past years, biogas fuelled waste collection lorries have been operating in Stockholm's Old Town. The biogas fuelled waste collection lorries have been greatly appreciated both by drivers and by residents, especially because they are so much quieter than their conventional counterparts. Residents are less disturbed by noise from the waste collection lorries, which operate from early morning throughout the day. For drivers, the

reduced noise means improved working conditions. All waste collection lorries are owned by contractors. Thus this replacement will be achieved by requiring a certain percentage of biogas vehicles when tendering for contracts for the collection of domestic solid waste in the City of Stockholm.

Within Trendsetter, the Waste Management Administration:

- require city contractors to operate one or two biogas-fuelled waste collection lorries;
- offer Trendsetter co-funding to contractors for extra costs incurred investing in biogas collection lorries, up to a total of eight to ten vehicles in the project;
- use the biogas vehicles in daily operation;
- evaluate operational use as well as citizens' attitudes regarding biogas fuelled waste collection lorries.

In October 2003 seven biogas waste collection lorries had been purchased within the framework of Trendsetter. The measure is being conducted by the Stockholm Waste Management Administration with a budget of 1 man-month and almost 40 000 €. This will co-finance extra costs for contractors to replace eight to ten diesel waste collection lorries with biogas waste collection lorries, on average about 4000 €/vehicle.

More information: Nils Lundkvist, Waste management administration, nils.lundkvist@rhf.stockholm.se

Clean vehicles in Stockholm's commercial fleets

In Stockholm, city efforts to promote cleaner vehicles have primarily focused on using clean vehicles in the municipal fleet. This was a strategic decision; these vehicles were city-owned, and the city could therefore use its own purchasing decisions to develop a market for cleaner fuels and associated infrastructure. Since private companies are very important to developing a market for these vehicles, as they buy about 70 percent of the cars sold in Stockholm, it was decided to concentrate public efforts on encouraging private companies to choose clean vehicles.

Thus, the City of Stockholm gives subsidies on up to 30% of the additional costs for cleaner vehicles. The subsidy is available for companies, organisations and governmental institutions situated within the Stockholm region. The City considers biogas, ethanol, electric hybrid and electric vehicles as clean vehicles. At present, the City of Stockholm itself operates 600 alternative fuel cars, the SL public transport authority 250 ethanol-powered inner city buses, and a number of different types of heavy trucks run on renewable forms of fuel.

More information: bjorn.hugosson@miljo.stockholm.se

3 Conclusions

This report provides a review of public-funded Research, Development and Demonstration projects in the area of biofuels for transport. It was assumed to search only for projects carried out in the last five years, i.e. since 1998. The search was mainly done through databases available on the internet and was complemented with interviews with experts. It should be noted that RD&D for more efficient and cheaper production methods of chemicals that can also be used as biofuels (e.g. ethanol) was not taken into account. The main conclusions are:

- very few public-funded research and development projects on biofuels for transport were carried out at EU level in the last five years. Even in the twelve projects identified, transport is in some case only mentioned as a potential end-use sector for biofuels;
- the main work in this area seems to have been realised between 1978 and 1995 under different EU programmes and stagnated since then. The research accomplished in those years contributed to bring to the market bioethanol from sugar or starch and biodiesel from rapeseed. It also showed the cost and technical difficulty of lignocellulose hydrolysis, currently being tested in Sweden in pilot plants;
- a new area of research activity is the production of hydrogen from biomass, which is out of the scope of this study (e.g. www.biohydrogen.nl);
- a significant number of demonstration and pilot projects were identified which shows the reasonable maturity of some technologies.

The recently adopted EU Directive on biofuel for transport could stimulate further research in the area. However, in a first phase, for the technology reasonably known (at least ethanol from sugar and starch fermentation, as well as biodiesel) the main problem is the cost of the feedstock. The focus is therefore currently on the design and choice of the economic instruments that are able to stimulate a market for biofuels.